# To Buyers of Mahler's Guides to Basic Ratemaking and Reserving

Howard C. Mahler, FCAS, MAAA

These study guides cover **the whole syllabus of CAS Exam 5**.

These study guides are split into four volumes.
The first two volumes cover Ratemaking: Sections 1 to 9, and Sections 10 to 20.
The next two volumes cover Reserving: Sections 1 to 11, and Sections 12 to 18.

I would split my time about equally between ratemaking and reserving.
For ratemaking, I would split my time about 60%/40% between my volumes one and two.
For reserving, I would split my time about 60%/40% between my volumes three and four.

**In the electronic version, use the bookmarks / table of contents in the Navigation Panel in order to help you find what you want.**

Information in bold is more important to pass your exam.
Sections and material in italics is less likely to be needed to directly answer exam questions, and should be skipped on your first time through.

I have doubled underlined highly recommended questions to do on your first pass through the material, underlined recommended questions to do on your second pass, and starred additional questions to do on a third pass through the material. No questions were labeled from the 2011 exam or later, in order to allow you to use them as practice exams.

There will be new types of questions for Exam 5, starting with the Fall 2023 sitting:

- Constructed Response
- Spreadsheet
- Multiple Choice, single response (new):
  Multiple answer choices are presented after a problem with only one correct answer.
- Multiple Choice, multiple selection (new):
  Multiple answer choices are presented after a problem with more than one correct answer.
- Fill in the Blank (new):
  A blank section is presented after a problem where the candidate must input the correct value.

"The CAS will be publishing a new sample exam in the Pearson VUE software for candidates to practice the functionality of these new item types."

**The CAS announced that it will not be releasing exams starting with Fall 2020.**

My solutions to questions are intended to be model solutions.[1] Often they are more detailed and contain more explanation than would be needed in order to get full credit.[2] This was done in order to give you a clearer and better understanding of the subject material.

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[1] In some cases, I even quote a reading word for word. This does not mean you need to be able to do so!
[2] Per the instructions to the exam, when a specific number of items is requested, only the items adding up to that number will be graded (i.e., if two items are requested and three are provided, only the first two are graded).

**After you have done one of the released exams, be sure to look closely at the CAS Examiner's Report**. **See the sample solutions in the Examiner's Reports, and read the comments of the examiners.**

In the case of verbal questions, do not concentrate on grammar or complete sentences. Feel free to list or outline your ideas. The selected use of abbreviations can save some time.
In any case, remember that spending considerable additional time to increase 80% credit to 100% credit on a single question is usually not a good use of your limited exam time. You can come back later to a question, if you have the time.

As stated in the CAS Syllabus: "The model response to the typical essay question is brief, less than one-half of a written page. Be concise — candidates do not need to answer in complete sentences when a well-composed outline format is more appropriate. Candidates should not waste time on obscure details. They should show that they have learned the relevant material and that they understand it. They should state the obvious, if it is part of the answer."

Also read "The Importance of Adverbs on Exams," in which the Exam Committee notes the difference between: briefly discuss, discuss, and fully discuss.
"Brief descriptions, discussions, etc., are worth 1/4 point.
(Unmodified) discussions or descriptions are worth 1/2 point.
Full descriptions or discussions are worth at least 1 point.
Please look carefully for these word choices and point values on all CAS upper-level exams. Most importantly, answer the question in accordance with the amount of information being asked."

My study aids include questions written by me, and some by J. Eric Brosius and Sholom Feldblum.[3] In addition, the former exam questions are arranged in chronological order. The more recent exam questions are on average more similar to what you will be asked on your exam, than are less recent questions. It is important that you **do problems when learning a subject and then some more problems a few weeks later**.[4]

Besides questions from past CAS Exams, my study guides also contain questions from past SOA Exams. While these SOA Exams cover very similar material, they are from different readings than the CAS Exams. Where appropriate, I have rewritten SOA questions in order to match the syllabus of your exam. The format of these SOA questions may be similar to some CAS questions on recent exams that have not been released; these SOA questions are integrated questions which often cover material in more than one section of my study guides. Thus you may benefit from looking over some of these past SOA questions.

There are two manners in which you should be doing problems. First you can do problems in order to learn the material. Take as long on each problem as you need to fully understand the concepts and the solution. Reread the relevant syllabus material. Carefully go over the solution to see if you really know what to do. Think about what would happen if one or more aspects of the question were revised. This manner of doing problems should be gradually replaced by the following manner as you get closer to the exam.

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[3] I thank Eric Brosius, Sholom Feldblum, and Meyer Lehman for the kind permission to use their material. Any mistakes are my responsibility.
[4] Note that In some cases, numerical values shown in one of my spreadsheets are unrounded, while the corresponding value in my text may be rounded.

The second manner is to do a series of problems under exam conditions, with the items you will have when you take the exam. Take in advance a number of points to try based on the time available. For example, if you have an uninterrupted hour, then one might try 60 / 4 = 15 points of problems. Do problems as you would on an exam in any order, skipping some and coming back to some, until you run out of time. Leave time to double check your work.

As you get closer to the exam, the portion of time spent doing problems should increase.

It is important that you develop the skill of quickly and clearly writing down what you know. Many of you will benefit by giving some of your solutions to questions to someone else to "grade".[5] They should give you feedback on whether they were able to follow what you did. They should point out where you wrote more than was necessary or not enough.

**Feel free to send me any questions or suggestions: hmahler@mac.com**
Please send me any suspected errors by Email prior to the exam.
(Please specify as carefully as possible the page and Exam number.)

**Sold separately are slides that would be presented at a seminar**. All the material, problems, and solutions are elsewhere in my study guide. The presentations are in the same order as the sections of my study guide. This provides another way to study the material.[6] Some of you will find it helpful to go through one or two presentations at a time, either alone or with someone else, pausing to do each of the problems included.

Past exam questions are copyrighted by the CAS or SOA.

Questions from past exams 5 prior to 2010, as well as questions from other exams, were based on different syllabus readings than your exam. While such questions can help you study for your exam, they should be used with appropriate caution.

CAS Technology-Based Examination:

**The CAS used computer based testing for the Fall 2020 Exam**,
**and will do so going forward**.
Be sure to check the CAS webpage for information.

You will be able to use a spreadsheet similar to Excel.[7]

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[5] Someone else taking this exam or who has just passed this exam would be a good choice.
[6] Personally, I found it helpful to vary somewhat how I studied, so as to keep up my energy and interest.
I also found it helpful to vary what I studied. On this is exam I would alternate between ratemaking and reserving, perhaps spending a week on each. As always, you should do whatever works best for you.
[7] Review the CAS testing guide prior to sitting for your exam to note any differences between the Excel and the Pearson testing environment.

Preparing for a CAS Exam--what to do with hard material

by Dr. J. Eric Brosius, FCAS

The syllabus for a typical CAS exam includes both easy and hard material. Many students learn the easy material well, but adopt less-than-optimal strategies for learning the hard material. Some spend a lot of time trying to understand syllabus readings that are nearly incomprehensible. Others ignore the more difficult readings altogether. Neither approach is a good idea, not if you hope to pass! I will suggest a better way to approach these readings. Your goal in studying is not to understand the material in general but to be able to answer the questions. Do not study the syllabus readings in a vacuum; consider also what types of questions are likely to be asked. Each exam contains both easy problems and hard problems.

We can divide the problems into four categories based on the difficulty of the material and the difficulty of the problem, as follows:

| | Easy Problems | Hard Problems |
|---|---|---|
| Hard Material | 4 | 3 |
| Easy Material | 1 | 2 |

Box 1 contains easy problems on easy material. These are easy to answer; unfortunately, there are not enough of them!

Box 2 contains hard problems on easy material. You can prepare for these by practicing problems from old tests and other sources of sample problems.

Box 3 contains hard problems on hard material. Few students can afford to spend the time required to answer all of these. Fortunately, the Examination Committee does not ask many of these question: even if they understand the reading well enough to do so, there isn't much point in a question that no one can answer. Be prepared to skip Box 3 problems if necessary.

Box 4 contains easy problems on hard material. These problems can supply the extra points you need to change a "5" into a “6". They appear often, because the Examination Committee tends to ask easy questions about hard readings. When a reading is technically difficult, and especially if it was recently added to the syllabus, even the simplest question poses a challenge. Study these readings with an eye to answering the obvious questions. It is a shame not to get points for a question that could have been answered if only you had read the first paragraph of the reading.

Plan for your exam in such a way that you **focus on Box 2 and Box 4**. Prepare for Box 2 questions by studying the easy material in detail, and by doing many sample problems. Prepare for Box 4 questions by outlining the high points of the material, and by trying to guess, alone or with other students, what questions on this material might appear on the exam.

CAS Post Exam Summaries:

"In light of the discontinuation of Examiners' Reports in 2020, the CAS has recognized the need to fill the void left in candidates' understanding of effective study strategies and overall exam performance. To bridge this knowledge gap, we are introducing the new Post Exam Summary crafted by the Syllabus and Examination Working Group. This resource is designed to provide candidates with insightful observations on candidates' exam performance, coupled with expert recommendations for improvement. The Post Exam Summary comprises a general summary section that applies universally to all constructed response exams, followed by individual sections for each of the exams administered during the last sitting. In the future, we look forward to expanding on this format and continuing to enhance this summary."

The CAS should be releasing such Post Exam Summaries after each exam sitting.
To the extent you might find them useful, be sure to check them out.[8]

[8] They might be particularly useful after taking an exam and unfortunately failing.

Pass Marks and Passing Percentages for CAS Part 5 Exams:[9]

| Exam 5 | Total Points | Pass Mark | % of Available Points | 95th Perc. | 75th Perc. | Number of Cand. | Number Passing | Raw Passing Percent | Effective Passing Percent |
|---|---|---|---|---|---|---|---|---|---|
| S2026 | | | | | | 851 | 326 | 38.3% | **42.3%** |
| F2025 | | | | | | 862 | 413 | 47.9% | **53.1%** |
| S2025 | | | | | | 885 | 340 | 38.4% | **43.0%** |
| F2024 | | | | | | 867 | 313 | 36.1% | **41.0%** |
| S2024 | | | | | | 952 | 506 | 53.2% | **57.6%** |
| F2023 | | | | | | 885 | 300 | 33.9% | **38.5%** |
| S2023 | | | | | | 1109 | 493 | 44.5% | **49.5%** |
| F2022 | | | | | | 757 | 255 | 33.7% | **36.8%** |
| S2022 | | | | | | 683 | 249 | 36.5% | **40.6%** |
| F2021 | | | | | | 643 | 186 | 28.9% | **33.6%** |
| S2021 | | | | | | 603 | 276 | 45.8% | **50.9%** |
| F2020 | | | | | | 929 | 518 | 55.8% | **59.5%** |
| F2019 | 53.5 | 37.0 | 69.16% | 42.75 | 37.50 | 732 | 209 | 28.6% | **31.8%** |
| S2019 | 52 | 37.5 | 72.12% | 44.13 | 39.38 | 734 | 294 | 40.1% | **42.6%** |
| F2018 | 55.0 | 36.5 | 66.36% | 43.00 | 38.00 | 600 | 187 | 31.17% | **33.8%** |
| Makeup | 53.5 | 40.25 | 75.23% | N.A. | N.A. | 928 | 557 | 60.0% | **63.1%** |
| S2018 | 55.5 | 42 | 75.68% | | | | | | |
| F2017 | 55.75 | 37 | 66.37% | 45.50 | 40.00 | 752 | 301 | 40.03% | **42.94%** |
| S2017 | 57.50 | 40.50 | 70.43% | 47.75 | 43.75 | 783 | 338 | 43.2% | **45.3%** |
| F2016 | 56.00 | 40.25 | 71.88% | 47.13 | 42.6 | 767 | 292 | 38.07% | **40.95%** |
| S2016 | 57.75 | 41.50 | 71.86% | 49.00 | 45.00 | 838 | 392 | 46.8% | **48.8%** |
| F2015 | 55.75 | 38.25 | 68.61% | 44.75 | 39.50 | 780 | 243 | 31.15% | **33.38%** |
| S2015 | 57.25 | 40.00 | 69.87% | 46.00 | 41.75 | 784 | 275 | 35.1% | **37.8%** |
| F2014 | 58.25 | 40.75 | 69.96% | 48.25 | 42.50 | 733 | 258 | 35.2% | **37.7%** |
| S2014 | 59.75 | 42.50 | 71.13% | 50.63 | 45.13 | 785 | 305 | 38.9% | **41.9%** |

[9] Information taken from the CAS webpage. Check the CAS webpage for updated information.
Starting in 2013, Exam 5 was given in both the Spring and the Fall. There was no Spring 2020 exam.

Both the original and makeup exams for Spring 2018 were via computer based testing using Excel. The number of candidates and number passing given are for the two exams combined.[10]

Since 2007 the total number of "points" on the exam has decreased from 100.
For example, Fall 2013 had 58.5 points.
Thus the point value of older exam questions is not directly comparable to your exam.
For example, a 3 point question in 2007 was 3% of the 4 hour exam,
while a 3 point question in Fall 2013 was instead about 5% of the 4 hour exam.

One measure of the difficulty of an exam is the ratio of the 75$^{th}$ percentile to the available points:[11]

| Exam 5 | Points | 75th percentile | Ratio |
|---|---|---|---|
| | | | |
| 2011 | 79.75 | 57.75 | 72.4% |
| 2012 | 66.25 | 52 | 78.5% |
| S2013 | 63.5 | 43.75 | 68.9% |
| F2013 | 58.5 | 42.5 | 72.6% |
| S2014 | 59.75 | 45.13 | 75.5% |
| F2014 | 58.25 | 42.5 | 73.0% |
| S2015 | 57.25 | 41.75 | 72.9% |
| F2015 | 55.75 | 39.5 | 70.9% |
| S2016 | 57.75 | 45 | 77.9% |
| F2016 | 56 | 42.6 | 76.1% |
| S2017 | 57.5 | 43.75 | 76.1% |
| F2017 | 55.75 | 40 | 71.7% |
| S2018 | N.A. | N.A. | N.A. |
| F2018 | 55 | 38 | 69.1% |
| S2019 | 52 | 39.38 | 75.7% |
| F2019 | 53.5 | 37.50 | 70.1% |

The lower the ratio of the 75$^{th}$ percentile to the available points, the harder the exam.

[10] Question 21 of the makeup exam was deemed defective, as it was missing a key piece of information to solve the problem. The available points and overall pass mark shown for the makeup exam exclude this question.
[11] There was no Spring 2020 exam.

Points on Ratemaking versus Reserving:

Starting in Spring 2011, Basic Ratemaking and Basic Reserving were put on the same exam.
Prior to that, Basic Reserving was on Exam 6 rather than Exam 5.
Here are the points on the two topics:[12] [13] [14]

| Exam | Ratemaking | Reserving | Total | % Ratemaking | % Reserving |
|---|---|---|---|---|---|
| | | | | | |
| 2011 | 40.75 | 39 | 79.75 | 51.10% | 48.90% |
| 2012 | 33.25 | 33 | 66.25 | 50.19% | 49.81% |
| Spring 2013 | 37 | 26.5 | 63.5 | 58.27% | 41.73% |
| Fall 2013 | 30.6 | 27.9 | 58.5 | 52.31% | 47.69% |
| Spring 2014 | 30.75 | 29 | 59.75 | 51.46% | 48.54% |
| Fall 2014 | 29.25 | 29 | 58.25 | 50.21% | 49.79% |
| Spring 2015 | 32.25 | 25 | 57.25 | 56.33% | 43.67% |
| Fall 2015 | 28 | 27.75 | 55.75 | 50.22% | 49.78% |
| Spring 2016 | 32 | 25.75 | 57.75 | 55.41% | 44.59% |
| Fall 2016 | 29 | 27 | 56 | 51.79% | 48.21% |
| Spring 2017 | 30.25 | 27.25 | 57.5 | 52.61% | 47.39% |
| Fall 2017 | 27.75 | 28 | 55.75 | 49.78% | 50.22% |
| S2018 | 29.25 | 26.25 | 55.5 | 52.70% | 47.30% |
| Makeup | 28.25 | 28 | 56.25 | 50.22% | 49.78% |
| F2018 | 28.75 | 26.25 | 55 | 52.27% | 47.73% |
| S2019 | 29 | 23 | 52 | 55.77% | 44.23% |
| F2019 | 30.75 | 22.75 | 53.5 | 57.48% | 42.52% |
| | | | | | |
| Avg. since 2016 | | | | 53.1% | 46.9% |

For 2016 some material was deleted from Ratemaking, while some material was added for Reserving.

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[12] Some questions could be answered out of more than one reading.
5/2013, Q.4 worth 3 points involves the Bornhuetter-Ferguson technique and can be answered out of either Basic Ratemaking or Estimating Unpaid Claims Using Basic Techniques. I have included 5/2013, Q.4 half in each.
11/2013, Q.6 worth 3.25 points involves a rate indication and the Berquist-Sherman reserving method.
I have included half of it in ratemaking and half in reserving.
5/2015 Question 11 worth 5.75 points relies somewhat on material from the reserving textbook.
5/2015 Question 15 worth 1.5 points while intended to be answered from the reserving textbook can also be answered from the ratemaking textbook.
11/2015 Question 7a worth 1.75 points was based on material from the reserving textbook,
while Question 7b worth 2.75 points was based on material from the ratemaking textbook.
11/2017 questions 6 and 15 covered both reserving and ratemaking.
5/2018 question 8 covered both reserving and ratemaking.
5/2018 makeup exam question 86 covered both reserving and ratemaking.
11/2018 question 7 covered both reserving and ratemaking.
5/2019 question 7 covered both reserving and ratemaking.
[13] Starting in 2013, Exam 5 was given in both the Spring and Fall.
[14] There was no Spring 2020 exam.
Starting with Fall 2020, the CAS will not be releasing its exams.

Volume One

# Mahler's Guide to
# Basic Ratemaking

## CAS Exam 5

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Study Aid 2027-**5-1**

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# Mahler's Guide to Basic Ratemaking

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This study guide covers the ratemaking topics on CAS Exam 5.
The loss reserving topics are covered in "Mahler's Guide to Basic Reserving".

Concepts in Basic Ratemaking by Werner and Modlin are demonstrated in my first 16 sections, with each section corresponding to the chapter in Basic Ratemaking with the same number.[1]

Afterwards are covered the syllabus readings:

"CAS Principles of Ratemaking",
"ASOP No. 13, Trending Procedures in Property/Casualty Insurance Ratemaking"
"Actuarial Standard of Practice No. 12: Risk Classification (for all Practice Areas)",
American Academy of Actuaries, 2005.

Finally I cover Lifetime Value Analysis.[2]

Information in bold or sections whose title is in bold are more important for passing the exam.
Larger bold type indicates it is extremely important.

Sections and material in italics is less likely to be needed to directly answer exam questions, and should be skipped on your first time through.

Highly Recommended problems are double underlined.
Recommended problems are underlined.
Additional problems are starred.
Solutions to the problems in each section are at the end of that section.[3]

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[1] I have incorporated all of the changes included in the May 2016 Fifth Edition of Basic Ratemaking.
The minor changes between the 4th and 5th edition are listed at the end of Basic Ratemaking.
[2] Discussed in Chapter 13 of Basic Ratemaking.
[3] Note that problems include both some written by me and some from past exams. The latter are copyright by the CAS or SOA. They are reproduced here solely to aid students in studying for exams. The solutions and comments are solely the responsibility of the author; the CAS or SOA bear no responsibility for their accuracy. While some of the comments may seem critical of certain questions, this is intended solely to aid you in studying and in no way is intended as a criticism of the many volunteers who work extremely long and hard to produce quality exams.

| Volume | Section # | Pages | Section Name |
|---|---|---|---|
| | | | |
| One | 1 | 10-25 | Introduction |
| One | 2 | 26-51 | *Rating Manuals* |
| One | 3 | 52-69 | Ratemaking Data |
| One | 4 | 70-149 | Exposures |
| One | 5 | 150-404 | **Premium** |
| | | | |
| One | 6 | 405-642 | **Losses and LAE** |
| One | 7 | 643-792 | Other Expenses and Profit |
| One | 8 | 793-1069 | **Overall Indication** |
| One | 9 | 1070-1233 | **Traditional Risk Classification** |
| Two | 10 | 1234-1420 | Multivariate Risk Classification |
| | | | |
| Two | 11 | 1421-1634 | Special Classification |
| Two | 12 | 1635-1743 | Credibility |
| Two | 13 | 1744-1778 | Other Considerations |
| Two | 14 | 1779-1872 | Implementation |
| Two | 15 | 1873-2022 | Commercial Lines Rating Mechanisms |
| | | | |
| Two | 16 | 2023-2129 | Claims-Made Ratemaking |
| Two | 17 | 2130-2150 | CAS Principles of Ratemaking |
| Two | 18 | 2151-2161 | Trending Procedures in Property/Casualty Insurance Ratemaking |
| Two | 19 | 2162-2182 | ASOP 12: Risk Classification |
| Two | 20 | 2183-2265 | *Lifetime Value Analysis* |

**Seminar Style Slides Sold Separately.**

## Past Exam Questions by Section of this Study Guide[4]

| Section | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|
| | | | | | |
| 1 | | | | | |
| 2 | | | | | 22 |
| 3 | | | | | |
| 4 | 53 | 6, 36, 51 | 8, 11, 40, 49 | 3, 5, 36 | 27, 29 |
| 5 | 44 | | 1, 48 | 30 | 31, 36 |
| | | | | | |
| 6 | 22, 37 | 1, 37, 46, 49 | 22, 36 | 4, 6, 7, 31, 37 | |
| 7 | 54 | 34 | 13 | 49 | 3, 50 |
| 8 | 15, 31 | 50 | 2, 32, 41, 51 | 38 | 30 |
| 9 | | 31a, 42a | 42 | 33, 40 | 32 |
| 10 | | | | | |
| | | | | | |
| 11 | 5, 6, 35 | 24, 27 | 17, 18, 43, 47 | 18, 23, 27a, 35, 45, 46 | 16, 21, 41a, 44, 46, 48 |
| 12 | 46 | 44 | | | 11, 42 |
| 13 | | | 44 | | |
| 14 | 55 | 35 | | | |
| 15 | 33 | 7, 8 | 26, 27 | 32 | 5, 6 |
| 16 | 1, 29, 30, 60 | 47 | 28, 29 | 39 | 12 |
| 17 | | 23 | 39 | 1, 28 | 1 |
| 18 | | 21 | 19 | | 28 |
| 19 | | | | | |
| 20 | | | | | 38 |

[4] Prior to 2000, Exam 6 was the basic ratemaking exam. Since 2000, Exam 5 has been the basic ratemaking exam.

| Section | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|
| | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | 25 | 3, 45 | 14, 43 | 43 |
| 5 | 4, 12, 19 | 25, 39, 41, 47 | 37a, 38, 44, 58 | 38 |
| | | | | |
| 6 | | | 39, 47 | |
| 7 | 26 | | 52 | 29 |
| 8 | 44 | 36, 42 | 30 | 39, 40 |
| 9 | 31, 43 | 26, 43 | 13 | 21, 54 |
| 10 | 45 | | | |
| | | | | |
| 11 | 8, 17, 24, 42 | 5, 7, 27, 34, 37 | 12, 15, 16, 40, 56, 57 | 24, 25, 27, 31, 45, 48, 50, 52 |
| 12 | 7, 21 | 4, 53 | 18, 21, 50, 53 | 23 |
| 13 | | | | 30, 53a |
| 14 | | | | 19 |
| 15 | 13, 35, 36 | 19, 32, 33 | 24, 35b, 36 | 9, 28, 51 |
| | | | | |
| 16 | 5, 33 | 15, 35 | 31, 32 | 44 |
| 17 | 25 | 46 | 41 | 22, 42 |
| 18 | 2 | 1 , 40 | 3, 7 | 55 |
| 19 | | | | |
| 20 | 30 | 52b | 34 | 47 |

| Section | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | 5, 6 | 9, 38 | 26, 27 | 30 | 14, 36 |
| 5 | 15, 38 | | 10, 11, 31, 33 | 7, 11, 31, 32, 35 | 12, 37, 38 |
| | | | | | |
| 6 | 2, 45, 47, 48 | 28, 31 | 12, 15 | 8, 37, 45 | 16, 40, 50 |
| 7 | 43 | 4, 18 | 35 | 13 | 42, 43 |
| 8 | 1, 37 | 17, 27, 44 | 28, 36 | 10, 33 | 44, 46 |
| 9 | 27 | 19 | | 29, 36, 40 | 45, 49 |
| 10 | | | | | |
| | | | | | |
| 11 | 7 | 14, 29, 30, 32, 42 | 38, 40 | 15, 34, 39, 41 | 19, 20, 39, 48, 51 |
| 12 | 17 | 10 | 39 | 46 | 17, 18, 41 |
| 13 | | 11 | 24 | 26a | |
| 14 | 36, 40 | | 37 | 14 | |
| 15 | 25, 26, 44 | 2, 3 | 17, 42 | 17, 43 | 22, 53, 54 |
| | | | | | |
| 16 | 46 | 43 | 22, 29 | 12 | 15 |
| 17 | 3, 4 | 1 | 30 | 9, 38 | 35 |
| 18 | 14 | 33 | | 47 | 13 |
| 19 | | | | | |
| 20 | 11, 23 | | 43 | 44 | 56 |

Questions on the P.P. Auto Manual, no longer on the syllabus: 2002 Q 8, 2004 Q.21, 2005 Q.6.

| Section | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | 24 | 33 | 12 | 17 |
| 5 | 5, 26, 27, 28 | 34, 35, 36, 37 | 13, 14, 15 | 18, 19, 20, 21 |
| | | | | |
| 6 | 7, 29a, 31, 32 | 22, 40, 46, 53 | 17, 18, 19 | 22, 24, 25, 26, 27 |
| 7 | 33, 34 | 7, 41 | 23, 24 | 29 |
| 8 | 36 | 8, 42, 43 | 25, 26, 27 | 23, 30, 31 |
| 9 | 8, 38, 39 | 44, 48 | 28, 29, 30, 33 | 33, 34, 37 |
| 10 | | | | |
| | | | | |
| 11 | 37, 41, 43, 44 | 9, 10, 47, 49, 50 | 16, 31, 32, 34, 35, 36, 45 | 36, 39b, 40, 41 |
| 12 | 35, 42 | 32, 38, 39 | 22 | 32 |
| 13 | 22a | | 42a | 14, 15 |
| 14 | | | | 38 |
| 15 | 10, 20, 40, 49 | 45, 51, 52 | 39, 40, 41 | 35, 43, 44 |
| | | | | |
| 16 | | 13 | 20, 21 | 28 |
| 17 | 25 | 11 | | 39a |
| 18 | | 6 | | |
| 19 | | | | |
| 20 | 50 | 28 | 43, 44 | 45 |

Prior to 2010, the material currently covered in Basic Ratemaking by Werner and Modlin, was covered in many separate readings.

Questions on the ISO P.P. Auto Manual, no longer on the syllabus: 2006 Q 3, 2007 Q.5.

| Section | 2010 | 2011 | 2012 | Spring 2013 | Fall 2013 | Spring 2014 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | 11, 12 | 8 | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | 16, 17 | 2, 3 | 2, 3 | 1 | 1 | 3 |
| 5 | 18, 19 | 4, 5 | 4, 5, 6 | 2 | 2 | 1 |
| | | | | | | |
| 6 | 20, 21, 23, 24 | 6, 7, 17 | 7 | 7, 8 | 3, 6 | |
| 7 | 25 | | | | 7 | |
| 8 | 26, 27 | 9, 10 | 9 | 3, 4, 5, 9 | 4, 5, 8 | 2, 4 |
| 9 | 29 | 11 | 13, 14 | 11 | 10 | 6, 8 |
| 10 | 36 | 13 | 11 | 12 | | 9 |
| | | | | | | |
| 11 | 30, 31, 32 | 14, 15, 16 | 12, 15 | | 11, 13 | |
| 12 | | | | | | 5, 7 |
| 13 | | | | | 12 | |
| 14 | 28 | 18 | | 14 | 9 | 10 |
| 15 | 33, 34 | 19 | | 13, 15 | | 11 |
| | | | | | | |
| 16 | 22 | | 8 | 6 | | |
| 17 | | | 10 | | | |
| 18 | | | | | | |
| 19 | | | | | | |
| 20 | 35 | 20 | | 10 | | |

Questions on the ISO P.P. Auto Manual, no longer on the syllabus: 2011 Q 1, 2012 Q.1.
Question on AAA “Risk Classification” no longer on the syllabus: 2011 Q.12.

Starting in Spring 2011, Basic Ratemaking and Basic Reserving were put on the same exam. Prior to that, Basic Reserving was on Exam 6 rather than Exam 5.

Starting in 2013, Exam 5 was given in both the Spring and Fall.

| Section | Fall 2014 | Spring 2015 | Fall 2015 | Spring 2016 | Fall 2016 | Spring 2017 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | | | 6 | | | |
| 2 | | | | | | |
| 3 | | 6 | | | | |
| 4 | 1 | 2, 3 | 2 | | 1 | 1 |
| 5 | 2, 3 | 4, 5 | 1, 4 | 2 | 2 | |
| | | | | | | |
| 6 | 4, 5 | 8, 15 | 5 | 1, 4 | 4, 5 | 3 |
| 7 | 6 | 9 | | 7 | 6, 7 | 2, 4 |
| 8 | 7 | 11 | 7 | 6, 8 | 8, 9 | 5, 13 |
| 9 | 9, 11 | 13 | | 13 | | |
| 10 | 10 | | 10 | 10 | 12 | 8 |
| | | | | | | |
| 11 | | 14 | 12 | | 11, 14 | 11 |
| 12 | 8 | | 3 | 11 | | 9 |
| 13 | | | | | | |
| 14 | | 10 | 9, 11 | 12 | 13 | 6, 7, 10 |
| 15 | | | 13 | 9 | 15 | 12 |
| | | | | | | |
| 16 | | 7 | | 5 | 3 | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | | | 3 | 10 | |
| 20 | 12 | | 8 | | | |

Question on the ISO P.P. Auto Manual, no longer on the syllabus: Spring 2015 Q.1.
Question on AAA “Risk Classification” no longer on the syllabus: 5/15 Q.12.

For the 2015 exams, “Personal Automobile Premiums: An Asset Share Pricing Approach for Property-Casualty Insurance,” by Sholom Feldblum, was dropped from the syllabus.

For the 2016 exams: the I.S.O. P.P. Auto Manual and Chapter 2 of Basic Ratemaking were dropped from the syllabus. AAA Committee on Risk Classification, “Risk Classification Statement of Principles,” June 1980, was replaced by Actuarial Standard of Practice No. 12: Risk Classification (for all Practice Areas), American Academy of Actuaries, 2005.

| Section | Fall 2017 | Spring 2018 | Makeup Exam Spring 2018 | Fall 2018 | Spring 2019 | Fall 2019 | 9/25 Sample Items |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | 1 | | 1 | 1 | 1 | 1 |
| 5 | 1, 3, 16 | | 1 | 3 | 2 | 2 | |
| | | | | | | | |
| 6 | 6 | 3, 5, 16 | 2, 3, 4 | 2, 5 | 4, 5 | 5 | |
| 7 | 7 | 7 | 5 | 6 | 6 | 6 | 2, 3 |
| 8 | 2, 5, 15 | 8 | 6, 13 | 7 | 7 | 7 | |
| 9 | | 10, 11 ,12 | 7, 8, 11 | 12 | 10 | 9 | |
| 10 | 10 | 13 | | 9 | 9 | 10, 11 | 6 |
| | | | | | | | |
| 11 | 11, 12 | 14 | 10, 12 | 10, 13 | | 13, 14 | |
| 12 | | 2, 4 | 9 | | | 3, 12 | |
| 13 | | | | | 8 | | |
| 14 | 13 | | | 8 | 12 | | |
| 15 | | 15 | | 11 | 11 | 15 | 5 |
| | | | | | | | |
| 16 | 4 | 6 | | 4 | 3 | 4 | |
| 17 | | | | | | 8 | |
| 18 | | | | | | | |
| 19 | | | | | | | |
| 20 | 9 | 9 | | | | | |

Both the original and makeup exams for Spring 2018 were via computer based testing using Excel.
For Fall 2018, the CAS went back to the traditional paper exam, using a calculator.

For Spring 2019 and Fall 2019, Exam 5 used the paper-and-pencil format of exam administration.

There was no Spring 2020 exam.

For Fall 2020, the CAS went back to computer based testing.
**The CAS did not release the Fall 2020 exam and will not release future exams.**

## Section 1, Introduction

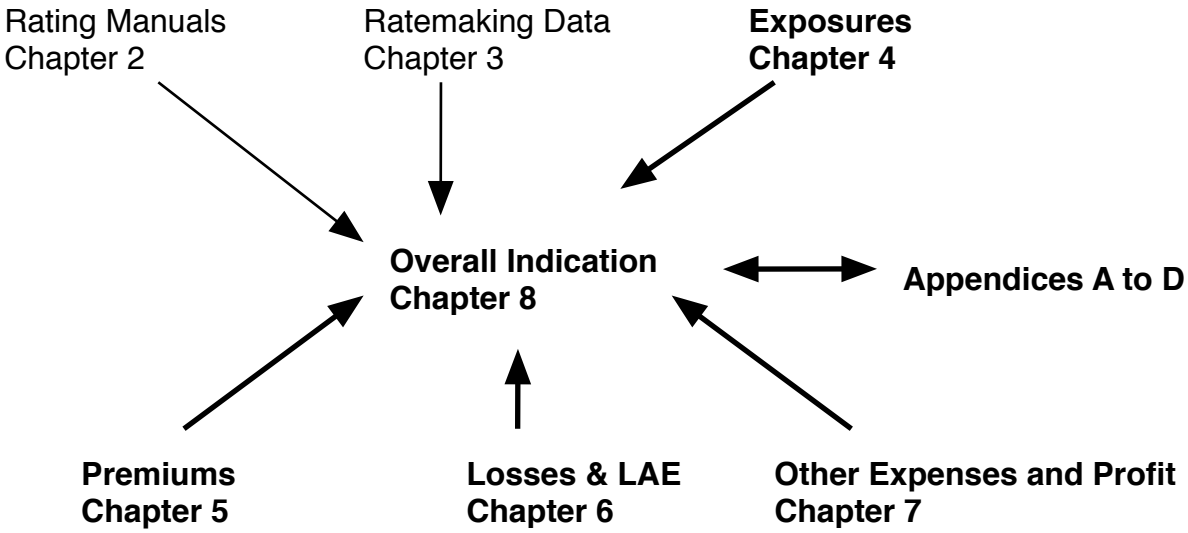
Basic Ratemaking replaced many separate papers that were formerly on the syllabus.[5] In some cases, the authors have taken or adapted material from these papers. Material has been updated and put on the level of comprehension and detail intended for your exam.[6] There is also much new material.

A single textbook has the advantage of a consistent notation, terminology, and approach. However, you should bear in mind that Basic Ratemaking was written by consulting actuaries who work for a single firm. Different actuaries would have presented some things from a somewhat different point of view, chosen different examples, and emphasized some different items.

Most of us learn by looking at specific, detailed examples. Be sure to carefully study those presented in the Appendices of Basic Ratemaking as well as the tables within the chapters. Learn these well for your exam; however, you should treat these as examples of the types of choices that could be made, rather than the one right way to do things.

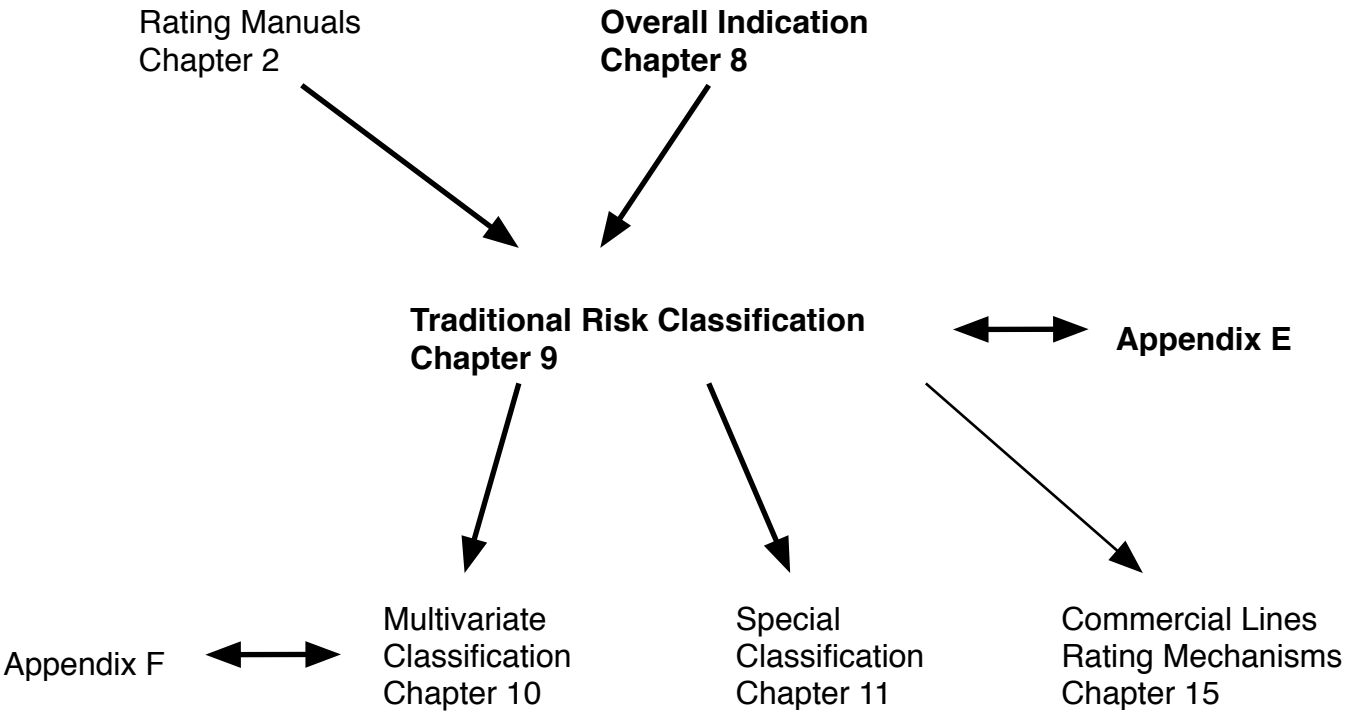
The purpose is to expose you to the general principles so that you will be able to do ratemaking yourself. In a practical application, you will have to make decisions as to what is appropriate for that particular situation, in light of any practical constraints.

In Chapter 1, the Introduction, basic ideas and terms are introduced, which are used in later chapters of Basic Ratemaking. The following diagrams attempt to describe the relationships of the chapters and possible orders in which you can read them.
Chapter 8 on Overall Rate Indications brings together material from earlier chapters. Before studying Chapter 8, you need to study Chapters 4 to 7 first, and glance at Chapters 2 and 3.[7]




[5] Basic Ratemaking was added to the syllabus for the 2010 exam.
[6] The authors were guided by a Committee of the CAS.
[7] While Chapter 2 is no longer on the syllabus, it has some useful background material.

Chapter 9 on Classification Ratemaking should be studied after Chapters 2 and 8, and before Chapters 10, 11, and 15.




Chapter 12 on Credibility should be studied after Chapter 8 on Overall Indications and Chapter 9 on Traditional Risk Classification.

Chapter 13 on Other Considerations should be studied after Chapter 9 on Traditional Risk Classification.

Chapter 14 on Implementation should be studied after Chapter 2 on Rating Manuals.

Chapter 15 on Commercial Lines Rating Mechanisms should be studied after Chapter 9 on Traditional Risk Classification and Chapter 12 on Credibility.

Chapter 16 on Claims-Made Ratemaking should be studied after Chapter 8 on Overall Indications.

Premiums and Exposures:

Price = Cost + Profit.

Price of Insurance = Premium.

**Premium** is the amount the insured pays for insurance coverage.

An **exposure** is the basic unit of risk that underlies the insurance premium.

Insurance premiums are calculated using a **rating manual** based on the exposures insured.[8]

The insured pays premiums to an insurer in exchange for a promise to pay claims.

Claims:

The person making the **claim** is called a **claimant**, and can be an insured or a third party.

There are many examples of first party claims. Your home burns down in a fire, and you make a claim with your Homeowners Insurer. Your car is stolen and you make a claim with your Automobile Insurer.

There are many examples of third party claims. Alice's dog bites Bob, and Bob makes a claim with Alice's Homeowners Insurer. Cal hits Debra's car with his car, and Debra makes a claim with Cal's Automobile Insurer. Eunice slips and falls in a store; she is injured and she makes a claim with the store's Liability Insurer.

The date of the event that caused the loss is called the date of loss, **accident date**, or occurrence date.

Usually, the accident is a sudden event. If instead the loss is the result of continuous or repeated exposure to substantially the same general hazardous conditions, the accident date is the date when the damage, or loss, is apparent.

For example, a coal miner is exposed to the silica and carbon in the coal dust in a mine over many years. If the miner is diagnosed with "black lung disease", the date of diagnosis is usually the accident date. Due to repetitive motions, a worker may develop tendonitis. Again the date of diagnosis is usually the accident date.

[8] The rating manual may be hardcopy and/or electronic.

Oil may seep from an old underground storage tank, over many years. The date that the damage caused by this pollution is recognized is usually the accident date.[9]

The date on which the insurer receives notice of a claim is the **report date**.

Claims not currently known by the insurer are referred to as **unreported claims** or incurred but not reported claims.

Until the claim is settled, the reported claim is considered an **open claim**. Once the claim is settled, it is categorized as a **closed claim**. In some instances, further activity may occur after the claim is closed, and the claim may be **reopened**.[10]

Losses:

**Loss** is the amount of compensation paid or payable to the claimant under the terms of the insurance policy. The terms associated with losses are: paid loss, case reserve, reported or case incurred loss, IBNR reserve, IBNER reserve, and ultimate loss.

**Paid losses** are those amounts that have been paid to claimants.

When a claim is reported, the insurer establishes a **case reserve**, which is an estimate of the amount of money required to ultimately settle that claim, minus anything that has already been paid. The amount of the case reserve is adjusted as payments are made and additional information is obtained about the claim.

**Reported Losses** = Case Incurred Losses = Paid Losses + Case Reserves.

**Ultimate loss** is the amount of money required to close and settle all claims for a defined group of
policies.

The amount estimated to be needed to ultimately settle unreported claims is referred to as an **incurred but not reported (IBNR) reserve**.[11]

The **incurred but not enough reported (IBNER) reserve** is the difference between the aggregate amount estimated to ultimately be needed settle the reported claims and the aggregate reported losses (paid + case) at the time the losses are evaluated.[12]

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[9] Courts ultimately decide which insurance policy or policies will provide coverage for pollution claims.
[10] For example, a worker who injured his back on the job, returns to work. If there are no more medical payments expected for treatments on his back, this claim is closed. However, he may re-injure his back, and not be able to work. This claim would then be reopened.
[11] Also called pure IBNR, in order to make it clear that it only relates to unknown claims.
[12] IBNER is called Bulk reserves at many insurers. It is the expected increase in incurred losses on known claims.

IBNER reserve = Estimated Ultimate on Reported Claims - Reported Losses.[13]

Current Estimate of Ultimate Losses = Reported Losses + IBNR Reserve + IBNER Reserve.

Neither the IBNR Reserve nor the IBNER Reserve are associated with individual claims. They are probably estimated separately by the reserving actuary.[14] They are probably estimated separately by line of insurance. They may be estimated separately by state or a countrywide reserve may be allocated to individual states.

Loss Adjustment Expenses:

Expenses that the insurer incurs in the process of settling claims are called loss adjustment expenses (**LAE**).

Allocated loss adjustment expenses (**ALAE**) are claim-related expenses that are directly attributable to a specific claim.

Unallocated loss adjustment expenses (**ULAE**) are claim-related expenses that cannot be directly assigned to a specific claim.

LAE = ALAE + ULAE.

For statutory financial reporting purposes, LAE is separated into defense and cost containment (DCC) and all other (AO) expenses.[15]

Underwriting Expenses:

**Commissions and brokerage** are amounts paid to insurance agents or brokers as compensation for generating business.

**Other acquisition costs** are expenses other than commissions and brokerage expenses paid to acquire business.

**General expenses** include the remaining expenses associated with the insurance operations and any other miscellaneous costs.

**Taxes, licenses, and fees** include all taxes and miscellaneous fees paid by the insurer excluding federal income taxes.

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[13] Reported losses = paid losses + case reserves.
[14] See for example, Estimating Claims Using Basic Techniques, by Jacqueline Friedland, CAS Study Note.
[15] In the United States, the National Association of Insurance Commissioners (NAIC) determines how data will be reported by insurers in their Annual Statements and Insurance Expense Exhibits.

Also the insurer will load into the premiums an (expected) Underwriting Profit.

Since premiums are collected before losses and lae are paid, the insurer earns investment income in addition to any underwriting profit or loss. For lines of insurance where the average delay in paying loss and lae is long, such as liability insurance, investment income is extremely important part of determining an appropriate target underwriting profit.

**Fundamental Insurance Equation**:[16]

**Premium = Losses + LAE + Underwriting Expenses + Underwriting Profit**.

The goal of ratemaking is to determine rates such that the premium is expected to cover all costs and achieve the target underwriting profit. This should be the case both for a book of business and to the extent possible for each individual insurance policy.[17]

It is common ratemaking practice to use relevant historical experience, suitably adjusted, to estimate the future expected costs that will be used in the fundamental insurance equation.

The following are some items that may necessitate a restatement of the historical experience:
- Rate changes
- Operational changes
- Inflationary pressures
- Changes in the mix of business written
- Law changes.

**A rate is reasonable and not excessive, inadequate, or unfairly discriminatory if it is an actuarially sound estimate of the expected value of all future costs associated with an individual risk transfer**.

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[16] When determining premiums to be charged, everything on the righthand side the equation is on a predicted, estimated, or target basis.
Once the business is written and loss and lae are at ultimate, this equation can be used to calculate the achieved underwriting profit.

[17] Overall rate indications are discussed in Chapter 8 of Basic Ratemaking. How to determine the rates for classes, territories, etc., relative to average is discussed in Chapters 9 to 11 of Basic Ratemaking.
Individual risk rating is discussed in Chapter 15 of Basic Ratemaking.

Various Ratios:

**Frequency** = $\frac{\text{Number of Claims}}{\text{Number of Exposures}}$.

Average Claim Cost = **Severity** = $\frac{\text{Total Losses}}{\text{Number of Claims}}$.[18]

Loss Cost = **Pure Premium** = $\frac{\text{Total Losses}}{\text{Number of Exposures}}$ = (Frequency) (Severity).

**Average Premium** = $\frac{\text{Total Premium}}{\text{Number of Exposures}}$.

**Loss Ratio** = $\frac{\text{Total Losses}}{\text{Total Premium}} = \frac{\text{Pure Premium}}{\text{Average Premium}}$.[19]

**LAE Ratio** = $\frac{\text{Total Loss Adjustment Expenses}}{\text{Total Losses}}$.

**Underwriting** (UW) **Expense Ratio** = $\frac{\text{Total Underwriting Expenses}}{\text{Total Premium}}$.[20]

**Operating Expense Ratio** = OER = UW Expense Ratio + $\frac{\text{LAE}}{\text{Earned Premium}}$.[21]

**Combined Ratio** = (Pure) Loss Ratio + Operating Expense Ratio.[22]

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[18] "Losses" in the numerator will in some cases be "Losses plus ALAE."

[19] "Losses" in the numerator will in some cases be "Losses plus ALAE," or "Losses plus LAE."
The denominator will usually be earned premium rather than written premiums.

[20] Underwriting Expenses include: commissions and brokerage, other acquisition costs, general expenses, and taxes, licenses, and fees. Usually general expenses are divided by earned premiums, while the other categories are divided by written premiums. This is discussed in my section on "Other Expenses and Profit."

[21] Insurers that use independent agents will have higher commissions. The independent agent may do some of the work in handling claims, which would otherwise result in the insurer incurring more LAE. The Operating Expense Ratio takes into account all expenses, regardless of whether they are called LAE or underwriting expenses.

[22] Each dollar of LAE should be one and only one of the two pieces

Retention is a measure of the rate at which existing insureds renew their policies upon expiration.

$$\textbf{Retention Ratio} = \frac{\text{Number of Policies Renewed}}{\text{Number of Potential Renewal Policies}}.$$ [23] [24]

A policy may not be renewed for many reasons, not necessarily disjoint:
Insurer decides not continue to insure this insured.
Insured decides not to continue to buy from this insurer.
Insurer and insured cannot agree on a price acceptable to both of them.
Insurer decides to not renew a whole book of business.
The insurer ends its relationship with an agent or vice versa.
The insured decides to self-insure.
Insurance is no longer required.[25]

Particularly for large commercial insureds, an insurer will offer to write coverage and quote a price.
Sometimes the insured will accept this offer of coverage and sometimes they will not.[26]

For personal lines, some of the potential new insureds who contact the insurer and who the insurer is willing to insure will become customers and some will not, possibly due to price.

The close ratio compares the rate quotes given to potential new business and the number of such insureds who end up being written by the insurer:

$$\textbf{Close Ratio} = \frac{\text{Number of Accepted Quotes}}{\text{Number of Quotes}}.$$

The close ratio is also known as hit ratio, quote-to-close ratio, or conversion rate. In general business jargon, the quote-to-close ratio (or “conversion rate”) is the measurement of actual customers or clients who buy, compared to the number of prospects you contacted or to the number of potential customers who visited your business.

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[23] It can be for a month or a year. It can be for a state or countrywide.
[24] Some insurers exclude from the denominator policies that cancel due to death and policies that an underwriter non-renews, while others do not.
[25] For example, the insured died, the insured went out of business, or the insured home was sold.
[26] Negotiation may lead to an agreed upon price.

Notation:[27]

While it should not be vital to learn all of the notation used in Basic Ratemaking, it can not hurt to know some of it. You should certainly learn and use this notation to the extent that you find it helpful.

**X = Exposures**.

**P = Premium**.
$\bar{P}$ = Average premium = P / X.

$P_c$ = Premium at current rates.
$\bar{P}_C$ = Average premium at current rates = $P_c$ / X.

$P_I$ = Premium indicated by rate review.
$\bar{P}_I$ = Average indicated premium = $P_I$ / X.

$P_P$ = Premium at proposed rates.[28]
$\bar{P}_P$ = Average premium at proposed rates = $P_P$ / X.

**L = Losses**.
$\bar{L}$ **= Pure Premium = Loss Pure Premium = L / X**.

**$E_L$ = Loss Adjustment Expense (LAE)**.
$\bar{E}_L$ = Average LAE per exposure = Loss Adjustment Expense Pure Premium = $E_L$ / X.

**$E_F$ = Fixed underwriting expenses**.[29]
$\bar{E}_F$ = Average fixed underwriting expense per exposure = Fixed Expense Pure Premium = $E_F$/X.
**F = Fixed expense ratio = $E_F$ / P**.

**$E_V$ = Variable underwriting expenses**.
**V = Variable expense provision = $E_V$ / P**.

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[27] See page vi in Basic Ratemaking. There is no standard actuarial notation for ratemaking.
[28] An insurer will file or adapt rates based to some extent on an actuarial rate indication. However, the proposed rates may differ to some extent from those indicated.
[29] As discussed in my section on “Other Expenses and Profit,” underwriting expenses are sometimes divided into fixed and variable.

$Q_C$ = Profit percentage at current rates.

**$Q_T$ = Target profit percentage = Underwriting Profit Provision**.

$B_C$ = Current base rate.[30]

$B_P$ = Proposed base rate.

$R1_{C,i}$ = Current relativity for the $i^{th}$ level of rating variable $R_1$.[31]

$R1_{P,i}$ = Proposed relativity for the $i^{th}$ level of rating variable $R_1$.

$A_C$ = Current fixed additive fee.[32]

$A_P$ = Proposed fixed additive fee.

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[30] Base rates are discussed in Chapter 2 of Basic Ratemaking on Rating Manuals, as well as subsequent chapters on classification rating.

[31] A class relativity is the pure premium or variable premium of a class relative to average or relative to the base class.
For example, the relativity for class 2 might be 1.5, one and half times that for the base class.
We might have several different rating variables; the resulting rates could be displayed in a multidimensional array.
This is discussed in Chapter 2 of Basic Ratemaking on Rating Manuals, as well as subsequent chapters on classification rating.

[32] This refers to a fixed amount added to the premium of each policy.
See Chapter 14 of Basic Ratemaking on Implementation.

Problems:

**1.1.** (2 points) Define each of the following:
a. Frequency.
b. Severity.
c. Pure Premium.
d. Average Premium.

**1.2.** (1.5 points) Define each of the following:
a. LAE.
b. ALAE.
c. ULAE.

**1.3.** (2.5 points) Define each of the following ratios:
a. Loss Ratio.
b. LAE Ratio.
c. UW Expense Ratio.
d. Operating Expense Ratio (OER).
e. Combined Ratio.

**1.4.** (1/2 point) State the "Fundamental Insurance Equation."

**1.5.** (2 points) Define each of the following underwriting expenses:
a. Commissions and brokerage.
b. Other acquisition costs.
c. General expenses.
d. Taxes, licenses, and fees.

*__1.6__*. (3 points) Define each of the following:
a. Paid loss.
b. Case reserve.
c. Reported loss.
d. IBNR reserve.
e. IBNER reserve.
f. Ultimate loss.

**1.7.** (1 point) Define each of the following ratios:
a. Retention Ratio.
b. Close Ratio.

**1.8.** (1 point) Use the following information:
Written Premium = $85 million
Earned Premium = $90 million
Commissions and Brokerage = $8 million
Other Acquisition Expenses = $5 million
Taxes, Licenses and Fees = $1 million
General Expenses = $4 million
Loss Ratio (excluding LAE) = 65%
LAE ratio (to loss) = 7%
(a) (0.5 points) Calculate the Underwriting Expense Ratio
(b) (0.25 points) Calculate the Operating Expense Ratio
(c) (0.25 points) Calculate the Combined Ratio

**1.9.** (1 point) Given the following information:

| | Calendar Year 2015 |
|---|---|
| Written premium | $550 million |
| Earned premium | $580 million |
| Commissions | $44 million |
| Taxes, licenses and fees | $12 million |
| General expenses | $31 million |
| Other Acquisition Expenses | $18 million |
| LAE ratio (to loss) | 12% |
| Combined ratio | 106% |

Calculate the 2015 operating expense ratio.

**1.10. (5, 5/10, Q.11)** (2 points)
a. (0.75 point) Explain how the standard economic formula, Price = Cost + Profit, relates to the fundamental insurance equation.
b. (1.25 points) Company ABC replaced inexperienced adjusters with experienced adjusters who have a greater knowledge of the product.
Explain the impact of this change on each component of the fundamental insurance equation.

**1.11. (5, 5/10, Q.12)** (1 point) Given the following information:
2008 earned premium = $200,000
2008 incurred losses = $125,000
Loss adjustment expense ratio = 0.14
Underwriting expense ratio = 0.25
Calculate the combined ratio.

**1.12. (5, 5/11, Q.8)** (1.25 points) Given the following information:

| | Calendar Year 2010 |
|---|---|
| Written premium | $280.00 |
| Earned premium | $308.00 |
| Commissions | $33.60 |
| Taxes, licenses and fees | $9.80 |
| General expenses | $36.96 |
| LAE ratio (to loss) | 8.2% |
| Combined ratio | 100% |

Calculate the 2010 operating expense ratio.

**1.13. (5, 11/15, Q.6)** (1 point) Given the following information:

| | Calendar Year 2014 |
|---|---|
| Written premium | $560.00 |
| Earned premium | $616.00 |
| Commissions | $67.20 |
| Taxes, licenses and fees | $19.60 |
| General expenses | $73.92 |
| LAE ratio (to loss) | 8.2% |
| Combined ratio | 100% |

Calculate the 2014 operating expense ratio.

Solutions to Problems:

**1.1.** Frequency = $\frac{\text{Number of Claims}}{\text{Number of Exposures}}$.

Severity = $\frac{\text{Total Losses}}{\text{Number of Claims}}$.

Pure Premium = $\frac{\text{Total Losses}}{\text{Number of Exposures}}$ = (Frequency) (Severity).

Average Premium = $\frac{\text{Total Premium}}{\text{Number of Exposures}}$.

**1.2.** a. Expenses that the insurer incurs in the process of settling claims are called loss adjustment expenses (LAE).
b. Allocated loss adjustment expenses (ALAE) are claim-related expenses that are directly attributable to a specific claim.
c. Unallocated loss adjustment expenses (ULAE) are claim-related expenses that cannot be directly assigned to a specific claim.

**1.3.** Loss Ratio = $\frac{\text{Total Losses}}{\text{Total Premium}} = \frac{\text{Pure Premium}}{\text{Average Premium}}$.

LAE Ratio = $\frac{\text{Total Loss Adjustment Expenses}}{\text{Total Losses}}$.

Underwriting (UW) Expense Ratio = $\frac{\text{Total Underwriting Expenses}}{\text{Total Premium}}$.

Operating Expense Ratio = OER = UW Expense Ratio + $\frac{\text{LAE}}{\text{Total Premium}}$.

Combined Ratio = (Pure) Loss Ratio + Operating Expense Ratio.

**1.4.** Premium = Losses + LAE + Underwriting Expenses + Underwriting Profit.

**1.5.** a. Commissions and brokerage are amounts paid to insurance agents or brokers as compensation for generating business.
b. Other acquisition costs are expenses other than commissions and brokerage expenses paid to acquire business.
c. General expenses include the remaining expenses associated with the insurance operations and any other miscellaneous costs.
d. Taxes, licenses, and fees include all taxes and miscellaneous fees paid by the insurer excluding federal income taxes.

**1.6.** a. Paid losses are those amounts that have been paid to claimants.
b. A case reserve is an estimate of the amount of money required to ultimately settle a particular claim, minus anything that has already been paid.
c. Reported Losses = Paid Losses + Case Reserves.
Note that for Calendar Year data, Reported Losses = Paid Losses + Change in Case Reserves.
d. Incurred but not reported (IBNR) reserve is the amount estimated to be needed to ultimately settle unreported claims.
e. The incurred but not enough reported (IBNER) reserve is the difference between the aggregate amount estimated to ultimately be needed settle the reported claims and the aggregate reported losses (paid + case) at the time the losses are evaluated.
f. Ultimate loss is the amount of money required to close and settle all claims for a defined group of policies.

**1.7.** a. Retention Ratio = $\frac{\text{Number of Policies Renewed}}{\text{Number of Potential Renewal Policies}}$.

b. Close Ratio = $\frac{\text{Number of Accepted Quotes}}{\text{Number of Quotes}}$.

**1.8.** (a) Take the ratio of General Expense to Earned premium: 4/90 = 4.44%.
Take the ratio of Commissions, Other Acquisition, plus Taxes, licenses and fees to written premiums: (8 + 5 + 1)/85 = 16.47%.
Underwriting Expense Ratio = 4.44% + 16.47% = **20.91%**.
(b) Operating Expense Ratio = LAE Ratio + UW Expense Ratio
= (7%)(65%) + 20.91% = **25.46%**.
(c) Combined Ratio = Loss Ratio + Operating Expense Ratio = 65% + 25.46% = **90.46%**.

**1.9.** Take the ratio of General Expense to Earned premium: 31 / 580 = 5.34%.
Take the ratio of Commissions, Other Acquisition plus Taxes, licenses and fees to Written premiums: (44 + 12 + 18) / 550 = 13.45%.
Underwriting Expense Ratio: 5.34% + 13.45% = 18.79%.
Combined Ratio = Loss & LAE Ratio + UW Expense Ratio.
$\Rightarrow$ 106% = (1.12) (Loss Ratio) + 18.79%. $\Rightarrow$ Loss Ratio = 77.87%.
$\Rightarrow$ Ratio of LAE to Earned Premium: (12%)(77.87%) = 9.34%.
Operating expense ratio = LAE / Earned Premium + UW Expense Ratio
= 9.34% + 18.79% = **28.13%**.
Comment: Similar to 5, 5/11, Q.8.

**1.10.** a. The "Fundamental Insurance Equation" is:
Premium = Losses + LAE + UW Expenses + UW Profit.

Premium. ⇔ Price.

Losses + Loss adjustment expenses + UW Expenses. ⇔ Cost.

UW Profit. ⇔ Profit.
b. Loss will go down due to better adjusting.
Loss adjustment Expense will go up due to larger salaries or fees paid to experienced adjuster.
UW expense should have no significant change.
Premium would go down if one assumes the same UW Profit.
On the other hand, UW profit would increase if one instead assumes the same premium.

**1.11.** 0.14 = LAE Ratio = LAE / Losses = LAE / 125,000.
⇒ LAE = (0.14)(125,000) = 17,500.
Combined Ratio = 125/200 + 17.5/200 + 0.25 = **96.25%**.
Comment: In the combined ratio, the Loss and LAE have earned premium in the denominator, but the underwriting expense ratio would have written premium in the denominator.
The Operating Expense Ratio = 17.5/200 + 0.25 = 33.75%.
The (pure) Loss Ratio = 125/200 = 62.5%. 62.5% + 33.75% = 96.25%.

**1.12.** Take the ratio of General Expense to Earned premium: 36.96/308.00 = 12.00%.
Take the ratio of Commissions plus Taxes, licenses and fees to written premiums:
(33.60 + 9.80)/280.00 = 15.50%.
Underwriting Expense Ratio = 12.00% + 15.50% = 27.50%.
Combined Ratio = Loss & LAE Ratio + UW Expense Ratio.
100% = (1.082) (Loss Ratio) + 27.50%. ⇒ Loss Ratio = 67.00%.
⇒ Ratio of LAE to Earned Premium = (8.2%)(67.00%) = 5.5%.
Operating expense ratio = LAE / Earned Premium + UW Expense Ratio
= 5.5% + 27.5% = **33.0%**.
Comment: Usually there would Other Acquisition Expenses.

**1.13.** General Expense Ratio (to earned) = 73.92 / 616 = 12.0%.
Commissions Ratio (to written) = $67.20 / $560.00 = 12.0%.
Taxes, licenses and fees (to written) = $19.60 / $560.00 = 3.5%.
UW Expense Ratio = 12% + 12% + 3.5% = 27.5%.
Combined Ratio = Loss & LAE Ratio + UW Expense Ratio.
⇒ 100% = (1.082) (Loss Ratio) + 27.5%. ⇒ Loss Ratio = 67.0%.
⇒ Ratio of LAE to Earned Premium: (8.2%)(67.0%) = 5.5%.
operating expense ratio = UW Expense Ratio + LAE / Earned Premium =
27.5% + 5.5% = **33.0%**.
Comment: Similar to 5, 5/11, Q.8.
The given figures for CY14 could be in millions of dollars.
I do not know why there is no other acquisition expanse.
In addition to the solution I gave, the CAS Examiner's Report included solutions where either implicitly one is relating General Expense to written premium, or Commissions and Taxes to earned premium. You should avoid doing so on your exam.

## *Section 2, Rating Manuals*

While **no longer on the syllabus**, Section 2 of Basic Ratemaking contains some useful background material. I suggest that you look at one example of a rating algorithm.

Rating Manuals are used by insurers to determine the premium that will be charged a particular insured for a particular policy. The information in a rating manual can be divided into three pieces: Rules, Rate Pages, and the Rating Algorithm.[33] In addition, the insurer will have Underwriting Guidelines which help determine how the rating manual is used. The rules include: general definitions, rules for determining classifications, discussions of endorsements, etc.

For example, in the ISO Personal Automobile Manual formerly on the syllabus, they define such items as: private passenger auto, liability, single limit liability, comprehensive coverage, etc.[34] The different classification variables are defined and discussed. For example, primary classification depends on: age, sex, and marital status of the operators, the use of the auto, and the eligibility of youthful operators for the Driver Training and/or Good Student Classes. The Safe Driver Insurance Plan, an individual risk rating plan, is discussed. Model Year / Age groups for physical damage are discussed. Cancellation rules are discussed.

The rate pages are a list of rates for different classes and territories. There may be additional items that have to be applied to the listed numbers in order to get the final premium to be charged. For example, for the Michigan Automobile Insurance Placement Facility:[35]

| Age of Any Resident Operator | Adult Driver | Not Owner or Principal Operator | Owner or Principal Operator |
|---|---|---|---|
| Under 19 | | 4A | 5A |
| 19–20 | | 4B | 5B |
| 21–22 | | 4C | 5C |
| 23–24 | | 4D | 5D |
| Adult 25 and Older | 1B | | |
| Retired or Unemployed, 60–64 | 1A | | |
| Senior Citizen, Unemployed 65–69 | 1AS | | |
| Senior Citizen, Unemployed 70 and Older | 1SS | | |
| Business Use | 3 | | |

In addition, the state is divided into territories. For example, Territory 13 consists of the cities of: Dearborn, Allen Park, Lincoln Park, and Melvindale.[36]

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[33] In some cases, the line between them can be blurry.
[34] The policy itself contains detail on the coverages provided, etc. The rating manual and the policy work together.
[35] This is for the residual market in one state. This is just an example. The classes used by ISO or an individual insurer would differ somewhat.
[36] Some territories may consist of several counties. Other territories may be parts of a large city.

Usually there is a base class or base risk.[37] For the above example, the base class would 1B: Adult Driver (25 years and older). The actuary would determine the rate to be charged the base class in each territory, and the relativities to go from the rate for the base class to the rates for the other classes.

For example, if the rate of Bodily Injury Liability (Basic Limits of 20/40) in Territory 13 for class 1B were $103, and the relativity for class 1A were 0.80, then the rate for class 1A would be: (0.8)($103) = $82. If the relativity for class 4D were 1.31, then the rate for class 4D would be: (1.31)($103) = $135. The base rate in Territory 19 would be different, for example $95.

For automobile liability there would be a list of increased limits factors, used to determine the premium if the insured buys more than the basic limits of liability.[38] For automobile physical damage, there would be a list of deductible credits for those who bought a larger deductible than the base deductible.[39]

How to get the final premium is explained via the Rating Algorithm. Basic Ratemaking gives three examples: Homeowners, Medical Malpractice, and Workers Compensation. While you should study these examples, remember that the details would differ by insurer and there are other features that would apply to other lines of insurance.

The manual rate is the rate calculated directly from the rate tables and factors in the manual.

Underwriting Guidelines:

Each insurer has its own guidelines for which insureds its underwriters should write.

So for example, a particular Workers Compensation insurer may not write nursing homes. Another Workers Compensation insurer might not write small risks. A private passenger automobile insurer may not insure sports cars. In each case, this may be due to perceived unprofitability of the risk or lack of expertise of the insurer.

Many times a group of insurers will have common ownership.[40] In that case, different insurers in the group can have different rates for the same line of insurance in the same state. In that case, the insurer needs underwriting guidelines to determine which insureds will be written in which company.

For example, the All Star Insurance Group writes private passenger automobile insurance in three companies. The preferred business is written in Vega Insurance Company at the lowest rate. The standard business is written in the Sirius Insurance Company, at a medium rate level. The substandard business is written in the Polaris Insurance Company at the highest rate.

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[37] This will be used in Classification Rating, as discussed in Chapter 9 of Basic Ratemaking.
[38] Increased Limits Factors are discussed in Chapter 11 of Basic Ratemaking.
[39] Pricing of deductibles is discussed in Chapter 11 of Basic Ratemaking.
[40] Where allowed by law, a single insurer may have more than one set of rates, in other words have different underwriting tiers. See the Homeowners example in Basic Ratemaking, to be discussed subsequently.

Sometimes, an underwriting guideline may turn into a rating variable, or be used to provide a credit to insureds. For example, credit scores of insureds, or some of the items that were later used to create credit scores, were first used by a few insurers as underwriting guidelines for private passenger automobile insurance.[41] As discussed in Chapter 9 of Basic Ratemaking, now many insurers use credit scores as a rating variable for personal lines of insurance.

An underwriting guideline can be somewhat subjective; the underwriter may have to apply some judgement. As will be discussed, in contrast a classification variable must be objective in its application.[42]

Note that most states have restrictions on underwriting guidelines. For example, one could not use race or religion to determine whether to write an insured or which underwriting tier to place them in. A state might not allow credit scores to be used as a rating variable, but might allow its use in underwriting guidelines.[43]

Basic Ratemaking list some examples of typical characteristics used in underwriting:[44]

Personal Automobile Insurance: Credit Score, Homeownership, Prior Bodily Injury Limits.[45]

Homeowners Insurance: Credit Score, Prior Loss Information, Age of Home.[46]

Workers Compensation: Safety Programs, Number of Employees, Prior Loss Information.

Commercial General Liability Insurance: Credit Score, Years in Business,
Number of Employees.

Medical Malpractice: Patient Complaint History, Years Since Residency,
Number of Weekly Patients.[47] [48]

Commercial Automobile: Driver Tenure, Average Driver Age, Earnings Stability.[49]

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[41] *Among the many items from credit reports that may be used to calculate a credit score for an individual are: late payments, bad debts, and financial leverage. See "A View Inside the Black Box: A Review and Analysis of Personal Lines Insurance Credit Scoring Models Filed in the State of Virginia,"*
*by Cheng-sheng Peter Wu and John R. Lucker, Winter 2004 CAS Forum.*

[42] See my section on "Traditional Risk Classification."

[43] A state might allow credit scores to be used for both.
Another state might allow credit scores to be used for neither.

[44] See Exhibit 2.2 in Basic Ratemaking. As mentioned, sometimes some of these would be rating variables.

[45] They are referring to the limit for Bodily Injury Liability the insured has on their policy that is about to expire.

[46] Prior Loss Information refers to the claims history of the insured.

[47] Residency is a stage of graduate medical training. In the United States, it leads to eligibility for board certification, and the ability of the doctor to practice medicine on his own.

[48] Presumably, the insurer might be concerned if the doctor has too heavy a work load. In any case, the more patients the doctor sees, the more chance for a medical malpractice claim, all else being equal.

[49] They mean the stability of profitability of the business being insured. These criteria seem suited to a trucking firm.

Homeowners Example:[50] [51]

$500 would be charged to insure a "base rate" home for one year.[52] [53]
This base rate of $500 applies to a home with $200,000 of insurance (Coverage A amount), in Territory 3, with frame construction, in Protection Classes 1-4, written in underwriting Tier C, that received no miscellaneous credits and bought no addition coverages.[54]

This base rate will be adjusted for the following items: Amount of Insurance (AOI), Territory, Protection Class and Construction Type, Underwriting Tier, Deducible Amount, Miscellaneous Credits, any Additional Optional Coverages, and the Expense Fee.

Coverage A of the Homeowners Policy covers the value of the dwelling itself. The Coverage A amount is the Amount of Insurance (AOI). The larger the amount of insurance purchased the larger the premium, all else being equal. In this example, the premium for a $125,000 home would be 75% of that for a $200,000 home. The premium for a $500,000 home would be 169% of that for a $200,000 home.[55] Note that the AOI relativities are not linear! [56]

A state is divided into geographical territories. In this example there are five territories.[57]
Territory 3 is the base territory. A home in territory 5 would pay 1.15 times that of a similar home in Territory 3.[58]

Masonry construction is less susceptible to damage by fire than frame construction.
Therefore, a masonry home pays less than a frame home.[59]

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[50] See pages 17 to 23 in Basic Ratemaking.
[51] Later I show an example of rate pages from the Illinois Fair Plan.
[52] This rate covers all perils. Some insurer's would charge a separate rate for hurricanes, with separate classes and territories. See for example, "Homeowners Ratemaking Revisited (Use of Computer Models to Estimate Catastrophe Loss Costs)," by Michael A. Walters and Francois Morin, PCAS 1997.
[53] They do not specify the level of coverage, which would differ between HO2 and HO3 for example.
[54] As will be discussed, the premium would be the base of rate of $500 plus a $50 policy fee, for a total premium of $550.
[55] See Exhibit 2.4 in Basic Ratemaking.
[56] *Helping to determine the curve of relatives by amount of insurance is an important task of homeowners actuaries. See for example, "Homeowners Insurance Pricing" by Mark Homan and "Homeowners Ratemaking" by Stacy Weinman, both in the 1990 CAS Discussion Paper Program. One could have different curves for different types of construction.*
[57] Typically, there would be several dozen territories. Typically, the relativities would vary much more.
The number assigned to each territory is arbitrary and may not have any relation to its relative rate.
[58] Maybe territory 5 is nearer the coast and thus more susceptible to hurricanes.
Constructing territories is an important task for actuaries, but is not discussed in detail in Basic Ratemaking.
*See for example, "The Construction of Automobile Rating Territories in Massachusetts, " by Robert F. Conger, PCAS 1987, and "Determination of Statistically Optimal Geographic Territory Boundaries," by Klayton N. Southwood, CAS Special Interest Seminar on Predictive Modeling, October 2006.*
[59] While fire (and lightning) is the single most important peril for Homeowners Insurance, constituting less than half of the loss dollars, there are other important perils such as: Wind & Hail, Water Damage & Freezing, Theft, Vandalism & Malicious Mischief, and Liability.

Towns are rated for their "Public Protection Class." Lower numbers indicate a quicker and/or better capability of fighting fires. Thus a home in a town with protection class 5 pays more than a similar home in a town with protection class 3.

There are combined relativities for Protection Class/Construction.[60] In this example, the base rate is for a Frame Home in Protection Classes 1-4. A Masonry Home in Protection Class 9 would pay 1.75 times the base rate.[61]

In this example, the insurer has four underwriting tier.[62] Those insured placed in Tier A pay less than the base rate. while those in tier D base the highest rate.[63]

Insureds may choose a deductible amount.[64] The larger the deductible amount the lower the premium, all else being equal.[65] $250 is the base deductible; they pay the base rate.[66] Those insured with a $5000 deductible get less coverage, and pay 70% of the base rate, all else being equal.[67]

This insurer offers Miscellaneous Credits: New Home Discount of 20%,
5-Year Claims-Free Discount of 10%, and Multi-Policy Discount of 7%.[68]

The basic limits for Homeowners Insurance are $100,000 of Liability Coverage and $500 of Medical Payments.[69] Insureds may purchase increased limits; they pay more premium. They pay $25 extra if they buy $300,000/$1000 limits, while they pay $45 extra if they instead buy $500,000/$2500 limits.[70] This rate for higher limits does not depend on the other rating factors.

Homeowners Insurance includes $2500 coverage for jewelry. Insureds may purchase increased limits. They pay $35 extra if they buy $5000 limits, while they pay $60 extra if they instead buy $10,000 limits.[71]

The insurer charges each policy a policy fee of $50.[72]

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[60] *Determining construction or protection/construction relativities is an important task of homeowners actuaries. See for example, "Fire Protection Classifications of Homeowners Insurance," by William Von Seggern, et al., Winter 1996 CAS Forum.*

[61] See Exhibit 2.6 in Basic Ratemaking.

[62] In this example, we assume the tiers are all written in the same company. They could instead each be written in a different insurer who is part of the same group, with common ownership and management.

[63] See Exhibit 2.7 in Basic Ratemaking.

[64] The homeowners deductible applies to property losses but not liability losses.

[65] Pricing of deductibles is discussed in Chapter 11 of Basic Ratemaking.

[66] They still pay less than if they had a $100 deductible, which is not offered by this insurer.

[67] See Exhibit 2.8 in Basic Ratemaking.

[68] See Exhibit 2.9 in Basic Ratemaking.
The Multi-Policy discount would apply to somebody who also bought auto insurance from this insurer.

[69] See Personal Insurance by C.M. Nyce, for a discussion of the coverages provided by Homeowners Insurance.

[70] See Exhibit 2.11 in Basic Ratemaking.

[71] See Exhibit 2.10 in Basic Ratemaking.

[72] This covers fixed expenses that do not vary with premium, as discussed in my section on "Other Expenses and Profit." In this case, this is a fee per policy rather than a fee per home.
Many insurers write each home on a separate policy.

Exercise: Lincoln Penny is buying insurance from the Wicked Good Insurance Company for his home. He is written in Underwriting Tier B. He chooses a $1000 deductible.
Since he also has his automobile policy with Wicked Good, he receives the multi-policy discount.
He buys increased limits of liability of $500,000/$2500.
His house is insured for $440,000. It is in Territory 5.
It is masonry and in Protection Class 3.
Determine his premium.
[Solution: AOI Relativity is 1.57, Territory Relativity is 1.15,
Protection/Construction relativity is 0.90.
His Underwriting Tier Relativity is 0.95. His Deductible Credit Factor is 0.85.
His Multi-Policy Discount results in a factor of: 1 - 7% = 0.93.
Increased Liability / Medical Coverage Rate = $45.
The policy fee is $50.
Premium = ($500)(1.57)(1.15)(0.90)(0.95)(0.85)(0.93) + $45 + $50 = $705.]

Rating Algorithm for this Homeowners Example:

R1 = Amount of Insurance Relativity
R2 = Territory Relativity
R3 = Protection Class / Construction Type Relativity
R4 = UnderWriting Tier Relativity
C1 = Deductible Credit Factor
C2 = 1 - (New Home Discount) - (Claims-Free Discount).[73]
C3 = 1 - Multi-Policy Discount

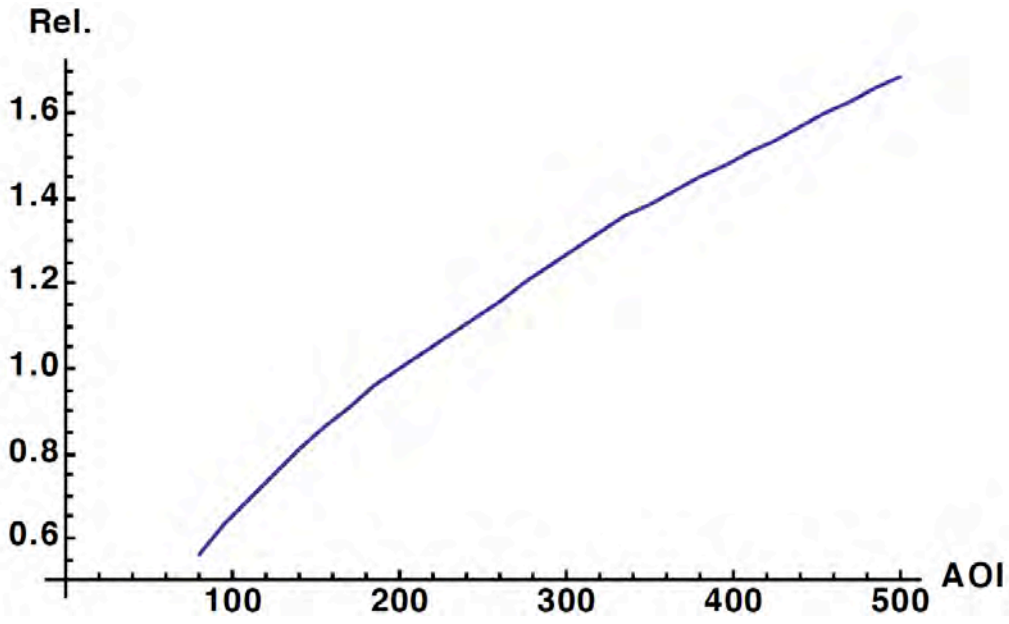
Premium = (Base Rate) R1 R2 R3 R4 C1 C2 C3 + Increased Jewelry Coverage Rate
+ Increased Liability / Medical Coverage Rate + Policy Fee.[74]

[73] Thus in this example, the new home and claims-free discounts are added together.
[74] *Premium is rounded to the nearest penny after each step, and rounded to the nearest dollar at the end.*

Exercise: Barbara Seville is buying insurance from the Wicked Good Insurance Company for her new home.
She is written in Underwriting Tier A. She chooses a $5000 deductible.
She buys increased jewelry coverage with a limit of $5000.
Her house is in Territory 1. It is insured for $110,000.
It is frame and in Protection Class 6.
Determine her premium.
[Solution: AOI Relativity is 0.69, Territory Relativity is 0.80,
Protection/Construction relativity is 1.10.
Her Underwriting Tier Relativity is 0.80. Her Deductible Credit Factor is 0.70.
Her new home discount results in a factor of: 1 - 20% = 0.80.
Her Increased Jewelry Coverage Rate = $35.
The policy fee is $50.
Premium = ($500)(0.69)(0.80)(1.10)(0.80)(0.70)(0.80) + $35 + $50 = $221.]

Table 2.4:

Basic Ratemaking gives an example of Rate Relativities by Amount of Insurance (AOI) for Homeowners. $200,000 is chosen as the base, with a relativity of 1.[75]




For example, $500,000 has a rate relativity 1.69.
The expected losses go up less than linearly with the amount of insurance.

[75] This is one of many reasonable choices and makes no difference in the rates charged.

Medical Malpractice Example:[76] [77]

This example involves nurses being covered for their profession liability.[78]

The base rate for an self-employed nurse is $3000.
The base rate for employed nurses, in other words other nurses, is $2500.[79]

There is a rate relativity based on the nurses specialty.[80]
The base is Family Practice.
For example, Psychiatric nurses are charged 80% of the base rate.

Part time nurses pay 50% of full-time nurses.[81]

Rates vary by territory.

There is a "claims-free" discount of 15%, that applies to each individual nurse.[82]

There is a schedule rating plan, that applies to each individual nurse,
with a maximum debit or credit of 25%:

| Item | Debit/Credit |
|---|---|
| Continuing Education | up to 25% credit |
| Procedure[85] | up to 25% debit |
| Workplace Setting | up to 25% debit |

The limits of liability are per claim with an annual aggregate limit.
For example, $500,000/$1 million, means the insurer will pay at most $500,000 for any one claim and will pay at most $1 million for losses covered by a single annual policy.[83] [84]
Buying higher limits of liability provides more coverage for a higher premium.[85]

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[76] See pages 23 to 28 in Basic Ratemaking.
[77] You should probably just glance at this example, and then return while you have studying Chapter 16 of Basic Ratemaking on Claims-Made Ratemaking.
[78] Doctors and hospitals also buy Medical Malpractice Insurance.
[79] Nurses might be employed by a hospital, medical practice, nursing home, psychiatric institution, school, etc.
[80] See Exhibit 2.15 in Basic Ratemaking.
[81] *Part-time is defined as 20 hours or less per week, at being a nurse.*
[82] To get the credit the nurse can not have had more than $5000 in reported losses over the last 3 years.
*Basing this on reported losses invites arguments about the insurer's case reserves.*
[83] The aggregate applies per policy not per nurse. So a large group practice would want a higher aggregate limit.
*In theory, the relativities should differ somewhat for a large group as opposed to a single nurse.*
[84] The limit here applies to loss without ALAE.
Other insurers write policies where the limit applies to losses plus ALAE.
[85] See Exhibit 2.18 in Basic Ratemaking.

One can buy different deductibles. A larger deductible provides less coverage for less premium.[86]

These are claims-made rather than occurrence policies.[87] A "first-year" claims-made policy written 1/1/2010 would cover claims reported during 2010 from incidents that occurred during 2010. A "second-year" claims-made policy written 1/1/2011 would cover claims reported during 2011 from incidents that occurred during either 2010 or 2011.

A second-year claims-made policy provides more coverage and therefore costs more than a first-year claims-made policy.[88] The base rate is for a "mature" policy.[89]

As discussed in my Chapter 16, an extended reporting endorsement (tail policy) should be purchased when a nurse who has been on claims-made coverage retires or leaves this practice.[90]

A 12-month extended reporting endorsement purchased 1/1/2010 would cover claims reported during 2010 from incidents that occurred during 2009. It would be purchased by a nurse who had been on claims-made coverage for 12 months. A 24-month extended reporting endorsement purchased 1/1/2010 would cover claims reported during 2010 from incidents that occurred during either 2008 or 2009. It would be purchased by a nurse who had been on claims-made coverage for 24 months.

A 24-month extended reporting endorsement provides more coverage and therefore costs more than a 12-month extended reporting endorsement.[91] [92]
One pays 94% of a mature claims-made policy for a 12 month extended reporting endorsement, and 170% for a 24 month extended reporting endorsement.

Groups with more than one nurse insured on the policy get a discount.[93]
For example, a group with 15 or more nurses gets a 10% credit.

Exercise: Sharona Fleming is a full-time self-employed nurse, who works in Territory 4.
Her specialty is pediatrics.
Determine the premium for her 3rd year claims-made policy with limits of $100K/$300K and no deductible.
[Solution: ($3000)(1.1)(1.50)(0.60)(0.800) = $2376.]

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[86] See Exhibit 2.19 in Basic Ratemaking. The deductible applies per claim.
[87] As discussed in Chapter 16 of Basic Ratemaking.
[88] See Exhibit 2.20A in Basic Ratemaking. Claims-made Maturity Factors are commonly called step factors.
[89] Here mature means a 7-year policy or more.
[90] It could also be purchased by the estate of a nurse or doctor who died.
[91] See Exhibit 2.20B in Basic Ratemaking.
These factors are multiplied by the base rates just as are the claims-made maturity factors.
[92] Pricing extended reporting endorsements is not discussed in Basic Ratemaking.
*See for example "Liabilities for Extended Reporting Endorsement Guarantees under Claims-Made Policies," by Charles L. McClenahan, 1988 CAS Discussion Paper Program.*
[93] See Exhibit 2.21 in Basic Ratemaking.

Exercise: Mildred Ratched is retiring as a nurse.
She worked at the Salem Mental Hospital located in Territory 3.
Her specialty is psychiatric.
She worked full-time.
She gets a 15% schedule rating credit.
Determine the premium for her 60 month extended reporting endorsement with limits of $2M/$4M and a $5000 deductible.
[Solution: ($2500)(0.80)(1.25)(0.85)(1.15)(0.92)(2.400) = $5396.]

Rating Algorithm for this Medical Malpractice Example:

R1 = Specialty Relativity
R2 = Part-time/Full-time Relativity
R3 = Territory Relativity
R4 = Limit Relativity
C1 = 1 - Claims Free Discount
C2 = 1 - Schedule Rating Credit/Debit[94]
C3 = 1 - Deductible Credit
C3 = 1 - Group Credit.
F1 = Claims-Made Factor (Either Step Factor or Extended Reporting Factor)

Premium = $\sum$ (Base Rate for Nurse) R1 R2 R3 C1 C2 R4 C3 F1 C4 .[95]

There is a minimum premium of $100, per nurse.

The total premium for a policy with several nurses is the sum of the premium for the individual nurses on the policy.

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[94] A credit of 10% corresponds to factor of 0.90. A debit of 15% corresponds to a factor of 1.15.
[95] *Premium is rounded to the nearest penny after each step, and rounded to the nearest dollar at the end.*

Workers Compensation Example:[96] [97]

There are hundreds of different classes. An employer will usually have different workers and their payroll assigned to more than one class.[98] Each class in each state has its own rate. Examples of classes: Clerical, Trucking, Plumbing, Box Manufacturing, Biotechnology, etc.

Exposures are in units of $100 of payroll.[99]

Manual premiums are: $\sum$(class rate) (payroll / $100) .[100]

Exercise: An employer has payroll in three classes with the following rates:

| Class | Payroll | Rate |
|---|---|---|
| 1 | $100,000 | $3 |
| 2 | $500,000 | $1 |
| 3 | $200,000 | $2 |

Determine this employers manual premium.
[Solution: (3)(1000) + (1)(5000) + (2)(2000) = $12,000.]

The manual premium would normally be multiplied by an experience modification factor.[101] However, in the example in Basic Ratemaking, the insured is too small to be experience rated.[102]

In addition, one can Schedule Rate an insured.[103] For each of a set of characteristics, there will be a range of credits or debits.[104]

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[96] See pages 29 to 34 in Basic Ratemaking.
[97] For a different example, see The Massachusetts Workers Compensation Rate Manual at: https://www.wcribma.org/Mass/Products/Manuals/MA_Manual.aspx
[98] *While it is usually a relatively straightforward process, it can be difficult to classify some employers. There are foot thick manuals going into all of the details.*
[99] As discussed in my section on Exposures, while payroll is the most commonly used exposure base for Workers' Compensation, one might consider using manweeks.
[100] Basic Ratemaking here does not use the term "manual premiums."
[101] Experience Rating is discussed in Chapter 15 of Basic Ratemaking. An insured with more than the expected losses pays more, while one with less than the expected losses pays less.
[102] In most states, all insureds above a certain size are experience rated.
[103] Schedule Rating is discussed in Chapter 15 of Basic Ratemaking.
Schedule rating is used to alter manual rates to reflect characteristics of the specific insured that are expected to affect future losses compared to the average reflected in the manual rate. If Experience Rating applies, then only characteristics that are not yet reflected in the prior experience should be reflected in Schedule Rating.
[104] See Exhibit 15.6 in Basic Ratemaking for a detailed example of a Schedule Rating Plan.

In the example, they list 6 characteristics with the following ranges:[105]

| Characteristic | Range of Credits and Debits |
|---|---|
| Premises | 10% credit to 10% debit |
| Classification Peculiarities | 10% credit to 10% debit |
| Medical Facilities | 5% credit to 5% debit |
| Safety Devices | 5% credit to no credit |
| Employees-Selection, Training, Supervision | 10% credit to 10% debit |
| Supervision, Management-Safety Organization | 5% credit to 5% debit |

Usually there is a maximum total credit and debit. In this example, the maximum credit is 25%, while the maximum debit is also 25%.

There is some underwriting judgement involved in applying Schedule Rating.

In this example, a particular insured is given a 10% credit for Premises, a 2.5% credit for Safety Devices, and a 5% credit for Employees-Selection, Training, Supervision.
The total credit is: 10% + 2.5% + 5% = 17.5%.[106]

The manual premium is multiplied by the effect of Schedule Rating.
In this example we multiply by: 1 - 17.5% = 0.825.

This insurer gives addition credits for specific items: Pre-employment Drug Screening 5%, Employee Assistance Program 10%, Return-to-Work Program 5%.[107]

Any of these credits that are applicable to a given insured employer are applied separately and multiplicatively. In the example, a 5% credit is given for Pre-employment Drug Screening, so the manual premium is multiplied by: 1 - 5% = 95%.

In addition, each policy is charged an Expense Constant of $150.[108]

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[105] See Exhibit 2.24 in Basic Ratemaking.
[106] The maximum does not have an effect in this case. Schedule Rating credits and debits add.
[107] See Exhibit 2.25 in Basic Ratemaking.
[108] This covers fixed expenses that do not vary with premium, as discussed in my section on "Other Expenses and Profit."

Exercise: An employer has a payroll of $500,000, all in a class with a rate of $2.
They have an experience modification of 0.96, a 4% credit.
They have a schedule debit of 3%.
They are given a credit of 10% for an Employee Assistance Plan.
They are given a credit of 5% for a Return-to-Work Program.
The Expense Constant is $150.
Determine the premium.
[Solution: ($500,000/100) ($2) = $10,000.
(0.96) (1 + 3%) (1 - 10%) (1 - 5%) ($10,000) + $150 = $8604.
Comment: The example in Basic Ratemaking does not include Experience Rating.
Larger insureds would get Premium Discounts,
as discussed in Chapter 11 of Basic Ratemaking.]

Rating Algorithm for this Workers Compensation Example:

Manual Premium = $\sum$ (class rate) (payroll / $100).

Factor 1 = 1 + Schedule Rating Credit/Debit.[109]
Factor 2 = 1 - Pre-Employment Drug Screening Credit
Factor 3 = 1 - Employee Assistance Program Credit
Factor 4 = 1 - Return-to-Work Program Credit

Premium = (Manual Premium) (Factor 1) (Factor 2) (Factor 3) (Factor 4) + Expense Constant.[110]

The Minimum Premium is $1500.

[109] A 5% credit corresponds to a factor of 0.95, while a 5% debit corresponds to a factor of 1.05.
[110] *Premium is rounded to the nearest penny after each step, and rounded to the nearest dollar at the end.*

*Sample of Illinois Fair Plan Homeowners Rates:*[111]

This is a concrete example of rates for homeowners insurance, for those who have not worked in that line of insurance.

Lake County, Protection Classes 1-8[112]

| | MASONRY | | FRAME | |
|---|---|---|---|---|
| Amount of Insurance | HO 2 | HO 3 | HO 2 | HO 3 |
| | | | | |
| $10,000 | $135 | $145 | $150 | $160 |
| $20,000 | $179 | $191 | $202 | $216 |
| $30,000 | $224 | $239 | $251 | $268 |
| $40,000 | $287 | $307 | $318 | $340 |
| | | | | |
| $50,000 | $352 | $377 | $395 | $423 |
| $75,000 | $559 | $599 | $623 | $666 |
| $100,000 | $799 | $859 | $883 | $946 |
| $150,000 | $1,279 | $1,379 | $1,403 | $1,506 |
| | | | | |
| $200,000 | $1,759 | $1,899 | $1,923 | $2,066 |
| $250,000 | $2,239 | $2,419 | $2,443 | $2,626 |
| $300,000 | $2,719 | $2,939 | $2,963 | $3,186 |
| $350,000 | $3,199 | $3,459 | $3,483 | $3,746 |
| | | | | |
| $400,000 | $3,679 | $3,979 | $4,003 | $4,306 |
| $450,000 | $4,159 | $4,499 | $4,523 | $4,866 |
| $500,000 | $4,639 | $5,019 | $5,043 | $5,426 |
| | | | | |
| Premium per $10,000 additional | $96 | $104 | $104 | $112 |

[111] www.illinoisfairplan.com Rates effective 1/1/02. The Fair Plan is the involuntary market for property insurance.
[112] Lake County in suburban Chicago, is north of Cook County, on Lake Michigan and the Wisconsin border.

The more insurance that is purchased, the more the premium. However, the relativities by amount of insurance are not linear. Here are selected relatives to $100,000:

| | MASONRY | | FRAME | |
|---|---|---|---|---|
| Amount of Insurance | HO 2 | HO 3 | HO 2 | HO 3 |
| $50,000 | 0.44 | 0.44 | 0.45 | 0.45 |
| $100,000 | 1.00 | 1.00 | 1.00 | 1.00 |
| $250,000 | 2.80 | 2.82 | 2.77 | 2.78 |
| $500,000 | 5.81 | 5.84 | 5.71 | 5.74 |

Less is charged for Masonry than Frame Construction.
For example for $100,000, for HO3: $859/$946 = 0.908.

Less is charged for HO2 than HO3.[113]
For example for $100,000, for Masonry: $799/$859 = 0.930.

[113] HO3 as an “all risk” policy provides more coverage than the HO2 “named peril” policy.
*Determining coverage relativities is an important task of homeowners actuaries.*

Lake County, Protection Class 9

| | MASONRY | | FRAME | |
|---|---|---|---|---|
| Amount of Insurance | HO 2 | HO 3 | HO 2 | HO 3 |
| | | | | |
| $10,000 | $166 | $178 | $184 | $197 |
| $20,000 | $220 | $236 | $245 | $263 |
| $30,000 | $276 | $295 | $307 | $328 |
| $40,000 | $350 | $375 | $390 | $417 |
| | | | | |
| $50,000 | $433 | $463 | $484 | $518 |
| $75,000 | $688 | $736 | $765 | $819 |
| $100,000 | $978 | $1,047 | $1,085 | $1,164 |
| $150,000 | $1,558 | $1,668 | $1,725 | $1,854 |
| | | | | |
| $200,000 | $2,138 | $2,290 | $2,365 | $2,544 |
| $250,000 | $2,718 | $2,911 | $3,005 | $3,234 |
| $300,000 | $3,298 | $3,533 | $3,645 | $3,924 |
| $350,000 | $3,878 | $4,154 | $4,285 | $4,614 |
| | | | | |
| $400,000 | $4,458 | $4,776 | $4,925 | $5,304 |
| $450,000 | $5,038 | $5,397 | $5,565 | $5,994 |
| $500,000 | $5,618 | $6,019 | $6,205 | $6,684 |
| | | | | |
| Premium per $10,000 additional | $116 | $124 | $128 | $138 |

More is charged for Protection Class 9 than Protection Classes 1-8.
For example, for $100,000, HO3, Masonry: $1,047/$859 = 1.22.
For example, for $100,000, HO3, Frame: $1,164/$946 = 1.23.

Cook County (except Chicago), Protection Class 9

| | MASONRY | | FRAME | |
|---|---|---|---|---|
| Amount of Insurance | HO 2 | HO 3 | HO 2 | HO 3 |
| | | | | |
| $10,000 | $198 | $212 | $220 | $235 |
| $20,000 | $263 | $282 | $292 | $312 |
| $30,000 | $329 | $352 | $366 | $391 |
| $40,000 | $419 | $448 | $466 | $499 |
| | | | | |
| $50,000 | $520 | $556 | $578 | $619 |
| $75,000 | $822 | $880 | $914 | $978 |
| $100,000 | $1,167 | $1,250 | $1,299 | $1,388 |
| $150,000 | $1,857 | $1,990 | $2,069 | $2,208 |
| | | | | |
| $200,000 | $2,547 | $2,730 | $2,839 | $3,028 |
| $250,000 | $3,237 | $3,470 | $3,609 | $3,848 |
| $300,000 | $3,927 | $4,210 | $4,379 | $4,668 |
| $350,000 | $4,617 | $4,950 | $5,149 | $5,488 |
| | | | | |
| $400,000 | $5,307 | $5,690 | $5,919 | $6,308 |
| $450,000 | $5,997 | $6,430 | $6,689 | $7,128 |
| $500,000 | $6,687 | $7,170 | $7,459 | $7,948 |
| | | | | |
| Premium per $10,000 additional | $138 | $148 | $154 | $164 |

More is charged in more urban Cook County than in less urban Lake County.[114]
For example, for $100,000, HO3, Masonry: $1,250 / $1,047 = 1.19.
For example, for $100,000, HO3, Frame: $1,388 / $1,164 = 1.19.

[114] There are other territories. Helping to determine territories and territory relativities is an important task of actuaries.

All of the above rates are for a $250 deductible.[115] If the insured chooses a larger deductible, then he pays less. The above base rates are multiplied by the following factors:

| Deductible: | $500 | $1000 | $2500 | $5000 | $10,000 |
|---|---|---|---|---|---|
| Up to $200,000 of Insurance: | 0.92 | 0.79 | 0.62 | N/A | N/A |
| $200,001 and over: | 0.96 | 0.89 | 0.75 | 0.67 | 0.62 |

Note that the 8% credit for a $500 deductible rather than a $250 deductible could be based on an Loss Elimination Ratio of 0.15 for $250 and a Loss Elimination Ratio of 0.22 for $500; (1 - 0.22) / (1 - 0.15) = 0.78 / 0.85 = 0.92.[116]

All of the above rates are for one or two family homes. For 3 or 4 family homes, the insured has to pay more premium; a factor of 1.3 is applied to the base rate shown.

All of the above rates are for $100,000 per person limits of Liability (coverage E) and $1000 per person Medical Payments (Coverage F). The insured can choose optional higher limits of liability and pay additional premiums. The extra flat amounts do not vary by territory, form, construction, etc.[117]

| Limit of Liability($000) | 100 | 200 | 200 | 300 | 300 |
|---|---|---|---|---|---|
| Medical Payments ($000) | 2 | 1 | 2 | 1 | 2 |
| Additional Premium | $24 | $20 | $25 | $27 | $30 |

[115] The deductible does not apply to Liability Coverage.
[116] These Loss Elimination Ratios were made up by me solely for illustrative purposes. Besides the ratio of loss elimination ratios, pricing of deductibles can include expense considerations and the issue of self-selection.
[117] I do not know the source of the particular values shown.

Problems:

**2.1.** (1.5 points) List the three items in a rating manual and briefly describe each one.

**2.2.** (2 points)
The Workers Compensation rates charged by Dependable Insurance in State X are:

| Class | Description | Rate |
|---|---|---|
| | | |
| 3383 | Jewelry Manufacturing | 1.46 |
| 7219 | Trucking | 9.41 |
| 8810 | Clerical Employees | 0.22 |

The Jay Jewelry Company is located in State X and has the following payrolls:

| Class | Description | Payroll |
|---|---|---|
| | | |
| 3383 | Jewelry Manufacturing | $200,000 |
| 7219 | Trucking | $30,000 |
| 8810 | Clerical Employees | $50,000 |

Dependable Insurance gives Jay Jewelry Company a 10% schedule credit.
In addition. they are given a 7% credit for a drug free work place.
Dependable Insurance company charges an Expense Constant of $200.
Determine the premium charged to Jay Jewelry Company. Show all work

**2.3.** (1 point) List four possible uses of Underwriting Guidelines.

**2.4.** (1 point) An insurer writes homeowners insurance in a large diverse state.
A particular type of burglar alarm has been shown to lead to a significant reduction in losses due to theft. The insurer plans to introduce a percentage discount for a this type of burglar alarm.
Briefly discuss a potential problem with this idea and a possible solution.

**2.5.** (3 points) Use the following information for Medical Malpractice Insurance:
- The Base Rate is $10,000 per doctor.
- Full-Time doctors are the base; part-time doctors have a relativity of 0.60.
- $100K/$300K limits of liability is the base; $1M/$3M has a relativity of 1.7.
- No deductible is the base; the credit for a $5000 deductible is 10%.
- A mature claims-made policy is the base. The relativities are as follows:

1st year 0.20 2nd year 0.35 3rd year 0.75
4th year 0.85 5th year 0.95 mature 1.00
60 month extended reporting endorsement: 2.00

The Friendly Pediatrics Group Practice consists of four practicing doctors.
Dr. Burns just retired and Dr. Fever took his place.

| | Type of Policy | | Schedule Rating |
|---|---|---|---|
| | | | |
| Dr. George Burns | 60 month extended reporting | Full-Time | 5% debit |
| Dr. Flo Schotte | Mature | Part-Time | 10% credit |
| Dr. Major Payne | Mature | Full-Time | 20% credit |
| Dr. Vera Sharpe-Needles | 4th year | Full-Time | 10% debit |
| Dr. Hy Fever | 1st year | Full-Time | no credit or debit |

The practice is located in Territory 5 with a relativity of 1.15.
They are all pediatricians; pediatrics has a relativity of 0.95.
The Friendly Pediatrics Group Practice purchases a claims-made policy covering all five doctors.
They purchase limits of $1M/$3M with a deductible of $5000.
They get a group credit of 7%, which is applied separately from the deductible credit.
Determine the premium for the Friendly Group Practice claims-made policy. Show all work.

**2.6.** (1 point) Basic Ratemaking list some examples of typical rating variables.
For each of the following four lines of insurance, list one rating variable:
Personal Automobile, Homeowners, Workers Compensation, and Medical Malpractice.
Do not use a given rating variable more than once.

Use the following information for Homeowners Insurance for the next two questions:
● Base Rate = $600.

| Amount of Insurance ($000) | Relativity |
|---|---|
| 50 | 0.6 |
| 100 | 1.0 |
| 200 | 1.3 |
| 300 | 1.5 |

| Territory | Rate Relativity | | Underwriting Tier | Rate Relativity |
|---|---|---|---|---|
| 1 | 0.5 | | Preferred | 0.85 |
| 2 | 1.0 | | Standard | 1.00 |
| 3 | 1.4 | | Substandard | 1.25 |

| Protection Class / Construction Type Rate Relativities | | |
|---|---|---|
| Protection Class | Frame | Masonry |
| 1-3 | 1.00 | 0.90 |
| 4-6 | 1.15 | 1.05 |
| 7-10 | 1.35 | 1.20 |

| Deductible | Rate Relativity | | Increased Liability and Medical Limits | |
|---|---|---|---|---|
| $250 | 1.1 | | Limit | Rate |
| $500 | 1.0 | | $100,000/$500 | Included |
| $1000 | 0.9 | | $500,000/$1000 | $30 |

● Policy Fee = $70.
● Rating Algorithm:
R1 = Amount of Insurance Relativity
R2 = Territory Relativity
R3 = Protection Class / Construction Type Relativity
R4 = Underwriting Tier Relativity
C1 = Deductible Credit Factor
C2 = 1 - (New Home Discount) - (Claims-Free Discount).
Premium = (Base Rate) R1 R2 R3 R4 C1 C2
+ Increased Liability / Medical Coverage Rate + Policy Fee

**2.7.** (1 point) Frame House. Protection Class 8. Territory 1.
Amount of Insurance = $50,000.
Written in the Substandard Tier. $250 deductible. Determine the premium.

**2.8.** (1 point) Masonry House. Protection Class 4. Territory 3.
Amount of Insurance = $200,000.
Written in the Preferred Tier. $1000 deductible. Increased Limits of $500,000/$1000.
Receives a 12% credit for being claims free for 5 years. Determine the premium.

**2.9.** (2 points) A rate manual for the Gecko Insurance Company in State X, shows the following information for private passenger automobile liability insurance:
Expense Fee (per automobile): $40.
One does not apply the class relativities or the increased limit factors to the Expense Fee.

| Territory | Base Rate |
|---|---|
| 1 | $78 |
| 2 | $141 |
| 3 | $126 |

| Class | Relativity |
|---|---|
| 1 | 1.00 |
| 2 | 1.45 |
| 3 | 2.40 |

| Combined Single Limit | Increased Limits Factor |
|---|---|
| $25,000 | 1.00 |
| $100,000 | 1.30 |
| $500,000 | 1.40 |

Determine the premium for the following policies.
(a) 1 automobile in Territory 1, Class 2, with $25,000 limit of liability.
(b) 2 automobiles in Territory 2, Class 3, with $500,000 limit of liability.
(c) 1 automobile in Territory 3, Class 1, with $100,000 limit of liability.

**2.10.** (1.5 points)
Basic Ratemaking list some examples of typical characteristics used in underwriting.
For each of the following six lines of insurance, list one characteristic:
Personal Automobile, Homeowners, Workers Compensation, Commercial General Liability, Medical Malpractice, and Commercial Automobile.
Do not use a given characteristic more than once.

**2.11.** (3 points) The Workers Compensation rates are:

| Class | Description | Rate in State X | Rate in State Y |
|---|---|---|---|
| 5183 | Plumbing | 4.07 | 6.80 |
| 5190 | Electrical Wiring | 3.17 | 4.92 |
| 5437 | Carpentry | 3.52 | 9.11 |
| 5474 | Painting | 8.50 | 11.97 |
| 5551 | Roofing | 42.57 | 54.04 |
| 8810 | Clerical | 0.18 | 0.25 |

The Cohen Construction Company operates in States X and Y. It has the following payrolls:

| Class | Description | Payroll in State X | Payroll in State Y |
|---|---|---|---|
| 5183 | Plumbing | $500,000 | $300,000 |
| 5190 | Electrical Wiring | $300,000 | $200,000 |
| 5437 | Carpentry | $900,000 | $400,000 |
| 5474 | Painting | $400,000 | $300,000 |
| 5551 | Roofing | $600,000 | $200,000 |
| 8810 | Clerical | $200,000 | 0 |

The Cohen Construction Company has an experience modification of 1.18, an 18% debit.
Their insurer gives Cohen Construction a 5% debit under schedule rating.
In addition, Cohen Construction is given an 8% credit for having recently put in place a back-to-work program.
An Expense Constant of $150 is charged.
For simplicity ignore the effects of any Premium Discounts.
Determine the premium charged to Cohen Construction Company. Show all work

***2.12. (6, 5/96, Q.22)*** *(1 point) Which of the following describe characteristics of the ISO expense fee program for Private Passenger Automobile Insurance?*
*1. Expense fees are considered a component of premium.*
*2. Expense fees are subject to increased limits factors.*
*3. Expense fees are subject to deductible relativities.*
*A. 1 only B. 3 only C. 1, 2 only D. 2, 3 only E. 1, 2, 3*

Solutions to Problems:

**2.1.** Rules: contain definitions, particularly how to classify a risk.
Rates pages: contain base rates, rating tables, etc.
Rating Algorithm: describes how to combine the components to determine the premium for a specific insured.

**2.2.** (1.46)(200,000/100) + (9.41)(30,000/100) + (0.22)(50,000/100) = $5853.
(1 - 10%)(1 - 7%)($5853) + $200 = **$5099**.
Comment: The payrolls would have been estimated at the time the policy was written.
While in theory the payrolls could be audited after policy inception, this insured is too small to make that worthwhile. Presumably, Jay Jewelry Company is to small to be Experience Rated.
There could have been a loss constant added to the premium of small insureds.

**2.3.** 1. Deciding whether to accept or reject a risk, or to refer it to a more senior underwriter.
2. Deciding in which of several companies in the group to place the insured.
3. Deciding in which of several underwriting tiers to place the insured.
4. How to apply Schedule Rating.

**2.4.** Assuming the alarm produces the same expected percentage reduction in theft losses in the different territories in the state, there is still the problem that the percent of loss dollars due to the theft almost certainly varies significantly across the state. (For example, theft may be 10% in a rural part of the state, but 30% in an urban area.) Thus as a percent of premiums, the appropriate discount would vary by territory.
The insurer could implement a rating plan that has separate base rates for each major peril covered and the individual rating variable relativities are applied to the applicable base rate; the burglar alarm discount applies to the theft base rate only.
Alternately, the insurer could have different percentage discounts by territory.

**2.5.** The factors that apply to the whole policy are:
Territory 1.15. Limit Factor 1.7. Deductible Factor 0.90. Group Credit 0.93.

| | Base Rate | Specialty | Part-Time | Schedule Rating | Claims-Made | Product |
|---|---|---|---|---|---|---|
| | | | | | | |
| Dr. Burns | $10,000 | 0.95 | 1.00 | 1.05 | 2.00 | $19,950 |
| Dr. Schotte | $10,000 | 0.95 | 0.60 | 0.90 | 1.00 | $5,130 |
| Dr. Payne | $10,000 | 0.95 | 1.00 | 0.80 | 1.00 | $7,600 |
| Dr. Sharpe-Needles | $10,000 | 0.95 | 1.00 | 1.10 | 0.85 | $8,883 |
| Dr. Fever | $10,000 | 0.95 | 1.00 | 1.00 | 0.20 | $1,900 |
| | | | | | | |
| Total | | | | | | $43,463 |

(1.15) (1.7) (0.9) (0.93) ($43,462) = **$71,118**.
Comment: Dr. Burns still needs coverage for incidents that occurred while he was practicing but have yet to be reported.

**2.6.** Personal Automobile: Driver Age and Gender, Model Year, Accident History.
Homeowners: Amount of Insurance, Age of Home, Construction Type, Protection Class.
Workers Compensation: Occupation Class Code.
Medical Malpractice: Specialty, Territory, Limit of Liability.
Comment: See Exhibit 2.1 in Basic Ratemaking.

**2.7.** ($600)(0.6)(0.5)(1.35)(1.25)(1.1) + $70 = **$404**.

**2.8.** ($600)(1.3)(1.4)(1.05)(0.85)(0.9)(0.88) + $30 + $70 = **$872**.

**2.9.** (a) (1.45)($78) + $40 = **$153**.
(b) (1.40)(2.40)($141) + $40 = $514. (2)($514) = **$1028**.
(c) (1.30)($126) + $40 = **$204**.

**2.10.** Personal Automobile Insurance: Credit Score, Homeownership, Prior Bodily Injury Limits.
Homeowners Insurance: Credit Score, Prior Loss Information, Age of Home.
Workers Compensation: Safety Programs, Number of Employees, Prior Loss Information.
Commercial General Liability Insurance:
Credit Score, Years in Business, Number of Employees.
Medical Malpractice:
Patient Complaint History, Years Since Residency, Number of Weekly Patients.
Commercial Automobile: Driver Tenure, Average Driver Age, Earnings Stability.
Comment: See Exhibit 2.2 in Basic Ratemaking.

**2.11.** Multiply the rates by the payrolls in hundreds of dollars:

| Class | Rate in X | Payroll in X | Premium in X | Rate in Y | Payroll in Y | Premium in Y |
|---|---|---|---|---|---|---|
| | | | | | | |
| 5183 | 4.07 | $500,000 | $20,350 | 6.80 | $300,000 | $20,400 |
| 5190 | 3.17 | $300,000 | $9,510 | 4.92 | $200,000 | $9,840 |
| 5437 | 3.52 | $900,000 | $31,680 | 9.11 | $400,000 | $36,440 |
| 5474 | 8.50 | $400,000 | $34,000 | 11.97 | $300,000 | $35,910 |
| 5551 | 42.57 | $600,000 | $255,420 | 54.04 | $200,000 | $108,080 |
| 8810 | 0.18 | $200,000 | $360 | 0.25 | $0 | $0 |
| | | | | | | |
| Sum | | | $351,320 | | | $210,670 |

The manual premium is: $351,320 + $210,670 = $561,990.
(1.18)(1 + 5%)(1 - 8%)($561,990) + $150 = **$640,751**.
Comment: The payrolls would have been estimated at the time the policy was written.
The payrolls would be audited after policy expiration.
Premium Discounts are discussed in Chapter 11 of Basic Ratemaking.

**2.12. A.** 1. True.
2. False. Increased Limit Factors are applied to the variable portion of the rate, not to the Expense Fee.
3. False. Deductible Relativities are applied to the variable portion of the rate, not to the Expense Fee.
Comment: See page G-2, Rule 3E, of the ISO Personal Vehicle Manual, formerly on the syllabus.

## Section 3, Ratemaking Data

Data is used by actuaries for many purposes including ratemaking.

For indications of the overall rate level, summarized data on exposures, premiums, losses, and ALAE is used.

Data on ULAE and underwriting expenses is usually from the insurer's accounting system; an aggregate amount may be allocated to line of insurance and/or state.

For classification and territory ratemaking, more detailed data on exposures, premiums, losses, and ALAE is used, broken down by class and territory.
For individual risk rating, data from a particular insured is used.

Actuaries also use detailed information for special studies, for example: determining territory definitions, determining increased limits factors, marketing studies, calculating individual risk rating plan parameters, determining deductible credits, determining the usefulness of a possible new rating variable or underwriting criterion, etc.

Ratemaking data is usually aggregated into years, as discussed below.

An insurer's data is often contained in a policy data base with exposures and premiums, and a separate claims data base with losses and alae.
Actuaries and underwriters rely on information besides the exposure, premium, loss, and expense data from their own insurer.

Data Quality:

**Any analysis performed by an actuary is no better than the quality of the data that goes into that analysis!**[118]

For example, assume that under the Workers Compensation Statistical Plan one insurer mistakenly reports $500 million of payroll in a class for an employer rather than $5 million. Assume that this results in about twice as much reported exposure in total for that class as was actually the case. Then the reported pure premium will be half of the actual pure premium. Unless this mistake is caught and corrected, the class relativity that results from any actuarial analysis will be erroneous!

Therefore, assuring the quality of data is important to actuaries. *Statistical Agents have many techniques to try to catch and correct any mistakes in the data reported to them. Insurers need to try to eliminate as many errors as possible in their data that is used for internal purposes.*

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[118] Garbage in, garbage out.

**Years of Data**:[119]

Premiums and losses can be organized in different ways.

**Calendar Year: All premiums and losses related to a given calendar year.**

Calendar Year 2011 will often be abbreviated as either CY2011 or CY11.

Calendar year data is typically not used for ratemaking; however it might be used for ratemaking on lines on insurance where claims are reported and settled quickly, such as Automobile Collision.

Fiscal Year: Similar to a Calendar Year; however a fiscal year starts on a date other than January 1.[120]
For example, a fiscal year might start on July 1 and end on the subsequent June 30.

**Accident Year: All the losses with accident dates during a given year.**[121]

For example, an accident occurs on March 15, 2003. All payments related to claims resulting from this accident, are part of Accident Year 2003, regardless of when those payments are made.

Calendar/Accident Year 2013 would consist of premiums for Calendar Year 2013 and losses for Accident Year 2013.

**Policy Year**: **All premiums and losses related to policies with effective dates during a given year**.

Policy Year 2012 consists of all premiums and losses related to policies written during 2012. Policy Year 2012 will often be abbreviated as either PY2012 or PY12.

For example, an accident occurs on March 15, 2013. If the policy providing coverage was written effective November 1, 2012, then all payments related to claims resulting from this accident, are part of Policy Year 2012, regardless of when those payments are made.

An actuary would usually not use a policy year until all its policies have expired, which takes a while. Assume annual policies. Then the last policy written during Policy Year 2012 does not expire until the end of 2013.

**Policy Year data has the best match of losses to premiums, with Accident Year next, and Calendar Year worst**. **Calendar Year data is available quickest, with Accident Year next, and Policy Year slowest**.

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[119] While a "year" could be any consecutive 12 months, unless stated otherwise a year starts on January 1 and ends on December 31.
[120] A calendar year is a special case of a fiscal year, that starts on January 1.
[121] Accident Year data is used in the examples of rate indications in Appendices A to D of Basic Ratemaking.

Report Date: the date the insurer receives notice of the claim.

**Report Year**: **All the losses on claims for which the insurer first receives notice during a given year**.

For example, an accident occurs on March 15, 2003. If on June 5, 2004 the insurer first receives notice of a claim resulting from this accident, then all payments related to this claim, are part of Report Year 2004, regardless of when those payments are made.

As will be discussed, Report Year data can be used for ratemaking for lines of insurance with a long reporting lag for claims, such as Medical Malpractice Insurance. Such lines of insurance are often written on a claims-made rather than occurrence basis.[122]

Policy Database:

The policy database contains detailed information on the exposures and premiums for policies written by an insurer.

Each data element is reported in its own "field". A group of fields is called a "record".
A policy may be reported as one record or may be broken down by coverage and/or class into several records, depending on the line of insurance. Cancelations and any midterm endorsements would each result in additional records being reported.

For a given line of insurance at a particular insurer, each record would contain the same fields in the same order, although occasionally a field is left blank in a particular record.

For example, here is a very simplified example of a record:
Field 1: Policy Number.
Filed 2: Policy Effective Date.
Field 3: State.
Field 4: Premium.

Typical fields for each record on the policy database:
- Policy identifier
- Risk identifier(s)
- Relevant dates
- Premium
- Exposure
- Characteristics: rating variables, underwriting variables, etc.

For use in ratemaking, records would usually be combined to create the form of the data to be used by the actuary. For example, if a policy were canceled midterm one would need to combine records to get the net premium and exposure for that policy.

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[122] See Chapter 16 of Basic Ratemaking.

Claims Database:

The claims database contains detailed information on the losses and alae for policies written by an insurer.

Typical fields for each record on the claims database:[123]
- Policy identifier
- The risk identifier(s)
- Claim identifier.
- Claimant identifier.
- Relevant loss dates: the date of loss, the report date, and the transaction date.
- Claim status: open, closed, or reopened.
- Reopen date.
- Claim count.
- Paid loss.
- Event identifier: for example a catastrophe.
- Case reserve.
- Allocated loss adjustment expense.
- Salvage/subrogation.
- Characteristics.[124]

Accounting Information:

Underwriting expenses and unallocated loss adjustment expenses (ULAE) are not collected in either the policy or claims databases; they are collected in the insurer's accounting system.

[123] Some of the fields listed may not be relevant for some lines of insurance.
[124] For example, for Workers Compensation one might record the "injury kind," cause of the accident, and the body part injured.

Data from Outside Sources:

Actuaries working at an insurer use many sources of information other than data from inside the insurer. Basic Ratemaking refers to these as external data.[125]

For example, statistical agents such as ISO and NCCI collect information from many insurers within a given state. In some cases, one can obtain this data totaled across all the reporting insurers.[126] Depending on the situation, one may only be able to get premiums, exposures, losses and ALAE in total for each year, or one may be able get breakdowns by class/territory or further detail. In some cases, one could request a special compilation to serve a particular purpose.[127]

The "Fast Track Monitoring System" tracks quarterly industry data for personal lines.[128]
The purpose of Fast Track is to monitor trends over time, as it provides a good indication of how claiming and loss patterns are increasing, decreasing, or remaining stable.

Contained in Fast Track are exposure, paid loss and paid claim data, from which claim frequency, average loss (severity) and loss cost (pure premium) experience is generated. Also included are earned premiums and incurred losses used to develop loss ratio information. Auto insurance data are reported by major coverage; the frequency, average loss and loss cost data are presented for bodily injury liability, property damage liability, all comprehensive, all collision, and personal injury protection, if applicable, while the loss ratio reports provide all liability coverages combined, all comprehensive and all collision. The homeowners insurance data for frequency, severity and loss cost are shown by policy form, while the loss ratio report combines all homeowners forms.

Other sources of aggregated industry data or reports:
A.M. Best[129], Highway Loss Data Institute (HLDI)[130], Insurance Research Council (IRC)[131], the Institute for Business and Home Safety (IBHS)[132], the National Insurance Crime Bureau (NICB)[133], and the Workers Compensation Research Institute (WCRI)[134].

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[125] *The term external data is commonly used elsewhere to refer to other than insurance data, such a CPIs.*
[126] This could be referred to as "industry data" even if not all writers reported to the particular statistical agent.
[127] When I worked at the Massachusetts Workers Compensation and Automobile Rating Bureaus, we issued many regular data reports. We also fulfilled all sorts of special requests for data from member companies. An insurer could get a report with only its own data or the entire industry.
[128] Fast Track Monitoring System (Fast Track) reports are prepared quarterly by the Independent Statistical Service, Inc. (ISS), Insurance Services Office, Inc. (ISO), and National Independent Statistical Service (NISS). These are statistical reports reflecting multiyear trends in private passenger auto and homeowners insurance experience. Approximately 50 of the largest companies (fewer for any given state) representing about 70 and 50 percent of the nationwide personal auto and homeowners premium volume, respectively, participate in this voluntary report.
[129] www.ambest.com
[130] http://www.iihs.org/research/hldi/composite_intro.html
[131] www.ircweb.org
[132] www.disastersafety.org
[133] www.nicb.org/cps/rde/xchg/nicb/hs.xsl/index.htm
[134] www.wcrinet.org

Insurers can often obtain competitor's rate filings and rate manuals from insurance departments.[135]

Sometimes Consumer Price Indices (CPIs) are used to help estimate trends.[136]

The U.S. Census has lots of potentially valuable information, for example: population density, weather, thefts, and annual miles driven.[137]

Credit scores of insureds, purchased from a firm that specializing in this, can be used for classification and/or underwriting.

Additional information that may be used:[138]
- Personal automobile insurance: vehicle characteristics, department of motor vehicle records
- Homeowners insurance: distance to fire station
- Earthquake insurance: type of soil
- Medical malpractice: characteristics of hospital in which doctor practices
- Commercial general liability: type of owner (proprietor, stock)
- Workers' compensation: OSHA inspection data.

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[135] *Sometimes these are obtained from recent former employees of these competitors or from insurance agents.*
[136] For example, in Appendix B of Basic Ratemaking, the expense trend is calculated based on the change in Consumer Price Indices.
[137] Geo-demographic data on the average characteristics of a particular area.
[138] See page 47 of Basic Ratemaking.

*Duties of Regulators*:[139]

1. **Financial solvency** and solidity of insurance companies - to ensure that the insurance companies will be able to meet their obligations to policyholders.

2. **Market conduct** - to ensure that insurers do not engage in unfair practices and that insurers fulfill the terms of their policies.

3. **Rate regulation** - to ensure that rates meet statutory standards, that is, that rates are not inadequate, excessive, or unfairly discriminatory.

Primary Data collected to carry out each of these three duties:

Financial solvency: Annual Statement.

Market conduct: Periodic market conduct examinations of individual insurers.

Rate regulation: Statistical information on premiums and losses reported to statistical agents.

Insurers may collect additional data for their own business needs.

*Summary Based versus Transaction Based Statistical Plans*:[140]

Summary-based Statistical Plans are less detailed and less expensive.
The premium and loss data in summary-based plans are collected on a summarized basis.

Transaction-based statistical plans are more detailed and more expensive.
Transaction level records are sent to the statistical agent on a regular basis.

Summary-based data is insufficient for many needs of actuaries.

| | |
|---|---|
| Workers Compensation Financial Calls | Summary Based |
| Workers Compensation Statistical Plan Data Calls | Transaction Based |

[139] See page 1 of CAS Study Note: ISO Statistical Plans, by Virginia R. Prevosto, formerly on the syllabus.
[140] See pages 3-4 of CAS Study Note: ISO Statistical Plans, by Virginia R. Prevosto, formerly on the syllabus.

*Five major data collection programs at NCCI:*[141]

1. **Annual Financial Call Data**: Aggregate premium and loss data (experience by state) primarily used to calculate overall loss cost and rate level changes.

2. **Workers Compensation Statistical Plan (WCSP) Data**: Individual policy loss and exposure (payroll) information collected with detail by classification, primarily used to calculate classification relativities and experience rating modifications.[142]

3. Detailed Claim Information (DCI) Data:
Sample of indemnity (mostly permanent partial disability) claims consisting of 85 data elements reflecting areas such as paid and incurred losses/claims, demographic, litigation and recovery information, used for special analyses and research.

4. Policy Issue Capture System (PICS) Data: Policy documents submitted by insurers. PICS is used to confirm proof of workers compensation coverage (and supply other information) to state accident boards and commissions. In most states, NCCI is designated as the commission's authorized agent to collect coverage information, so there is no need for insurers to submit policy information to the state commission. PICS is also used to let NCCI know when to expect a unit report.

5. Residual Market Data: Submissions from servicing carriers, including policy and calendar year premiums, losses and expenses (by state). As part of NCCI's role and responsibilities as administrator of the National Pool and other residual market pools, NCCI serves as the central clearinghouse for information on pool transactions. This information is used for pool financial reporting procedures, quarterly distribution of operating results and the determination of pool IBNR reserves.

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[141] See page 1 of CAS Study Note: NCCI Data collection Calls and Statistical Plans, by Richard B. Moncher, formerly on the syllabus.
[142] This detailed information is used by workers compensation actuaries for all types of studies.

*An example of data compiled from the Workers Compensation Statistical Plan:*[143]

Massachusetts Workers Compensation Unit Statistical Plan Data
(Including Large Deductible Policies)
Composite Policy Year 1999/2000[144] at First Report[145]

Class Code: 5, Farm: Nursery Employees & Drivers
*Industry Group: Goods & Services*
*Hazard Group: 2*

| | |
|---|---|
| Payroll | $12,761,866 |
| Manual Premium | $456,751 |
| Standard Premium | $471,494 |
| Total Losses | $202,093 |

| | |
|---|---|
| Loss Ratio to Manual Premium | 44.2% |
| Loss Ratio to Standard Premium | 42.9% |
| Pure Premium (per $100 payroll) | $1.58 |

| | |
|---|---|
| Indemnity Losses | $133,030 |
| Medical Losses | $69,063 |
| Claim Count | 60 |

| | | | |
|---|---|---|---|
| Fatal: | Claim Count 0 | | |
| Permanent Total: | Claim Count 0 | | |
| Major Partial Disability: | Indemnity: $36,690 | Medical: $3,335 | Claim Count: 1 |
| Minor Partial Disability: | Indemnity: $16,717 | Medical: $4,986 | Claim Count: 1 |
| Temporary Total: | Indemnity: $79,623 | Medical: $48,629 | Claim Count: 11 |
| Medical Only: | | Losses: $12,113 | Claim Count: 47 |

Note that data compiled for a class would usually be from several or many employers.
Detailed information would be available by employer.
Detailed information would be available by claim, for those claims of size greater than $2000.

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[143] From the Massachusetts Workers Compensation Rating and Inspection Bureau.
Unit Statistical Reports similar to the those collected by the NCCI.
[144] *Policies with effective dates 7/1/99 to 6/30/00.*
[145] First report is 18 months after the policy effective date. For Statistical Plan Data, there are now a total of 10 reports, separated by 12 months.

*Workers Compensation Policy Year Financial Calls*:[146]

Each insurer or insurer group reports data separately by state.
Data is reported by year for each of more than 20 years at latest report.
Data from policies with Large Deductibles is excluded.[147]
In each case, the reported premiums and losses are accumulated through a given report rather than being the incremental change from the previous report.

Earned Premiums are reported in three different ways:
Standard at NCCI Designated Statistical Reporting (DSR) Level,[148]
Standard at Company Level,
Net.[149]

Losses are reported in eight different pieces:[150]
Indemnity Paid
Medical Paid
Indemnity Case Reserves
Medical Case Reserves
Indemnity Bulk Reserves
Medical Bulk Reserves
Indemnity IBNR
Medical IBNR

In addition, an incurred indemnity claim count is reported.[151]

*ALAE is reported (separately) for years 1994 and subsequent.*

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[146] A similar call is made for Calendar/Accident Year Data.
Calendar Year losses may be obtained from either call.
[147] Large deductibles usually have a deductible of $100,000 or more.
Experience from policies with small deductibles is included.
In some states, experience from large deductibles is collected separately in a similar format.
[148] Prior to the effect of any individual insurance company competitive pricing activity.
In many states, premium at the DSR level does not include any provision for expenses, in other words, at the level of published NCCI loss costs.
[149] Net direct earned premium is net of premium discounts, individual company deviations, and pricing programs.
It is used to reconcile the insurance company's Annual Statement to information reported on this Financial Call.
[150] See pages 2 and 3 of the call.
Outstanding, excluding IBNR = case reserves plus bulk reserves.
Some insurance companies put up bulk reserves that account for the development on known claims and additional payments on claims that will be reopened. These company's IBNR would be what is called pure IBNR.
Other companies would just include these bulk reserves in what they call IBNR.
[151] This claim count excludes medical only claims.

*An example of data compiled from the Workers Compensation Financial Calls:*[152]

Massachusetts Workers Compensation
Annual Financial Call Data
**Accident** Year Data[153]
Indemnity Plus Medical Losses ($ million)

| Paid Plus Case Reserves | | | | | |
|---|---|---|---|---|---|
| | Report | | | | |
| AY | 1 | 2 | 3 | 4 | 5 |
| 1993 | 319 | 404 | 434 | 446 | 447 |
| 1994 | 263 | 349 | 378 | 394 | |
| 1995 | 240 | 344 | 377 | | |
| 1996 | 252 | 347 | | | |
| 1997 | 231 | | | | |

1st report for AY93 is as of 12/31/93 (12 months).
2nd report for AY93 is as of 12/31/94 (24 months).
3rd report for AY93 is as of 12/31/95 (36 months).

There is similar data for older accident years.
For older accident years, one could have as many as 20 reports.

One can separate Indemnity and Medical losses.
One can separate Paid losses and Case Reserves.
One can also compile Total Incurred losses (including Bulk plus IBNR.)

*ALAE is reported (separately) for years 1994 and subsequent.*
*One can separate data by insurer (or insurer group.)*

*Financial Calls would have been submitted to the rating bureau in early Spring 1998.*
*Consistency checks and data quality checks would be performed.*
*Insurers would submit corrections.*
*The above information would have been available for use by actuaries in late Summer 1998.*

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[152] From the Massachusetts Workers Compensation Rating and Inspection Bureau.
[153] As shown below, one would have similar data for Policy Years.

MASSACHUSETTS WORKERS COMP.
Annual Financial Call Data
**Policy** Year Data
Indemnity Plus Medical Losses ($ million)

| Paid Plus Case Reserves | | | | | |
|---|---|---|---|---|---|
| | Report | | | | |
| PY | 0 | 1 | 2 | 3 | 4 |
| 1993 | 172 | 353 | 397 | 411 | 415 |
| 1994 | 135 | 319 | 367 | 389 | |
| 1995 | 116 | 306 | 364 | | |
| 1996 | 135 | 306 | | | |
| 1997 | 121 | | | | |

Policy Year is just another way to break the same total losses into pieces.

1st report for PY93 is as of 12/31/94 (12 months).
2nd report for PY93 is as of 12/31/95 (24 months).
3rd report for PY93 is as of 12/31/96 (36 months).

*Incomplete Policy Year:*

Under the Workers Compensation Financial Calls, as of December 31, 2006, one would report Policy Year 2006. As of December 31, 2006, most of the policies written during 2006 would yet to have expired. This data would be referred to variously as: an incomplete policy year, policy year at report 0, or policy year at report 1/2.[154]

Like subsequent reports, the incomplete policy year has paid losses, case reserves, and reserves for losses that have yet to be reported. In addition, many of the losses that will be in PY 2006 have yet to occur by December 31, 2006.[155]

Thus this information is extremely immature. There is much more loss development on an incomplete policy year than on a policy year at first report. Therefore, an incomplete policy year is usually not used directly in ratemaking.[156]

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[154] Policy Year 2006 as of December 31, 2007, would be referred to as Report 1.
[155] If policies are written evenly throughout the year, half of the losses that will make up Policy Year 2006, have yet to occur by 12/31/2006.
[156] However, for example, the actuary may compare the level of the most recent incomplete policy year to the previous one, in order to see if anything unusual may be going on.

Problems:

**3.1.** (2 points) Briefly define each of the following:
Calendar Year
Accident Year
Policy Year
Report Year

**3.2.** (2 points) Use the following information on three annual homeowners policies:
- Policy A is written on June 1, 2011 with an annual premium of $2,000.
  The home is located in Territory 4 and has a deductible of $250.
  On December 1, 2011 the insured increases the deductible to $500.
  The full annual term premium after the deductible change is $1800.
- Policy B is written on May 1, 2011 with an annual premium of $1,500.
  The insured home is located in Territory 15 and the insured has a $500 deductible.
  The policy remains unchanged for the full term of the policy.
- Policy C is written on August 1, 2011 with an annual premium of $800.
  The insured home is located in Territory 7 and the insured has a deductible of $250.
  The policy is canceled on October 31, 2011.

Show the records related to these policies as they would appear in a policy database.
Display the fields: Original effective date, original termination date, transaction effective date, deductible, territory, written exposures, and written premiums.

**3.3.** (1 point) Ratemaking analysis is often supplemented with third-party data that is not specific to insurance. List two examples, stating in each case the relevant line of insurance.

**3.4.** (1.5 points) Briefly discuss the organization of a policy database for each of the following lines of insurance:
(a) Homeowners
(b) Workers Compensation
(c) Personal Automobile

*__3.5__*. (3 points) A loss occurs on August 26, 2011 and is covered under policy MA12.
It is reported to the insurer on September 4, 2011 and is labeled claim C2728.
At that time a case reserve of $25,000 is established.
The insurer makes a payment of $10,000 on November 6, 2011, and revises the case reserve to $20,000.
The insurer revises the case reserve to $40,000 on July 1, 2012.
The insurer pays $35,000 on October 8, 2012 and closes the claim.
The insurer reopens the claim on February 1, 2013 and establishes a case reserve of $30,000.
The insurer pays $15,000 on April 16, 2013 and closes the claim, this time for good.
Show the records related to this claims as they would appear in a claims database.
Display the fields: Policy, Claim Number, accident date, report date, transaction effective date, claim status, loss payment, loss case reserve.

**3.6.** (1 point) List 4 fields that are usually present in each record of a policy database.

**3.7.** (1 point) State one advantage and one disadvantage for use in ratemaking of:
Calendar Year data, Accident Year data, and Policy Year data.

**3.8.** (2 points) List 8 sources of data external to an insurer that may be used to help make rates for that insurer. Four should be insurance data and four should not.

**3.9.** (3 points) List 12 fields that are usually present in each record of a claims database.

**3.10. (5, 5/15, Q. 6)** (1.5 points) Discuss the appropriateness of applying each of the following data aggregation methods to the given line of business:
a. (0.5 point) Calendar Year Aggregation for Auto Physical Damage
b. (0.5 point) Policy Year Aggregation for Homeowners
c. (0.5 point) Report Year Aggregation for Medical Professional Liability

Solutions to Problems:

**3.1.** Calendar Year: All premiums and losses related to a given calendar year.
Accident Year: All the losses with accident dates during a given year.
Premiums are those for the corresponding Calendar year.
Policy Year: All premiums and losses related to policies with effective dates during a given year.
Report Year: All the losses on claims for which the insurer first receives notice during a given year.

**3.2.** Policy A with a mid-term adjustment is represented by three records. The first record includes all the information at policy inception. The second record negates the portion of the original policy that is unearned at the time of the endorsement: -0.50 exposure and -$1000 premium. The third record represents the information applicable to the portion of the policy written with the new deductible: +0.50 exposure and +$900 premium.
Policy B expired at its original expiration date and had no changes, thus the entire policy can be represented with one record.
Policy C was canceled before the policy expired. This is represented by two records. The first record for Policy C contains the information known at the inception of the policy. The second record represents an adjustment for the cancelation such that when aggregated, the two records show a result net of cancellation. Policy C was canceled 1/4 of the way through the policy period; the second record should show -0.75 exposure and written premium of:
-($800)(0.75) = -$600.

| Policy | Original Effective Date | Original Termination Date | Transaction Effective Date | Deductible | Territory | Written Exposures | Written Premiums |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| A | 6/1/11 | 5/31/12 | 6/1/11 | $250 | 4 | 1 | $2000 |
| A | 6/1/11 | 5/31/12 | 12/1/11 | $250 | 4 | -0.5 | -$1000 |
| A | 6/1/11 | 5/31/12 | 12/1/11 | $500 | 4 | 0.5 | $900 |
| B | 5/1/11 | 4/30/12 | 5/1/11 | $500 | 15 | 1 | $1500 |
| C | 8/1/11 | 7/31/12 | 8/1/11 | $250 | 7 | 1 | $800 |
| C | 8/1/11 | 7/31/12 | 10/31/11 | $250 | 7 | -0.75 | -$600 |

Comment: See Table 3.1 in Basic Ratemaking.
For Policy A: the first 6 months the deductible is 250 and the earned premium is 2000/2 = 1000, the second 6 months the deductible is 500 and the earned premium is 1800/2 = 900; thus the total earned premium is 1900, matching the net written premium.

**3.3.** 1. Personal automobile insurance:
vehicle characteristics, department of motor vehicle records
2. Homeowners insurance: distance to fire station
3. Earthquake insurance: type of soil
4. Medical malpractice: characteristics of hospital in which doctor practices
5. Commercial general liability: type of owner (proprietor, stock)
6. Workers compensation: OSHA inspection data.
Comment: Give only two examples.

**3.4.** In homeowners insurance, a record may be a home for an annual policy period.
In workers compensation insurance, rating is based on the payroll of relevant industry classifications so separate records are often maintained at the classification level.
In personal auto insurance, separate records are typically created for each coverage.
If multiple autos are insured on one policy, separate records also may be created for each individual auto on a policy. Moreover, separate records may be maintained for individual operators on each auto.

**3.5.**

| Policy | Claim Number | Accident Date | Report Date | Transaction Date | Claim Status | Loss Payment | Loss Case Reserve |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| MA12 | C2728 | 8/26/11 | 9/4/11 | 9/4/11 | open | $0 | $25,000 |
| MA12 | C2728 | 8/26/11 | 9/4/11 | 11/6/11 | open | $10,000 | $20,000 |
| MA12 | C2728 | 8/26/11 | 9/4/11 | 7/1/12 | open | $1 | $40,000 |
| MA12 | C2728 | 8/26/11 | 9/4/11 | 10/8/12 | closed | $35,000 | $0 |
| MA12 | C2728 | 8/26/11 | 9/4/11 | 2/1/13 | reopened | $0 | $30,000 |
| MA12 | C2728 | 8/26/11 | 9/4/11 | 4/16/13 | closed | $15,000 | $0 |

Comment: See Table 3.2 in Basic Ratemaking.
We could also have alae paid and alae case reserves.
We could have salvage and subrogation.
The reported losses (paid + case reserves) are: $25,000 @ 9/4/11, $30,000 @ 11/6/11, $50,000 @ 7/1/12, $45,000 @ 10/8/12, $75,000 @ 2/1/13, and $60,000 @ 4/16/13.
The CY paid losses are: $10,000 in CY11, $35,000 in CY12, and $15,000 in CY13.
The CY reported losses are paid plus the difference in case reserves at the end and beginning: $30,000 in CY11, $15,000 in CY12, and $15,000 in CY13.
Both the paid and reported losses by CY sum to $60,000, the ultimate reported losses.

**3.6.** Policy identifier, Risk identifiers, Relevant dates, Premium, Exposure, Characteristics (for example, rating variables, underwriting variables, etc.)
Comment: List only four.

**3.7.** Calendar Year data is available quicker than the others, but has the worst match between losses and premiums.
Accident Year data is available more quickly than Policy Year data, but less quickly than Calendar Year data.
Accident Year data has a better match of losses to premiums than Calendar Year data, but not as good a match as Policy Year data.
Policy Year data has the best match of losses to premiums, but is available less quickly than the others.

**3.8.** Insurance:
1. Statistical agents such as ISO and NCCI
2. The Fast Track Monitoring System
3. A.M. Best
4. Highway Loss Data Institute (HLDI)
5. Insurance Research Council (IRC)
6. Institute for Business and Home Safety (IBHS)
7. National Insurance Crime Bureau (NICB)
8. Workers Compensation Research Institute (WCRI)
9. Competitor's rate filings and rate manuals

Not Specific to Insurance:
1. Consumer Price Indices from the Bureau of Labor Statistics
2. The U.S. Census
3. Credit scores of insureds
4. Department of motor vehicle records
5. OSHA inspection data
6. State Medical Boards (information on complaints against or formal actions taken against physicians by state licensing and disciplinary boards on doctors)

Comment: List only four of each kind. There are other possible answers.

**3.9.** Policy identifier, Risk identifiers, Claim identifier, Claimant identifier, Relevant loss dates, Claim status (open, closed, or reopened), Claim count, Paid loss,
Event identifier (for example a catastrophe code), Case reserve for losses, ALAE Paid,
Case Reserve for ALAE, Salvage/subrogation,
Claim characteristics (for example type of injury, physician information, etc.).

Comment: List only 8.

**3.10.** (a) Since most Auto Physical Damage claims are reported and settled very quickly, Calendar Year data is appropriate. Calendar Year data is available more quickly than Accident Year Data.
Alternately, not appropriate as calendar year is fixed at year-end (transaction based), but Auto Physical Damage losses will still develop.
(b) The property piece of Homeowners is reported and settled quickly, while the liability piece takes somewhat longer. The majority of the expected losses are from property rather than liability.
Policy Year data would take longer to be available, and therefore Accident Year data is more appropriate for Homeowners.
Alternately, Policy Year aggregation provides for a good match between premium/exposures and losses. This would be a good choice if we are trying to isolate the effects of underwriting changes such as changes to policy limits or deductibles which could be appropriate for homeowners policies.
(c) Since Medical Professional Liability claims can take a very long time to be reported and then settled, Report Year is an appropriate method of aggregation.
Comment: Werner and Modlin use Accident Years for Homeowners in Appendix B and Accident Years for Medical Malpractice in Appendix C.
In its Examiner's Report, the exam committee stated that one had to mention claims-made policies in part (c)! This seems to have been based on page 42 of Estimating Unpaid Claims Using Basic Techniques: "For some lines of insurance, such as medical malpractice, products liability, errors and omission, and directors' and officers' liability, coverage may be dependent on the date on which the claim is reported to the insurer (i.e., claims-made coverage). For these lines of business, actuaries often prefer to use *report year data* for developing estimates of unpaid claims."
In fact, report year is also useful for Medical Malpractice occurrence policies, as shown in Chapter 16 of Basic Ratemaking. Occurrence policies have a longer average time from writing to claim settlement than do similar claims-made policies; see principle 5 of claims-made ratemaking at page 314 of Basic Ratemaking. Thus, report year can also be useful for analyzing occurrence policies.
For part (c), in its Examiner's Report the exam committee listed as a sample answer:
"RY aggregation is not appropriate because it cannot be used to estimate IBNR which is very important for a long-tailed line such as this."
This answer is based on page 43 of Estimating Unpaid Claims Using Basic Techniques:
"Estimation techniques based on claims aggregated by report year only measure development on known claims and not pure IBNR; and pure IBNR is frequently the more difficult part of the total unpaid claims estimate to determine. Other methods for developing unpaid claim estimates are required to derive the pure IBNR when using report year data."
First, for claims-made policies there is no (pure) IBNR, so that would not apply if we followed the CAS Examiner's Report and focused on claims-made policies. Second, for occurrence policies, one can estimate IBNR by analyzing a sufficient number of lags for old report years. Also one can estimate IBNER by analyzing a single RY/lag combination evaluated as of different points in time.

## Section 4, Exposures

**Some Examples of Exposure Bases**:[157]

Automobile: car-years.
Workers Compensation: $100 of payroll.[158]
Homeowners: House Years.[159]
General Liability: Sales (mercantile or manufacturing) or payroll (contracting).

**Desirable Properties of an Exposure Base**:

**1. Proportional to Expected Loss**
**2. Practical**
**3. Historical Precedence**

Proportional to Expected Loss:

**Exposure base implies a uniform and continuous multiplicative relationship between the variable and the expected losses.**

For homeowners insurance, homes with a larger number of occupants have a somewhat larger expected loss, all else being equal. However, the expected loss is not proportional to the number of occupants. For example, a home with 5 occupants might have expected losses 10% higher than an otherwise similar home with 2 occupants, rather than 2.5 times the expected losses. Thus, while one might use number of occupants (residents) as a rating variable or an underwriting criterion, one should not use it as an exposure base for homeowners.

**The exposure base should be responsive to any change in exposure to risk**.

If a contractor hires more workers, his firm is doing more work, and the possibility of a general liability claim increases.[160] His payroll would increase due to the additional workers. The exposure base of payroll is responsive to the change in his exposure to risk.

**The exposure base is not a rating variable, although the dividing line between the two is somewhat arbitrary at times.**

For example, in automobile insurance, car years is the usual exposure base. Insure 2 similar cars and we charge you twice as much.[161] Insure 3 similar cars and we charge you three times as much as for one car.

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[157] See Table 4.1 in Basic Ratemaking.
[158] Payroll is limited for officers and sole proprietors, and partners.
In at least one state, manweeks are used rather than payroll.
[159] Insurance Years ($100 or $1000 of value insured for 1 year) is also used.
[160] The example could equally well deal with the same workers working more hours per week.
[161] *In some situations the insured might be given a multi-car discount and for example might pay only 1.95 as much.*

We might use age as a rating variable for automobile insurance. However, we would not charge a 40 year old driver twice as much as a 20 year old driver.[162] If we employ business versus pleasure use as a rating variable, there is nothing inherently numerical about these discrete categories.

Practical:

- Objective and well defined
- Relatively easy and inexpensive to obtain
- Relatively easy and inexpensive to verify

This will allow the exposure base to be:

- Consistently measured
- Not subject to manipulation by insureds, agents, or underwriters.

For example, self-reported miles driven would be subject to manipulation. Self-reported miles driven is not a practical exposure base.[163]

For products liability insurance, the exposure to loss is approximately proportional to the number items in use. Since this is hard to track or estimate, the number of items in use is not a practical exposure base. Instead current sales are used. This can result in problems when the level of sales changes significantly over time.[164]

For example, the Acme Ladder Company sold an average of 100,000 ladders per year during the 1990s. Since then, they sold only an average of 50,000 ladders per year. Ladders remain in use for many years. Therefore, we expect some current accidents while using ladders that were sold in the 1990s. Therefore, in this case, the current lower level of sales underestimates the exposure to loss.[165]

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[162] In fact, we would probably charge the 40 year old driver less.

[163] Using odometer readings would still be subject to some manipulation. A GPS tracking and recording system on a longhaul truck can be used to determine miles driven, resulting in a practical exposure base.

[164] This problem could be referred to as "Temporal Mismatch."
See "Exposure Bases Revisited," by Amy S. Bouska, PCAS 1989, formerly on the syllabus.

[165] This potential problem will exists whether occurrence or claims-made policies are sold. There are current accidents which are due to old sales. Coverage is provided based on either when the accident occurred or the claim is made, not when the ladder was sold.

Historical Precedence:

**Exposure bases are rarely changed once they have been established**.

Potential temporary problems caused by changing the exposure base:

- Large swings in premiums for individuals
- Changes in the rating procedures (computer programs, etc.)
- Can no longer directly use historical exposures for ratemaking

**Therefore, one would only change an exposure base if one thought the new base was significantly better**.

For example, the Workers Compensation exposure base used to be payroll limited to $300 per week. The switch to "unlimited payroll" made it difficult to estimate classification rates for several years.[166] [167]

New exposures increased compared to historical exposures, but classes with more high wage workers were affected more. New rates by class were estimated that would be appropriate to multiply by the unlimited payroll by class.[168]

However, these class rates were less accurate than if there had been no change in exposure base. Also individual insureds with certain mixes of classes would have had very significant changes in their premiums just due to the change in exposure base.

Therefore, when exposures bases are changed, a transition program is important. For example, during the first few years, one might have averaged premiums computed based on the new exposure base and rates with premiums computed based on the old exposure base and comparable rates.

After several years, data with the new exposure base will have been collected. At that point, one would get the gain from the new exposure base, after suffering the pain during the transition.

One would run into more severe transition problems if one switched the Workers Compensation exposure base from payroll to manweeks (hours worked).

For Automobile Insurance, one would have transition problems if one switched the exposure base from car years to miles driven.

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[166] This switch was mostly made in the 1970s, on a state by state basis.
[167] Payroll is limited for officers and sole proprietors, and partners.
[168] The overall rate indication in Workers Compensation is based on loss ratios and does not use exposures.

Written Exposures:

**Written Exposures are the exposures insured by a policy**.

An annual automobile policy that insures one car, has one car year.
A six-month automobile policy that insures one car, has a half of a car year.
A six-month automobile policy that insures three cars, has one and a half car years.

All of the exposures written on a policy go into the calendar year, calendar quarter, or policy year in which the policy effective date falls.

Earned Exposures:

Coverage is provided under an insurance policy for a period of time. For an annual policy written December 1, at the end of the year only 1/12 of the coverage was provided. If this policy covers one car, then at the end of the year 1/12 of a car year has been earned.

**Earned Exposures are the portion of exposures for which coverage has been provided by a certain date**.

Exercise: An annual policy covering one home is written with effective date March 1, 2008.
What does it contribute in written and earned exposures to different Calendar Years?
[Solution: 1 written house year to Calendar Year 2008, and no written house years to Calendar Year 2009. 5/6 earned house year to Calendar Year 2008, and 1/6 earned house years to Calendar Year 2009.]

While for Calendar Years of data written and earned differ, for Policy Years of data they are the same at ultimate.

Exercise: An annual policy covering one home is written with effective date March 1, 2008.
What are the Policy Year written and earned exposures as of December 31, 2008?
What are the Policy Year written and earned exposures as of December 31, 2009?
[Solution: As of December 31, 2008, 1 written house year to Policy Year 2008.
As of December 31, 2008, 5/6 earned house year to Policy Year 2008.
As of December 31, 2009, 1 written house year to Policy Year 2008.
As of December 31, 2009, 1 earned house year to Policy Year 2008.]

Of course one can add up the contributions of many policies. For example, one might aggregate the exposures for all of an insurer's policies for a certain line of insurance in certain given state. One might aggregate the exposures separately by class and territory.

Unearned Exposures:

**Unearned Exposures are the portion of exposures for which coverage has not been provided by a certain date**.

Exercise: An annual policy covering one home is written with effective date March 1, 2008.
What are the unearned exposures as of December 31, 2008?
What are the unearned exposures as of December 31, 2009?
[Solution: 1/6 unearned house year as of December 31, 2008.
No unearned house years as of December 31, 2009.]

For an individual policy at any given point in time:
Written Exposures = Earned Exposures + Unearned Exposures.

Inforce Exposures:

**Inforce Exposures are the number of exposures for which coverage is being provided at a given point in time**.

The 19th Century Insurance Company provides homeowners insurance. On July 23, 2009, if all the homes they insure in a certain state were destroyed, they would have to pay to replace 10,000 homes. Then, as of July 23, 2009, they have 10,000 inforce exposures in this state.

This would be 10,000 inforce homes; inforce exposures have no time duration attached to them. Inforce exposures represent a snapshot of the insurer's book of business at a given point in time.

The 19th Century Insurance Company also provides private passenger automobile insurance. On July 23, 2009, they have 50,000 semi-annual policies in effect, covering a total of 70,000 cars. If all the cars they insure were destroyed, they would have to pay to replace 70,000 cars. As of July 23, 2009, they have 70,000 inforce exposures in this state.[169]

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[169] There are differences in definition between different insurers. According to Basic Ratemaking,
"Most companies define insured units to be the count of items exposed to loss at a given point in time. For example, if an automobile policy insures three cars, that one policy could contribute three in-force exposures at a given point in time. Alternatively, some companies may define insured unit in terms of the number of policies (the auto example above would have one in-force exposure under this definition) or the written exposures (in the auto example, there could be three in-force exposures if the term is annual, or 1.5 in-force exposures if the term is semiannual)."
In this example, some insurers would say the inforce exposures were the number of policies 50,000, the number of semi-annual policies divided by two or 25,000, or the number of cars divided by two or 35,000.

Cancelations:

An annual policy covering one car is written with effective date September 1, 2009.
If the policy is canceled on December 1, 2009, then only 3 months of coverage was provided, and there is 1/4 car year contributed to both written and earned exposures for Calendar Year 2009.

If instead the policy is canceled on March 1, 2010, then only 6 months of coverage was provided. However, at the end of 2009 we would not know that the policy would be canceled. Thus there would be 1 car year contributed to Calendar Year 2009 written exposures and -1/2 car year contributed to Calendar Year 2010 written exposures. The total written exposures add up to the correct 1/2 car year. 1/3 of a car year is contributed to the earned exposures for Calendar Year 2009, and 1/6 of a car year is contributed to the earned exposures for Calendar Year 2010, for a total of 1/2 car year.

Endorsements:

An annual policy covering one car is written with effective date September 1, 2009.

If the policy is endorsed on December 1, 2009 to add another car, then the second car will be provided with only 9 months of coverage. This policy contributes 1.75 car years to Calendar Year 2009 written exposures. From the first car, there are 4/12 car years earned in CY09 and 8/12 car years earned in CY10. From the second car, there are 1/12 car years earned in CY09 and 8/12 car years earned in CY10. Thus this policy contributes 5/12 car years to CY09 earned exposures and 16/12 car-years to CY10 earned exposures, for a total of 1.75 car years.

| Car | CY09 Written | CY10 Written | CY09 Earned | CY10 Earned |
|---|---|---|---|---|
| 1 | 1 | 0 | 4/12 | 8/12 |
| 2 | 0.75 | 0 | 1/12 | 8/12 |
| Total | 1.75 | 0 | 5/12 | 16/12 |

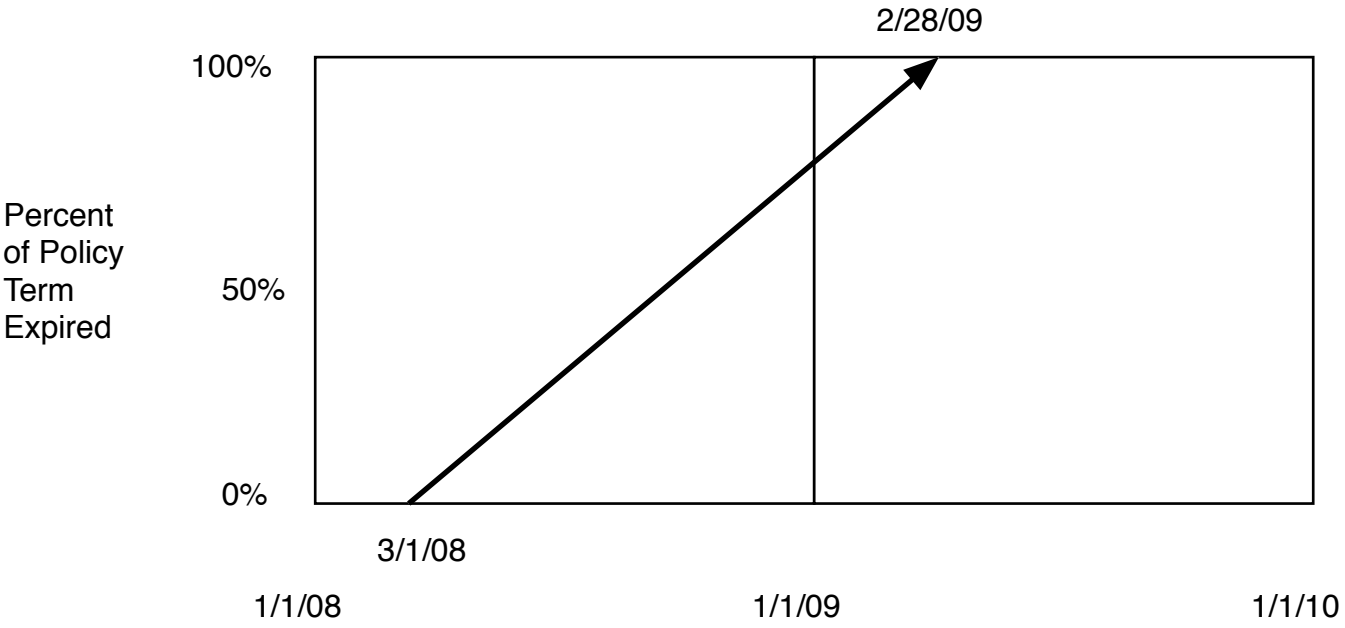
If instead the policy is endorsed on March 1, 2010 to add another car, then the second car will be provided with only 6 months of coverage. As of the end of 2009 we would not know that this policy would be endorsed. Therefore, this policy contributes 1 car year to Calendar Year 2009 written exposures and 1/2 car year to Calendar Year 2010 written exposures. From the first car, there are 4/12 car years earned in CY09 and 8/12 car years earned in CY10. From the second car, there are 6/12 car years earned in CY10. Thus this policy contributes 4/12 car years to CY09 earned exposures and 14/12 car years to CY10 earned exposures, for a total of 1.5 car years.

| Car | CY09 Written | CY10 Written | CY09 Earned | CY10 Earned |
|---|---|---|---|---|
| 1 | 1 | 0 | 4/12 | 8/12 |
| 2 | 0 | 1/2 | 0 | 6/12 |
| Total | 1 | 1/2 | 4/12 | 14/12 |

Diagrams:

One can draw diagrams to represent exposures and premium. Such diagrams are the basis of the parallelogram method of putting premiums on-level.[170] Some people will find them helpful for dealing with exposures.

For example, let us assume an annual policy is written with an effective date of March 1, 2008. Then coverage runs from 3/1/08 to 2/28/09. We can represent this in the following diagram, with time on the horizontal axis, and the percent of the policy term that has expired on the vertical axis:



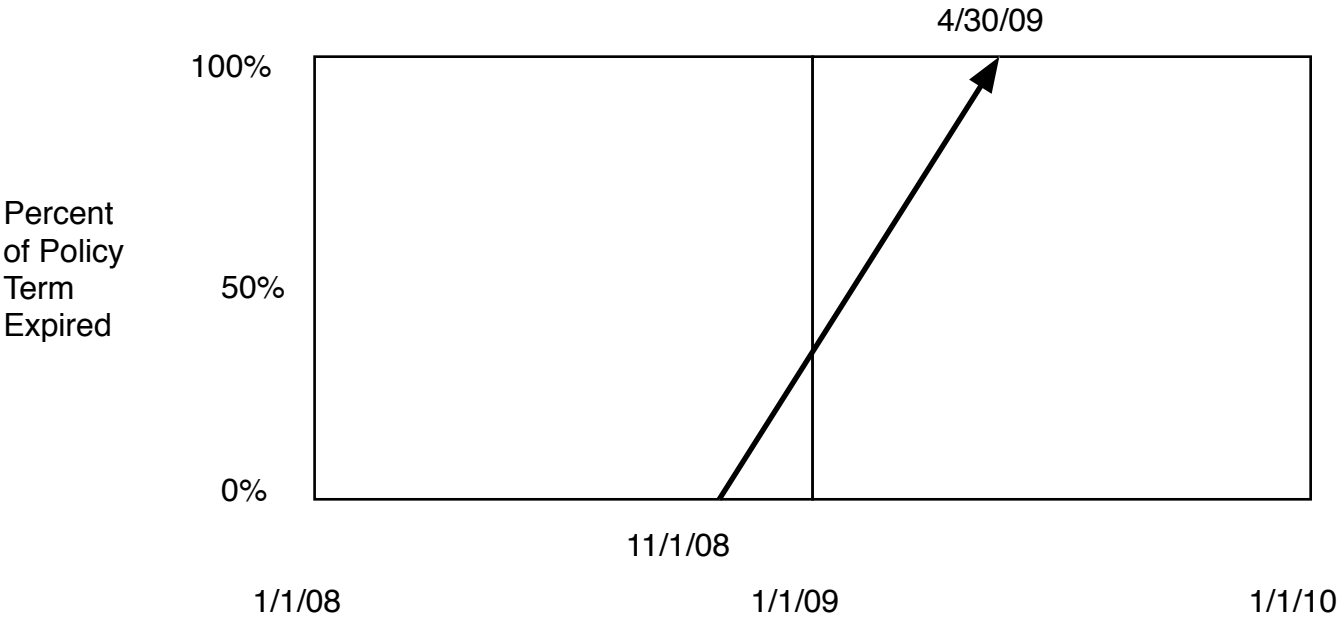

The lefthand square represents Calendar Year 2008 earned exposures, while the righthand square represents Calendar Year 2009 earned exposures. The arrow corresponds to the policy written 3/1/08. Since 5/6 of the length of the arrow is in the lefthand square, 5/6 of the exposures from this policy are earned during Calendar Year 2008. The remaining 1/6 of the exposures from this policy are earned during Calendar Year 2009.

Since this is an annual policy, the expiration date is one year after the inception date.
**The slope of the line representing an annual policy is one**.

We have to take into account the number of exposures written on each policy. If the 3/1/08 annual policy covered one car, then it would contribute 5/6 of a car year to Calendar Year 2008 and 1/6 of a car year to Calendar Year 2009. If instead the policy had covered two cars, then it would contribute 5/3 of a car year to Calendar Year 2008 and 1/3 of a car year to Calendar Year 2009.

[170] To be discussed in my section on Premiums.

Exercise: Draw a similar diagram representing a six-month policy written 11/1/08.
[Solution: Since this is a six month policy, the expiration date is half a year after the inception date.

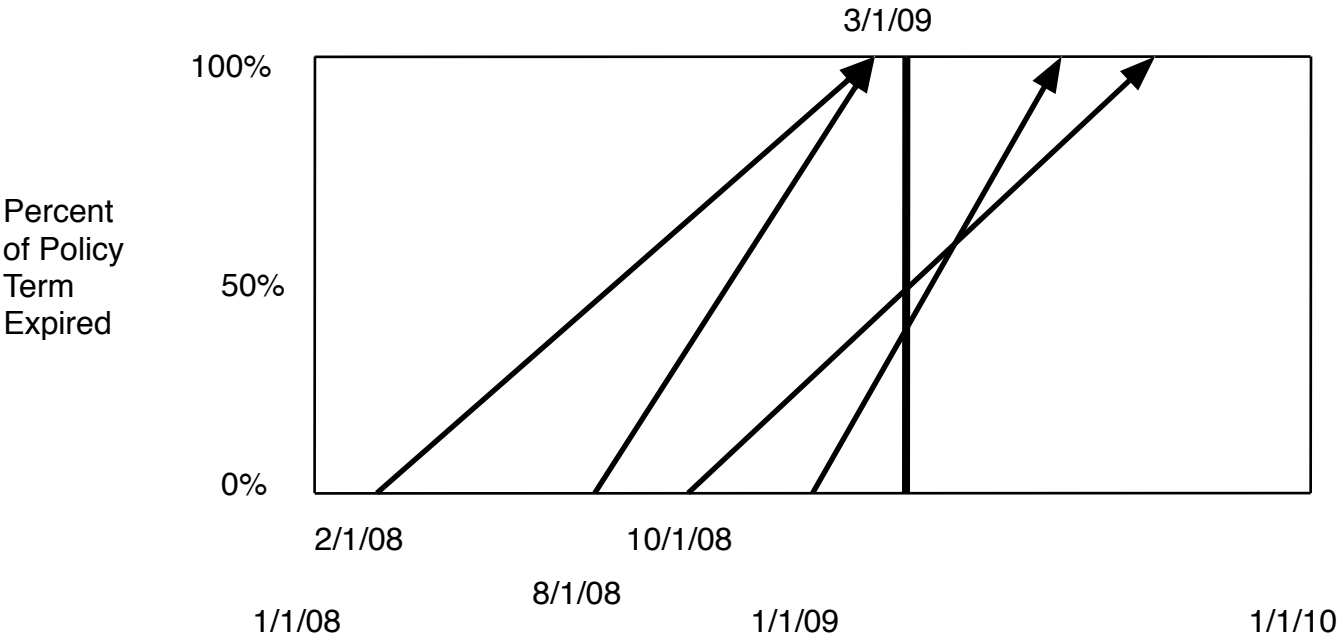



Comment: Since 1/3 of the length of the arrow is in the lefthand box, 1/3 of the exposures from this policy are earned during Calendar Year 2008. The remaining 2/3 of the exposures from this policy are earned during Calendar Year 2009.]

**The slope of the line representing a six month policy is two.**
**In general, the slope of the line representing a policy is one over its term**.

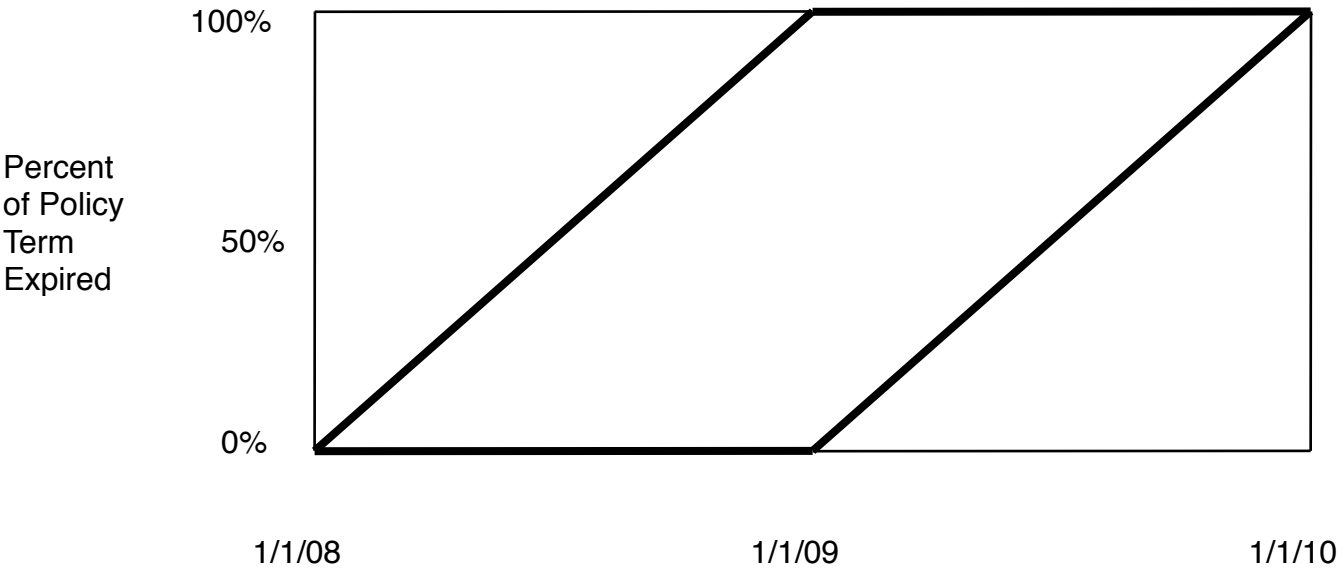
Inforce exposures can be represented by a vertical line on the given date. If the sloped line representing a policy touches the vertical line, then it is inforce on the given date.

Exercise: Annual policies are written 2/1/08 and 10/1/08.
Six-month policies are written on 8/1/08 and 1/1/09.
Draw a diagram to help determine the inforce exposures on 3/1/09.
[Solution: The 10/1/08 annual policy and 1/1/09 six month policy each contribute to the 3/1/09 inforce exposures.




Comment: If each policy covered one car, then the inforce exposures on 3/1/09 would be 2 cars.]

While a Calendar Year is represented by a square, a Policy Year is represented by a parallelogram. For example, Policy Year 2008 is the parallelogram below:



Rate at Which Exposures are Earned:

**Unless stated otherwise, assume that exposures are earned evenly throughout the policy term.**

However, there are situations in which exposures are not earned evenly throughout the policy term.[171]

An example is warranty policies, as mentioned in a footnote in Basic Ratemaking.[172]
The claims under a warranty policy tend to be more frequent as the covered product, for example an automobile, ages. In that case, premium is earned less quickly during the first part of the policy term and more quickly during the second part of the policy term.

For example, one might have the following uneven earning pattern:[173]

| Time | 0 | 12 mos | 24 mos | 36 mos | 48 mos | 60 mos | 72 mos |
|---|---|---|---|---|---|---|---|
| Expected losses | 0 | 2 | 5 | 15 | 45 | 75 | 100 |
| Earned | 0% | 2% | 5% | 15% | 45% | 75% | 100% |
| Unearned | 100% | 98% | 95% | 85% | 55% | 25% | 0% |

Additional examples include policies covering seasonal risks. For example, boatowners policies have more claims during the warmer parts of the year, while snowmobile policies have more claims during the colder parts of the year. Hurricane policies (and reinsurance treaties) only have claims due to events during hurricane season.[174]

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[171] See for example, 5, 11/19, Q1.
[172] A warranty is a type of guarantee that a manufacturer or similar party makes regarding the condition of its product. It also refers to the terms and situations in which repairs or exchanges will be made in the event that the product does not function as originally described or intended.
A warranty policy might extend the warranty provided by the manufacturer.
A warranty policy might cover a new home.
The policy terms of warranty policies are typically longer than one year, often three to five years (or even longer).
[173] This illustrative example is for a six years / 72,000 miles (6/72) extended warranty on an automobile with an underlying three year manufacturer warranty.
Taken from "Automobile Warranty Unearned Premiums and Deferred Policy Acquisition Expenses," by Joe S. Cheng, Casualty Actuarial Society E-Forum, Fall 1999.
[174] The Atlantic hurricane season is the period in a year from June through November.

Exposure Trend:

Certain exposure bases are inflation sensitive. For example, sales or payroll are expected to increase with inflation.[175] Therefore, prior to being used to get an overall rate indication for General Liability Insurance or Workers Compensation, such exposures bases are adjusted from the past inflation level to the inflation level expected in the future. An exposure trend factor will be applied to the historical data.

For example, assume that Workers Compensation Policy Year 2010 exposures (payrolls) were $100 million.[176] We are trying to be make new rates to be effective during Policy Year 2013. We think that exposures will increase due to inflation by 2% per year.

Then we project the reported exposures for three years of inflation:
($100 million) $(1.02^3)$ = $106.1 million.

Audits:

Certain exposure bases such as sales or payroll are usually subject to audit.[177]

For example, when written a certain Commercial General Liability policy assumed $80 million in sales for purposes of determining the preliminary premium. Sometime after expiration of the policy the actual sales during the policy period are determined and used to calculate the final premium.[178] The actual sales will turn out to be different than $80 million.

Such audits can have a number of effects on exposures.

A policy written in one year can contribute to the Calendar Year written exposures for the next year. For example, a policy is written March 1, 2010, with an initial estimate of sales of $80 million. At final audit on July 1, 2011, the sales are determined to be $82 million. Then $2 million of written exposures are contributed to Calendar Year 2011. If instead the audited sales were $77 million, then this policy would contribute -$3 million of written exposures to Calendar Year 2011.

Policy Year written exposures take a while to be final; they develop.
For example, the audits of the policies written late in 2010 will not have been completed until sometime in early 2012. Thus Policy Year 2010 written exposures will not be final until then.

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[175] Sales or payroll will also change as due to economic cycles and the changes in business done by particular insureds.

[176] Premiums would be put on the current rate level and developed to ultimate as discussed in my section on Premiums.

[177] In the case of Workers Compensation, the insurer would determine the payroll by state and classification.

[178] There may be audits every quarter or more frequently, in addition to the final audit.
The larger the insured, the more frequent the audits tend to be.

*Composite Rating*:[179]

Composite rating can be applied to large insureds. Instead of rating different lines of insurance using different exposure bases, a single exposure base is used, such as sales, payrolls, etc.

There are two different forms of composite rating. In the first form of composite rating, the composite rate is based on the manual rates for the different lines of insurance.

For example, let us assume the Winfred-Lauder Department Stores have the following data for the most recent 12 months available, extending by the current manual rates:

| Line of Insurance | Exposures | Manual Premium |
|---|---|---|
| Auto Liability | 40 vehicles | $80,000 |
| CGL Premises and Operations | $500 million in sales | $600,000 |
| CGL Products and Completed Operations | $500 million in sales | $200,000 |
| Burglary | $300,000 | $10,000 |

The total manual premium is: $890,000.
If we use the special exposure base of $1000 of sales, then there were 500,000 units.
The composite rate per unit is: $890,000/500,000 = $1.78.
Thus if at audit the sales turned out to be $600 million, the premium would be:
(600,000)($1.78) = $1,068,000.[180]

In the second form of composite rating, called “loss rating”, the composite rate is based on the insureds recent experience. This will be discussed in my section on
“Commercial Lines Rating Mechanisms.”

*Cyber Insurance*:[181]

Cyber insurance has been available in various forms since the 1990s but is still a relatively new product and continues to evolve. Most carriers of cyber insurance offer a core set of coverages, either as a package or part of a modular policy, as well as a number of supplementary coverages, which can vary from one carrier to another. Core coverages include privacy liability, network security liability, cyber event response, network interruption, recovery and restoration of digital assets, regulatory actions, fines and penalties, and payment card industry assessments. Supplementary coverages include cyber extortion, cybercrime, media content liability, technology errors and omissions, and bodily injury and property damage that results directly or indirectly from a cyber event.

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[179] See page 51 of Basic Ratemaking by Modlin and Werner.
[180] One could also apply experience rating, schedule rating, and/or retrospective rating.
If retrospective rating is not applied, one could apply a premium discount.
[181] Quoted from “Exposure Measures for Pricing and Analyzing the Risks in Cyber Insurance,” by Michael A. Bean, a Casualty Actuarial Society Research Paper.

A good exposure measure has the following properties:[182]
- Simplicity: The exposure measure is easy to calculate.
- Auditability: The calculation of the exposure measure can be readily audited.
- Relationship to losses: There is a strong, typically linear, relationship between the exposure measure and losses.
- Stability: The calculated value of the exposure measure is stable over the period of insurance coverage.
- Legally determinable: The information required to calculate the exposure measure can be legally obtained and shared with insurers or other third parties without violating any privacy laws or regulations.

For coverages where losses primarily involve exposure to individuals, e.g., privacy liability coverage, cyber event response coverage, etc., and the number of employees and customers can be determined, the recommended exposure measure is:
- The number of employees if this is greater than the number of customers or
- The number of customers or accounts (depending on the context) if the number of employees is less than the number of customers.

Note that an employee is an individual who provides a product or service to the organization while a customer is an individual who receives a product or service from the organization.

For coverages where losses primarily involve exposure to computer systems hardware or software, e.g., network security liability coverage, recovery and restoration of digital assets coverage, etc., the recommended exposure measure is number of endpoints (desktops, laptops, mobile devices, etc.) or number of distinct user IDs, whichever is easier to determine.

For all other coverages, e.g., network interruption coverage, regulatory actions, fines and penalties coverage, etc., the recommended exposure measure is revenue or sales over a specified period.

Whatever exposure measure is used for a coverage, it should be scaled appropriately based on the context.

Note that each of the identified measures of exposure satisfies the criteria stated earlier – simplicity, auditability, strength of relationship to losses, stability and legal determinability – although the degree to which the criteria are satisfied can vary.

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[182] Relationship to losses. ⇔ Proportional to Expected Loss.

The other criteria relate to the exposure base being practical.

Problems:

**4.1.** (3 points) For each of the following lines of insurance, give a typical exposure base:
Personal Automobile
Homeowners
Workers Compensation
Commercial General Liability (list four exposure bases)
Commercial Business Property
Physician's Professional Liability
Professional Liability Personal Articles Floater

**4.2.** (4 points) You are given the following exposures written by quarter during 2011 and 2012.

| Quarter | Written Exposures |
|---|---|
| First 2011 | 11,000 |
| Second 2011 | 10,000 |
| Third 2011 | 11,000 |
| Fourth 2011 | 12,000 |
| First 2012 | 15,000 |
| Second 2012 | 12,000 |
| Third 2012 | 13,000 |
| Fourth 2012 | 14,000 |

Determine the number of exposures earned in Calendar Year 2012.
Show all work.
(a) (2 points) Assume that all policies are annual.
(b) (2 points) Assume that all policies are six-month.

***4.3.*** *(1 point) Which of the following correctly identify the line of business with its common exposure base?*

| *Line of Business* | *Exposure Base* |
|---|---|
| *1 Burglary and theft* | *Insured value in thousands of dollars* |
| *2. Boiler and machinery* | *Number of objects* |
| *3. Fidelity* | *Contract cost* |
| *4. Credit* | *Dollars of indebtedness* |

**4.4.** (6 points) You are given the following caryears written by month during 2010.

| Month | Exposures (caryears) |
|---|---|
| January | 3000 |
| February | 600 |
| March | 600 |
| April | 1200 |
| May | 600 |
| June | 600 |
| July | 1800 |
| August | 600 |
| September | 600 |
| October | 1200 |
| November | 600 |
| December | 600 |

Determine the number of caryears earned in Calendar Year 2010.
Show all work.
(a) (3 points) Assume that all policies are annual.
(b) (3 points) Assume that all policies are six-month.

***4.5.*** *(1 point) According to Bouska in "Exposures Bases Revisited", which of the following statements correctly reflect the history of the man hours versus payroll issue for the workers compensation exposure base?*

*1. In the early 1980s, the exposure base for workers compensation in most states was changed from limited payroll to unlimited payroll in order to partially alleviate the inequities resulting from differing wage scales by employers in the same industry.*

*2. In the mid-1980s, the perceived inequity resulting from the workers compensation exposure base became a matter of national debate not only because of the union vs. nonunion wage differentials, but also because of the varying wage scales that appeared as a result of deregulation in many industries.*

*3. The NCCI's analysis of the Oregon data in its "Study of Premium Equity by Employer Groups" found no bias against either union or high wage paying employers among the small and medium sized employers, but it did show that high wage paying and union employers in the large sized group developed lower loss costs per premium dollar.*

***4.6.*** *(1 point) Which of the following have served as partial solutions to the perceived inequity for the high wage paying employers in workers compensation?*

*1. In one state, each of several construction classes was split into two new classifications (high and low wage rates.)*

*2. In one state, a table of credits based on wage rates was implemented for all contracting classes.*

*3. In one state, a program was implemented for specific construction classes, which made the experience rating plan more responsive to the individual employer's three-year loss ratio.*

***4.7.*** *(1 point) For ISO's revised [i.e., post-1987] Commercial Lines rating plan, match the exposure bases used for premises/operations coverage with the industry groups:*

*Exposure Bases: X. Gross sales Y. Payroll*

*Industry Groups: 1. Manufacturing 2. Contracting 3. Mercantile*

**4.8.** (1 point) Which of the following statements is true?

1. One should review the exposure base used for a line of insurance at least every decade.
2. The widespread use of computers, now allows exposure bases to be changed without much difficulty.
3. When exposures bases are changed, a transition program is important.

***4.9*****.** (2 points) Briefly describe how the reporting of payrolls as an exposure base may be affected by the underwriting cycle.

Briefly discuss how this might affect the data used for ratemaking.

***4.10*****.** (5 points) Per 1 million widgets sold in year X, the expected number of products liability claims is by year of occurrence:

| Year of occurrence: | X | X+1 | X+2 | X+3 | X+4 | X+5 |
|---|---|---|---|---|---|---|
| Number of claims: | 5 | 5 | 4 | 3 | 2 | 1 |

On average half of the claims are reported in their year of occurrence, while the other half are reported in the following year.

(a) (1/2 point) ABC Widget Company sold 10 million Widgets in 2006, and every year for the last ten years.

What is the expected number of products liability claims from ABC that will occur in 2006?

(b) (1/2 point) What is the expected number of products liability claims from ABC that will be reported in 2006?

(c) (2 points) XYZ Widget Company has the following sales figures in millions of widgets:

| Year: | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sales: | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 |

What is the expected number of products liability claims from XYZ that will occur in each of 2005 and 2006?

(d) (1/2 point) What is the expected number of products liability claims from XYZ that will be reported in 2006?

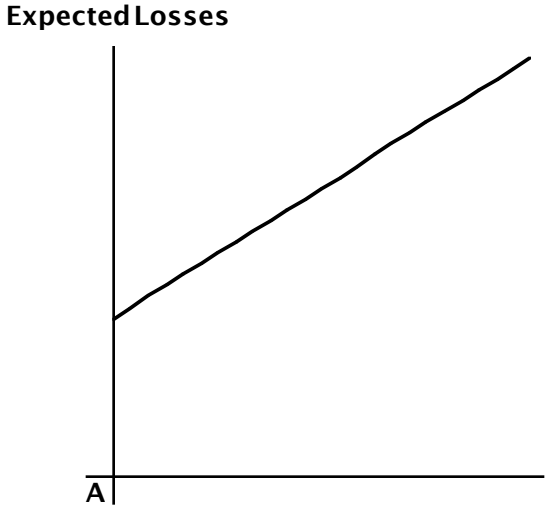
(e) (1.5 points) Briefly discuss the choice of an exposure base for products liability in light of your answers to the previous parts of this questions.

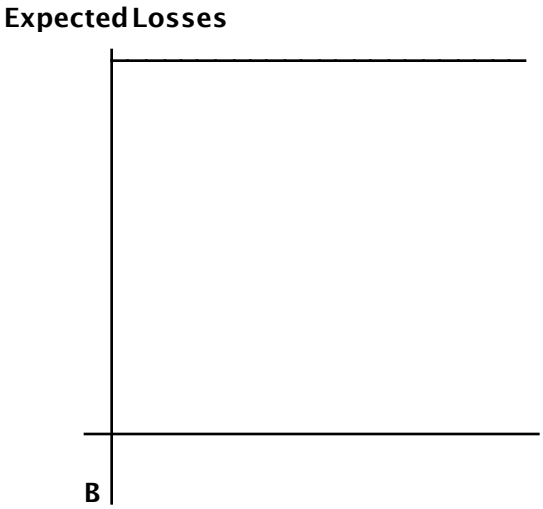
**4.11.** (3 points) Given the following information:
● All policies have a six-month policy term.
● There were 100,000 car years written during calendar year 2013.
● There were 104,000 car years written during calendar year 2014.
a. (1 point) Estimate the earned car years for calendar year 2014.
b. (1 point) All policies written from January 1, 2015 onwards have an annual policy term.

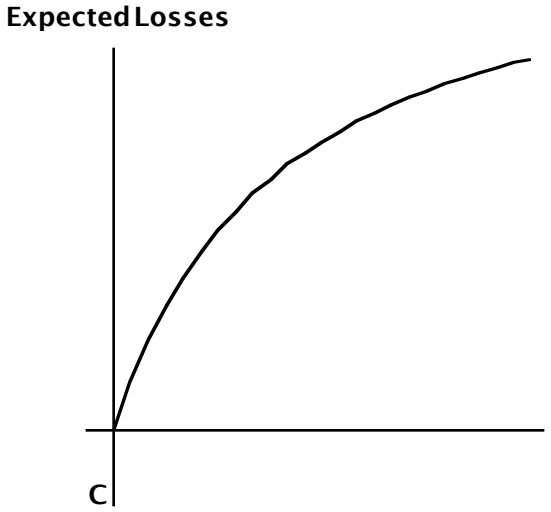
| Time Period | Written Car Years |
|---|---|
| January 1 through June 30, 2015 | 100,000 |
| July 1 through December 31, 2015 | 16,000 |

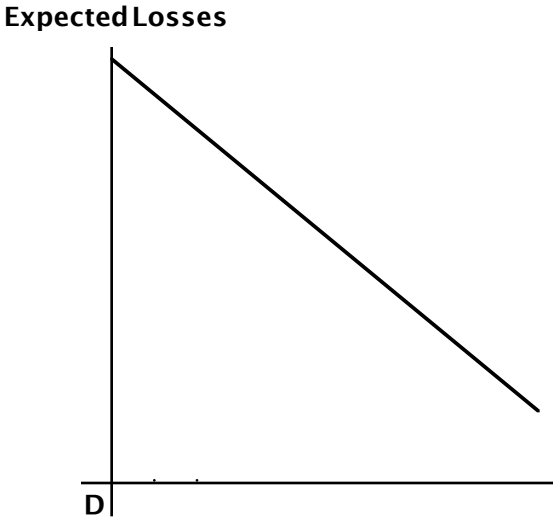
Estimate the earned car years for calendar year 2015.
c. (1 point) Estimate the retention ratio.
Assume no cancellations or endorsements.

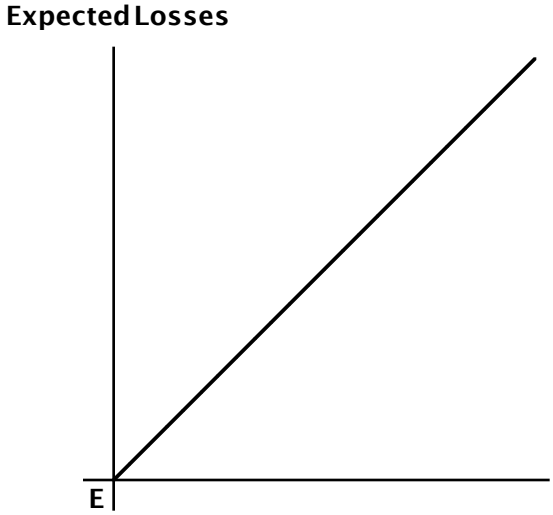
**4.12.** (1 point) The expected losses as a function of 5 different quantities:




Which of these quantities would best serve as an exposure base for this line of insurance?

**4.13.** (3 points) The following six policies are written:

| Policy Effective Date | Policy Term | Number of Automobiles Covered |
|---|---|---|
| September 1, 2004 | 6 months | 1 |
| October 1, 2004 | 12 months | 2 |
| January 1, 2005 | 12 months | 3 |
| June 1, 2005 | 6 months | 1 |
| August 1, 2005 | 6 months | 2 |
| December 1, 2005 | 12 months | 1 |

As of December 31, 2005, determine the following: Calendar Year 2005 Written Exposures, Calendar Year 2005 Earned Exposures, Unearned Exposures, and the Inforce Exposures.

*__4.14__*. (2 points) Consider the following table of data regarding number of auto policies, each covering a single car, and policy effective and expiration dates:

| Number of Policies | Effective Date | Expiration Date |
|---|---|---|
| 200 | 7/1/2001 | 12/31/2001 |
| 100 | 7/1/2001 | 6/30/2002 |
| 100 | 10/1/2001 | 3/31/2002 |
| 200 | 1/1/2002 | 6/30/2002 |
| 100 | 1/1/2002 | 12/31/2002 |
| 100 | 4/1/2002 | 9/30/2002 |
| 250 | 7/1/2002 | 12/31/2002 |
| 100 | 7/1/2002 | 6/30/2003 |
| 200 | 10/1/2002 | 3/31/2003 |

How many exposures (car-years) are earned and written in calendar year 2002?

***4.15.*** *(1 point) According to "Ratemaking" by McClenahan, the exposure unit used for a given type of insurance depends upon which of the following factors?*

*1. Reasonableness: The exposure unit should be a reasonable measure of the exposure to loss.*
*2. Ease of Determination: The exposure base should be subject to accurate determination.*
*3. Stability: The exposure measure should be stable over time.*
*4. Historical Practice: Changes in the exposure base could render any prior history unusable, which may hinder current ratemaking.*

**4.16.** (2.5 points) Each of five annual personal automobile policies covers one car.
Given the following activity on these policies:

| Policy | Effective Date | Original Expiration Date | Mid-term Cancellation Date |
|---|---|---|---|
| 1 | March 1, 2014 | February 28, 2015 | N/A |
| 2 | August 1, 2014 | July 31, 2015 | April 30, 2015 |
| 3 | January 1, 2015 | December 31, 2015 | N/A |
| 4 | April 1, 2015 | March 31, 2016 | October 30, 2015 |
| 5 | October 1, 2015 | September 30, 2016 | July 31, 2016 |

The exposure base is earned car years.
a. (0.5 point) Calculate the 2015 calendar year written exposure.
b. (0.5 point) Calculate the 2015 calendar year earned exposure.
c. (0.5 point) Calculate the 2014 policy year written exposure.
d. (0.5 point) Calculate the 2015 policy year written exposure as of June 30, 2016.
e. (0.5 point) Calculate the in-force exposure as of May 1, 2015.

**4.17.** (2.25 points)
Given the following 6-month automobile policies each of which covers one car:

| Effective Date | Number of Policies |
|---|---|
| January 1, 2017 | 250 |
| April 1, 2017 | 200 |
| July 1, 2017 | 230 |
| October 1, 2017 | 220 |
| January 1, 2018 | 300 |
| April 1, 2018 | 260 |
| July 1, 2018 | 290 |
| October 1, 2018 | 270 |

● Assume that no policies are canceled midterm.
a. (0.5 point) Calculate the written car-years for calendar year 2018.
b. (0.25 point) Calculate the in-force cars as of December 31, 2017.
c. (0.5 point) Calculate the earned car-years for calendar year 2018.
d. (0.5 point) Calculate the written car-years for the fiscal year ending June 30, 2018.
e. (0.5 point) Calculate the earned car-years for the fiscal year ending June 30, 2018.

**4.18.** (1 point) Briefly discuss the pros and cons of using gallons of gas as an exposure base for private passenger automobile liability insurance.

**4.19.** (1 points) An insurance company portfolio consists of the following:
● Each policy covers one home.
● 500 two-year policies with an effective date of June 1, 2015.
● 600 two-year policies with an effective date of June 1, 2016.
● 700 two-year policies with an effective date of June, 2017.
● 1000 one-year policies with an effective date of October 1, 2015.
● 1100 one-year policies with an effective date of October 1, 2016.
● 1200 one-year policies with an effective date of October 1, 2017.
a. (0.25 points) Calculate the written exposures for calendar year 2017.
b. (0.75 points) Calculate the earned exposures for calendar year 2017.

***4.20*.** (4.5 points) Given the following quarterly exposure information:

| Calendar Year and Quarter | Written Exposures |
|---|---|
| 2018 Q 1 | 1000 |
| 2018 Q 2 | 3000 |
| 2018 Q 3 | 4000 |
| 2018 Q 4 | 2000 |
| 2019 Q 1 | 1200 |
| 2019 Q 2 | 3500 |
| 2019 Q 3 | 5000 |
| 2019 Q 4 | 2500 |

● The insurer started writing business on January 1, 2018.
● The insurer stops writing business on December 31, 2019.
● All policies are annual.
● All policies are written on the first day of the quarter.
● There are no policy cancellations and no mid-term adjustments.
● The quarterly earnings pattern was set by analyzing historical experience across the industry and is not uniform. For each policy, regardless of in which quarter it is written, it earns 15% in Q1 of a year, 30% in Q2 of a year, 35% in Q3 of a year, and the remaining 20% of its written exposures in Q4 of a year.
(a) (1 point) Determine the earned exposures for each quarter of CY 2018.
(b) (1.5 points) Determine the earned exposures for each quarter of CY 2019.
(c) (1 point) Determine the earned exposures for each quarter of CY 2020.
(d) (0.5 point) Calculate the 2018 policy year earned exposures as of March 31, 2019.
(e) (0.5 point) Calculate the unearned exposures as of the end of 2019.

***4.21. (6, 5/92, Q.53)*** *(3 points) In "Exposure Bases Revisited", Bouska discusses Causes and Controversy Involved in Changing Exposure Bases.*
*(a) (1 point) What are the three desirable traits of an exposure base?*
*(b) (1.5 points) Discuss the issues surrounding Workers Compensation with regard to using hours worked versus payroll.*
*(c) (1/2 point) What were the findings of the special study made in Oregon regarding this issue?*

**4.22. (6, 5/93, Q.6)** (1 point) Consider the following table of data regarding number of auto policies, each covering a single car, and policy effective and expiration dates:

| Number of Policies | Effective Date | Expiration Date |
|---|---|---|
| 100 | 1/1/92 | 6/30/92 |
| 150 | 4/1/92 | 9/30/92 |
| 200 | 7/1/92 | 12/31/92 |
| 250 | 10/1/92 | 3/31/93 |

How many exposures(car-years) are earned and written in calendar year 1992?

***4.23. (6, 5/93, Q.36)*** *(3 points)*
*a. (1 point) According to Bouska, "Exposure Bases Revisited," what is the distinction between a rating variable and an exposure base?*
*b. (2 points) Describe the three types of problems encountered in the selection of an exposure base and give an example of each type.*

**4.24. (6, 5/93, Q.51)** (3 points) American Galactic Insurance started a new insurance product in 1993. The annual written exposures are projected to be 1000x from x = 0 to x = 3 and level thereafter with x = 0 at 1/1/93 and x = 3 at 1/1/96.
All policies are six month policies.
Calculate the projected percentage increase in earned exposures from calendar year 1994 to calendar year 1995.

**4.25.** (3 points) In the previous question, 6, 5/93, Q.51, determine each of the following.
(a) (1 point) Earned exposures for calendar year 1993.
(b) (1.5 points) Earned exposures for calendar year 1996.
(c) (0.5 points) Earned exposures for calendar year 1997.

**4.26. (6, 5/94, Q.8)** (1 point) For a new line of business:
● All policies are annual policies.
● The annual written exposure units at time x is $1000\ x^2$ for x = 0 to x = 1.
Determine the earned exposures in the first year for a new line of business.
Note: I have rewritten this past exam question to match the current syllabus.

**4.27. (6, 5/94, Q.11)** (1 point) Which of the following are true?
1. For a given line of business more than one medium should be selected as the exposure base.
2. An exposure base should have a uniform multiplicative relationship with all expected loss costs and rates.
3. The exposure base recognizes the average situation in exposure to loss.

***4.28. (6, 5/94, Q.40)*** *(2 points)*
*Bouska, "Exposure Bases Revisited," describes proper selection of exposure bases.*
*(a) (1 point) Describe three types of problems in the selection of an appropriate exposure base.*
*(b) (1 point) Identify two serious problems with exposure bases arising out of insurance company practices.*

**4.29. (6, 5/94, Q.49)** (1.5 points)
(a) (1 point) Give two reasons for using total payroll as the exposure base for Workers Compensation.
(b) (1/2 point) Give one reason against using total payroll as the exposure base for Workers Compensation medical benefits.

**4.30. (6, 5/95, Q.3)** (1 point) Which of the following are true?
1. Inflation-sensitive exposure bases increase the need for frequent rate filings.
2. In a steady state, rates eventually respond to a systematic underestimation of the exposures.
3. The exposure base is not the true exposure to loss.

**4.31. (6, 5/95, Q.5)** (1 point) Unique Insurance Company starts writing a new line of business. In the first year of writing the insurance, it finds that the annual rate of written exposures at time "x" is 1000x. All policies are one-year policies.
Determine the unearned exposure at the end of the first year.

**4.32. (6, 5/95, Q.36)** (3 points) According to McClenahan, chapter 3, "Ratemaking," Foundations of Casualty Actuarial Science, the specific exposure unit used for a given type of insurance should depend on several factors.
*(a) (2 points) List and briefly describe the four factors he discusses.*
(b) (1 point) Based on the four factors in (a), discuss the use of the following exposure units for automobile ratemaking:
1) car years
2) miles driven per year

**4.33. (6, 5/96, Q.27)** (3 points)
(a) (2 points) List four desirable characteristics of exposure bases.
(b) (1 point) Discuss how well unlimited payroll, as an exposure base for Workers Compensation, satisfies each of the four desirable characteristics referred to in (a) above.

**4.34. (6, 5/96, Q.29)** (4.5 points) You are given:

- Annual rate of written exposures at time x equals 1000x.
- x = 0 at 1/1/94
- All policies are annual.

(a) (1.5 points) Determine the earned exposures for calendar year 1995, assuming annual writings continue throughout 1995.
(b) (1.5 points) Determine the earned exposures for calendar year 1995. assuming no new policies are issued after June 30, 1995.
(c) (1.5 points) Determine the earned exposures for calendar year 1995, assuming no new policies are issued after June 30, 1995 and all in-force policies are canceled June 30, 1995.
Note: I have rewritten this past exam question in order to match the current syllabus.

*__4.35__*__. (6, 5/97, Q.25)__ (4 points)
(b) (2 points) Describe the process of selecting an exposure base for a line of insurance.
(c) (2 points) The standard exposure bases are often not used for large risks. Briefly describe two alternative rating plans used for large risks that modify the usual exposure base.
Note: Part (a) of this question referred to the "Statement of Principles Regarding Property and Casualty Ratemaking."

**4.36. (6, 5/98, Q.3)** (1 point) Which of the following are true?
1. The factor selected as the exposure base should have a uniform multiplicative relationship with all of the expected loss costs and rates.
2. Although it makes the plan more difficult to use, the complexity of the exposure base is likely to enhance its perceived equity.
3. For policies subject to audit, systematic underestimation of the exposure may eventually lead to excessive rates.

***4.37. (6, 5/98, Q.45)*** *(3 points) Bouska, in "Exposure Bases Revisited," discusses three types of problems that are encountered in the selection of the exposure base.*
*a. (1.5 points) Briefly describe the three types of problems.*
*b. (1.5 points) For each of the three problems identified in part (a), select one of the following policy types and explain how that policy type highlights the problem.*

- *Products Liability Insurance*
- *Pollution Liability Insurance*
- *Directors and Officers Insurance.*

**4.38. (6, 5/99, Q.14)** (1 point) Which of the following statements are true?
1. The factor selected as the exposure base should have a uniform multiplicative relationship with all of the expected loss costs and rates.
2. If a large risk is loss-rated, the exposure base is the risk itself.
3. Triggering products liability coverage on the date of injury, rather than the date of sale, gives rise to a temporal mismatch.

**4.39. (6, 5/99, Q.43)** (2 points)
a. (1 point) What is the first step in developing an exposure base for a new and unique insurance product?
b. (1 point) What are the two reasons why the uniform multiplicative relationship between the exposure base and the expected loss costs is modified in calculating the premium?

***4.40. (5, 5/00, Q.43)*** *(3 points) Bouska, "Exposure Bases Revisited," lists 3 types of problems in selecting an exposure base that will appropriately reflect the potential for future losses. Describe and give an example of each of the 3 problems.*

***4.41. (5, 5/01, Q.5)*** *(1 point)*
*According to Bouska, "Exposure Bases Revisited," which of the following reasons is given for ISO's changing of General Liability exposure base from area to receipts?*
*A. Sensitivity to inflation*
*B. Eliminated interpretive mismatch*
*C. Receipts provide a more uniform exposure base to losses than area*
*D. Eliminated temporal mismatch*
*E. Eliminated sensitivity to economic cycles*

**4.42. (5, 5/01, Q.6)** (1 point) Which of the following is a serious problem that can arise from insurance company practices in the application of exposure bases.
A. Different insurers use different exposure bases, creating confusion in the market.
B. Exposure estimates can be and are manipulated in response to the competitive situation.
C. Exposure bases change frequently, which creates distortions in ratemaking analyses.
D. Geographic and social differences across the U.S. make exposure bases less relevant in some areas relative to others.
E. None of A, B, C, D are true.

**4.43. (5, 5/02, Q.9)** (1 point) Which of the following statements is true?
A. The factor selected as the exposure base should generally have a uniform multiplicative relationship with all the expected loss costs and rates.
B. The exposure base is considered a rating variable since the dividing line between the two may be somewhat arbitrary at times.
C. The failure to accurately predict the frequency and/or severity of future losses is usually a sign of a failing exposure base.
D. For a given line of business more than one medium should be selected as the exposure base.
E. None of A. B, C, D are true.

***4.44. (5, 5/02, Q.38)*** *(1 point) Bouska, "Exposure Bases Revisited," describes a problem she defines as temporal mismatch. Give an example of temporal mismatch that occurs with medical malpractice claims-made policies.*

**4.45. (5, 5/03, Q.26)** (2 points) A severe mismatch between premiums and losses can be introduced by low exposure estimates.
a. (1 point) Explain when this would typically happen and why.
b. (0.5 point) What is the eventual outcome of the systematic underestimation of exposures in a steady state environment?
c. (0.5 point) What might be the result if this steady state environment abruptly changed and the low exposure estimates stopped?

**4.46. (5, 5/03, Q.27)** (1 point) Explain why the exposure base is a proxy for the true exposure, using automobile collision coverage as an example.

**4.47. (5, 5/04, Q.30)** (3.5 points)
a. (1.5 points) State three desirable criteria for an exposure base.
b. (2 points) For each of the lines of business listed below, state a reasonable exposure base and discuss the exposure base considering one of the criteria stated in part a. above.
1. Workers Compensation.
2. Boatowners Insurance.

**4.48. (5, 5/05, Q.14)** (1 point) A twelve-month policy providing coverage on two automobiles was written on May 1, 2004. A second twelve-month policy providing coverage on one automobile was written on November 1, 2004.
Which of the following represents the exposures as of December 31, 2004?

| | Calendar Year 2004 Written Exposures | Calendar Year 2004 Earned Exposures | Inforce Exposures |
|---|---|---|---|
| A. | 3.0 | 1.5 | 1.5 |
| B. | 3.0 | 1.5 | 3.0 |
| C. | 3.0 | 3.0 | 3.0 |
| D. | 6.0 | 1.5 | 3.0 |
| E. | 6.0 | 3.0 | 3.0 |

**4.49. (5, 5/05, Q.36)** (2 points)
a. (1 point) Briefly explain each of the following two statement.
1. The exposure base is not the true exposure.
2. The exposure base is not a rating variable.
b. (1 point) "Miles driven" is a potential exposure base for Personal Auto Liability Insurance. Give one reason for and one reason against its use as an exposure base.

**4.50. (5, 5/06, Q.24)** (2 points) Total payroll is commonly used as an exposure base for Workers' Compensation insurance. For each of the following coverages, briefly explain why total payroll may not be the best exposure base. Suggest an alternative exposure base for each coverage and explain why it would be an improvement over total payroll.
a. (1 point) Workers' Compensation Medical Benefits Coverage
b. (1 point) Workers' Compensation Indemnity Benefits Coverage

**4.51. (5, 5/07, Q.33)** (1.5 points) Provide one brief argument for and one brief argument against using each of the following exposure bases for worker's compensation coverage:
a. (0.5 point) Hours-worked.
b. (0.5 point) Limited payroll.
c. (0.5 point) Unlimited payroll.

**4.52. (5, 5/08, Q.12)** (2.5 points) An insurance company plans to sell identity theft insurance related to unauthorized credit card use and needs to select an exposure base.
a. (1.5 points)
Identify and briefly explain three desirable characteristics of an appropriate exposure base.
b. (1.0 point) Identify a possible exposure base for identity theft insurance and evaluate this particular exposure base relative to the characteristics identified in part a. above.

**4.53. (5, 5/09, Q.17)** (2 points) An insurance company is considering changing the personal automobile exposure base from earned car years to number of miles driven.
a. (1 point) Identify four desirable characteristics of an exposure base.
b. (1 point) Discuss whether or not the change to a miles-driven exposure base should be made, referencing each of the four characteristics identified in part a. above.

**4.54. (5, 5/10, Q.16)** (2 points)
a. (1 point) Identify and briefly describe two criteria for a good exposure base.
b. (0.5 point) Evaluate "market value of the house" as an exposure base for homeowners insurance using the two criteria identified in part a. above.
c. (0.5 point) Provide two reasons why a change in exposure base may be difficult.

**4.55. (5, 5/10, Q.17)** (2 points)
Given the following activity on five annual personal automobile policies as of June 30, 2009:

| Policy | Effective Date | Original Expiration Date | Mid-term Cancellation Date |
|---|---|---|---|
| 1 | July 1, 2007 | June 30, 2008 | N/A |
| 2 | October 1, 2007 | September 30, 2008 | March 31, 2008 |
| 3 | January 1, 2008 | December 31, 2008 | N/A |
| 4 | March 1, 2008 | February 28, 2009 | June 30, 2008 |
| 5 | July 1, 2008 | June 30, 2009 | N/A |

The exposure base is earned car years.
a. (0.5 point) Calculate the 2008 calendar year written exposure.
b. (0.5 point) Calculate the 2008 calendar year earned exposure.
c. (0.5 point) Calculate the 2007 policy year written exposure.
d. (0.5 point) Calculate the in-force exposure as of April 1, 2008.

**4.56. (5, 5/11, Q.2)** (1.5 points)
An insurer is considering changing the exposure base used to price personal auto from earned car years to annual miles driven. Evaluate the merits of this change based on each of three different criteria of a good exposure base.

**4.57. (5, 5/11, Q.3)** (1.25 points) Given the following:
● Each policy insures only one car
● Policies are earned evenly throughout the year

| Policy | Effective Date | Original Expiration Date | Cancellation Date |
|---|---|---|---|
| A | February 1, 2009 | July 31, 2009 | |
| B | May 1, 2009 | October 31, 2009 | |
| C | August 1, 2009 | January 31, 2010 | |
| D | November 1, 2009 | April 30, 2010 | January 31, 2010 |
| E | January 1, 2010 | June 30, 2010 | |
| F | July 1, 2010 | December 31, 2010 | |

a. (0.25 point) Calculate the written car years in calendar year 2010.
b. (0.25 point) Calculate the written car years in policy year 2010.
c. (0.25 point) Calculate the earned car years in calendar year 2010.
d. (0.25 point) Calculate the earned car years in policy year 2010.
e. (0.25 point) Calculate the number of in-force policies as of January 1, 2010.

**4.58. (5, 5/12, Q.2)** (1.5 points) An insurance company is considering changing its exposure base for workers compensation from payroll to number of employees. Evaluate the merits of this change based on each of three different criteria of a good exposure base.

**4.59. (5, 5/12, Q.3)** (1.5 points) Given the following information:
● An insurance company started writing business on January 1, 2011.
● All policies are one-year term.

| Policy Effective Dates | Exposures |
|---|---|
| January 1 through March 31 | 100 |
| April 1 through June 30 | 200 |
| July 1 through September 30 | 300 |
| October 1 through December 31 | 400 |

a. (1 point) Calculate the 2011 earned exposures assuming policies are written uniformly during each quarter.
b. (0.5 point) Discuss the appropriateness of the assumption in part a. above given the exposure data.

**4.60. (5, 5/13, Q.1)** (2 points)
Given the following information for an insurance company that writes 24-month term policies:

| Policy Group | Effective Date | Expiration Date | Number of Vehicles |
|---|---|---|---|
| A | January 1, 2010 | December 31, 2011 | 50 |
| B | July 1, 2010 | June 30, 2012 | 100 |

All policies within each group have the same effective date.
a. (0.5 point) Calculate the earned car-years for calendar year 2011.
b. (0.5 point) Calculate the earned car-years for policy year 2010 evaluated as of December 31, 2010 and as of December 31, 2011.
c. (0.5 point) Assume Policy Group B cancels on January 1, 2011. Calculate the 2010 policy year written car-years evaluated as of December 31, 2010 and as of December 31, 2011 for Policy Group B.
d. (0.5 point) Assume Policy Group B cancels on July 1, 2011. Calculate the 2010 and 2011 calendar year written car-years for Policy Group B.

**4.61. (5, 11/13, Q.1)** (1.5 points) An insurance company is considering changing its exposure base for workers compensation from payroll to hours worked.
Evaluate the merits of this change based on three different criteria of a good exposure base.

**4.62. (5, 5/14, Q.3)** (2.25 points) For a single personal auto policy with an annual policy term:
- A = Calendar year 2013 written exposures as of December 31, 2013.
- B = Calendar year 2012 earned exposures + calendar year 2013 earned exposures as of February 1, 2013.
- C = Calendar year 2013 unearned exposures as of February 1, 2013.
- D = In-force exposures as of February 1, 2013.
- $A < 0 < B < C < D$.
- Exposure is earned uniformly throughout the policy term.
- This policy cancels mid-term.

a. (1 point) Provide the range of valid effective dates for this policy.
b. (0.5 point) Provide the range of valid dates of the mid-term cancellation for this policy.
c. (0.75 point) Demonstrate that it would never be possible to have $A < 0 < B < C < D$ if B, C, and D were as of July 1, 2013 instead of February 1, 2013.

**4.63. (5, 11/14, Q.1)** (2 points)
In an attempt to improve poor workers compensation underwriting results, an insurance company is considering changing its exposure base from number of employees to number of hours worked.
a. (0.5 point) Identify two criteria of a good exposure base.
b. (0.5 point) Briefly discuss whether this change in exposure base is appropriate for each of the criteria from part a. above.
c. (0.25 point) Briefly describe the impact the exposure base change could have on frequency.
d. (0.25 point) Briefly describe the impact the exposure base change could have on severity.
e. (0.5 point) Discuss an impact the exposure base change could have on the company's loss ratio.

**4.64. (5, 5/15, Q.2)** (2 points) An insurer is considering changing the exposure base for a commercial auto line of business to one of the following:
i. Annual fuel expense
ii. Number of miles driven
Using three relevant actuarial criteria, evaluate the effectiveness of each of these potential exposure bases and provide a recommendation for the preferred exposure base.

**4.65. (5, 5/15, Q.3)** (3 points) Given the following information for an insurance product:

| Time Period | Written Car Years |
|---|---|
| January 1 through June 30, 2013 | 106.0 |
| July 1 through December 31, 2013 | 107.5 |
| January 1 through June 30, 2014 | 210.0 |
| July 1 through December 31, 2014 | 45.0 |

● All policies written before January 1, 2014 had a six-month policy term.
● All policies written from January 1, 2014 onwards had an annual policy term.
a. (1.25 points) Calculate the earned car years for calendar year 2014, assuming that policies were written uniformly throughout each period.
b. (1.25 points) Assume new policies in 2014 were written uniformly over the year and the retention ratio prior to the policy term change was 77%.
Assess the effect of the policy term change on the retention ratio.
c. (0.5 point) Assess the appropriateness of the assumption of uniform writings in the calculation of calendar year 2014 earned car years.

**4.66. (5, 11/15, Q.2)** (1.5 points)
a. (0.75 point) Based on two relevant criteria, propose and briefly justify an appropriate exposure base for a general liability policy for a restaurant.
b. (0.75 point) Based on two relevant criteria, propose and briefly justify an appropriate exposure base for a hospital professional liability policy.

**4.67. (5, 11/16, Q.1)** (1.25 points)
Given the following automobile policies issued during calendar years 2013 through 2015:

| Effective Date | Expiration Date | Number of Policies |
|---|---|---|
| April 1, 2013 | September 30, 2013 | 100 |
| October 1, 2013 | March 31, 2014 | 110 |
| April 1, 2014 | September 30, 2014 | 105 |
| October 1, 2014 | March 31, 2015 | 100 |
| April 1, 2015 | September 30, 2015 | 110 |
| October 1, 2015 | March 31, 2016 | 105 |

● All policies have a 6-month term.
a. (0.5 point) Calculate the written car-years for calendar year 2014.
b. (0.25 point) Calculate the in-force car-years as of December 31, 2014.
c. (0.5 point) Calculate the earned car-years for calendar year 2015.

**4.68. (5, 5/17, Q.1)** (1.25 points) An insurance company portfolio consists of the following:
● 1,000 two-year policies with an effective date of April 1, 2015.
● 1,000 one-year policies with an effective date of July 1, 2015.
a. (0.75 point) Calculate the following for calendar year 2015:
i. Written exposures
ii. Earned exposures
b. (0.5 point) Calculate the earned exposures for calendar year 2016.

**4.69. (5, 5/18, Q.1)** (1.50 points) Given the following for an insurance company:
● The exposure base is number of occupants in the home per year.
● The company writes a one-year homeowners policy effective April 1, 2017 for a home with four occupants.
● On October 1, 2017, two occupants leave the home, and the home has only two occupants for the remainder of the policy term.
a. (0.25 points) Calculate the total written exposures for calendar year 2017.
b. (0.25 points) Calculate the total earned exposures for calendar year 2017.
c. (0.25 points)
Calculate the total policy year 2017 written exposures evaluated as of September 30, 2017.
d. (0.75 points)
Briefly evaluate the number of occupants based on the three criteria of an exposure base.

**4.70. (5, 11/18, Q.1)** (2.5 points) An insurer is considering changing the exposure base for boat owners line of business from boat-years to the insured value of the boat.
The insurer offers the following coverages for boat owners:
i. Liability coverage pays for damages to another boat or injuries of people not on the insured's boat.
ii. Physical damage coverage pays for damages to the insured's boat caused by common risks, such as sinking, fire, storms, theft, and collision.
Using three criteria for a good exposure base, evaluate the effectiveness of the proposed change in exposure base for both liability and physical damage coverages and provide a recommendation for the preferred exposure base.

**4.71. (5, 5/19, Q.1)** (2.5 points) Given the following:

| Policy | Number of Vehicles | Effective Date | Expiration Date |
|---|---|---|---|
| A | 2 | January 1, 2018 | June 30, 2018 |
| B | 3 | March 1, 2018 | August 31, 2018 |
| C | 1 | July 1, 2018 | December 31, 2018 |
| D | 2 | October 1, 2018 | March 31, 2019 |
| E | 1 | November 1, 2018 | April 30, 2019 |

● All policies remain in-force until their expiration date.
● An exposure is defined as one vehicle insured for one year.
a. (0.25 point) Calculate the calendar year 2018 written exposures.
b. (0.5 point) Calculate the calendar year 2018 earned exposures.
c. (0,5 point) Calculate the policy year 2018 earned exposures as of February 28, 2019.
d. (0.25 point) Calculate the in-force exposures as of October 15, 2018.
e. (1 point) Identify two criteria of an exposure base and briefly evaluate miles driven as an exposure base for personal auto insurance using those criteria.

**4.72. (5, 11/19, Q.1)** (1.75 points) Given the following quarterly exposure information:

| Calendar Year and Quarter | Written Exposures | Earned Exposures |
|---|---|---|
| 2017 Q 1 | 100 | 5.00 |
| 2017 Q 2 | 450 | 247.50 |
| 2017 Q 3 | 400 | 427.50 |
| 2017 Q 4 | 100 | 52.50 |
| 2018 Q 1 | 125 | 53.75 |
| 2018 Q 2 | 550 | 528.75 |
| 2018 Q 3 | 475 | 562.50 |
| 2018 Q 4 | 30 | 59.00 |

- The company started writing business on January 1, 2017.
- The company stops writing business on December 31, 2018.
- The quarterly earnings pattern was set by analyzing historical experience across the industry and is not uniform.
- All policies are annual.
- All policies are written on the first day of the quarter.
- There are no policy cancellations and no mid-term adjustments.

a. (0.5 point) Calculate the 2017 policy year earned exposures as of March 31, 2018.
b. (0.25 point) Calculate the in-force exposures as of May 31, 2018.
c. (0.5 point) Calculate the calendar year 2018 unearned exposures.
d. (0.5 point) Calculate the calendar year 2019 quarter 1 earned exposures.

**4.73. (CAS Exam 5, 9/25, Sample Item 1)** (1 point)
Given the below table of data, select the best exposure base to use in rating.

| Policy | Sales | Number of Products | Number of Employees | Payroll | Losses |
|---|---|---|---|---|---|
| 1 | 3,754,250,000 | 17 | 16,462 | 1,234,685,000 | 1,275,000 |
| 2 | 5,631,375,000 | Unknown | 31,734 | 2,469,370,000 | 2,550,000 |
| 3 | 1,242,215,070 | 10 | 9,146 | 726,285,294 | 750,000 |
| 4 | 4,378,808,120 | 47 | 43,519 | 3,413,540,882 | 3,525,000 |
| 5 | 838,495,170 | 12 | 11,842 | 871,542,353 | 900,000 |
| 6 | 946,800,800 | Unknown | 14,321 | 1,312,155,431 | 1,355,000 |
| 7 | 982,611,530 | 25 | 24,038 | 1,815,713,235 | 1,875,000 |
| 8 | 913,828,720 | 31 | 33,604 | 2,251,484,412 | 2,325,000 |
| 9 | 1,370,743,080 | 62 | 56,024 | 4,502,968,824 | 4,650,000 |
| 10 | 215,560,400 | 13 | 12,500 | 944,170,882 | 975,000 |

a) Sales
b) Number of Products
c) Number of Employees
d) Payroll
Note: The CAS has retired this past exam item.

Solutions to Problems:

**4.1.** Personal Automobile: Earned Car Year
Homeowners: Earned House Year
Workers Compensation: Payroll
Commercial General Liability: Sales Revenue, Payroll, Square Footage, Number of Units
Commercial Business Property: Amount of Insurance Coverage
Physician's Professional Liability: Number of Physician Years
Professional Liability: Number of Professionals (e.g., Lawyers, Actuaries, or Accountants)
Personal Articles Floater: Value of Item
Comment: See Table 4.1 in Basic Ratemaking.
For Homeowners Insurance, Amount of Insurance Years is sometimes used.
For Workers Compensation, manweeks is sometimes used.
Commercial General Liability package policy use different exposures bases for different sublines.
A personal articles floater might for example insure an expensive piece of jewelry or an expensive musical instrument.

**4.2.** (a) Assume each block of policies is written in the middle of its quarter.
For example, we assume the policies written in the first quarter of 2011 are all effective 2/15/11, and 3/24 of their exposures are earned in Calendar Year 2012.

| Quarter | Written Expos | Assumed Effective Date | % Earned During CY 2012 | Earned Expos CY 2012 |
|---|---|---|---|---|
| | | | | |
| First 2011 | 11,000 | 2/15/11 | 0.125 | 1,375 |
| Second 2011 | 10,000 | 5/15/11 | 0.375 | 3,750 |
| Third 2011 | 11,000 | 8/15/11 | 0.625 | 6,875 |
| Fourth 2011 | 12,000 | 11/15/11 | 0.875 | 10,500 |
| First 2012 | 15,000 | 2/15/12 | 0.875 | 13,125 |
| Second 2012 | 12,000 | 5/15/12 | 0.625 | 7,500 |
| Third 2012 | 13,000 | 8/15/12 | 0.375 | 4,875 |
| Fourth 2012 | 14,000 | 11/15/12 | 0.125 | 1,750 |
| | | | | |
| Total | 98,000 | | | **49,750** |

(b) For example, we assume the policies written in the third quarter of 2011 are all effective 8/15/11, and 3/12 = 1/4 of their exposures are earned in Calendar Year 2012.

| Quarter | Written Expos | Assumed Effective Date | % Earned During CY 2012 | Earned Expos CY 2012 |
|---|---|---|---|---|
| | | | | |
| First 2011 | 11,000 | 2/15/11 | 0 | 0 |
| Second 2011 | 10,000 | 5/15/11 | 0 | 0 |
| Third 2011 | 11,000 | 8/15/11 | 0.25 | 2,750 |
| Fourth 2011 | 12,000 | 11/15/11 | 0.75 | 9,000 |
| First 2012 | 15,000 | 2/15/12 | 1 | 15,000 |
| Second 2012 | 12,000 | 5/15/12 | 1 | 12,000 |
| Third 2012 | 13,000 | 8/15/12 | 0.75 | 9,750 |
| Fourth 2012 | 14,000 | 11/15/12 | 0.25 | 3,500 |
| | | | | |
| Total | 98,000 | | | **52,000** |

Comment: See Table 4.23 in Basic Ratemaking, which has data by month rather than by quarter.

**4.3.** Fidelity has the exposure base: number of persons.
Comments: Surety has the exposure base: contract costs.

**4.4.** (a) Assume each block of policies is written in the middle of its month.
For example, we assume the policies written in January are all effective 1/15/10, and 23/24 of their exposures are earned in Calendar Year 2010.

| Month | Written Expos | Assumed Effective Date | % Earned During CY 2010 | Earned Expos CY 2010 |
|---|---|---|---|---|
| | | | | |
| January | 3,000 | 1/15/10 | 0.9583 | 2,875 |
| February | 600 | 2/15/10 | 0.8750 | 525 |
| March | 600 | 3/15/10 | 0.7917 | 475 |
| April | 1,200 | 4/15/10 | 0.7083 | 850 |
| May | 600 | 5/15/10 | 0.6250 | 375 |
| June | 600 | 6/15/10 | 0.5417 | 325 |
| July | 1800 | 7/15/10 | 0.4583 | 825 |
| August | 600 | 8/15/10 | 0.3750 | 225 |
| September | 600 | 9/15/10 | 0.2917 | 175 |
| October | 1,200 | 10/15/10 | 0.2083 | 250 |
| November | 600 | 11/15/10 | 0.1250 | 75 |
| December | 600 | 12/15/10 | 0.0417 | 25 |
| | | | | |
| Total | 12,000 | | | **7,000** |

(b) For example, we assume the policies written in July are all effective 7/15/10, and 11/12 of their exposures are earned in Calendar Year 2010.

| Month | Written Expos | Assumed Effective Date | % Earned During CY 2010 | Earned Expos CY 2010 |
|---|---|---|---|---|
| | | | | |
| January | 3,000 | 1/15/10 | 1.0000 | 3,000 |
| February | 600 | 2/15/10 | 1.0000 | 600 |
| March | 600 | 3/15/10 | 1.0000 | 600 |
| April | 1,200 | 4/15/10 | 1.0000 | 1,200 |
| May | 600 | 5/15/10 | 1.0000 | 600 |
| June | 600 | 6/15/10 | 1.0000 | 600 |
| July | 1800 | 7/15/10 | 0.9167 | 1,650 |
| August | 600 | 8/15/10 | 0.7500 | 450 |
| September | 600 | 9/15/10 | 0.5833 | 350 |
| October | 1,200 | 10/15/10 | 0.4167 | 500 |
| November | 600 | 11/15/10 | 0.2500 | 150 |
| December | 600 | 12/15/10 | 0.0833 | 50 |
| | | | | |
| Total | 12,000 | | | **9,750** |

Comment: Uses the "15th of the month rule" as in Table 4.23 in Basic Ratemaking.
Treat part (b) as a separate question, where the given caryears just happen to be the same as in part (a). With 6-month policies, 3000 exposures corresponds to 6000 cars.
For part (b) one could convert all the given values to cars, then do your work, and make sure your answer is in caryears.
If an insurer were writing 12-month policies and switched to 6-month policies, then the number of cars written in each month would change, as would the cars years written each month. However, in the long run, the annual number of car years written should stay the same as when 12-month policies were written.

**4.5.** The reason in statement #1 is not correct. Unlimited payroll is easier to verify, and reduces the size of rate revisions (payroll limited to for example $300 per week would increase at less than the rate of inflation.) *Also unlimited payroll requires more work at audit.*
Statement # 3 is false. There was no need to study large risks, which were (then) self-rated under the experience rating plan. *(Large Workers Compensation risks would now get a large, but less than 100% credibility. See Howard Mahler's discussion of Robin Gillam's "Parametrizing the Workers Compensation Experience Rating Plan", PCAS 1993.)* For medium size risks, they found a bias against high wage employers and union employers.

**4.6.** If one gives an insured larger credibility in an experience rating plan, the exposure base, rating variables, and class plan, all have less effect on the final premium.

**4.7.** Manufacturing and Mercantile use sales. Contracting uses payroll.

**4.8.** 1. Once an exposure base has been established, it has a great tendency to remain in place for many decades.
2. Even with the help of computers, changing exposure bases is expensive and difficult.
3. True. When unlimited payroll was introduced in Workers Compensation, transition programs were generally used to spread over several years the impact of the change on individual employers.

**4.9.** During the competitive part of the underwriting cycle, underwriters have a tendency to underestimate the payrolls for insureds. In theory, such "errors" will be corrected when the policy is audited, but that is usually eighteen months in the future (and after the renewal). Under the calendar/accident year ratemaking used for many lines, audit premiums are reported and fully earned in the calendar year of the audit, not the calendar year(s) when the policy premium was earned. Thus, even in the case of perfectly correct audits, a severe mismatch between the premiums and losses can be introduced by low exposure estimates. In the case of policy year data, while the audited payroll will be assigned to the correct policy year, the payroll/premium development factors will fluctuate with the underwriting cycle, making it difficult to estimate ultimate policy year payrolls and premiums.

**4.10**. (a) ABC is in a steady state situation. The expected number of claims occurring each year is: (10)(5 + 5 + 4 + 3 + 2 + 1) = 200.
(b) ABC is in a steady state situation. The expected number of claims reported each year is 200.
(c) XYZ is not in a steady state.
For example, for the 17 million widgets sold in 1999, we expect claims by year of occurrence of: (17)(5) = 85, (17)(5) = 85, (17)(4) = 68, (17)(3) =51, (17)(2) - 34, and (17)(1) = 17.

| Year of Occur. | Year of Sale 1999 | Year of Sale 2000 | Year of Sale 2001 | Year of Sale 2002 | Year of Sale 2003 | Year of Sale 2004 | Year of Sale 2005 | Year of Sale 2006 | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| 1999 | 85 | | | | | | | | |
| 2000 | 85 | 80 | | | | | | | |
| 2001 | 68 | 80 | 75 | | | | | | |
| 2002 | 51 | 64 | 75 | 70 | | | | | |
| 2003 | 34 | 48 | 60 | 70 | 65 | | | | |
| 2004 | 17 | 32 | 45 | 56 | 65 | 60 | | | 275 |
| 2005 | | 16 | 30 | 42 | 52 | 60 | 55 | | **255** |
| 2006 | | | 15 | 28 | 39 | 48 | 55 | 50 | **235** |

We expect 255 claims occurring in the year 2005.
We expect 235 claims occurring in the year 2006.
(d) Half of the claims occurring in 2005 will be reported in 2006.
Half of the claims occurring in 2006 will be reported in 2006.
We expect (255 + 235)/2 = 245 claims reported in 2006.
(e) It is common to use sales for the year of coverage as the exposure base.
Thus in this case, ABC and XYZ would have the same number of exposures for 2006.
If one is writing on an occurrence basis, we see that we expect 235 claims from XYZ compared to 200 claims from ABC.
If one is writing on a claims made basis, we see that we expect 245 claims from XYZ compared to 200 claims from ABC.
In either case, current year sales is not a precise measure of the exposure to loss.
This is an example of “temporal mismatch.”
The mismatch would be worse if either the length of average time from sale to occurrence were longer or the change in sales by year were greater.
Comment: For a widget company whose sales had been increasing to 10 million in 2006, the expected number of claims occurring in 2006 would have been less than 200. XYZ has a larger legacy of old widgets sold, which continue to be involved in accidents and produce claims.
Many products would have a much longer average time between sale and occurrence of claim than was the case in this question, making the effect of a changing volume of sales much larger.
This legacy of old sales is somewhat similar to the legacy costs of General Motors due to paying the health insurance costs of retired workers. General Motors current workforce is much smaller than its workforce in the past, just as XYZ’s current sales are smaller than its sales in the past.

**4.11.** (a) 6-month policies written during January 1 through June 30, 2013 contribute none of their written exposures to CY14 earned exposures.
6-month policies written during July 1 through December 31, 2013 contribute on average half of their written exposures to CY14 earned exposures.
6-month policies written during January 1 through June 30, 2014 contribute all of their written exposures to CY14 earned exposures.
6-month policies written during July 1 through December 31, 2014 contribute on average half of their written exposures to CY14 earned exposures.
(100,000)(0 + 1/2)/2 + (104,000)(1 + 1/2)/2 = **103,000**.
(b) Since they are six-month policies, those written during the first half of 2014 contribute nothing to CY2015 earned exposures. Those written during the second half of 2014 contribute on average 1/2 of their exposures to CY2015 earned exposures. Thus, CY2014 written exposures contribute on average 1/4 of their exposures to CY15 earned exposures.
The annual policies written during the first half of 2015 contribute on average 3/4 of their exposures to CY15 earned exposures.
(The average date of writing for the first half of 2015 is April 1.
An annual policy written April first has 3/4 of its policy term during 2015.)
The annual policies written during the second half of 2015 contribute on average 1/4 of their exposures to CY15 earned exposures.
(The average date of writing for the second half of 2015 is October 1.
An annual policy written October first has 1/4 of its policy term during 2015.)
CY15 earned exposures: (1/4)(104,000) + (3/4)(100,000) + (1/4)(16,000) = **105,000**.
(c) There were 16,000 caryears written during the second half of 2015. None of these can be due to policies written during the first half of 2015, since there are no cancelations or endorsements (to add additional autos to an existing policy.) If during the first half of 2015 there were also 16,000 exposures for new policies, then we can estimate the retention ratio as:
(100 - 16) / 104 = **80.8%**.
Comment: Similar to 5, 5/15, Q.3.
Given enough time the number of exposures written would eventually even out between the two halves of a year, although it might take decades.

As per page 10 of Basic Ratemaking: Retention Ratio = $\frac{\text{Number of Policies Renewed}}{\text{Number of Potential Renewal Policies}}$.

Here there is no way to determine the number of policies invited to renew or that are able to be renewed.

**4.12. E.** The exposure base should be (approximately) proportional to expected losses.
For example, 3 times the exposure should have (approximately) 3 times the expected losses.

**4.13.** The four policies written during 2005, contribute all of their exposures to the written exposures for Calendar Year 2005.
The written exposures for Calendar Year 2005 are: 3 + 1/2 + 2/2 + 1 = **5.5 cars years**.
For the first policy written Sept. 1, 2004, a 6 month policy which expires February 28, 2005, 1/3 of its exposures are during Calendar Year 2005.
For the second policy written Oct. 1, 2004, an annual policy that expires on Sept. 30, 2005, 3/4 of its exposures are during Cal. Year 2005.
For the third policy written Jan. 1, 2005, an annual policy that expires on Dec. 31, 2005, all of its exposures are during Cal. Year 2005.
For the fourth policy written June 1, 2005, a 6 month policy which expires Nov. 30, 2005, all of its exposures are during Cal. Year 2005.
For the fifth policy written Aug. 1, 2005, a 6 month policy which expires Jan. 31, 2006, 5/6 of its exposures are during Cal. Year 2005.
For the sixth policy written Dec. 1, 2005, an annual policy that expires on Nov. 30, 2006, 1/12 of its exposures are during Cal. Year 2005.
Calendar Year 2005 Earned Exposures are:
(1/3)(1/2) + (3/4)(2) + (1)(3) + (1)(1/2) + (5/6)(2/2) + (1/12)(1) = **6.083 car years**.

| Effective Date | Policy Term (years) | Expiration Date | Portion Earned in CY 2005 | Cars | Exposures (car years) | Exposures Earned in CY 2005 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 9/1/04 | 0.5 | 2/28/05 | 0.333 | 1 | 0.5 | 0.167 |
| 10/1/04 | 1 | 9/30/05 | 0.750 | 2 | 2 | 1.500 |
| 1/1/05 | 1 | 12/31/05 | 1.000 | 3 | 3 | 3.000 |
| 6/1/05 | 0.5 | 11/30/05 | 1.000 | 1 | 0.5 | 0.500 |
| 8/1/05 | 0.5 | 1/31/06 | 0.833 | 2 | 1 | 0.833 |
| 12/1/05 | 1 | 11/30/06 | 0.083 | 1 | 1 | 0.083 |
| | | | | | | |
| Sum | | | | | | **6.083** |

On December 31, 2005, only the last two policies have Unearned Exposures:
(1 - 5/6)(2/2) + (1 - 1/12)(1) = **1.083 car years**.
Alternately, for the four policies written in 2005, their Calendar Year 2005 earned exposures are:
(1)(3) + (1)(1/2) + (5/6)(2/2) + (1/12)(1) = 4.416 car years.
The written exposures for Calendar Year 2005 are: 3 + 1/2 + 2/2 + 1 = 5.5 car years.
Therefore, the unearned exposures at the end of 2005 are: 5.5 - 4.416 = 1.083 car years.
On December 31, 2005, the 3rd, 5th, and 6th policies are providing coverage for a total of six automobiles; the Inforce Exposures are **6 cars**.
Comment: Similar to 5, 5/05, Q.14.
Note that inforce exposures do not have any time duration associated with them.
For example, for Collision Insurance, the inforce exposures today would be the number of cars you would need to pay for if all of your insureds wrecked their cars today in one car accidents.
Inforce exposures on a given date are the sum over all policies that provide coverage on that date of the cars insured on those policies. Thus inforce exposures are in cars, not caryears.

**4.14.**

| | | Car Years | Earned CY02 | Written CY02 |
|---|---|---|---|---|
| 200 policies | 7/1/01 to 12/31/01 | 100 | 0 | 0 |
| 100 policies | 7/1/01 to 6/30/02 | 100 | 50 | 0 |
| 100 policies | 10/1/01 to 3/31/02 | 50 | 25 | 0 |
| 200 policies | 1/1/02 to 6/30/02 | 100 | 100 | 100 |
| 100 policies | 1/1/02 to 12/31/02 | 100 | 100 | 100 |
| 100 policies | 4/1/02 to 9/30/02 | 50 | 50 | 50 |
| 250 policies | 7/1/02 to 12/31/02 | 125 | 125 | 125 |
| 100 policies | 7/1/02 to 6/30/03 | 100 | 50 | 100 |
| 200 policies | 10/1/02 to 3/31/03 | 100 | 50 | 100 |
| Total | | | **550** | **575** |

Comment: Similar to 6, 5/93, Q.6.
Remember that a six month policy covering one car represents 1/2 car-year.

**4.15.** Exposures measures such as payroll are responsive to changes in wage level, which for Workers Compensation insurance is a desirable rather than an undesirable feature.

**4.16.**

| Policy | CY15 Written | CY15 Earned | PY14 Written | PY15 Written As of 6/30/16 | 5/1/15 In-Force |
|---|---|---|---|---|---|
| 1 | 0 | 1/6 | 1 | 0 | 0 |
| 2 | -1/4 | 1/3 | 3/4 | 0 | 0 |
| 3 | 1 | 1 | 0 | 1 | 1 |
| 4 | 7/12 | 7/12 | 0 | 7/12 | 1 |
| 5 | 1 | 1/4 | 0 | 1 | 0 |

(a) For policy #2, there would have been 1 written exposure assigned to CY14
(which is closed at the end of 2014 for accounting purposes.)
Therefore, when this policy is cancelled midterm during 2015, we need to put -1/4 written exposure in CY15, so that in total for policy #2 we have exposures of: 1 - 1/4 = 3/4.
In the case of policy #4, we know it has been cancelled by the end of 2015, so we only have 7/12 exposure contributed to CY15 written exposures.

CY15 written exposures: -1/4 + 1 + 7/12 + 1 = $2\frac{1}{3}$ car years.

(b) In each case, we take the portion of the year that the policy is in effect.

CY15 earned exposures: 1/6 + 1/3 + 1 + 7/12 + 1/4 = $2\frac{1}{3}$ car years.

(c) We only look at policies written during 2014.
PY14 written exposures: 1 + 3/4 = **1.75** car years.
(d) We only look at policies written during 2015.
Note that as of 6/30/16, we do not yet know that policy #5 will be cancelled on 7/31/16.

PY15 written exposures: 1 + 7/12 + 1 = $2\frac{7}{12}$ car years.

(e) We see whether or not the policy is in effect on 5/1/15.
In-force exposure as of May 1, 2015: 1 + 1 = **2** cars.
Comment: Similar to 5, 5/10, Q.17.

**4.17.** (a) Only the six-month policies written in 2018 contribute.
Each policy contributes half a caryear:
(300 + 260 + 290 + 270)/2 = **560 car-years**.
(b) Only the six-month policies written July 1, 2017 and October 1, 2017 are in force on December 31, 2017.
As of December 31, 2017 the insurer is covering: 230 + 220 = **450 cars**.
(c) The six-month policies written October 1, 2017 contribute half their exposures.
The six-month policies written January 1, 2018 contribute all of their exposures.
The six-month policies written April 1, 2018 contribute all of their exposures.
The six-month policies written July 1, 2018 contribute all of their exposures.
The six-month policies written October 1, 2018 contribute half their exposures.
(1/2) (220/2 + 300 + 260 + 290 + 270/2) = **547.5** car-years.
(d) Only the six-month policies written in July 2017, October 2017, January 2018, and April 2018 contribute. Each policy contributes half a caryear:
(230 + 220 + 300 + 260)/2 = **505 car-years**.
(e) The six-month policies written April 1, 2017 contribute half their exposures.
The six-month policies written July 1, 2017 contribute all of their exposures.
The six-month policies written October 1, 2017 contribute all of their exposures.
The six-month policies written January 1, 2018 contribute all of their exposures.
The six-month policies written April 1, 2018 contribute half their exposures.
(1/2) (200/2 + 230 + 220 + 300 + 260/2) = **490 car-years**.
Comment: Similar to 5, 11/16, Q.1.

**4.18.** Pros: Those who use more gas, drive more miles. The more miles driven the larger the chance of a claim. Thus the exposure base varies with the hazard.
Highway miles are safer and also use less gas than city miles, thus the exposure base varies with the hazard.
It could be implemented via a pay at the pump system.
Smaller cars are less likely than larger cars to cause massive damage to other vehicles or seriously injure passengers in other cars. Thus, smaller cars are a smaller hazard for liability insurance. Smaller cars also get more miles per gallon. Thus under this system smaller cars will pay less per mile driven than larger cars. The exposure base is closer to proportional to the hazard than either car years or miles driven.
Cons: The hazard is not proportional to the gallons of gas used. A more fuel efficient car will get more miles per gallon, and therefore more expected accidents per gallon.
This exposure base is not currently in use.
It would be difficult or impractical to implement without government intervention. If it were not a mandated system, similar to the gasoline tax, it would be difficult for the insurer to determine gallons of gas used and it would be easy for the insured to manipulate.
Comment: Say just a few reasonable things that demonstrate you understand exposures.
It is not being assumed that rating variables such as age of driver, use of vehicle, territory, etc., would be eliminated, although it is unclear how this would fit into a pay at the pump system.
See for example, "Pay-at-the-Pump Auto Insurance," by J. Daniel Khazzoom.
http://www.rff.org/documents/RFF-DP-98-13-REV.pdf
See also Auto Insurance Alert, by Andrew Tobias.
See also "Pay as You Drive, Some Considerations Before You Hit the Road," by Kevin Bingham, Peter Boyd, Michael Green, and Rob Brown, January/February 2009 Contingencies.
Pay-as-you-drive insurance plans charge by the mile driven. The rate per mile can vary by where you drive, how you drive, and when you drive.

**4.19.** (a) The written exposures for CY17 are: (2)(700) + 1200 = **2600 house years**.
(b) Each of the two year policies written 6/1/15 contributes 5/12 of an earned exposure to CY17.
Each of the two year policies written 6/1/16 contributes 1 earned exposure to CY17.
Each of the two year policies written 6/1/17 contributes 7/12 of an earned exposure to CY17.
Each of the one year policies written 10/1/16 contributes 9/12 of an earned exposure to CY17.
Each of the one year policies written 10/1/17 contributes 3/12 of an earned exposure to CY17.
The earned exposures for CY17 are:
(5/12)(500) + (1)(600) + (7/12)(700) + (9/12)(1100) + (3/12)(1200) = **2342 house years**.
Comment: Similar to 5, 5/17, Q.1.

**4.20.** (a) For example, for 2018 Q3, the exposures earned in 2018 Q3 to 2019 Q2 are:
(35%)(4000) = 1400, (20%)(4000) = 800, (15%)(4000) = 600, (30%)(4000) = 1200.

| Calendar Year and Quarter | Written Exposures | Earned in 2018 Q1 | Earned in 2018 Q2 | Earned in 2018 Q3 | Earned in 2018 Q4 |
|---|---|---|---|---|---|
| | | | | | |
| 2018 Q 1 | 1000 | 150 | 300 | 350 | 200 |
| 2018 Q 2 | 3000 | | 900 | 1050 | 600 |
| 2018 Q 3 | 4000 | | | 1400 | 800 |
| 2018 Q 4 | 2000 | | | | 400 |
| | | | | | |
| Total | | **150** | **1200** | **2800** | **2000** |

The exposures earned in 2018 Q4 are: (20%)(1000 + 3000 + 4000 + 2000) = 2000.
(b) We get contributions from policies written in both 2018 and 2019.

| Calendar Year and Quarter | Written Exposures | Earned in 2019 Q1 | Earned in 2019 Q2 | Earned in 2019 Q3 | Earned in 2019 Q4 |
|---|---|---|---|---|---|
| | | | | | |
| 2018 Q 1 | 1000 | | | | |
| 2018 Q 2 | 3000 | 450 | | | |
| 2018 Q 3 | 4000 | 600 | 1200 | | |
| 2018 Q 4 | 2000 | 300 | 600 | 700 | |
| 2019 Q 1 | 1200 | 180 | 360 | 420 | |
| 2019 Q 2 | 3500 | | 1050 | 1225 | 700 |
| 2019 Q 3 | 5000 | | | 1750 | 1000 |
| 2019 Q 4 | 2500 | | | | 500 |
| | | | | | |
| Total | | **1530** | **3210** | **4095** | |

The exposures earned in 2019 Q3 are: (35%)(2000 + 1200 + 3500 + 5000) = 4095.
(c) We only get contributions from policies written in 2019.

| Calendar Year and Quarter | Written Exposures | Earned in 2020 Q1 | Earned in 2020 Q2 | Earned in 2020 Q3 | Earned in 2020 Q4 |
|---|---|---|---|---|---|
| | | | | | |
| 2019 Q 1 | 1200 | | | | |
| 2019 Q 2 | 3500 | 525 | | | |
| 2019 Q 3 | 5000 | 750 | 1500 | | |
| 2019 Q 4 | 2500 | 375 | 750 | 875 | |
| | | | | | |
| Total | | **1650** | **2250** | **875** | **0** |

The exposures earned in 2020 Q2 are: (30%)(5000 + 2500) = 2250.
(d) All of the exposures earned in 2018, plus the exposures earned in Q1 of 2019 from policies written in 2018: (150 + 1200 + 2800 + 2000) + (450 + 600 + 300) = **7500**.
Alternately the PY18 unearned exposures as of March 31, 2019 are:
(4000)(30%) + (2000)(30% + 35%) = 2500.
Thus the PY18 earned exposures as of March 31, 2019 are:
1000 + 3000 + 4000 + 2000 - 2500 = **7500**.

(e) Given the insurer stops writing business on December 31, 2019: 1650 + 2250 + 875 = **4775**.
Alternately, given that the insurer started writing business on January 1, 2018, we can add up all of the written exposures by quarter and subtract the sum of all of the earned exposures by quarter through the end of 2019: 22,200 - 17,425 = **4775**.
Comment: Similar to 5, 11/19, Q.1.

**4.21.** (a) 1. Accurately measure the exposure to loss.
2. Should be easy for the insurer to determine.
3. Should not be subject to manipulation by the insured or underwriters.
(b) For indemnity benefits (lost wages), payroll is a reasonably accurate measure of the exposure to loss. The more hours worked the more payroll and the more work related accidents one expects. However, the higher the wage rate, the higher the average weekly wage, and the higher the indemnity benefit, (within limits.) Therefore, while both payroll and hours worked would capture the frequency component, only payroll captures the severity component of indemnity losses. Therefore, with respect to indemnity benefits, payrolls would more accurately measure this portion of the exposure to loss than would hours worked.
For medical benefits, there is no direct connection between the hourly wage and the average severity. Thus it is unclear why an employer who pays a higher hourly wage should pay more premium to cover expected medical benefits. If in fact there is little connection between hourly wages and medical losses, then hours worked would more accurately measure the medical portion of the exposure to loss than would payrolls.
Hours worked is harder for insurers to obtain than payroll.
Also payroll is harder for insureds to manipulate than hours worked.
Another advantage of payrolls is that it is inflation sensitive, and thus reduces the need for annual rate increases.
(c) Large employers were excluded from the study. No bias against either union or high wage paying employers was found among the small employers. For medium sized employers, high wage paying and union employers developed lower loss costs per premium dollar.
Comment: See also pages 13-15 of Feldblum's "Workers Compensation Ratemaking", formerly on the syllabus.
"Accuracy (Predictability): Total payroll may be more predictive of losses, for both indemnity and medical benefits, than either limited payroll or man-hours worked. Higher paid employees are more aware of Workers' Compensation benefits, seek higher quality medical treatment, and are more likely to engage attorneys to represent their claims. The statutory limits on indemnity benefits have only a partial effect on these influences."

**4.22.**

| | | Earned CY92 | Written CY92 |
|---|---|---|---|
| 100 policies | 1/1/92 to 6/30/92 | 50 | 50 |
| 150 policies | 4/1/92 to 9/30/92 | 75 | 75 |
| 200 policies | 7/1/92 to 12/31/92 | 100 | 100 |
| 250 policies | 10/1/92 to 3/31/93 | 62.5 | 125 |
| Total | | **287.5** | **350** |

Comment: Remember that a six month policy for one car represents 1/2 car-year.
For the last set of policies, half is earned during CY92 and half is earned during CY93.

**4.23.** a. "Once the risk's classification is known, the rate for that classification is multiplied by the number of exposure units to produce the premium. The use of a variable in the exposure base implies a uniform and continuous multiplicative relationship between the variable and the expected losses; use as a rating element implies a discrete, nonlinear relationship. For example, physician-month is an exposure base; and coverage for two physician-months costs twice as much as the coverage for one physician-month. On the other hand, age is a rating variable; and coverage for Driver A, who is twice as old as Driver B, does not (usually) cost twice as much."
b. 1. Temporal mismatch. A temporal mismatch between expected losses and an otherwise acceptable exposure base can arise. The two outstanding examples of this are claims-made policies and products liability.
2. Interpretive Mismatch. Ambiguous policy language may lead to more coverage than was intended.
3. Complexity of Hazard. The exposure base is too complex to quantify as in Directors and Officers. When there are too many factors to consider it is very difficult to pick an exposure base.

**4.24.** x = 0 at 1/1/93 and x = 3 at 12/31/96.

For six month policies, the portion earned during 1994 is: $\begin{cases} 0 \text{ for } 0 \le x < 0.5 \\ 2x - 1 \text{ for } 0.5 \le x < 1 \\ 1 \text{ for } 1 \le x < 1.5 \\ 4 - 2x \text{ for } 1.5 \le x \le 2 \end{cases}$

For example, for x = 3/4, 50% is earned in 1994.
For example, for x = 15/8, 25% is earned during 1994.

For six month policies, the portion earned during 1995 is: $\begin{cases} 0 \text{ for } 0 \le x < 1.5 \\ 2x - 3 \text{ for } 1.5 \le x < 2 \\ 1 \text{ for } 2 \le x < 2.5 \\ 6 - 2x \text{ for } 2.5 \le x \le 3 \end{cases}$ .

Earned exposures for CY1994:

$$\int_{0.5}^{1} 1000x\,(2x - 1)\,dx + \int_{1}^{1.5} 1000x\,dx + \int_{1.5}^{2} 1000x\,(4 - 2x)\,dx = 208.33 + 625 + 416.67 = 1250.$$

Earned exposures for CY1995:

$$\int_{1.5}^{2} 1000x\,(2x - 3)\,dx + \int_{2}^{2.5} 1000x\,dx + \int_{2.5}^{3} 1000x\,(6 - 2x)\,dx = 458.33 + 1125 + 666.67 = 2250.$$

Percentage increase from CY94 to CY95 is: 2250/1250 - 1 = **80%**.
Alternately, one year later the annual rate of writing is exactly 1000 higher.
So if the earned exposures for CY94 are 1250, then we know that those for CY95 must be 2250.
Proceed as before.
Alternately, one can do a discrete approximation by quarters of a year.
In order to get the exposures written in a given quarter, we integrate the given rate, 1000 x, over the time period covered by a given quarter.

For example, for the third quarter of 1993: $\int_{0.5}^{0.75} 1000\,x\,dx = (500)(0.75^2 - 0.5^2) = 156.25.$

Then we need to get the portion of those exposures contributed to a given earned calendar year.
For example, for the third quarter of 1993, the average date of writing is very approximately the middle of quarter, at time 5/8. (Since the rate is increasing, this is only an approximation.)
From time 5/8 to 1 does not contribute to CY94 earned, while from time 1 to 9/8 does.
(Recall that we have 6 month policies.)
Thus the portion contributed to CY94 earned is: (9/8 - 1) / (1/2) = 1/4.

The whole calculation is shown in the following spreadsheet:

| Quarter | Written Expos | Portion Earned CY94 | Product | | Quarter | Written Expos | Portion Earned CY95 | Product |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 93Q1 | 31.25 | 0.00 | 0.0000 | | 94Q1 | 281.25 | 0.00 | 0.0000 |
| 93Q2 | 93.75 | 0.00 | 0.0000 | | 94Q2 | 343.75 | 0.00 | 0.0000 |
| 93Q3 | 156.25 | 0.25 | 39.0625 | | 94Q3 | 406.25 | 0.25 | 101.5625 |
| 93Q4 | 218.75 | 0.75 | 164.0625 | | 94Q4 | 468.75 | 0.75 | 351.5625 |
| 94Q1 | 281.25 | 1.00 | 281.2500 | | 95Q1 | 531.25 | 1.00 | 531.2500 |
| 94Q2 | 343.75 | 1.00 | 343.7500 | | 95Q2 | 593.75 | 1.00 | 593.7500 |
| 94Q3 | 406.25 | 0.75 | 304.6875 | | 95Q3 | 656.25 | 0.75 | 492.1875 |
| 94Q4 | 468.75 | 0.25 | 117.1875 | | 95Q4 | 718.75 | 0.25 | 179.6875 |
| | | | | | | | | |
| Sum | | | **1250.0000** | | Sum | | | **2250.0000** |

**4.25.** (a) x = 0 at 1/1/93 and x = 3 at 12/31/96.

For six month policies, the portion earned during 1993 is: $\begin{cases} 1 \text{ for } 0 \le x < 0.5 \\ 2 - 2x \text{ for } 0.5 \le x \le 1 \end{cases}$

Earned exposures for CY1993:

$$\int_0^{0.5} 1000x \, dx + \int_{0.5}^{1} 1000x \, (2 - 2x) \, dx = 125 + 166.67 = \mathbf{291.67}.$$

(b) For six month policies, the portion earned during 1996 is: $\begin{cases} 0 \text{ for } 2 \le x < 2.5 \\ 2x - 5 \text{ for } 2.5 \le x < 3 \\ 1 \text{ for } 3 \le x < 3.5 \\ 8 - 2x \text{ for } 3.5 \le x \le 4 \end{cases}$.

Starting at x = 3, the annual rate of writing is constant at 3000.
Earned exposures for CY1996:

$$\int_{2.5}^{3} 1000x \, (2x - 5) \, dx + \int_{3}^{3.5} 3000 \, dx + \int_{3.5}^{4} 3000 \, (8 - 2x) \, dx = 708.33 + 1500 + 750 = \mathbf{2958.33}.$$

Alternately, one can do a discrete approximation by quarters of a year:

| Quarter | Written Expos | Portion Earned CY93 | Product | | Quarter | Written Expos | Portion Earned CY96 | Product |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 93Q1 | 31.25 | 1.00 | 31.2500 | | 95Q1 | 531.25 | 0.00 | 0.0000 |
| 93Q2 | 93.75 | 1.00 | 93.7500 | | 95Q2 | 593.75 | 0.00 | 0.0000 |
| 93Q3 | 156.25 | 0.75 | 117.1875 | | 95Q3 | 656.25 | 0.25 | 164.0625 |
| 93Q4 | 218.75 | 0.25 | 54.6875 | | 95Q4 | 718.75 | 0.75 | 539.0625 |
| 94Q1 | 281.25 | 0.00 | 0.0000 | | 96Q1 | 750 | 1.00 | 750.0000 |
| 94Q2 | 343.75 | 0.00 | 0.0000 | | 96Q2 | 750 | 1.00 | 750.0000 |
| 94Q3 | 406.25 | 0.00 | 0.0000 | | 96Q3 | 750 | 0.75 | 562.5000 |
| 94Q4 | 468.75 | 0.00 | 0.0000 | | 96Q4 | 750 | 0.25 | 187.5000 |
| | | | | | | | | |
| Sum | | | **296.8750** | | Sum | | | **2953.1250** |

(c) Starting at the beginning of 1996, the annual rate of writing is constant at 3000.
Thus the earned exposures for CY1997 is **3000**.

**4.26.** For a policy written during the first year at time x,
the portion earned during the first year is: 1 - x.
(For example, if written at time 1/4, 3/4 is earned during the first year.)

Earned exposures the first year is: $\int_0^1 (1 - x) \, 1000x^2 \, dx = 1000/12 = \mathbf{83.3}$.

**4.27.** 1. False. 2. True. 3. True.

**4.28.** a. 1. Temporal mismatch. A temporal mismatch between expected losses and an otherwise acceptable exposure base can arise. The two outstanding examples of this are claims-made policies and products liability.
2. Interpretive Mismatch. Ambiguous policy language may lead to more coverage than was intended.
3. Complexity of Hazard. The exposure base is too complex to quantify as in Directors and Officers. When there are too many factors to consider it is very difficult to pick an exposure base.
b. 1. Exposure estimates can be (and are) internally manipulated in response to the competitive situation.
2. Even when the policy premium is based on the correct exposures, the coding of the exposure information into the computer records is often poor, with whole dollars frequently switched with “per hundreds” or “per thousands.”

**4.29.** (a) 1. Historical Precedence: payroll is currently being used.
2. Practical: payroll is already being collected for tax purposes, so the data is readily available.
3. Proportional to Expected Loss: As the manweeks worked increases, so does the payroll. The number of expected workplace accidents (for a given classification) is approximately proportional to the manhours worked, and payroll is proportional to the manhours worked. In addition, as the weekly wage goes up so do the indemnity benefits paid. For a give number of manweeks worked, the payroll increases in proportion to the average weekly wage.
4. Inflation Sensitive: Payroll goes up with inflation, reducing the number of rate revisions needed.
(b) Medical benefits paid do not depend on a workers average weekly wage. A company that pays its workers more per hour, will have a higher payroll, but not more in medical benefits than would an otherwise identical company that paid its workers less per hour. Thus for medical benefits, payroll is <u>not</u> proportional to expected medical benefits paid.
<u>Comment</u>: There have been some studies which have shown that the level of weekly wages and expected medical benefits are positively correlated, although not proportional.
At pages 50-51 of Basic Ratemaking: “Workers compensation has historically used payroll as an exposure base. In the 1980s, there was a lot of pressure to change the exposure base to hours worked for medical coverage in order to correct perceived inadequacies of the exposure base for union companies with higher pay scales. Although hours worked made intuitive sense, the exposure base was not changed at that time, and one of the major reasons cited was concerns regarding the transition. Instead, the rating variables and rating algorithm were adjusted to address the inequities. This debate over the choice of workers compensation exposure base continues to reemerge.”

**4.30.** 1. False. Inflation-sensitive exposure bases, such as sales or payroll, <u>decrease</u> the need for frequent rate filings, since as the exposure increases, so does the collected premium even as the rates stay the same. Rates still need to be revised, but on average not as often as if the exposure base were not inflation sensitive. 2. True. 3. True.

**4.31.** A policy written at time x, has x exposures unearned at the end of the first year.
For example a policy written with one exposure at time 0.6, has 0.4 exposures earned during this year, and 0.6 exposures earned next year. Unearned exposure at the end of the first year are: $\int_0^1 x\,(1000x)\,dx = 333.33x^3\Big]_{x=0}^{x=1} = \mathbf{333.33}$.

**4.32.** (a) Reasonableness: The exposure unit should be a reasonable measure of the exposure to loss. Ease of Determination: The exposure unit should be accurately determinable. If an exposure base is not subject to determination, then an insurer can never be assured of receiving the proper premium for the actual exposure.
Responsiveness to Change: An exposure unit that reflects changes in the exposure to loss is preferable to one that does not.
Historical Practice: Where a significant body of historical exposure data is available, any change in the exposure base could render the prior history unusable. Since ratemaking generally depends upon the review of past statistical indications, exposure bases are rarely changed once they have been established.
(b) Car years: Reasonable to some extent. The more cars the greater the exposure to loss. However, it won't distinguish between an old Chevy and a new Rolls Royce. Easy to determine. Can be accurately measured. Somewhat responsive to change. Responsive to adding a vehicle but not to replacing with a different vehicle. Historical practice: This has been an historical measure of exposure and should remain so.
Miles driven: Reasonable to some extent. The more miles you drive, the greater the exposure to loss. However, it won't distinguish between city and country exposures. Not easy to measure accurately. Would have to rely on insured's statement of miles driven, or pay the expense of independently taking odometer readings, or use expensive GPS related technology. Very responsive to change. Generally if an insured drives more miles than last year, exposure to loss has increased. Historical practice: Used in ranges as part of classification systems and should remain so.
Comment: There is more than one right answer to part b.

**4.33.** (a) 1. It should be an accurate measure of the exposure to loss.
2. It should be easy for the insurer to determine.
3. It should be difficult for the insured to manipulate.
4. Require that the exposure base be immune to manipulation by underwriters.
(b) Unlimited payroll is easy to determine. Unlimited payroll is hard to be manipulated by the insured and underwriters as it is used for tax purposes. For indemnity losses, unlimited payroll is a reasonably accurate measure of the exposure, with the accuracy decreased if there are limitations on benefits. While it makes sense for the number of medical losses to be approximately proportional to the hours worked, the size of medical losses is not necessarily closely related to the worker's hourly wage. Therefore, in the case of medical losses, unlimited payroll may not reflect the exposure to loss accurately.
Comment: One could have somewhat different sensible answers to part b.

**4.34.** a. $x = 0$ at 1/1/94 and $x = 2$ at 12/31/95.

The portion earned during 1995 is: $\begin{cases} x, \text{ for } 0 \le x \le 1 \\ 2 - x, \text{ for } 1 < x \le 2 \end{cases}$.

For example, for $x = 1/4$, 3/4 is earned during 1994 while 1/4 is earned during 1995.
For $x = 1.2$, 80% is earned during 1995 while 20% is earned during 1996.

Earned exposures for 1995: $\int_0^1 1000x \, x \, dx + \int_1^2 1000x \, (2 - x) \, dx = (1000)(1/3 + 2/3) = 1000.$

b. Since we only write policies up to $x = 1.5$, the second integral only goes from 1 to 1.5.

$$\int_0^1 1000x \, x \, dx + \int_1^{1.5} 1000x \, (2 - x) \, dx = (1000)(1/3 + 11/24) = 792.$$

c. Since all in-force policies are canceled June 30, 1995, any policy written during the second half of 1994 earns half of an exposure during 1995.
Also for example a policy written on April 1, 1995 only provides 3 months of coverage before it is cancelled; all of this policy or 1/4 of an exposure is earned during 1995.

Exposures earned during 1995 is: $\begin{cases} x, \text{ for } 0 \le x \le 1/2 \\ 1/2, \text{ for } 1/2 \le x \le 1 \\ 1.5 - x, \text{ for } 1 < x \le 1.5 \end{cases}$.

$$\int_0^{1/2} 1000x \, x \, dx + \int_{1/2}^1 1000x \, (1/2) \, dx + \int_1^{1.5} 1000x \, (1.5 - x) \, dx = (1000)(1/24 + 3/16 + 7/48) = 375.$$

**4.35.** (b) 1. Analyze the coverage offered and the coverage trigger to determine what factors influence the expected losses. Some of these factors will not be usable in the determination of premiums.
2. Those which are usable will be divided into two groups: the first group, consisting of one factor, will be the exposure base, and the second group will be the rating variables, which influence the projected expected losses indirectly by affecting the rate.
(c) Composite rating plan: the risk's premium is calculated normally and then divided by a proxy exposure base, such as mileage or receipts for long-haul trucking firms. This gives a rate per proxy unit. When the policy expires, the firm's records are audited in order to determine the actual receipts (or mileage), and this is used to calculate the final premium.
Loss-rated: the premium is calculated directly from the risk's historical losses without any reference to the standard rating plans. In this case, it is correct to say that the exposure base is the risk itself and the rate is its expected losses.

**4.36.** 1. True. 2. False. The factor selected as the exposure base should be simple and have an obvious relationship to losses. In addition to making the plan easier to use, simplicity is likely to enhance its perceived equity, even if the technical accuracy is not improved.
3. True. If underreporting of exposures is related to the underwriting cycle, this can have serious impacts on the data used for ratemaking, resulting in inaccurate rates.

**4.37.** Temporal mismatch: A mismatch between the timing of expected losses and an otherwise acceptable exposure base.
Example, Products Liability: Products liability coverage is triggered by the injury, but the exposure base is sales. For products with a long lifetime, there can be many years or even decades between the sale and injury, creating the temporal mismatch.
Interpretive mismatch: A mismatch arises through deliberate or accidental misinterpretation of the coverage trigger.
Example, Pollution Liability: Policy language has sometimes been interpreted to provide coverage for pollution arising out of disposal of waste by the insured prior to policy inception.
Complexity of Hazard: The situation may be so complex, that it is extremely difficult, if not impossible, to list of all factors affecting the expected level of losses.
Example, Directors and Officers Insurance: Examples of factors affecting the expected level of losses are: the number of directors and officers, business activities, change in revenues, change in profits, change in assets, number of stockholders, number of employees, hiring/firing policies, change in overall financial condition as rated by S&P, change in stock price, attractiveness as an acquisition, responses to past acquisition offers (e.g., "poison pills"), state of domicile, response to any recent emergencies (accidents, etc.), recent changes in management, whether and how executives are granted stock options, accounting firm used, etc. Determining which factors are most important and how they are related to expected loss is a complicated task. "For example, does a company with twice as many directors have twice the exposure to loss? Probably not."
Comments: As an example of temporal mismatch, Bouska also mentions claims-made policies, used for example for medical malpractice insurance.
Interpretive mismatch has also arisen with respect to coverage for exposure to asbestos.
You should not try to list all of the factors affecting D&O insurance; two or three would have been enough. *In 2000, what factors might have entered into an attempt to determine the expected loss under Enron's future D&O insurance policy? After Enron's bankruptcy, its Directors and Officers Policy Limits of about $350 million were paid out in various settlements.*

**4.38. All of the these statements are true**.

**4.39.** a. The first step is to analyze the coverage offered and the coverage trigger to determine what factors influence the expected losses.
b. Expected losses (and premium) do not vary only with the exposure base, but also with many other factors which are built into the rating variables. (For example, most insurers charge a private passenger automobile policy with two vehicles, less than they would charge two separate policies, in order to reflect the decreased driving per vehicle and better loss experience.) Also there may be expenses that are not proportional to expected losses. (This is reflected in Workers Compensation insurance by use of the Expense Constant and Premium Discount.)

**4.40.** a. Temporal mismatch: the exposure base does not accurately reflect the timing of losses. For example, in products liability, sales is often used as an exposure base. If a company goes out of business, sales are zero, but the product liability exposure still exists if the products are still being used by the consumer.
b. Interpretive mismatch: if a misinterpretation of policy language occurs, this is not typically reflected in the exposure base. This occurred with the misinterpretation of the "sudden and accidental" pollution coverage in CGL policies. Insurance companies ended up paying more losses than what was reflected in the exposure base used.
c. Complexity of the hazard: certain risks are affected by a large number of factors often there are too many factors to list or the relationship between them and the risk is difficult to quantify. An example of this is directors' and officer's coverage. Many factors affect the risk of liability for D&O and they are difficult to quantify.

**4.41. A.** Other reasons were: simplification of rating and sensitivity to economic cycles.

**4.42. B.** Another potential problem is that even when the policy premium is based on the correct exposures, the coding of the exposure information into the computer records is often poor, with whole dollars frequently switched with "per hundreds" or "per thousands."

**4.43. A.** While the dividing line between the two may be somewhat arbitrary at times, the exposure base is not a rating variable. A failure to accurately predict the frequency and/or severity of future losses is usually a problem with our ratemaking tools, not the sign of a failing exposure base.

**4.44.** Claims-made policies are triggered by the notice of a claim, but rated on the normal occurrence exposure base, a physician-month in medical malpractice, for example.
Comment: This problem can be dealt with via the incorporation of a rating step to recognize the number of years under claims-made coverage.

**4.45.** Competitive pressures tend to degrade the exposure data. In a very competitive (soft) insurance market, a low price can be produced in a variety of ways. In some instances, it is easier for the underwriter to "low-ball" the exposure estimate. In theory, such "errors" will be corrected when the policy is audited, but that is usually eighteen months in the future (and after the renewal). Under the calendar/accident year ratemaking used for many lines, audit premiums are reported and fully earned in the calendar year of the audit, not the calendar year(s) when the policy premium was earned. Thus, even in the case of perfectly correct audits, a severe mismatch between the premiums and losses can be introduced by low exposure estimates. In a steady state, the rates eventually respond to a systematic underestimation of the exposures; but when the insurance cycle changes quickly and the "low-balling" stops abruptly, the problem of excessive rates appears.

Comment: Actuaries use old information to make rates for the future. The actions of underwriters can affect your ratemaking data. If the actuary does not take this into account, then the resulting rates will not be appropriate. This same phenomena would affect the premium or exposure development factors for Policy Year data. *For example, assume every year there are 100 exposures (perhaps payroll) accurately estimated at the time of writing and 70 in losses. Ignoring expenses, taxes, profits, etc., the rate would be set equal to the pure premium of .70. Things go along fine in this manner for several years. Assume in "Year 10" the underwriters start to low ball the exposures and only 80 is reported. The insureds pay (0.7)(80) = 56 rather than 70 in initial premium. If we assume at audit the "extra" 20 in exposures would be picked up, then the insureds would pay an extra (20)(0.7) = 14 in premiums. So the correct premium is collected in total for the coverage provided, but some of it has been delayed, which if one considered the time value of money would be significant. This audit exposure related to policies written in Year 10 would be reported as part of Calendar Year 12. Then the ratemaking data would look like this:*

| *Year* | *Exposures* | *Losses* | *Pure Premium* | *Will be Used to Set Rate for Year* |
|---|---|---|---|---|
| *9* | *100* | *70* | *0.70* | *11* |
| *10* | *80* | *70* | *0.875* | *12* |
| *11* | *80* | *70* | *0.875* | *13* |
| *12* | *80 + 20 = 100* | *70* | *0.70* | *14* |
| *13* | *80 + 20 = 100* | *70* | *0.70* | *15* |
| *14* | *80 + 20 = 100* | *70* | *0.70* | *16* |

*So we would expect the rate to jump up in year 12 to an excessive level and then settle back down in year 14 to a steady state at the assumed correct level of 0.70.*

*Assume that in Year 20 the underwriters return to accurately estimating the exposures as 100 at policy inception. We would still get 20 in audit exposures from policies written in Year 18 reported in Calendar Year 20. Then the ratemaking data would look like this:*

| *Year* | *Exposures* | *Losses* | *Pure Premium* | *Will be Used to Set Rate for Year* |
|---|---|---|---|---|
| *19* | *80 + 20 = 100* | *70* | *0.70* | *21* |
| *20* | *100 + 20 = 120* | *70* | *0.583* | *22* |
| *21* | *100 + 20 = 120* | *70* | *0.583* | *23* |
| *22* | *100* | *70* | *0.70* | *24* |
| *23* | *100* | *70* | *0.70* | *25* |

*In year 22 the rates would decline to an inadequate level, but in two years would once again return to a steady state at the assumed correct level of 0.70. All of this assumes the actuaries when making rates are not clever enough to spot what is going on and make the appropriate adjustments to compensate for the distortions in the exposure data.*

**4.46.** "The exposure base is not the true exposure. The exposure base is a proxy for the true exposure, which we are unable to know, both because it is constantly changing and because it is generally a function of a large number of variables. For example, the collision exposure of a private passenger auto is effectively zero when it is parked in a secure garage, somewhat higher when it is being driven on an isolated highway by an alert and competent driver, and substantially higher on a crowded street with a drunk driver. The exposure base (car-month) recognizes the average situation rather than these fluctuations in the true exposure to loss."
The probability of an accident, as well as the average severity of an accident if it occurs, varies with the amount the car is driven, as well as for example the time of day, the day of the week, the speed of the vehicle, the weather conditions, the road conditions, the type of road, the number and type of other drivers on the road, the mental and physical condition of the driver, the condition of the vehicle, etc. Using a car-year or car-month as the exposure base does not capture any of this variation in the exposure to loss.
Comment: *One can think of a claims intensity which varies over time as a complicated function of the interaction of many different factors.*

**4.47.** a. 1. should accurately reflect the overall exposure to loss.
2. should be simple to compile. 3. should not be subject to manipulation.
4. should be responsive to change. 5. should reflect historical practice.
b. For Workers Compensation one could use payroll.
Payroll is a reasonably accurate reflection of exposure to indemnity losses, where the payments depend on the injured workers weekly wage. Payroll is not as an accurate reflection of the exposure to medical losses.
Payroll is relatively simple to compile, however one must adjust to remove the effects of higher wage rates for overtime.
Payroll is not easy to manipulate since it also used for tax purposes.
Payroll reflects changes in wage rates as well as the number of manhours worked.
Payroll has been used in most states, so that one can continue to use historical data.
Alternately, for Workers Compensation one could use manhours.
Manhours reflects the exposure to indemnity losses, but not as well as payrolls, since indemnity payments depend on the injured workers weekly wage. Manhours is reasonably accurate reflection of the exposure to medical losses.
Manhours is relatively simple to compile.
Manhours is not easy to manipulate, since wage records are used for tax purposes.
However, one could underreport manweeks for insurance purposes and still report the correct wages for tax purposes.
Manhours reflects the number of employees and how long they each work; however, manhours does not reflect changes in wage rates paid.
Manhours has not been used in most states, so that one would not be able to directly use historical data.
For Boatowners Insurance one could use “boatyears” Insuring one boat for one year would be one boatyear.
A boatyear does a good job of reflecting the overall exposure to loss, assuming one has a classification system to supplement it.
A boatyear is simple to compile.
A boatyear is hard to manipulate.
A boatyear is not responsive to inflationary changes, as would for example be the value of the boat.
Boatyears has been used, so that one can continue to use historical data.
Comment: In part b, discuss only one exposure base for each line of insurance. For Boatowners, one could also use amount of insurance years. *Boatowners Insurance provides coverage for your boat and boating equipment, including unattached accessories and trailer. This insurance also includes medical payment coverage and liability protection.*

**4.48. B.** All of the policies are written during 2004, and therefore there are 3 car years of written exposures for Calendar Year 2004.
For the first policy written May 1, 2004, 2/3 of its exposures are during Calendar Year 2004.
For the second policy written Nov. 1, 2004, 1/6 of its exposures are during Cal. Year 2004.
Calendar Year 2004 Earned Exposures are: (2)(2/3) + (1)(1/6) = 1.5 car years.
On December 31, 2004, these policies are providing coverage for three automobiles;
the Inforce Exposures are 3 cars.

**4.49.** a. "The exposure base is not the true exposure. The exposure base is a proxy for the true exposure, which we are unable to know, both because it is constantly changing and because it is generally a function of a large number of variables. For example, the collision exposure of a private passenger auto is effectively zero when it is parked in a secure garage, somewhat higher when it is being driven on an isolated highway by an alert and competent driver, and substantially higher on a crowded street with a drunk driver. The exposure base (car-month) recognizes the average situation rather than these fluctuations in the true exposure to loss."
"the exposure base is not a rating variable, although the dividing line between the two is somewhat arbitrary at times. In order to determine the correct manual premium for a risk, it is first necessary to classify the risk, based on whatever the rating variables are for the risk under consideration. Once the risk's classification is known, the rate for that classification is multiplied by the number of exposure units to produce the premium. As is noted above, the use of a variable in the exposure base implies a uniform and continuous multiplicative relationship between the variable and the expected losses; use as a rating element implies a discrete, nonlinear relationship."
For example, one would use type of business and state, to determine the rate per $100 of payroll for Workers' Compensation Insurance. However, one would then multiply by the number of exposures (payroll/$100) to get the manual premium.
b. Possible reasons for using miles driven:
The more miles driven, the larger the probability of an accident and therefore claims costs to the insurer. The exposure to loss is approximately proportional to the miles driven.
Miles driven is responsive to changes in the exposure to loss, while car years is not.
Possible reasons for not using miles driven:
Miles driven could be difficult and costly to verify.
Miles driven is subject to manipulation by either the insured or agent.
Car years are currently used, and one should avoid changing exposure bases, due to problems caused by transitioning.
Comment: The probability of an accident per mile driven, as well as the average severity of an accident if it occurs, varies with the time of day, the day of the week, the speed of the vehicle, the weather conditions, the road conditions, the type of road, the number and type of other drivers on the road, the mental and physical condition of the driver, the condition of the vehicle, etc. Thus even within a class/territory cell, the expected losses would not be proportional to the miles driven. If the exposure was changed from car years to miles driven, the class/territory relativities would change. For example, part of the reason senior citizens are charged less than average per car-year, is because on average they drive less. It is likely that the expected losses per mile driven, as opposed to per car-year, are higher than average for senior citizens.

**4.50.** a. Usually medical benefits are unlimited for work related injuries. For a given classification, it is not clear that the frequency or severity of accidents and the resulting medical benefits has very much to do with the average hourly wage. Rather the number of accidents would depend largely on the man-hours worked. An alternative exposure that better reflected the expected medical losses might be man-hours worked, which measures the exposure to work related accidents.
b. If a unionized construction company pays more per hour, using unlimited payroll this company will have a higher payroll, and therefore pay more for its workers compensation coverage. To some extent its average severity for indemnity benefits will be higher. However, most states have a maximum benefit per week, and therefore the average severity will not be proportional to the higher pay per hour compared to a nonunion contractor. Thus unlimited payroll is less than an ideal exposure base, at least for these classifications. An alternative exposure that better reflected the expected indemnity losses might be payroll limited to a certain maximum amount per week.
Comment: There may be other acceptable answers to this question.

**4.51.** a. Argument for: Hours worked are related to the number of accidents. A worker is more likely to be injured if he works longer hours.
Argument against: Hours worked may be difficult to verify. Also indemnity benefits depend on the worker's average weekly wage, which is not captured by hours worked. Also hours worked is not inflation sensitive.
b. Argument for: Limited payroll is related to indemnity benefits since indemnity benefits depend on the worker's average weekly wage, but are capped at the state benefit maximum.
Argument against: Limited payroll is not related to medical expenses since most states' workers compensation statutes provide for unlimited medical expenses. Also medical expenses are not directly related to weekly wages.
c. Argument for: Unlimited payroll is easy to verify through tax records.
Argument against: Unlimited payroll does not reflect the fact that the indemnity benefits are capped at the state maximum. Also medical expenses are not directly related to weekly wages.
Comment: In each case, give only one argument for and one argument against.
While in the past most states used limited payroll, all of those states have moved to unlimited payroll. I believe that Massachusetts was the last state to make this change in the early 1980s.
Workers Compensation in Washington state uses instead hours worked as the exposure base.
In part (b), we would for example limit the payroll to $1000 per week per employee.
Thus an employee who made $1500 in week, would only contribute $1000 of payroll to the exposures. In contrast, in part (c) such an employee would contribute $1500 of payroll.
Let us assume that the benefits for someone out of work in State X were 60% of his weekly wage subject to a maximum of $600 per week. Then full-time workers who made $1000, $1500, or $2000 per week would get the same maximum benefit. However, in part (c) these three workers would contribute different amounts of exposure.
Unlimited payroll versus limited payroll can have a big practical impact for classes where the weekly wages vary significantly between employers, such as in construction. Recall that manual premium is the class rate times the exposure. Thus an employer who paid more per week on average would have a higher manual premium than an otherwise similar employer who paid on average less per week.

**4.52.** a. 1. should accurately reflect the overall exposure to loss.
2. should be simple to compile.
3. should not be subject to manipulation.
4. The exposure base should accurately reflect differences in exposure to loss.
Alternately:
1. It should be an accurate measure of the exposure to loss.
2. It should be easy for the insurer to determine.
3. It should be difficult for the insured to manipulate.
Alternately:
1. Reasonableness - The exposure unit should be a reasonable measure of the exposure to loss. The selected measure should directly relate to loss potential to the extent possible.
2. Ease of Determination - If an exposure base is not subject to determination, then an insurer can never be assured of receiving the proper premium for the actual exposure.
3. Responsiveness to Change - An exposure unit that reflects changes in the exposure to loss is preferable to one which does not.
4. Historical Practice - Where a significant body of historical exposure data is available, any change in the exposure base could render the prior history unusable. Since ratemaking generally depends upon the review of past statistical indications, exposure bases are rarely changed once they have been established.
Alternately:
1. Verifiable – can the insurance company determine if the information provided is accurate?
2. Practical – Is the exposure base easy to estimate, or does it require costly inspections?
3. Varies with hazard – Does the exposure base increase and decrease as the actual exposure does?
b. One possible exposure base is the number of credit cards owned by the insured.
1. Verifiable through credit bureaus.
2. Practical since credit checks are fairly inexpensive.
3. Varies with hazard since more credit cards implies a larger expected loss from unauthorized use of those cards.
Comment: In part a, give three different characteristics.
There are other possible answers to part b.
Unauthorized credit card use is not the same as identity theft.
*Identity thieves use personal information to impersonate a victim, stealing from bank accounts, establishing phony insurance policies, opening unauthorized credit cards or obtaining unauthorized bank loans. Identity theft coverage provides the customer reimbursement for the expenses associated with the identity and credit restoration process including phone bills, lost wages, notary and certified mailing costs, and sometimes attorney fees (with the prior consent of the insurer.) Identity theft protection and resolution service is included in some companies' homeowner and auto policies at no additional cost. The service provides the consumer with a fraud specialist to assist and guide them through the process of restoring and protecting their identity. See http://www.iii.org/individuals/other/insurance/identitytheft/*

**4.53.** a. 1) varies with the hazard.
2) verifiable.
3) not subject to manipulation.
4) follow historical precedent.
b. 1) Miles driven varies with the hazard; the more miles driven the more likely you are to get in an accident.
2) Miles driven may not be easy to verify. Someone would have to inspect each car at the end of the year to read the odometer.
3) Miles driven is subject to manipulation. If the insured was asked how many miles driven in a year without verification, he could easily lie. Even if the miles were based on odometer readings, there are still ways to turn the numbers on an odometer back.
4) Miles driven does not follow historical precedent.
Overall, the change to miles driven should not be made due to the problems with verification and the possibility of manipulation.
Comment: There are many other possible answers.

**4.54.** (a) **Proportional to Expected Loss**
The exposure base chosen should be directly proportional to expected loss. In other words, all else being equal, the expected loss of a policy with two exposures should be twice the expected loss of a similar policy with one exposure.
**Practical**
The exposure base should be practical. In other words, the selected base should be objective and relatively easy and inexpensive to obtain and verify.
**Historical Precedence**
There are great advantages to continuing to use the same exposure base as used in the past, and significant problems with switching the exposure base.
(b) For homeowners insurance the expected loss is not proportional to the market value of the home, since there are many small property losses, theft losses, liability losses, etc.
The market value of a home is not practical. It is relatively expensive to assess the market value of a home. In some parts of the country, at some points in time, the market value of a home may involve a lot of judgement; it is not objective.
Market value of the home is not currently used, so this does not satisfy the criteria of historical precedence.
(c) First, any change in exposure base can lead to large premium swings for individual insureds.
Second, a change in exposure base will require a change in the rating algorithm, which depending on the unique circumstances, may require a significant effort to adjust the rating systems, manuals, etc.
Third, ratemaking analysis is normally based on several years of data. A change in exposure base may necessitate significant data adjustments for future analyses.
Comment: Only give two criteria in part (a) and give only two reasons in part (c).
There may be other full credit answers to part (b).

**4.55.**

| Policy | CY08 Written | CY08 Earned | PY07 Written | 4/1/08 In-Force |
|---|---|---|---|---|
| 1 | 0 | 1/2 | 1 | 1 |
| 2 | -1/2 | 1/4 | 1/2 | 0 |
| 3 | 1 | 1 | 0 | 1 |
| 4 | 1/3 | 1/3 | 0 | 1 |
| 5 | 1 | 1/2 | 0 | 0 |

(a) For policy #2, there would have been 1 written exposure assigned to CY07
(which is closed at the end of 2007 for accounting purposes.)
Therefore, when this policy is cancelled midterm during 2008, we need to put -1/2 written exposure in CY08, so that in total for policy #2 we have exposures of: 1 - 1/2 = 1/2.
In the case of policy #4, we know it has been cancelled by the end of 2008, so we only have 1/3 exposure contributed to CY08 written exposures.

CY08 written exposures: -1/2 + 1 + 1/3 + 1 = $1\frac{5}{6}$ car years.

(b) In each case, we take the portion of the year that the policy is in effect.

CY08 earned exposures: 1/2 + 1/4 + 1 + 1/3 + 1/2 = $2\frac{7}{12}$ car years.

(c) We only look at policies written during 2007.
PY07 written exposures: 1 + 1/2 = **1.5** car years.
(d) We see whether or not the policy is in effect on 4/1/08.
In-force exposure as of April 1, 2008: 1 + 1 + 1 = **3** cars.
Comment: Since it is not stated otherwise, assume one car per policy.
Since as of June 30, 2009 all of the policies written in 2007 have expired, in fact all five policies have expired, the PY07 written and earned exposures are equal. As of an earlier date, such as April 1, 2008, they would differ.
For PY07 evaluated as of June 30, 2009, we know that policy #2 has been canceled midterm, and thus we have only 1/2 exposure.
As of Dec. 31, 2007, we would have instead 1 exposure contributed to PY07 from policy #2.

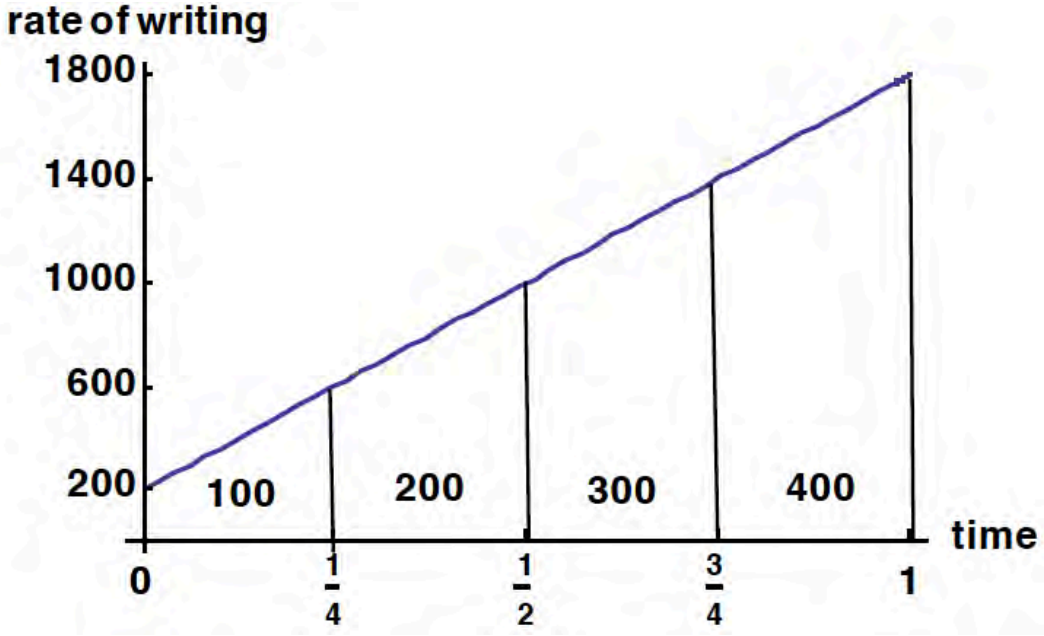
**4.56.** 1. Proportional to expected losses: the more miles one drives the larger the expected losses. For a given class of driver in a given territory it is approximately proportional, so this criterion is satisfied.
2. Practical. Objective and relatively easy and inexpensive to obtain and verify:
One could fit the car with a broadcasting GPS device that would allow the insurer record the miles driven. This would be relatively easy and inexpensive. It is verifiable since the insurer would be getting real time data rather than depending on odometer readings or asking the insured.
Thus his criterion is satisfied.
3. Historical precedence; is currently being used: since we would be switching from earned car years, this criterion is not satisfied.
Comment: Different conclusions would be OK with respect to the first two criteria; the main thing is to make sure you demonstrate that you know their meaning and say something sensible.

**4.57.** a. Only policies E and F were written in 2010; however, policy D was cancelled in 2010.
Policies E and F contribute 1/2 car year each to CY10 written.
Policy D contributes 1/2 car year to CY09 written.
Since Policy D is cancelled after the close of CY09, we need to include a negative in CY10.
Policy D is in effect for only 3 months, so it contributes -1/4 car years to CY10
-1/4 + 1/2 + 1/2 = **0.75 car years**.
b. Only policies E and F were written in 2010.
Policies E and F contribute 1/2 car year each to PY10 written.
1/2 + 1/2 = **1 car year**.
c.
Policy A: 0.
Policy B: 0.
Policy C: 1/12.
Policy D: 1/12.
Policy E: 1/2
Policy F: 1/2
1/12 + 1/12 + 1/2 + 1/2 = **1.167 car years**.
d. Only policies E and F were written in 2010.
As of 12/31/10 or later they each contribute 1/2 car year to PY10 earned.
1/2 + 1/2 = **1 car year**
e. As of 1/1/10, Policies C, D, E are in-force. **3 in-force policies**.

**4.58.** The three criteria of a good exposure base:
1. Proportional to Expected Loss
2. Practical
3. Historical Precedence
An increase in either base would increase expected losses. However, payroll takes into account both how many workers are employed (in each class) but also how many hours they work. In for example construction, the number of hours worked per week can vary considerably from year to year; this can be affected by economic conditions. In addition some employees are part time rather than full time. Also payroll is proportional to the Average Weekly Wage, which affects the severity of claims, while number of employees does not. Thus I think that payroll is better based on the first criterion.
Payroll is collected for other purposes, such as taxes.
Payroll is well-defined and verifiable.
Thus payroll is practical
Number of employees varies from week to week, in some industries considerably.
Should some sort of average number of employees be used?
Also one should distinguish between full time and part time workers.
The number of employees is harder to verify than payroll.
The number of employees is easier for the employer to manipulate than payroll.
Number of employees may require additional expense to collect.
Thus, number of employees is less practical than payroll.
Payroll has been used for many years and thus is preferred based on historical precedent.
There would be significant difficulties transitioning from payroll to number of employees.
Possible difficulties include: large premium swings for individual insureds, reprogramming of the computers and other system changes, changes required in the rating algorithm, and for several years a lack of ratemaking data on the new exposure basis.
Based on all of the above, I would not recommended switching to number of employees.
Comment: Washington state uses hours worked (by class) as the exposure base.

**4.59.** a. Assuming uniform by quarter, the first set of policies is written on average February 15. Therefore, 7/8 of these exposures are earned in 2011.
(7/8)(100) + (5/8)(200) + (3/8)(300) + (1/8)(400) = **375** earned exposures.
b. The written exposures are increasing with time, which makes sense for a new insurer.
Thus it seems likely that for example there are more exposure written in September than in July.
However, the assumption in part (a) was that these are the same. Thus while the assumption is a good first approximation, it will lead to an overestimate of the earned exposures for 2011.
It would be more appropriate to assume written exposures increase linearly.
Comment: If one ignored the growth of exposures through the year, then half of the exposures would be assumed to be earned during 2011 or 500 exposures.
The assumption of uniform by quarter is much better than ignoring the growth all together.
If one assumed that exposures increased linearly, then for each quarter the average date of writing is further through the quarter than halfway.
For this data, a reasonable assumption would be that the annual rate at which exposures are written throughout the year increases linearly: $200 + 1600t$, $0 \le t \le 1$.
Then the exposures written during the first quarter are:

$$\int_0^{0.25} (200 + 1600t)\, dt = (200)(0.25) + (1600/2)(0.25^2) = 100.$$




Similarly, the exposures written during the last quarter are:

$$\int_{0.75}^{1} (200 + 1600t)\, dt = (200)(1 - 0.75) + (1600/2)(1^2 - 0.75^2) = 400.$$

Then the earned exposures for 2011 are:

$$\int_0^1 (1 - t)(200 + 1600t)\, dt = 200 \int_0^1 1 + 7t - 8t^2\, dt = (200)(1 + 7/2 - 8/3) = 366.67.$$

**4.60.** (a) Half of the exposures for A are earned in CY2011: (50)(2)/2 = 50.
Alternately, one year of A is earned in CY2011: (50)(1) = 50.
Half of the exposures for B are earned in CY2011: (100)(2)/2 = 100.
Alternately, one year of B is earned in CY2011: (100)(1) = 100.
CY2011 Earned Exposures are: 50 + 100 = **150**.
(b) Evaluated as of 12/31/2010:
Only half of A has been earned: (50)(2)/2 = 50.
Only one quarter of B has been earned: (100)(2)/4 = 50.
Total earned exposures: 50 + 50 = **100**.
Evaluated as of 12/31/2011:
All of A has been earned: (50)(2) = 100.
Only three quarters of B has been earned: (100)(2)(3/4) = 150.
Total earned exposures: 100 + 150 = **250**.
(c) Evaluated as of 12/31/2010:
B PY2010 written exposures: (100)( 2) = **200**.
Evaluated as of 12/31/2011:
B has been canceled and policies were in effect for only 1/2 year rather than 2 years.
B PY2010 written exposures: (100)(1/2) = **50**.
Alternately, B has been canceled and we need to subtract 3/4 of the exposures from the written.
B written exposures: (100)(2) - (100)(2)(3/4) = **50**.
(d) CY2010 B written exposures: (100)(2) = **200**.
Due to the cancelation, the written exposures decrease by 100.
However, since the cancelation took place after the end of 2010, the change goes into CY2011.
CY2011 B written exposures: (-100)(2)/2 = **-100**.
Comment: The calendar year exposures are not changed after the end of the year.
In part (d), the total written exposures for the two calendar years total to the correct 100.

**4.61.** The three criteria of a good exposure base:
1. Proportional to Expected Loss
2. Practical
3. Historical Precedence
An increase in hours worked would increase the frequency of losses; but the payroll would also increase proportionally if more hours are worked. Payroll is also proportional to the Average Weekly Wage, which affects the severity of indemnity benefits, while hours worked is not. Since indemnity benefits are the majority of dollars paid, I think that payroll is better based on the first criterion.
On the other hand, the severity of medical benefits do not obviously vary with payroll, so there is some merit to hours worked.
Payroll is collected for other purposes, such as taxes.
Payroll is well-defined and verifiable.
Thus payroll is practical.
Number of hours worked is harder to verify than payroll.
Number of hours worked is easier for the employer to manipulate than payroll.
Number of hours worked may require additional expense to collect.
Thus, number of hours worked is less practical than payroll.
Payroll has been used for many years and thus is preferred based on historical precedent.
There would be significant difficulties transitioning from payroll to hours worked.
Possible difficulties include: large premium swings for individual insureds, reprogramming of the computers and other system changes, changes required in the rating algorithm, and for several years a lack of ratemaking data on the new exposure basis.
Based on all of the above, I would not recommended switching to hours worked.
Comment: Washington state uses hours worked (by class) as the exposure base.

**4.62.** (a) Since $D > 0$, the policy was in force on February 1, 2013; thus the policy could not have been written after February 1, 2013, and also must have been canceled after February 1, 2013.
$A < 0$, therefore, the policy was written in 2012 and cancelled in 2013.
Since $D > 0$ and it was an annual policy, it must have been written after February 1, 2012.
If for example, it were written on March 1, 2012, then as February 1, 2013, B would be 11 months and C would be 1 month. However, we want $B < C$, so this is no good.
If instead it were written on August 2, 2012, then as February 1, 2013, B would be just less than 6 months and C would be just more than 6 months; $B < C$.
Put another way, in order for $C > B$ since these are annual policies, we must have more than 6 months left of the policy term on February 1, 2013.
So the range of effective dates is August 2, 2012 to December 31, 2012.
(b) $A < 0$, therefore, the policy was written in 2012 and cancelled in 2013.
If it had been cancelled 2/1/2013, then $D = 0$, but we want $D > 0$.
If it had been cancelled 12/31/2013, then since it was written in 2012, the policy could not have been cancelled midterm.
Thus it must have been cancelled after February 1, 2013 and before December 31, 2013.
(c) $A < 0$, therefore, the policy was written in 2012 and cancelled in 2013.
$D > 0$ implies the policy is in-force on 7/1/2013.
(Assume for simplicity one car is insured.)
Thus since the annual policy was written in 2012, as of July 1, 2013, $B \geq 1/2$ and $C \leq 1/2$.
Thus it cannot be that $B < C$.

**4.63.** (a) 1. Proportional to Expected Loss
2. Practical: objective, easy to obtain, and inexpensive to verify.
3. Historical Precedence
(b) The number of hours worked should be closer to proportional to expected losses than would the number of employees; the more hours someone works the more chance for a work place accident and thus a workers compensation claim.
The number of hours should be recorded for other purposes and thus should be practical (with the possible exception of workers not paid by the number of hours worked. However, such workers usually have much smaller expected losses than those who are paid based on the number of hours worked.)
On the other hand, number of hours worked would be more subject to manipulation by the employer than would number of employees.
The number of hours worked has not been used prior, so this does not satisfy the criteria of historical precedence. There would be difficulties in transitioning to a new exposure base with: difficulty estimating class rates, expensive changes to systems, and the likelihood of large premium swings for individual insureds.
(c) Frequency is number of claims per exposure. The number of hours worked is greater than the number of employees, and thus the frequency per exposure would decrease.
(d) Severity is dollars of loss per claim, and should be unaffected by a change in exposure base.
(e) The exposure base change should not directly affect the companies loss ratio, provided the insurer manages to create new rates by class based on the new exposure base which produce the same total premium as would the old rates based on the old exposure base.
(This is not an easy task.)
However, this insurer would now attract employers whose workers have fewer hours worked per week than average for a class, and would lose employers whose workers have more hours worked per week than average for a class. The former are expected to have fewer work place accidents on average and thus lower workers compensation costs. This favorable selection would lead to an improvement in the insurer's loss ratio, all else being equal.
Alternately, the exposure base change could lead to wide premium swings. Thus many good customers will go to other insurers, while bad risks who cannot get coverage elsewhere remain. Therefore this insurer's loss ratio is likely to get worse.
Comment: Switching to a new exposure base that is closer to proportional to expected losses has a similar affect to introducing a new useful classification variable. The insurer can attract better insureds which are currently being written by competitors who stay with the old scheme.

**4.64.** i. While annual fuel expense would vary somewhat with the potential for loss, it would also be affected by the price of gasoline (or diesel fuel) and the fuel efficiency of vehicles neither of which varies with the expected losses. Thus this exposure is not proportional to loss costs.
For example, let us assume you make rates with cost of fuel as the exposure base, based on an average price of gas of $3 a gallon. However, during the period of time the rates are in effect the average price of gas is $2.50, then the projected premiums will be inadequate when the rates are applied to the annual fuel expense. If instead the price of average price of gas during the period of time the rates are in effect is $3.50, then the premiums will be excessive.
Annual fuel expense is practical, since the insured business already keeps track of this for other purposes. (Alternately, they may not keep careful track for each vehicle separately, which would be important if there are vehicles of different types in the insured fleet.)
Annual fuel expense lacks historical precedence. Changing to a new exposure base would cause large premium swings, it would be costly to implement, and would cause extra work for information technology and actuarial staff.
I would not change to annual fuel expense as the exposure base since it is less proportional to losses than caryears.
ii. As the number of miles driven increases, the expected number of accidents increases, and thus the expected losses increase. While it would matter whether these are miles driven on a highway or city streets, this exposure base is more closely proportional to expected losses than is caryears. Miles driven may be practical, depending on the technology used to determine the miles driven. (Odometer readings can be manipulated. On the other hand, a fleet of interstate trucks may already for other purposes keep careful track of the miles driven by each vehicle.)
Number of miles driven lacks historical precedence. Changing to a new exposure base would cause large premium swings, it would be costly to implement, and would cause extra work for IT (Information Technology) and actuarial staff.
Assuming that the appropriate affordable technology (for example telematics) is available to verify the miles driven by each vehicle, I would change to number of miles driven as the exposure base, since it is more proportional to expected losses than caryears.
Comment: One could instead decide not to change the exposure base to either of the two choices.

**4.65.** (a) 6-month policies written during January 1 through June 30, 2013 contribute none of their written exposures to CY14 earned exposures.
6-month policies written during July 1 through December 31, 2013 contribute on average half of their written exposures to CY14 earned exposures.
12-month policies written during January 1 through June 30, 2014 contribute on average (1 + 1/2)/2 = 3/4 of their written exposures to CY14 earned exposures.
12-month policies written during July 1 through December 31, 2014 contribute on average (1/2 + 0)/2 = 1/4 of their written exposures to CY14 earned exposures.
(0)(106) + (1/2)(107.5) + (3/4)(210) + (1/4)(45) = **222.5**.

| Time Period | Written caryears | Avg. Written Date | % earned in 2014 | Earned caryears in 2014 |
|---|---|---|---|---|
| 1/1/13-6/30/13 | 106 | 4/1/13 | 0% | (0%)(106) = 0 |
| 7/1/13-12/31/13 | 107.5 | 10/1/13 | 50% | (50%)(107.5) = 53.75 |
| 1/1/14-6/30/14 | 210 | 4/1/14 | 75% | (75%)(210) = 157.5 |
| 7/1/14-12/31/14 | 45 | 10/1/14 | 25% | (25%)(45) = 11.25 |
| Total | | | | **222.5** |

(b) Of the 6-month policies written during the second half of 2013, if 77% renew, then since they would be annual policies, they would produce (2)(77%)(107.5) = 165.55 caryears. We wrote 45 exposures during the second half of 2014, which are new policies.
If we had a similar 45 new exposures in the first half of 2014, then we would expect 166.55 + 45 = 210.55 caryears written during the first half of 2014. Since there were 210 caryears written during the first half of 2014, the retention ratio seems about the same as it was prior to the change in policy term.
We can estimate the retention ratio as: (210 - 45)/ {(2)(107.5)} = 76.7%, very close to 77%.
(c) Clearly an assumption of uniform writings each year would be inappropriate for the calculation of calendar year 2014 earned car years, since we observe that there are many more exposures written in the first half of 2014 than in the second half. In the absence of any additional information, an assumption of uniform writings each half year seems appropriate for the calculation of calendar year 2014 earned car years, as was done in part (a).
Alternately, the policies up for renewal from prior to PY2014 are 6 month which means they will be up for renewal in the first half of 2014. Since all policies are shifted from six months to annual, they will be up for renewal in the first half of 2015; the next wave of written car years will not occur until the first half of CY 2015 on these annual renewals. Thus the assumption of uniform writing during 2014 is inappropriate.
Comment: We have to assume no cancellations or endorsements; otherwise an endorsement can add cars to a policy, which may be some of the written exposures during the second half of CY14.
Given enough time the number of exposures written would eventually even out between the two halves of a year, although it might take decades.
Retention Ratio = $\frac{\text{Number of Policies Renewed}}{\text{Number of Potential Renewal Policies}}$. Here there is no way to determine the number of policies invited to renew or that are able to be renewed.

**4.66.** (a) I propose **sales** as the exposure base.
**Sales is proportional to expected losses**. More sales corresponds to more customers, which corresponds to more expected losses. There is a uniform and continuous multiplicative relationship between sales and the expected losses. Sales is responsive to a change in the amount of business done by the restaurant and thus a change in exposure to risk. Sales also has the advantage of being inflation sensitive. During periods of high inflation, average severity will increase but so will sales.
**Sales are practical**. Sales are objective and well defined, relatively easy and inexpensive to obtain, and relatively easy and inexpensive to verify. Thus sales can be consistently measured, and are not subject to manipulation by insureds, agents, or underwriters.
(b) I propose a **combination of average number of occupied beds and annual number of outpatient visits**.
Average number of occupied beds is proportional to expected losses from liability related to inpatient events, while annual number of outpatient visits is proportional to expected losses from liability related to outpatient events.
These are practical. They are objective and well defined, relatively easy and inexpensive to obtain, and relatively easy and inexpensive to verify. They are each items hospitals have to keep track of anyway. They can be consistently measured, and are not subject to manipulation by insureds, agents, or underwriters.
Comment: In part (b) one could instead propose gross revenue from patients; this would have the advantage of being inflation sensitive. Other possibilities: number of patients, number of medical professionals (doctors and nurses) on staff, payroll for medical professionals, number of physician-years (the number of physicians adjusted for those who are only on staff for part of a year in analogy to houseyears for homeowners), occupied beds.
In part (a) one could instead propose payroll.
In my solution I have not discussed the third desirable feature, Historical Precedence, since the exposure bases for these lines of insurance are not covered on the syllabus of this exam. You could do so if you are familiar with what is currently being used as an exposure base.
I believe sales is used for a general liability policy for a restaurant.
I believe a combination of average number of occupied beds and number of outpatient visits are used (by at least some insurers) for a hospital professional liability policy.

**4.67.** I will assume that each policy only covers one car.
(a) Only the six-month policies written in 2014 contribute: 105/2 + 100/2 = **102.5 car-years**.
(b) Only the six-month policies written October 1, 2014 are in force on December 31, 2014.
Since the question asks for in-force car-years one could answer: 100/2 = **50 car-years**.
(c) The six-month policies written October 1, 2014 contribute half their exposures.
The six-month policies written April 1, 2015 contribute all of their exposures.
The six-month policies written October 1, 2015 contribute half their exposures.
100/4 + 110/2 + 105/4 = **106.25** car-years.
Comment: In part (b), I think a better answer to a better written question would be 100 cars, since as of December 31, 2014 the insurer is covering 100 cars.

**4.68.** I will assume that each policy insures one exposure per year.
a. Then the written exposures for CY15 are: (2)(1000) + (1)(1000) = **3000**.
Each of the policies written 4/1/15 contributes 3/4 of an earned exposure to CY15.
Each of the policies written 7/1/15 contributes 1/2 of an earned exposure to CY15.
The earned exposures for CY15 are: (3/4)(1000) + (1/2)(1000) = **1250**.
b. Each of the policies written 4/1/15 contributes 1 earned exposure to CY16.
(Each of these policies expires at the end of June 2017.)
Each of the policies written 7/1/15 contributes 1/2 of an earned exposure to CY16.
The earned exposures for CY16 are: (1)(1000) + (1/2)(1000) = **1500**.
Comment: The question should have said for example, that each policy covers one home.

**4.69.** (a) CY17 written exposures: (4)(1/2) + (2)(1/2) = **3**.
(b) CY17 earned exposures: (4)(1/2) + (2)(1/4) = **2.5**.
(c) As of September 30, 2017 we do not know of the change,
so the PY17 written exposures are **4**.
(d) 1. Proportional to Expected Loss:
The expected losses varies only slightly with the number of occupants.
For most perils, the number of occupants does not affect the expected losses.
4 occupants probably increase the expected losses very slightly compared to 2 occupants due to increased number of guests and thus an increased chance of liability claims. However, the expected homeowners losses are nowhere close to twice as much for twice the number of occupants.
Thus number of occupants violates this criterion.
2. Practical:
It would be difficult and costly to keep track of and verify the number of occupants.
It would be subject to manipulation by the insured.
It would be ambiguous; what if a relative comes to stay for a visit, how long does the visit have to be before they count as an occupant.
Thus number of occupants violates this criterion.
3. Historical Precedence:
Number of occupants is not currently used for homeowners insurance; house years (or amount of insurance years) is currently used. There would be a lack of industry benchmarks. There would also be serious difficulties in ratemaking for several years while moving to this new exposure base; all of the historical data would be on the old basis. Thus number of occupants violates this criterion.
Comment: While the original policy has 4 exposures, since the change takes place during 2017 it affects the CY17 exposures, similarly to endorsing an auto policy to add or remove a vehicle. Assuming there are no further changes, at ultimate PY17 written exposures will be 3.
Number of occupants could be used as either a rating variable or underwriting variable.

**4.70.** 1. Proportional to Expected Loss:
For physical damage, the more expensive the boat the more monetary damage to the boat. While expected loss from physical damage coverage may not go up exactly proportional to the insured value of the boat, it is approximately the case, and thus this criteria is satisfied.
(Based on homeowners insurance and the existence of partial losses, I would expect that expected losses to go up somewhat less than linearly with insured value.)
The higher the insured value of the boat, the larger the boat is likely to be. Larger boats are able to do more damage to other boats and more likely to seriously injure passengers of those other boats. Thus expected liability losses should increase with insured value, however, it might not be close to proportional.
Insured value sort of satisfies this criterion; more so for physical damage than liability.
While two boats have twice the expected loss of one boat, all else being equal, the expected loss is very different for boats of very different value. Thus, boat-years does <u>not</u> satisfy this criterion.
2. Practical:
For physical damage coverages, the insurer already collects and uses the insured value of the boat.
Thus using insured value would be neither difficult nor costly.
It would not be particularly subject to manipulation by the insured.
Insured value satisfies this criterion.
3. Historical Precedence:
Since it is not currently used as the exposure base, insured value violates this criterion.
There would be a lack of industry benchmarks. There would also be some difficulties in ratemaking for several years while moving to this new exposure base; this would be made easier since insured value is already collected for boats that buy physical damage coverage.

I would recommend staying with boat-years as the exposure base. This will avoid the disruption of changing the exposure base, for very little if any benefit. Insured value should continue to be used to rate physical damage coverages. If insured value is not being used to help rate liability coverages, nor something related like size of boat, then it would be worthwhile to start using insured value to help rate liability coverages.
<u>Comment</u>: There are many possible full credit answers.

**4.71.** All policies are 6-month and written in 2018.
(a) CY 2018 written exposures: 2/2 + 3/2 + 1/2 + 2/2 + 1/2 = **4.5 caryears**.
(b) Policy D is 1/2 earned in 2018. Policy E is 1/3 earned in 2018.
CY 2018 earned exposures: 2/2 + 3/2 + 1/2 + (2/2)(1/2) + (1/2)(1/3) = **3.67 caryears**.
(c) As of February 28, 2019, only 5/6 of Policy D is earned and only 4/6 of E is earned.
PY 2018 earned exposures as of February 28, 2019:
2/2 + 3/2 + 1/2 + (2/2)(5/6) + (1/2)(4/6) = **4.167 caryears**.
(d) As of October 15, 2018, policies C and D are in force.
(Policy E has yet to become effective.)
Thus the in-force exposures as of October 15, 2018 are: 1 + 2 = **3 cars**.
Alternately, since the policies are semi-annual: (1+2)/2 = **1.5 caryears**.
(e) 1. Proportional to expected losses: Exposure base implies a uniform and continuous multiplicative relationship between the variable and the expected losses. The exposure base should be responsive to any change in exposure to risk.
As the number of miles driven increases, the expected number of accidents increases, and thus the expected losses increase. While it would matter whether these are miles driven on a highway or city streets, on balance this criterion is satisfied.
Miles driven does not satisfy this criteria for Other Than Collision Coverage (Comprehensive).
2. Practical. Objective and relatively easy and inexpensive to obtain and verify:
This will allow the exposure base to be consistently measured and not subject to manipulation by insureds, agents, or underwriters.
One could fit the car with a telemetric device that would allow the insurer to record the miles driven. This would be relatively easy and inexpensive. It is verifiable and not subject to manipulation.
Thus this criterion is satisfied.
3. Historical precedence: is this exposure base currently being used by this insurer.
If miles driven is currently being used then this criteria is satisfied.
Since it satisfies all three criteria, I conclude that miles driven is a good exposure base to use.
Comment: There are other reasonable answers to part (e).
If caryears are currently being used, then switching to miles driven would incur some expense. For several years one would not have historical exposure data useful for ratemaking. Also switching exposure bases could produce large swings in premiums for individual insureds.
The CAS accepted either of the two answers to part (d).
In part (d), I would have followed Table 4.15 in Basic Ratemaking and answered 3 cars, which makes sense to me.
However, according to Basic Ratemaking:
“Most companies define insured units to be the count of items exposed to loss at a given point in time. For example, if an automobile policy insures three cars, that one policy could contribute three in-force exposures at a given point in time. Alternatively, some companies may define insured unit in terms of the number of policies (the auto example above would have one in-force exposure under this definition) or the written exposures (in the auto example, there could be three in-force exposures if the term is annual, or 1.5 in-force exposures if the term is semiannual).”

**4.72.** (a) We can cumulate the earned exposures through March 31, 2018:
5 + 247.5 + 427.5 + 52.5 + 53.75 = 786.25.
However, this includes a contribution from policies written in the first quarter of 2018.
Based on the contribution of policies written in the first quarter of 2017 to the earned exposures in the first quarter of 2017, I estimate the similar contribution of 2018 Q1 as: (125)(5/100) = 6.25.
Thus, the 2017 policy year earned exposures as of March 31, 2018 are: 786.25 - 6.25 = **780**.
(b) This includes 2017 Q3, 2017 Q4, 2018 Q1, 2018 Q2:
400 + 100 + 125 + 550 = **1175**.
(c) Assume that they meant to ask for the unearned exposures as of the end of 2018.
Given that the insurer started writing business on January 1, 2017, we can add up all of the written exposures by quarter and subtract the sum of all of the earned exposures by quarter, through the end of 2018:
2230 - 1936.5 = **293.5**.
(d) We need to figure out how the written exposures in a quarter are earned over time.
Each annual policy (written at the beginning of a quarter) is earned over the four quarters it is in effect.
It turns out the given table is based on the following.
For each policy, regardless of in which quarter it is written, it earns 5% in Q1 of a year, 45% in Q2 of a year, 45% in Q3 of a year, and the remaining 5% of its written exposures in Q4 of a year.
There would be contributions to Q1 of 2019 earned exposures from the written exposures in each of the last three quarters of 2018, since annual policies written in these three quarters are still in effect during the first quarter of 2019. (There is no new business written in 2019.)
These policies each contribute 5% of their written exposures to Q1 of 2019 earned exposures:
(5%)(550 + 475 + 30) = **52.75**.
Comment: A question that covers a situation not discussed in any detail in the syllabus reading.
In my opinion, it was totally unfair to expect students to infer what the underlying earnings pattern was under exam conditions; personally I would not have been able to.
For example, 2018 Q1: (450 + 400 + 100 + 125)(5%) = 53.75.
For example, 2018 Q2: (400 + 100 + 125 + 550)(45%) = 528.75.
This earnings pattern is based on some kind of seasonality; for this line of insurance most of the incidents that result in claims must happen in the second and third quarters of a year.
Based on this underlying earning pattern, for the exposures written in the 3rd quarter of 2017, 45% is earned in the 3rd quarter of 2017, 5% is earned in the 4th quarter of 2017, and 5% is earned in the 1st quarter of 2018. Thus 55% is earned by March 31, 2018.
Similarly, for the exposures written in the 4th quarter of 2017, 5% is earned in the 4th quarter of 2017, and 5% is earned in the 1st quarter of 2018. Thus 10% is earned by March 31, 2018.
Thus an alternate way to solve part (a) is: 100 + 450 + (400)(0.55) + (100)(0.1) = 780.
Unearned exposures is not a useful concept for a calendar year as opposed to a policy year.
Nevertheless, I would have answered part (c) for CY18:
unearned exposures = written exposures - earned exposures =
(125 + 550 + 475 + 30) - (53.75 + 528.75 = 562.50 + 59) = 1180 - 1204 = -24.
This was not the solution given in the CAS Examiner's Report.

**4.73. D.** There are two missing values for number of products, so I will not use this.
We want an exposure base that is (approximately) proportional to losses.

| Sales (millions) | Losses / Sales | Number of Employees | Losses / Employees | Payroll | Losses / Payroll | Losses |
|---|---|---|---|---|---|---|
| 3754 | 340 | 16,462 | 77 | 1,234,685,000 | 0.001033 | 1,275,000 |
| 5631 | 453 | 31,734 | 80 | 2,469,370,000 | 0.001033 | 2,550,000 |
| 1242 | 604 | 9,146 | 82 | 726,285,294 | 0.001033 | 750,000 |
| 4379 | 805 | 43,519 | 81 | 3,413,540,882 | 0.001033 | 3,525,000 |
| 838 | 1,073 | 11,842 | 76 | 871,542,353 | 0.001033 | 900,000 |
| 947 | 1,431 | 14,321 | 95 | 1,312,155,431 | 0.001033 | 1,355,000 |
| 983 | 1,908 | 24,038 | 78 | 1,815,713,235 | 0.001033 | 1,875,000 |
| 914 | 2,544 | 33,604 | 69 | 2,251,484,412 | 0.001033 | 2,325,000 |
| 1371 | 3,392 | 56,024 | 83 | 4,502,968,824 | 0.001033 | 4,650,000 |
| 216 | 4,523 | 12,500 | 78 | 944,170,882 | 0.001033 | 975,000 |

This is the case for **payroll**, and not the case for the other two.
Comment: In practical applications one would not get such a constant ratio.
While payroll is better than employees, the ratio of losses to employees might be good enough to use in a practical application if payroll was not available.
Payroll also has the advantage of being inflation sensitive while number of employees is not.
Losses are also proportional to the number of products.

Volume Three

# Mahler's Guide to
# Basic Reserving

## CAS Exam 5

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Study Aid 2027-**5-2**

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# Mahler's Guide to Basic Reserving

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This study guide covers the reserving topics on CAS Exam 5:

Estimating Unpaid Claims Using Basic Techniques, by Jacqueline F. Friedland,
and Actuarial Standard of Practice No. 43: Property/Casualty Unpaid Claim Estimates, American Academy of Actuaries, 2007 and Updated for Deviation Language Effective May 2011.[1]

Information in bold or sections whose title is in bold are more important for passing the exam.
Larger bold type indicates it is extremely important.

Sections and material in italics is less likely to be needed to directly answer exam questions, and should be skipped on your first time through.

Highly Recommended problems are double underlined.
Recommended problems are underlined.
Additional problems are starred.
Solutions to the problems in each section are at the end of that section.[2]

A good introduction to this subject is "Loss Reserving", by Ronald F. Wiser, revised and updated by Jo Ellen Cockley and Andrea Gardner, Chapter 5 of Foundations of Actuarial Science, not on the syllabus.

If you know the computer language R, you might want to check out the package ChainLadder.
It does the computations for a number of different reserving techniques.

[1] ASOP43 is in Appendix B of the textbook by Friedland. However, there was a minor update to ASOP43 in 2011.
[2] Note that problems include both some written by me and some from past exams. The latter are copyright by the CAS or SOA. They are reproduced here solely to aid students in studying for exams. The solutions and comments are solely the responsibility of the author; the CAS or SOA bear no responsibility for their accuracy. While some of the comments may seem critical of certain questions, this is intended solely to aid you in studying and in no way is intended as a criticism of the many volunteers who work extremely long and hard to produce quality exams.

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| Four | 16 | 1473-1561 | Estimating Unpaid Allocated Claim Adjustment Expenses |
| Four | 17 | 1562-1710 | Estimating Unpaid Unallocated Claim Adjustment Expenses |
| Four | 18 | 1711-1724 | *ASOP #43, Unpaid Claim Estimates* |

The seventeen chapters of Estimating Unpaid Claims Using Basic Techniques by Friedland are covered in my first seventeen sections.

## Past Exam Questions by Section of this Study Guide

Many exam questions involve material from more than one chapter of Friedland.
Generally I have put such past exam questions in the highest numbered relevant section;
in some cases there are other reasonable choices of which section in which to place a question.

| Section | Exam 6, 2000 | Exam 6, 2001 | Exam 6, 2002 | Exam 6, 2003 | Exam 6, 2004 |
|---|---|---|---|---|---|
| | | | | | |
| 1 | | | | | |
| 2 | | | | | |
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| 6 | | | | | |
| 7 | 41a | 35 | | 22a | |
| 8 | | | 25a | | |
| 9 | 40, 59a | 1, 54 | 22 | 23 | 25, 31 |
| 10 | 68 | | 42a | 44 | 49 |
| | | | | | |
| 11 | 57 | 33 | 24 | | 20 |
| 12 | 72 | 32 | | 21 | 8 |
| 13 | 60 | 8 | 26 | | 22, 23 |
| 14 | | | | | |
| 15 | | | | 2 | 2 |
| | | | | | |
| 16 | 39, 43a | | | 20 | |
| 17 | 32, 44 | *7, 31* | 3, 9, *12* | 1, 11 | 5, 30, 36 |
| 18 | | | | | |

Prior to 2011, Basic Reserving was on Exam 6 rather than Exam 5.
Prior to 2000, Reserving was on Exam 7.

| Section | Exam 6, 2005 | Exam 6, 2006 | Exam 6, 2007 | Exam 6, 2008 | Exam 6, 2009 |
|---|---|---|---|---|---|
| | | | | | |
| 1 | | | | | |
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| 6 | | 2 | 40 | | |
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| 8 | | | | | 9 |
| 9 | 10, 16 | 1, 15a&b, 16a | 42a, 46 | 2, 10b&c, 11 | |
| 10 | 38 | 12, 45 | 21, 22 | 36 | 10, 31 |
| | | | | | |
| 11 | 14 | 14 | 35 | 3 | 4 |
| 12 | *22* | | | | |
| 13 | 8, 9 | 19, 21 | 33, 38 | 4, 5, 6 | 11, 15 |
| 14 | *36a* | | | | 1 |
| 15 | | | 43 | 27 | 16 |
| | | | | | |
| 16 | | 17 | 47 | | 13 |
| 17 | 2 | 3, 18 | | 16a&b | 14 |
| 18 | | | | | |

In 2009, Estimating Unpaid Claims Using Basic Techniques by Jacqueline Friedland replaced many separate readings formerly on the syllabus.

| Section | Exam 6, 2010 | 2011 | 2012 | Spring 2013 | Fall 2013 | Spring 2014 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | | | | | | |
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| 3 | 13 | 21 | 16 | | | 12 |
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| 5 | 10 | 22 | | | 14 | |
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| 6 | 15 | 23 | 23 | 20 | 15 | |
| 7 | | 24, 36 | 17 | 16 | | |
| 8 | | 25, 30 | 21 | | | 19 |
| 9 | 12 | 37 | 29 | | 17 | 14 |
| 10 | 18a | 27 | 18 | 18 | 20 | 15, 17 |
| | | | | | | |
| 11 | 16 | 26, 28 | 20 | 19, 22 | 16 | |
| 12 | 2 | 29 | 19 | 17 | | 23 |
| 13 | 1 | 31 | 22, 24 | 23, 26 | 18, 21 | 13, 18 |
| 14 | | 32, 33 | 25, 26 | 24 | 22 | 16, 20 |
| 15 | | | 30 | 21 | 23, 24 | 22 |
| | | | | | | |
| 16 | 7 | 34 | 27 | | | 21 |
| 17 | | 35 | 28 | 25 | 19 | |
| 18 | | | | | | |

Starting in Spring 2011, Basic Ratemaking and Basic Reserving were put on the same exam. Prior to that, Basic Reserving was on Exam 6 rather than Exam 5.

Starting in 2013, Exam 5 was given in both the Spring and Fall.

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| Section | Fall 2014 | Spring 2015 | Fall 2015 | Spring 2016 | Fall 2016 | Spring 2017 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | 13 | | | | | |
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| 4 | | | | | | |
| 5 | | | 16 | | | |
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| 6 | 14 | | | | | 15 |
| 7 | 16 | | 14 | 14 | | 14, 20 |
| 8 | 15 | 18 | 17 | | | |
| 9 | 18 | 19 | 15, 18, 19 | 16 | 18 | 18, 26 |
| 10 | | 17 | | 18 | 21 | 23 |
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| 11 | 17 | 20, 21 | 20 | 19 | 20, 22 | 16, 17 |
| 12 | 24 | | | 17 | 19 | 19 |
| 13 | 19, 20 | 16, 22, 23 | 21, 22 | 20, 21 | 16, 23 | 21, 22 |
| 14 | 21 | 24 | 23 | | 24 | |
| 15 | 22 | | 25 | 24 | 27 | |
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| 16 | | | 24 | 23 | 25 | 25 |
| 17 | 23 | 25 | | 22 | 26 | 24 |
| 18 | | | | | | |

| Section | Fall 2017 | Spring 2018 | Makeup Exam Spring 2018 | Fall 2018 | Spring 2019 | Fall 2019 | 9/25 Sample Items |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | | | | 14 | | 16 | |
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| 3 | | | 14 | | 13 | | |
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| 6 | | | | | | 17 | |
| 7 | 17, 19 | | 15, 16, 19, 20 | | 14, 16 | | |
| 8 | | | | | | | 10 |
| 9 | | 17, 19 | | 16 | 17, 19 | | 9 |
| 10 | 21 | | 18, 25 | 18, 19 | 18 | 19 | |
| | | | | | | | |
| 11 | 18, 20, 23, 27, 28 | 18 | 17 | 17 | 15, 20 | 20, 23 | |
| 12 | 22 | 20 | | | | 18 | 7, 8 |
| 13 | 24 | 21, 26 | 21 | 20 | 22 | 21 | 4 |
| 14 | 25 | 22 | 22 | 15, 21 | 21, 23 | 22 | |
| 15 | | 24 | 26 | 24 | | 25 | |
| | | | | | | | |
| 16 | | 25 | 24 | 23 | 24 | | |
| 17 | 26 | 23 | 23 | 22 | | 24 | |
| 18 | | | | | | | |

Both the original and makeup exams for Spring 2018 were via computer based testing using Excel.
For Fall 2018, the CAS went back to the traditional paper exam, using a calculator.

For Spring 2019 and Fall 2019, Exam 5 used the paper-and-pencil format of exam administration.

There was no Spring 2020 exam.

For Fall 2020, the CAS went back to computer based testing.

**The CAS did not release the Fall 2020 exam and will not release future exams.**

## Section 1, Introduction

Estimating Unpaid Claims Using Basic Techniques replaced many separate papers that were formerly on the syllabus.[3] In some cases, Friedland has taken or adapted material from these papers. Material has been updated and put on the level of comprehension and detail intended for your exam.[4] There is also some new material.

A single textbook has the advantage of a consistent notation, terminology, and approach.[5] However, you should bear in mind that Estimating Unpaid Claims Using Basic Techniques was written by a single actuary. Different actuaries would have presented some things from a somewhat different point of view, chosen different examples, and emphasized some different items.

There are some differences in terminology from Basic Ratemaking.[6]
There is some overlap with Basic Ratemaking.

Estimating Unpaid Claims Using Basic Techniques is divided into four parts:
- Part 1 – Introduction: Chapters 1-2.
- Part 2 – Information Gathering: Chapters 3-6.
- Part 3 – Basic Techniques for Estimating Unpaid Claims: Chapters 7-15.
- Part 4 – Estimating Unpaid Claim Adjustment Expenses: Chapters 16-17.

Why Reserves Are Important for Insurers:

Alfred E. Neumann founded the Whatmeworry Insurance Company in order to write private passenger automobile insurance. Two years after its founding, the insurer has collected $50 million in premium, has spent $10 million in expenses, paid $35 million in loss and loss adjustment expenses, and earned $5 million in investment income.

Exercise: Alfred believes that his insurer has made a profit of $10 million. Why is Alfred wrong?
[Solution: There are policies still providing coverage for which the insurer has collected premiums. While Alfred has ignored this, insurers take this into account via unearned premium reserves. Also, there are claims for covered incidents which have been reported to the insurer, but which have yet to be paid. While Alfred has ignored this, insurers set up case reserves based on an estimate of what will eventually be paid. (An insurer usually will also set up a Bulk reserve for development on known claims based on an actuarial analysis.) There are also covered incidents that have yet to be reported to the insurer. While Alfred has ignored this, insurers set up Incurred But Not Reported (IBNR) reserves based on an actuarial analysis.
Comment: Insurers use a form of accrual accounting. ]

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[3] Estimating Unpaid Claims Using Basic Techniques was added to the syllabus for the 2009 exam.
The current 2010 edition includes minor revisions of the original 2009 edition.
[4] The author was guided by a Committee of the CAS.
[5] When I took the reserving exam in the late 1970s, we studied the original papers from the Proceedings of the CAS. We needed to look at either the hardcover book or a photocopy of the paper. This was well before PDFs or downloading things from the internet. At the time, longtime members of the CAS thought we had it easy being able to study from photocopies of the papers.
[6] The terminology used by Friedland will be discussed subsequently.

Variance of Loss Reserve Estimates:

This exam concentrates on point estimates of loss reserves. For example, the actuary might estimate a loss reserve of 200 million using one of the techniques discussed by Friedland.

In a practical application, the actuary should review the sensitivity of this estimate to various selections the actuary has made. In addition, the actuary would probably compare estimates from using several different techniques. This would lead to a range of reasonable estimates for the loss reserve, for example 180 million to 220 million.[7]

However, insurers record a point estimate of unpaid claims in their balance sheet.
Actuarial Standard of Practice No. 43 (ASOP 43) defines the actuarial central estimate as an estimate that represents an expected value over the range of reasonably possible outcomes.[8]

There have been developed less ad hoc and more mathematical/statistical methods of estimating the variance of loss reserve estimates and ranges of unpaid claim estimates; however, these are not on the syllabus of this exam.[9]

Delays in Settling Claims:

Typical reasons for the delay between the loss event and the settlement of the claim include: delays in reporting claims, delays in processing claims (at the insurer or their representative), delays due to legal proceedings (including settlement conferences).

The time between the occurrence and reporting of a loss event varies significantly by the line of business, and by the type of loss. In auto insurance, loss events are typically reported relatively quickly, although the severity of the loss may not be known for some time. In medical malpractice insurance there may be a long delay between the occurrence and reporting of a loss event, as the injury or loss may not be apparent for some time.

Individual claims may be settled in a single lump sum, but for complex claims involving injury there may be a series of interim payments before the claim is finally settled and closed. Workers Compensation claims often involve periodic payments.

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[7] Then the actuary would probably present this range of reasonableness to upper management of the insurer, which based on business considerations would then pick a value in this range to use in its financial reporting. When an insurer has a low loss ratio, management tends to strengthen IBNR reserves, while when the loss ratio is high, they tend to weaken IBNR reserves. This smoothing of calendar results is a well studied phenomenon.

[8] ASOP 43 is on the syllabus of this exam.

[9] See for example,"Measuring the Variability of Chain Ladder Reserve Estimates," by Thomas Mack, CAS Forum, Spring 1994, currently on the syllabus of CAS Exam 7.
See also The Actuary and Enterprise Risk Management: Integrating Reserve Variability by Mark R. Shapland and Jeffrey A. Courchene, CAS Monograph Series Number 12.

**Importance of Accurately Estimating Unpaid Claims**:

- **Insurers sell a promise to pay for a future covered event**.
- **Insurers may not know the ultimate cost of a covered event for many years**.
- **Insurers must regularly report their financial results**.[10]
- **Claim reserves are set up to cover the future costs of covered events that have already occurred but for which the insurer has yet to pay**.[11]
- **Actuaries estimate the ultimate claims and thus the needed claim reserves**.[12] [13]

Friedland discusses the importance of accurate estimates of unpaid claims from the viewpoints of internal management, investors, and regulators.[14]

From the Viewpoint of Internal Management:

Accurate claims reserves are important for:
- **Ratemaking/Pricing**.
- Deciding to Expand or Contract its Book of Business.
  This could include whether to tighten or loosen its underwriting guidelines.
  This could include whether to exit a current market or enter a new market.
- Deciding on Reinsurance Needs.
- Deciding which lines of business get a larger proportion of Allocated Capital.

From the Viewpoint of Investors:[15]

Accurate claims reserves are important for:
- Decisions on whether to buy or sell stock in the insurer.

From the Viewpoint of Regulators:[16]

Accurate claims reserves are important for:
- **Accurately assessing the Financial Condition of the insurer**.
  Inadequate reserves may cause the regulators to fail to spot a potential insolvency in time to intervene.
- Deciding whether or not to approve a requested rate change.[17]

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[10] In the United States, insurers have to prepare and submit to regulators the Annual Statement.
Most other countries have similar requirements.
[11] There are individual case reserves which are set up by claims adjusters. In addition there is IBNR.
[12] Actuaries help determine IBNR (Incurred But Not Reported) reserves.
[13] "Actuaries around the world work with insurers and self-insurers to quantify, evaluate, and monitor estimates of unpaid claims."
[14] See for example 5, 11/19, 16b.
[15] Some insurers are stock companies in which people can invest by buying stock.
In contrast, mutual insurers are owned by their policyholders.
[16] In the United States, insurers are principally regulated by insurance departments of the different states.
[17] For some lines of insurance in some places insurers need approval before changing rates.

*From the Viewpoint of Potential Policyholders*:[18]

The financial strength of insurance companies is rated by various entities.
For example, A.M. Best issues credit ratings of Property/Casualty insurers. A is better than B, etc. These rating depend to a large extent on the financial statements filed by the insurers.
In turn, these financial statements are based on an estimate of unpaid loss reserves.

If these unpaid loss reserves are inadequate, then the insurer will probably get a higher rating than it deserves. If these unpaid loss reserves are excessive, then the insurer will probably get a lower rating than it deserves.

An individual buying homeowners or automobile insurance may look at such ratings when choosing an insurer. Commercial insureds are very likely to consider such ratings when choosing an insurer.[19]

**Components of the Estimate of Unpaid Claims**:[20]

The unpaid claims estimate includes five components:
- **case outstanding on known claims.**
- **provision for future development on known claims.**
- **estimate for reopened claims.**
- **provision for claims incurred but not reported.**
- **provision for claims in transit (i.e., claims reported but not recorded).**[21]

Case outstanding on known claims consists of individual case reserves set by claims adjusters.

The remaining four components make up **IBNR, Incurred But Not Reported**.
**IBNR = IBNER + Pure IBNR**.

**IBNER = Incurred But Not Enough Reported = Development on Known Claims**.[22]
IBNER includes: the provision for future development on known claims plus
the estimate for reopened claims.

**Pure IBNR = IBNYR = Incurred But Not Yet Reported**.
Pure IBNR includes: the provision for claims incurred but not reported plus
the provision for claims in transit (i.e., claims reported but not recorded).

Reported claims, which are paid claims plus case outstanding, typically represent a high proportion of ultimate claims at early maturities for short-tailed lines such as automobile physical damage insurance and property insurance.

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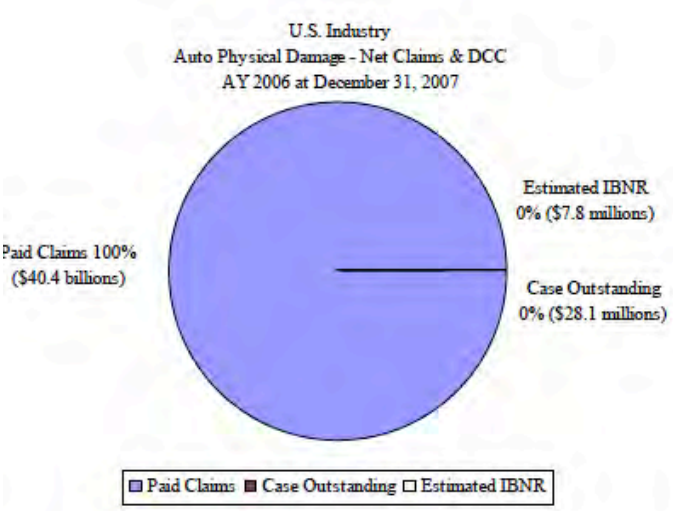
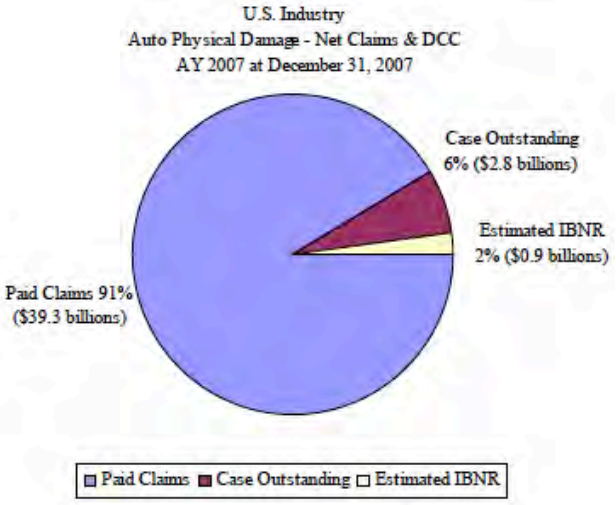
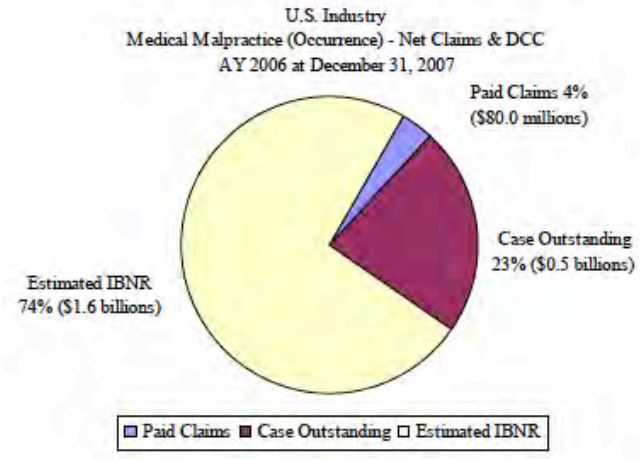
[18] Not discussed by Friedland.
[19] Certain entities may only be allowed to buy insurance from an insurer with at least a certain rating.
[20] See for example 5, 11/19, 16a.
[21] Nowadays, the provision for claims in transit is usually insignificant.
[22] Also called Bulk Reserves.

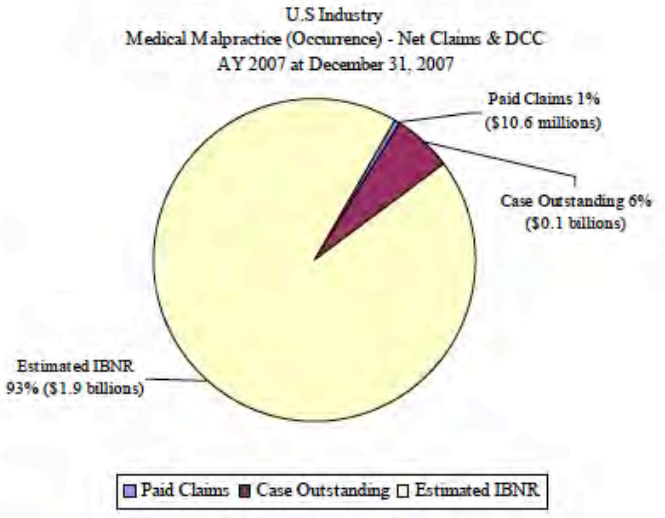
For long-tailed lines of insurance such as medical malpractice occurrence, workers compensation, and general liability, it takes a long time to report and settle many claims.[23] Thus at early maturities most of the estimated ultimate losses are IBNR. Lines of insurance such as homeowners and automobile liability are in between these two extremes.

The following pie charts illustrate the differences in the proportions between paid, case outstanding, and IBNR for different maturities and lines of insurance:[24]




For automobile physical damage 92% of the losses have been paid by first report, while almost all of the losses have been paid by second report. In contrast for medical malpractice occurrence, at first reported 93% of the estimated ultimate losses are IBNR, and at second report only 4% of the estimated ultimate losses have been paid.

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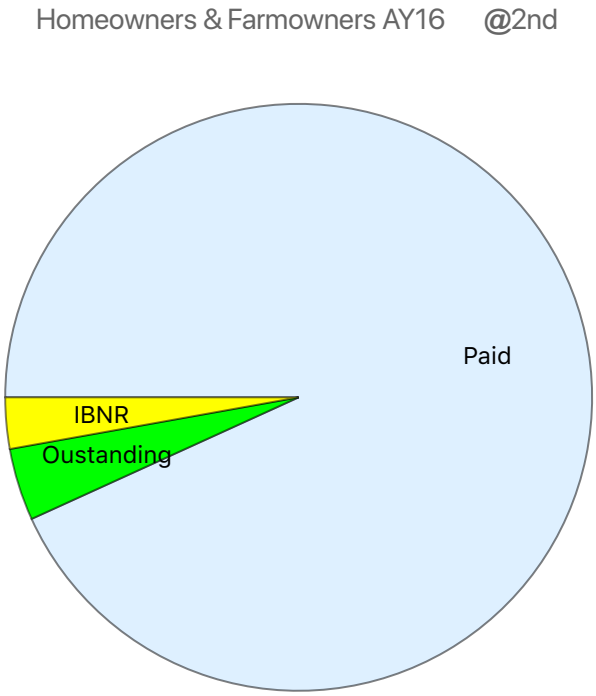
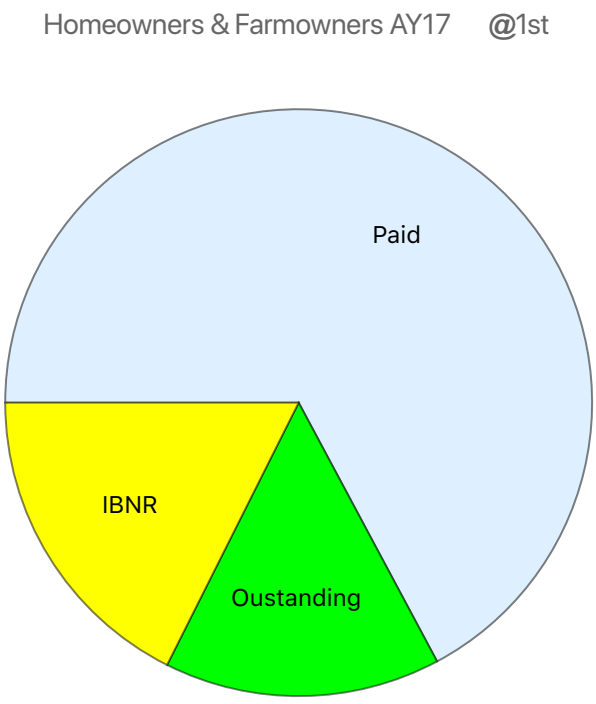
[23] Medical malpractice policies are either occurrence or claims-made.

[24] See Page 80 of Friedland. Data as of December 31, 2007, for the consolidated U.S. industry data for automobile physical damage and for medical malpractice occurrence.
Presumably Friedland took this data from Best's Aggregates and Averages.

Here are similar pie charts for homeowners and farmowners insurance:[25]




At first report 67% of estimated ultimate losses are paid, while at second report 93% are paid.

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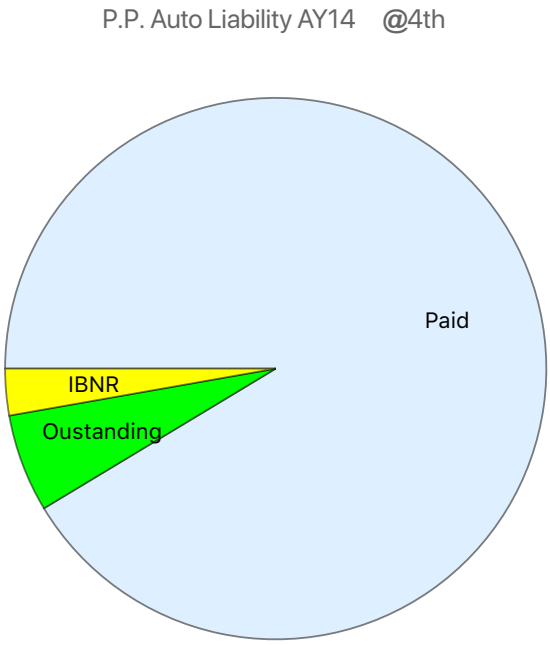
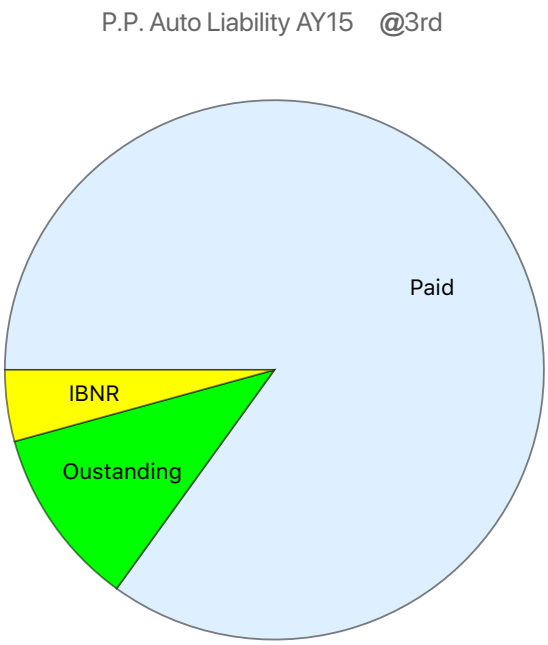
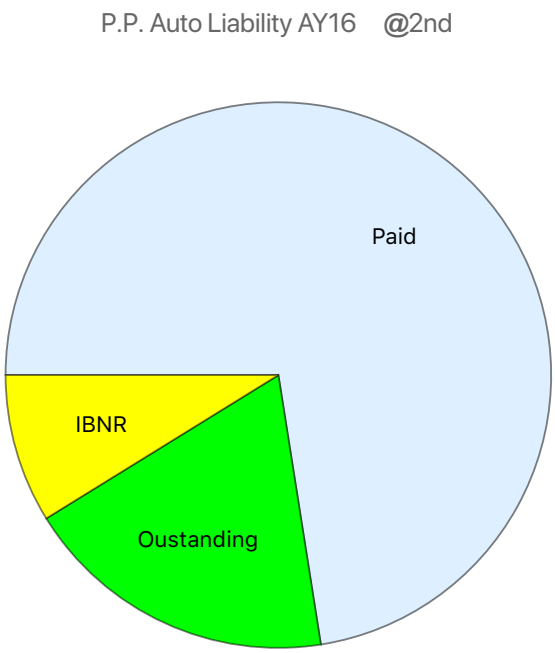
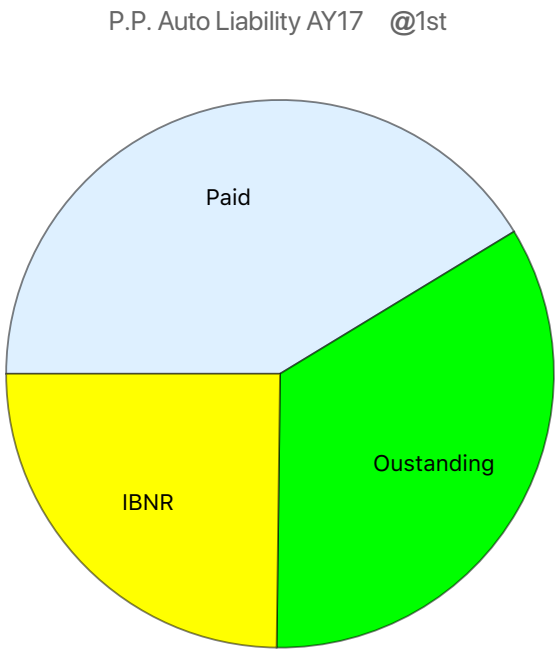
[25] Direct and assumed losses without claims adjustment expenses.
From Best's Aggregates and Averages. Data as of December 31, 2017.

Here are similar pie charts for private passenger automobile liability insurance:[26]




At first report 41% of estimated ultimate losses are paid, while at fourth report 91% are paid.

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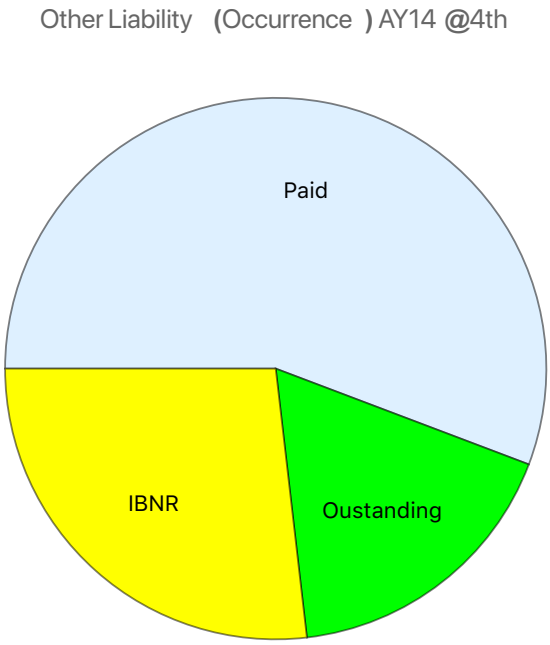
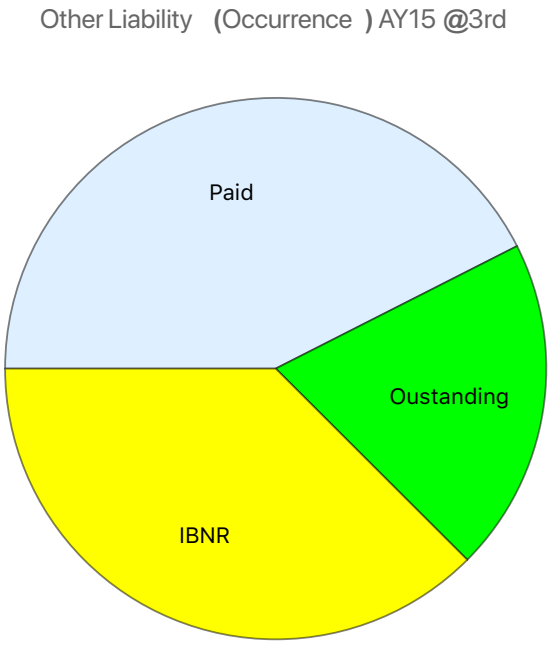
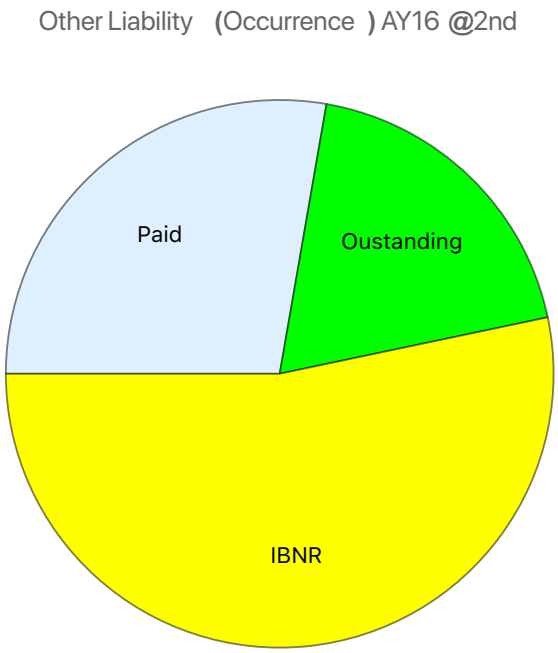
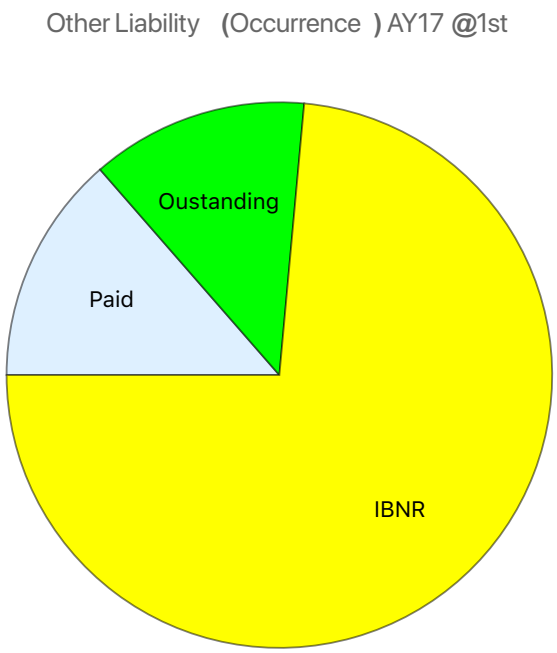
[26] Direct and assumed losses without claims adjustment expenses. Includes Medical Payments coverage. From Best's Aggregates and Averages. Data as of December 31, 2017.

Here are similar pie charts for other liability insurance (occurrence):[27]




At first report 14% of estimated ultimate losses are paid, while at fourth report 56% are paid.

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[27] Direct and assumed losses without claims adjustment expenses.
From Best's Aggregates and Averages. Data as of December 31, 2017.

Terminology Used by Friedland:

Insurer: Any risk bearer for Property & Casualty exposures, such as an insurance company, self-insured, etc.[28]

Unpaid claim estimate: estimate of the obligation for future payment resulting from claims due to past events.[29]

Claims: Dollars of Loss.

Claim Counts: Number of claims.

**Reported Claims: Paid Claims plus Case Reserves**.

Ultimate Claims: Total dollars after all claims are settled and closed without any chance of reopened claims.

Claim Related Expenses: Claim Adjustment Expenses.

Experience Period: The past years used in estimating unpaid claims.

Emergence: The reporting or development of claims and claim counts over time.

*More on the Importance of Loss Reserves*:[30]

"In addition to being random in their frequency and severity, insurance losses are characterized by lags between the time the insured event happens and is reported and between the date reported and the date it is finally settled. These lags give rise to the need to recognize liabilities for unpaid losses and their associated loss adjustment expenses (hereinafter, simply losses.) Since these lags, along with claim frequencies and severities, are stochastic, recorded liabilities for losses have substantial risk that the actual values realized will depart materially from the expectation. Actual results can vary from expectations due to the number of claims, the amount of claims or the timing of payments.

In many countries, loss reserves are the single largest liability on the insurance industry's balance sheet. The delayed and stochastic nature of the timing and amount of insured loss payments not only makes the insurance industry unique, it effectively dominates or defines much of the financial management - and risk and opportunity management - of an insurance company. For example, insurers are typically hesitant to utilize a significant amount of debt in their capital structure, as their capital is already leveraged by reserves. Also, the characteristics of unpaid loss liabilities (e.g., cash flow, duration, volatility) heavily influence insurer investment policy."

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[28] In certain contexts this may include reinsurance companies, captive insurers, pooling associations, etc.
[29] The carried reserve for unpaid claims is the amount in a statement of financial condition.
[30] Quoted from Section 5.2 by Paul J. Brehm in
Enterprise Risk Management for Property & Liability Insurance Companies, not on the syllabus of this exam.

Claim Related Expenses:

Claim adjustment expenses are the costs of administering, determining coverage for, settling, or defending claims even if it is ultimately determined that the claim is invalid.[31]

Loss adjustment expenses can be divided into two parts: allocated loss adjustment expenses (ALAE) and unallocated loss adjustment expenses (ULAE).
ALAE can be assigned to a particular claim, such as legal and expert witness expenses.
ULAE is not easily allocated to a specific claim, such as the payroll, rent, and computer expenses for the claims department of an insurer.

In the United States, for statutory reporting purposes, loss adjustment expenses are divided into two parts: defense and cost containment (DCC) and adjusting and other (A&O).
DCC expenses include all defense litigation and medical cost containment expenses regardless of whether internal or external to the insurer; A&O expenses include all claims adjusting expenses, whether internal or external to the insurer.

Generally, Friedland's examples and your exam questions deal with ALAE and ULAE, rather than DCC and A&O.

Regulation and Loss Reserves:

Many jurisdictions have legal requirements for accurate estimation of unpaid claim, and put the responsibility on the Appointed Actuary. For example, in the United States, the National Association of Insurance Commissioners (NAIC) requires that insurers obtain a Statement of Actuarial Opinion signed by a qualified actuary using the title of Appointed Actuary.[32] [33]

*Friedland also discusses Canada, Australia, and Slovenia, as other examples of regulation of loss reserves.*

*Insurance Coverages Referred to By Friedland*:[34]

Friedland describes various lines of insurance. It would not hurt to briefly look over the list and briefly review any coverages with which you are unfamiliar.

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[31] Some claims produce very little adjustment expense. Other claims, such as an asbestos claim, may revolve around complex legal and medical issues and may involve many interested parties; an asbestos claim often involves litigation, which can lead to high defense costs and expert fees and thus, very high expenses which may be significantly greater than the indemnity payment itself.
[32] The NAIC is an association of the insurance commissioners of the individual States. Among other things it drafts model regulations which most if not all States adopt.
[33] The Appointed Actuary, who is appointed by the board of directors, can be either an employee or a consultant. Each state determines who can qualify to be an Appointed Actuary; generally one must be an ACAS, FCAS, or somehow demonstrate ones qualification.
[34] See pages 11 to 13 of Friedland.

Problems:

*__1.1__.* (1 point) List the components of an unpaid claims estimate.

__1.2__.(0.75 point) Briefly describe how an excessive unpaid claims estimate can impact the decision-making of each of the following parties:
i. Internal management
ii. Investors
iii. Regulators

**1.3.** (2 points) Fully discuss the broad definition of IBNR, the definition of pure IBNR, and the definition of Incurred but not enough reported (IBNER).

**1.4.** (1 point) Discuss the concept and duties of an Appointed Actuary.

**1.5** (3 points)
(i) (1 point) Briefly describe the purpose of Claim Reserves.
(ii) (2 points) List and briefly describe three reasons why there might be a delay between a loss event and the claim settlement.

**1.6.** (1 point) These three pie charts are for Private Passenger Physical Damage, Private Passenger Liability, and Other Liability. Each is for an accident year at first report. Identify which pie chart is for each line of insurance.

Chart One

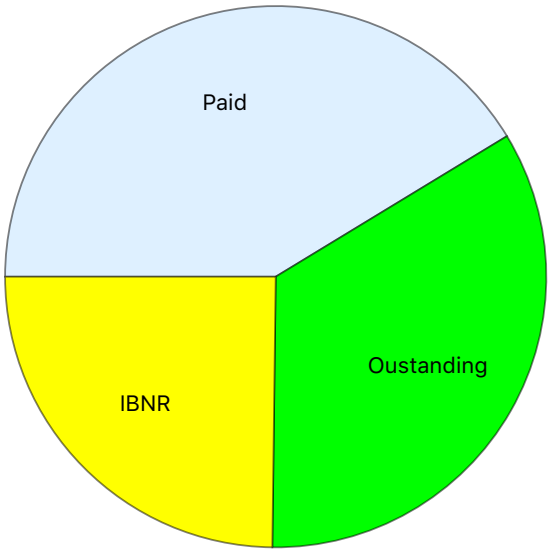



Chart Two

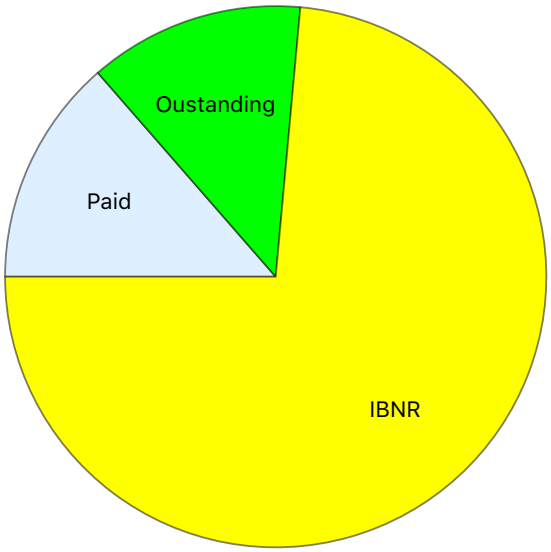
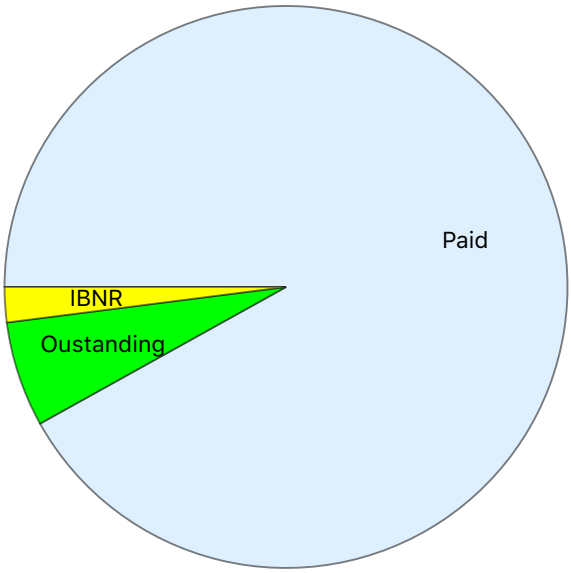



Chart Three



**1.7. (5, 11/14, Q.13)** (1.5 points) The importance of accurately estimating unpaid claims can be examined from three points of view: internal management, investors, and regulators.
a. (0.75 point) Briefly describe how a redundant unpaid claim estimate can impact decisions for each of these three groups.
b. (0.75 point) Briefly describe how an inadequate unpaid claim estimate can impact decisions for each of these three groups.

**1.8. (5, 11/18, Q.14)** (1.5 points) For each of the following stakeholders, describe the importance of having accurate unpaid claim estimates:
i. Internal Management
ii. Investors
iii. Regulators

**1.9. (5, 11/19, Q.16)** (1.5 points)
a. (0.75 point) List three components of an unpaid claims estimate.
b. (0.75 point) Briefly describe how an inadequate unpaid claims estimate can impact the decision-making of each of the following parties:
i. Internal management
ii. Investors
iii. Regulators

Solutions to Problems:

**1.1**. The unpaid claims estimate includes five components:
● case outstanding on known claims
● provision for future development on known claims
● estimate for reopened claims
● provision for claims incurred but not reported
● provision for claims in transit (i.e., claims reported but not recorded).
Comment: Similar to 5, 11/19, Q.16a.

**1.2**. i. Possible answers for the decision-making of Internal Management:
● Might decide to raise rates when this is not warranted.
● Might make an incorrect decision to contract business that is profitable.
● Might make an incorrect decision to tighten underwriting guidelines.
● Might make an incorrect decision on reinsurance needs.
● Might make an incorrect decision on which lines of business get a larger proportion of allocated capital.
ii. Likely to believe that the insurer is less profitable than it actually is.
iii. Possible answers for the decision-making of Regulators:
● May unnecessarily intervene as if there were a potential insolvency.
● Might approve an unneeded rate increase.
Comment: Similar to 5, 11/19, Q.16b.

**1.3.** Actuaries refer to the sum of the provision for future development on known claims, estimate for reopened claims, provision for claims incurred but not reported, and the provision for claims in transit as the broad definition of incurred but not reported (IBNR).
IBNR claims are often further separated into two components:
● Incurred but not yet reported claims (pure IBNR or narrow definition of IBNR).
● Incurred but not enough reported (IBNER, commonly referred to as development on known claims).
Thus unpaid = case outstanding on known claims + pure IBNR + IBNER.
Comment: The unpaid claims estimate includes five components:
● case outstanding on known claims
● provision for future development on known claims
● estimate for reopened claims
● provision for claims incurred but not reported
● provision for claims in transit (i.e., claims reported but not recorded).
The provision for future development on known claims is part of IBNER.
The provision for claims incurred but not reported is part of pure IBNR.
However, Friedland does not state where the estimate for reopened claims and the provision for claims in transit (pipeline claims) go. I think the estimate for reopened claims would go into IBNER, since this involves known claims (which have been reported and the insurer thinks are closed.) I think the provision for claims in transit would go into pure IBNR, since these are claims which are not yet in the data used by the reserving actuary.

**1.4.** Many jurisdictions directly tie the legal requirements for accurate estimation of unpaid claims to the responsibilities of the actuary. The role of the Appointed Actuary has been created through insurance legislation in countries around the world.
For example, in the United States most P&C insurers have to obtain a Statement of Actuarial Opinion signed by a qualified actuary, using the title of Appointed Actuary. The statement contains the Appointed Actuary's opinion regarding the reasonableness of the carried statutory loss and loss adjustment expense reserves as shown in the statutory annual statement. The Appointed Actuary is appointed by the Board of Directors or its equivalent, and can be either an employee or a consultant.

**1.5.** (a) (i) Accuracy in estimating unpaid claims is critical to insurers. Unlike manufacturers, insurers may not know the true cost of goods sold during a financial reporting period until several years later. An insurer sells its promise to pay the policyholder or an injured party on behalf of the policyholder in the event of an occurrence covered by the insurance policy. Claims Reserves help to estimate the financial condition of the insurer, and thereby help to make sure that the insurer has enough assets to pay for all claims on incidents for which it has provided coverage.
(ii) Reasons why there might be a delay between a loss event and the claim settlement:
● Delays in reporting.
For example, in medical malpractice insurance there may be a long delay between the occurrence and reporting of a loss event, as the injury or loss may not be apparent for some time.
● Claims processing delays.
Once a loss is reported, the insurer must ascertain the details of the event, assess the extent to which the loss is covered under the insurance, wait for estimates of the severity of the loss, and investigate potential recovery from other parties (subrogation) or from the residual value of insured property acquired by the insurer after a claim is settled (salvage). Individual claims may be settled in a single lump sum, but for complex claims involving injury there may be a series of interim payments before the claim is finally settled and closed.
● Disputes Over the Amount of the Claim and/or Legal proceedings.
Legal disputes typically involve disagreements about the appropriate amount of indemnification for a loss, or disagreements about the allocation of blame between different parties.
Comment: While these are the three reasons for delay, one could instead divide up the delay differently.

**1.6.** Chart 3 is for Private Passenger Physical Damage, the shortest tailed of the three.
Chart 1 is for Private Passenger Liability.
Chart 2 is for Other Liability, the longest tailed of the three.

**1.7.** (a) Internal management (any one):
- A redundant estimate of unpaid claims may drive an insurer to increase rates unnecessarily. The increased rates could lead to loss of market share, resulting in a loss of premium revenue to the insurer. A significant loss of revenue could negatively impact the financial strength of the insurer.
- The insurer may purchase unnecessary reinsurance contracts or choose to increase reinsurance limits.
- May lead the insurer to make an incorrect decision to exit a line of business.

Investors: An insurer with redundant reserves may show a weaker position than its true state. This could cause investors to sell the stock of the insurer.
Regulators (any one):
- If an insurer has redundant reserves a regulator may put unnecessary restrictions on the amount of business the insurer may write.
- The regulator may grant an unwarranted rate increase.

(b) Internal management (any one):
- An inadequate estimate of unpaid claims could drive an insurer to reduce its rates not realizing that the estimated unpaid claims were insufficient to cover historical claims.
- May decide to grow their business when they should not because their profits are not as high as they believe or are nonexistent.
- May be overly optimistic and thus may reduce its reinsurance limits.
- Could lead internal management to maintain less than a prudent amount of policyholder surplus.

Investors: An insurer with insufficient reserves may present itself to investors in a stronger position than it truly is. This may lead Investors to invest in the insurer even though they should not.
Regulators: If a financially struggling insurer is masking its true state with inadequate reserves, a regulator may not become involved until too late in the process to prevent the insurer from going insolvent.
Alternately, the regulator may not grant a warranted rate increase.
Comment: See Chapter 1 of Friedland.

**1.8.** i. Possible answers for the decision-making of Internal Management:
- Might decide to lower rates when this is not warranted.
- Might make an incorrect decision to expand business that is unprofitable.
- Might make an incorrect decision to loosen underwriting guidelines.
- Might make an incorrect decision on reinsurance needs.
- Might make an incorrect decision on which lines of business get a larger proportion of allocated capital.

ii. Possible answers for the decision-making of Investors:
- Likely to believe that the insurer is more profitable than it actually is.
- Company will be overvalued and attract investors.

iii. Possible answers for the decision-making of Regulators:
- May not spot a potential insolvency in time to intervene.
- Might not approve a needed rate increase.

**1.9.** (a) The unpaid claims estimate includes five components:
● case outstanding on known claims
● provision for future development on known claims
● estimate for reopened claims
● provision for claims incurred but not reported
● provision for claims in transit (i.e., claims reported but not recorded).
(b) i. Possible answers for the decision-making of Internal Management:
● Might decide to lower rates when this is not warranted.
● Might make an incorrect decision to expand business that is unprofitable.
● Might make an incorrect decision to loosen underwriting guidelines.
● Might make an incorrect decision on reinsurance needs.
● Might make an incorrect decision on which lines of business get a larger proportion of allocated capital.
ii. Possible answers for the decision-making of Investors:
● Likely to believe that the insurer is more profitable than it actually is.
● Company will be overvalued and attract investors.
iii. Possible answers for the decision-making of Regulators:
● May not spot a potential insolvency in time to intervene.
● Might not approve a needed rate increase.
Comment: See Chapter 1 of Friedland. In part (a), list only three components.
If the unpaid claims were instead overstated this would also impact the decision making of each of the three parties, but in the opposite direction.

## Section 2, The Claims Process

Claims professionals are responsible for estimating case outstanding on claims that are reported to the insurer. These estimates for individual claims are called unpaid case, case estimates, or case reserves. "The actuary must understand why the estimated value of a reported claim could vary over time and how changes in case outstanding are processed by an insurer."

Claims Professionals:

A claims examiner, claims adjuster, or claims handler, can be an employee of the insurer or an employee of an organization external to the insurer such as a Third Party Administrator (TPA).

*An insurer may hire an independent adjuster (IA) to handle an individual claim or a group of claims. This may involve a specific type of claim or a claim in a particular region. Also in the case of a catastrophe, an insurer may hire independent adjusters to help handle the unusual large volume of claims.*

*Is a Claim Covered?:*

When a claim is reported, a claims adjuster first determines whether or not the reported claim is covered under the terms of a valid insurance policy.[35] The claims adjuster generally reviews the following: effective dates of the policy, date of occurrence, terms and conditions of the policy, policy exclusions, and policy endorsements.

Setting Case Reserves:

Assuming a claim is covered the claims adjuster sets up an initial case reserve.[36] The claims adjuster generally reviews the following: policy limits, deductibles, reinsurance or excess coverage, reporting requirements, mitigation of loss requirements, extent of injury and damages, extent of fault, potential other parties at fault, and potential other sources of recovery.

There are many different approaches used to set initial case reserves. These vary between insurers and lines of insurance. Often the claims adjuster uses some judgement. After the initial case reserve is set, it will be revised as more information is available and any payments are made. Also case reserves on open claims may be reviewed periodically.

Some insurers include case reserves of ALAE with those for losses; other insurers set up separate case reserves for ALAE. Some insurers take into account anticipated salvage and subrogation in their case reserves, while others do not. Most insurers when practical will have case reserves both gross and net of reinsurance.[37]

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[35] "Insureds or third parties may report claims in several ways, including but not limited to: telephone (often to a call center), internet (the insurer's website), e-mail, in person at an insurer's branch office, notice to an insurance intermediary (such as an insurance agent or broker), or a lawyer's letter with a formal statement of a claim."

[36] Very simple claims are often paid and closed without setting up a case reserve.

[37] This would be possible with either quota share reinsurance or excess of loss reinsurance.

The Life of a Claim:

**Claim activity typically extends over a period of time, often several years**.
**The estimated value of a claim changes over the life of the claim;**
**the value of a claim is not ultimately established until the claim is finally closed**.[38]
An insured claim can have many different types of payments and many dates associated with it. Some claims close without any payment.

Transactions could include: establishment of the initial case outstanding estimate, notification to the reinsurer if the claim is expected to exceed the insurer's retention, a partial claim payment to injured party, expense payment for an independent adjuster, change in case outstanding estimate, claim payment (assumed to be final payment), takedown of case outstanding and closure of claim, reopening of the claim and establishment of a new case outstanding estimate, partial payment for defense litigation, final claim payment, final payment for defense litigation, and closure of the claim.

An Example of Claim Transactions:[39] [40]

| Date | Transaction | Reported Value of Claim to Date | Cumulative Paid to Date |
|---|---|---|---|
| December 1, 2022 | Accident occurs | | |
| January 15, 2023 | Claim is reported and opened with initial case reserve of $20,000 | $20,000 | 0 |
| October 20, 2023 | Case reserve increased to $30,000 | $30,000 | 0 |
| March 7, 2024 | Expense payment to Independent Adjuster of $2000 | $27,000 | $27,000 |
| | Claim Closed with payment of $25,000 | | |
| July 31, 2024 | Claim Reopened with case reserve of $10,000 | $37,000 | $27,000 |
| August 22, 2024 | Case Closed with payment of $10,000 | $38,000 | $38,000 |
| | Expense payment to Independent Adjuster of $1000 | | |

This is just one example. Some claims are paid and closed the same day they are reported. Other claims remain open for many years. Some claims include partial payments; the case reserves would be reduced, but not necessarily by the amount of the payment. Only a minority of claims are reopened once they are closed. Some claims would have expenses such as: attorney fees, court fees, lab tests, fees for expert testimony, medical cost containment expenses, rehabilitation costs, etc.

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[38] Some claims are reopened.
[39] See Table 1 in Chapter 2 of Friedland. See also 5, 11/15, Q.16a.
[40] All of these paid and reported values would go into accident year 2022 and report year 2023.
The policy year would depend on the effective date of the policy providing coverage.

The calendar year reported claims are:
claims paid during calendar year + change in case reserves.

For this example, the calendar year 2023 reported loss and ALAE is $30,000.
The calendar year 2024 reported loss and ALAE is: $38,000 - $30,000 = $8000.

Dates Associated With a Claim:

- Policy effective date
- Accident date
- Report date
- Transaction date(s): either a case outstanding transaction takes place or a payment is made
- Closing date(s)
- Reopening date

Examples of Changes in Reported Value:[41]

| Accident Date | Transaction Date | Amount Paid on Transaction Date ($) | Ending Case Outstanding ($) |
|---|---|---|---|
| April 30, 2021 | November 24, 2021 | 2000 | 3000 |
| | July 11, 2022 | 0 | 4000 |
| | March 7, 2023 | 3500 | 0 |

The calendar year 2021 paid losses are $2000 and reported losses are $5000.
The calendar year 2022 paid losses are 0 and reported losses are $4000 - $3000 = $1000.
The calendar year 2023 paid losses are $3500 and reported losses are $3500 - $4000 = -$500.

Examples of three more claims:

| Claim ID | At December 31, 2022 | | | Transactions During 2023 | | | At December 31, 2023 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cumulative Paid Claims | Case O/S | Reported Claims | Paid Claims | Change in Case O/S | Reported Claims | Cumulative Paid Claims | Case O/S | Reported Claims |
| 1 | 600 | 1000 | 1600 | 300 | -100 | 200 | 900 | 900 | 1800 |
| 2 | | 700 | 700 | 400 | -700 | -300 | 400 | 0 | 400 |
| 3 | | 5000 | 5000 | 5000 | -5000 | 0 | 5000 | 0 | 5000 |

[41] See Table 2 in Chapter 2 of Friedland.

Four-Phase Approach to Loss Reserving:[42]

- **Exploring the data** to identify its key characteristics and possible anomalies.[43] Balancing data to other verified sources should be undertaken at this point.

- **Applying appropriate techniques for estimating unpaid claims**.[44]

- **Evaluating** the conflicting results of the various methods used, with an attempt to reconcile or explain the different outcomes. At this point, the projected ultimate amounts are evaluated in contexts outside their original frame of analysis.[45]

- **Monitoring** projections of claim development over subsequent calendar periods.[46] Deviations of actual development from projected development of counts or amounts are one of the most useful diagnostic tools in evaluating the accuracy of unpaid claim estimates.

[42] See Page 27 of Friedland, referring to the chapter on reserving in Foundations of Casualty Actuarial Science.
[43] See for example Chapter 6 of Friedland.
[44] See Chapters 7 to 13 of Friedland.
[45] See Chapter 15 of Friedland.
[46] See Chapter 15 of Friedland.

Problems:

**2.1.** (1 point) List four types of dates that may be associated with a claim.

**2.2.** (1 point) The following transactions occur on a claim:

| | |
|---|---|
| February 14, 2022 | Accident occurs |
| May 21, 2022 | Claim is reported and opened with initial case outstanding of $25,000 |
| November 6, 2022 | A payment of $4,000 is made<br>and case outstanding is reduced to $20,000 |
| March 15, 2023 | The case outstanding is increased to $30,000 |
| October 22, 2024 | An additional payment of $33,000 is made<br>and case outstanding is reduced to $0 |
| January 13, 2025 | $15,000 is recovered on the claim through subrogation |

Determine the reported losses for Accident Year 2022 as of:
- December 31, 2022.
- December 31, 2023.
- December 31, 2024.
- December 31, 2025.

***2.3.*** (1 point) Which of the following statements are true?
(Choose all that apply).
☐ A. Claim activity typically often extends over several years.
☐ B. Some claims close without any payment.
☐ C. The estimated value of a claim changes over the life of the claim.
☐ D. There is a standard way to determine the amount of initial case estimates.
☐ E. The value of a claim is not ultimately established until the claim is permanently closed.

**2.4.** (1 point) Given the following information:

| | | 2021 Transactions | | 2022 Transactions | | 2023 Transactions | |
|---|---|---|---|---|---|---|---|
| Claim ID | Accident Date | Calendar Year Payments | Ending Case O/S | Calendar Year Payments | Ending Case O/S | Calendar Year Payments | Ending Case O/S |
| 1 | January 16, 2021 | 600 | 900 | 0 | 1000 | 0 | 1500 |
| 2 | June 24, 2021 | 300 | 100 | 50 | 50 | 100 | --- |
| | | | | | | | |
| 3 | May 11, 2022 | | | 200 | 50 | 70 | --- |
| 4 | December 5, 2022 | | | 400 | 500 | 250 | 200 |
| | | | | | | | |
| 5 | April 28, 2023 | | | | | 0 | 700 |

Determine the calendar year 2021 reported losses.
Determine the calendar year 2022 reported losses.
Determine the calendar year 2023 reported losses.

**2.5.** (1 point) List four types of transactions that may be associated with a claim.

Solutions to Problems:

**2.1.** Possible responses (any four):
● Policy effective date
● Accident date
● Report date
● Transaction date(s): either a case outstanding transaction takes place or a payment is made
● Closing date(s)
● Reopening date
Comment: See page 22 of Friedland.

**2.2.** AY22 reported losses as of December 31, 2022: **$24,000**.
AY22 reported losses as of December 31, 2023: **$34,000**.
AY22 reported losses as of December 31, 2024: **$37,000**.
AY22 reported losses as of December 31, 2025: **$22,000**.
Comment: Similar to Table 1 in Chapter 2 in Friedland.

**2.3. A, B, C, and E.** Statement D is not true.
There are many different approaches used to set initial case reserves. These vary between insurers and lines of insurance. Often the claims adjuster uses some judgement.

**2.4.** CY21 reported losses: 600 + 900 + 300 + 100 = **1900**.
CY22 reported losses: 0 + (1000-900) + 50 + (50 - 100) + 200 + 50 + 400 + 500 = **1250**.
CY22 reported losses:
0 + (1500-1000) + 100 + (0 - 50) + 70 + (0-50) + 250 + (200 - 500) + 0 + 700 = **1220**.
Comment: Similar to Table 2 in Chapter 2 in Friedland.

**2.5.** Possible responses (any four):
● Establishment of the initial case outstanding estimate
● Notification to the reinsurer if the claim is expected to exceed the insurer's retention
● A partial claim payment to injured party
● Expense payment for an independent adjuster
● Change in case outstanding estimate
● Claim payment (assumed to be final payment)
● Takedown of case outstanding and closure of claim
● Reopening of the claim and establishment of a new case outstanding estimate
● Partial payment for defense litigation
● Final claim payment
● Final payment for defense litigation
● Closure of the claim.
Comment: See page 20 of Friedland.

## Section 3, Understanding the Types of Data Used

In this Chapter, Friedland discusses basic ideas related to insurance data used by actuaries. Most of these ideas apply to ratemaking as well as reserving.[47]

**Homogeneity and Credibility of Data**:[48]

Claims from different lines of insurance, or even subcoverages, behave differently. Also, claims for umbrella and excess insurance behave different from claims for primary insurance.

"It is often possible to improve the accuracy of estimating unpaid claims by subdividing experience into groups exhibiting similar characteristics, such as comparable claim experience patterns, settlement patterns, or size of claim distributions."

When separating data into subgroups, some key characteristics:
- Credibility: volume of data in each subgroup
- Similar Reporting Patterns
- Similar Settlement Patterns
- Similar Severity
- Similar Adequacy of Case Reserves
- Similar Likelihood of a Claim Reopening
- Consistency of the coverage triggered by the claims in the group (i.e., group claims that will generally be subject to the same or similar laws, policy terms, claims handling, etc.)

**An actuary wants to divide the data into sufficiently homogeneous groups while maintaining sufficient credibility of the data**.[49] There is a tension. Larger groups tend to be less homogeneous, but if a group is too small it may lack credibility and thereby may not allow an accurate estimate.[50]

The Importance of Knowing the Meaning of Terminology:

Different insurers, or even different departments within the same insurer, may use the same term to mean different things. Actuaries must be sure what is meant by a given term in both practical applications and when reading the actuarial literature.

For example, "incurred losses" may mean the sum of payments made during a time period plus the change in total unpaid claims including IBNR.[51] Instead incurred losses could mean paid losses plus the change in case reserves (excluding IBNR); this is often called case incurred. Friedland uses the term "reported claims" for case incurred losses.

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[47] See "Mahler's Guide to Basic Ratemaking".
[48] These general ideas apply to reserving, ratemaking, and other tasks of actuaries.
[49] "Credibility refers to the predictive value given to a group of data. Increasing the homogeneity of the group of data or increasing the volume of data in the group tends to increase credibility."
[50] This idea also applies to defining classes and territories for ratemaking.
[51] The incurred loss triangles in Schedule P of the U.S. Annual Statement include IBNR.

"unpaid claims" and "reserves" may include or exclude IBNR.
Is the unpaid claim estimate net or gross of deductibles or other types of recoveries, including salvage, subrogation, and reinsurance recoveries?

Do the case reserves include or exclude ALAE?

**Are paid claims cumulative or incremental?**
Do paid claims include ALAE?
Are paid claims net or gross of recoveries?

It is absolutely essential that actuaries fully understand the data that they are using.

Large Claims:

Actuaries have to be aware of the potential impact of unusually large claims.[52] An actuary may choose to exclude the large claims from the initial projection and then at the end add a specific provision for these large claims.

There is no single definition of what counts as a large claim for purposes of an actuarial analysis. It varies by line of insurance, insurer, etc. There is also some actuarial judgement involved.[53] Among considerations in setting a large claim threshold:
- Number of claims over the threshold each year
- Size of claim relative to policy limits
- Size of claim relative to reinsurance limits
- Credibility of internal data regarding large claims
- Availability of relevant external data

A large claim threshold that has been used for a particular analysis year after year should be reviewed every once in a while.

Premiums and Exposures:[54]

Premiums are used in some loss reserving techniques. Sometimes they are put on-level. Various types of exposures are also used such as: the number of vehicles insured, payroll, sales, policies in force, and policy limits by region (for the early estimation of unpaid claims related to a natural catastrophe).

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[52] This is true for both reserving and ratemaking. See pages 95 to 97 of Basic Ratemaking.
[53] The actuary can also seek advice from the reinsurance department when deciding upon the large claim threshold.
[54] More important for ratemaking than for reserving. See "Mahler's Guide to Basic Ratemaking".

Friedland gives examples of exposures by line of insurance:[55]

| Line of Insurance | Exposure |
|---|---|
| U.S. workers compensation | Payroll |
| Automobile liability | Number of vehicles or miles driven |
| General liability for public entities | Population or operating expenditures |
| General liability for corporations | Sales or square footage |
| Hospital professional liability | Average occupied beds and outpatient visits |
| Property | Property values |
| Crime | Number of employees |

Claims Data:

- Incremental paid claims
- Cumulative paid claims
- Paid claims on closed claims
- Paid claims on open claims
- Case outstanding
- Reported claims: sum of cumulative paid claims plus case outstanding
- Incremental reported claims

Claim Count Data:

- Reported claim counts
- Claim counts on closed with payment
- Claim counts on closed with no payment
- Open claim counts
- Reopened claim counts

Claim Related Expenses:

- Allocated Loss Adjustment Expense (ALAE)
- Unallocated Loss Adjustment Expense (ULAE)

[55] See Table 1 in Chapter 3 of Friedland.
While this is labeled for self-insureds, most of it also applies to insurance companies.

Key Dates:

Dates for the organization of claim data include:
- Policy effective dates: beginning and end of the policy effective period
- Accident date
- Report date[56]
- Accounting date: an actuary is estimating the unpaid claims or IBNR for accidents on or prior to this date.
- Valuation date: date as of which the data is valued; transactions after this data are excluded.[57]

Calendar Year Data:[58]

Calendar year data is transactional data: premiums and losses related to a given calendar year.

CY24 Earned Premium = CY24 Written Premium + Change in Unearned Premium Reserve.

CY24 Paid Claims = Payments made during 2024.

CY24 Reported Claims = CY Paid Claims + Change in Case Reserves.

CY24 Reported Claim Counts = Number of claims reported during 2024.

CY24 Closed Claim Counts = Number of claims closed during 2024.

Exercise: You are given the following information:
- Calendar 2024 Written Premium: $33 million.
- Unearned Premium Reserve as of December 31, 2023: $9 million.
- Unearned Premium Reserve as of December 31, 2024: $11 million.
- Calendar 2024 Paid Claims: $20 million.
- Case Reserves as of December 31, 2023: $12 million.
- Case Reserves as of December 31, 2024: $15 million.

Determine the Calendar Year 2024 Earned Premium and Reported Claims.
[Solution: CY24 Earned Premium = 33 + 11 - 9 = $35 million.
CY24 Reported Claims: 20 + 15 - 12 = $23 million. ]

Calendar year claims are very rarely used in loss reserving.
However, calendar year exposures are sometimes used in loss reserving.

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[56] Some insurers will maintain a date on which a claim is reported to the insurer, and a somewhat later date on which the claim is recorded in its data base. There may also be a notification date, on which the insurer was notified of a possible claim prior to a claim actually being filed,

[57] While most commonly the accounting date and valuation date are equal, an actuary could for example use data valued as of September 30, 2024 to estimate unpaid claims for accidents on or prior to December 31, 2024.

[58] See also “Mahler’s Guide to Basic Ratemaking.”

Advantages of Calendar Year Data:

- There is no future development. The values remains fixed at the end of the calendar year.
- Since insurers conduct financial reporting on a calendar year basis, this data is readily available.

Disadvantage of Calendar Year Data:

- The fixed nature of calendar year data means that it can not be used to measure loss development.

**Accident Year Data**:[59]

Accident year data consists of calendar year premiums/exposures plus those losses on accidents that occur during a given year. Accident Year data is by far the most common grouping used in loss reserving, both in practical applications and on your exam.

- Accident Year 2024 Paid Claims: Amounts paid for accidents that occurred during 2024.
- Accident Year 2024 Reported Claims: AY24 paid claims plus the corresponding case reserves.

Both paid and reported accident year claims depend on the evaluation date.
So for example for Accident Year 2024, their values as of December 31, 2024 will differ from their values as of December 31, 2025.

Other Accident Periods:

Sometimes actuaries will work with half accident years, accident quarters, or accident months. For example, one could work separately with accidents from the first and second halves of 2024.

Sometimes actuaries will work with “composite accident years”. For example, composite accident year 2020/2021 would include accidents from July 1, 2020 to June 30, 2021.

Advantages of Accident Year Data:

- Easy to obtain.
- Easy to understand.
- Represents claims occurring over a shorter time frame than for policy year data. Thus Accident Year data matures more quickly than Policy Year data.
- Numerous industry benchmarks are available.
- Valuable when there is a change due to economic or regulatory forces.[60]
- Valuable when there are major claim events.[61]

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[59] See also “Mahler’s Guide to Basic Ratemaking.”
[60] Such as inflation or law amendments.
[61] Such as atypical weather or a major catastrophe.

Disadvantages of Accident Year Data:

- Mismatch between claims and premiums/exposures.
- Includes claims from policies at more varied times than policy year data.[62]
- *For self-insureds with high deductibles, it can mask changes in retention levels and/or changes in insurers or reinsurers.[63]*

Policy Year Data:[64]

Policy year data consists of premiums/exposures and losses for policies written during a given year.[65] For example, Policy Year 2024 includes all data from policies with effective dates from January 1, 2024 to December 31, 2024.[66] For annual policies, PY24 will include some claims with accident dates as early as January 1, 2024 and as late as December 31, 2025.

Sometimes actuaries will work with "composite policy years". For example, composite policy year 2020/2021 would include policies from July 1, 2020 to June 30, 2021.

Both paid and reported policy year claims depend on the evaluation date.
So for example for Policy Year 2024, their values as of December 31, 2025 will differ from their values as of December 31, 2026.

Advantages of Policy Year Data:

- Match between claims and premiums/exposures.
- Valuable when underwriting or pricing changes occur.[67]
- *Useful for self-insureds where only one policy may apply.*

Disadvantages of Policy Year Data:

- The extended time frame; a longer time until the ultimate claims can be reliably estimated.
- Can make it difficult to understand and isolate the effect of a catastrophe.
- Can make it difficult to understand and isolate the effect of a major court ruling.

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[62] These policies may have different rate levels and/or underwriting criteria.
[63] Such changes could have an effect on claim development patterns.
[64] See also "Mahler's Guide to Basic Ratemaking."
[65] Reinsurers call data grouped by when a reinsurance treaty becomes effective, Underwriting Year data.
[66] Insurers differ in how they code multiyear policies; some insurers code them as separate annual policies.
[67] Such as a shift from full coverage to large deductible policies, or a new emphasis on certain classes of business. A rate change could lead to a change in expected claim ratios and possibly a change in the type of policyholder insured.

Calendar Year vs. Accident Year vs. Policy Year:

**Policy Year data provides the best match between premiums and losses, but at the cost of taking longer to be available**.

**Calendar Year data provides the worst match between premiums and losses, but has the advantage of becoming available sooner**.

**Accident Year data has a better match between premiums and losses than Calendar Year, but not as good a match as Policy Year**.[68]
**Accident Year data is available sooner than Policy Year, but not as soon as Calendar Year**.

For example, Calendar Year 2020 data would be available very early in 2021. It would be final; Calendar data does not develop.

The earned premiums would be from a mixture of 2020, 2019, and possibly 2018 policies. The reported losses would be those paid during 2020 plus the change in reserves during 2020. These losses would be from claims on a mixture of many years of policies from 2020 and prior. The claims would on average be from older policies than the premiums. The written premiums would be mostly from 2020 policies.[69] The paid losses would be those paid during 2020. These losses would be from claims on a mixture of many years of policies from 2020 and prior.

Accident Year 2020 data would be available early in 2021, at first report (as of December 31, 2020). However, it would be subject to development.[70] AY2020 at second report (as of December 31, 2021) would be available early in 2022.

The earned premiums would be from a mixture of 2020, 2019, and possibly 2018 policies. The reported losses would be from accidents that occurred during 2020. The claims would on average be from the same period as the premiums are earned. For example, Calendar Year 2020 earned premiums would include 1/4 of the premium from an annual policy with effective date of October 1, 2020. On average Accident Year 2020 losses would include 1/4 of the losses from this policy. In this manner, we can match up portions of policies with each other.[71]

Policy Year 2020 data would be available early in 2022, at first report (as of December 31, 2021).[72] It would be subject to development.[73] PY2020 at second report (as of December 31, 2022) would be available early in 2023. The earned premiums would be from 2020 policies. The reported losses would be from claims covered by those exact same policies.

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[68] However, for self-insurers, calendar year premiums do represent an exact match with the accident year claims.
[69] Endorsements and cancellations on policies written in 2019 can contribute to the 2020 written premium.
[70] Premiums develop for lines with premium audits. For some lines of insurance there is a lot of loss development.
[71] For a line of insurance with audits, this match is worse; audits from older policies will be included in CY2020 premiums, while audits from 2020 policies will be in later Calendar Years.
[72] An annual policy written 12/31/20 would expire on 12/30/21.
[73] Premiums develop for lines with premium audits. For some lines of insurance there is a lot of loss development.

Report Year Data:[74]

Report year claims consists of those claims reported to an insurer during a given year.[75]
For example, Report Year 2024 consists of all claims reported during 2024.
These claims are from accidents occurring in many different years and covered by policies effective in many different years.

In claims-made coverage, the coverage depends on the date the claim is reported to the insurer.[76] [77] [78] Claims-made coverage is commonly used for lines of insurance, such as medical malpractice, products liability, errors and omission, and directors' and officers' liability.

Report Year data can be used to estimate the ultimate value of known claims. Thus Report Year data is useful for loss reserving claims-made policies, which do not have pure IBNR.

Report year data can also be used to test the adequacy of case reserves on known claims over time.

Advantages of Report Year Data:

- The number of claim counts is fixed at the close of the year.[79]
- More stable data than Accident Year data.
- More determinable development patterns than Accident Year data.

Disadvantage of Report Year Data:

- Only measures development on known claims and not pure IBNR.[80]

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[74] See also "Mahler's Guide to Basic Ratemaking."
[75] There are not Report Years premiums/exposures.
[76] See "Mahler's Guide to Basic Ratemaking" and Basic Ratemaking.
[77] For some claims-made policies, the notification date rather than the report date triggers the coverage.
[78] Some claims-made policies have extended reporting endorsements that may not be coded as a new policy, and hence development beyond 12 months may be possible even for annual policies.
[79] Other than for claims reported but not yet recorded.
[80] Other data would be needed to estimate Pure IBNR.

*Verification of Data:*

Actuaries should verify that the data utilized is reliable and sufficient for its intended purpose. This may include the following steps:
- Consistency with financial statement data
- Consistency with prior data
- Data reasonableness
- Data definitions: the actuary should know how each of the data items is defined
- Discussions with auditors

*Multiple Currencies:*

Claims data for some insurers may be in different currencies.[81] An actuary could separately analyze the data by currency, and then combine the separately estimated reserves all converted to a single currency.

External Data:

Actuaries often use sources of data external to an insurer in addition to internally-generated data. This is most common for small insurers, or when an insurer is entering a new line of insurance or a new region. External information can be particularly valuable when selecting tail development factors, trend rates, and expected claim ratios. External information can also help to make a final selection of ultimate claims and an unpaid claim estimate among estimates using different techniques.

**Generally internal data is preferable to external data**. External data may be inappropriate due to differences relating to: insurance products, case reserves, claim settlement practices, the insurers' operations, coding, geographic areas, mix of business, and product types.
The actuary must carefully evaluate the relevance and value of external data.

*Sources of External Data:*

Examples of external sources of information available in the United States:
- Insurance Services Office, Inc. (ISO)
- National Council on Compensation Insurance (NCCI)
- Reinsurance Association of America (RAA)
- The Surety & Fidelity Association of America (SFAA)
- A.M. Best Company (Best)
- NAIC Annual Statement data

[81] For example, there may be data in U.S. Dollars, Canadian Dollars, and Mexican Pesos.

Problems:

**3.1.** (10 points) There are three annual policies, each with $24,000 in premium.
Policy A: Effective Date March 1, 2025.
Claim #1: Accident Date June 1, 2025
Report Date August 1 2025
Reserve as of December 31, 2025: $8000
$6000 paid on May 1, 2026 and the claim is closed.
Claim #2: Accident Date September 1, 2025
Report Date October 1, 2025
Reserve as of December 31, 2025: $5000
Reserve as of December 31, 2026: $10,000
$12,000 paid on April 1, 2027 and the claim is closed.
Claim #3: Accident Date February 1, 2026
Report Date May 1, 2026
$2000 paid on July 1, 2026 and the claim is closed.
Policy B: Effective Date September 1, 2025.
Claim #4 Accident Date November 1, 2025.
Report Date March 1, 2026
$7000 paid on April 1, 2026 and the claim is closed.
Policy C: Effective Date March 1, 2026.
Claim #5: Accident Date May 1, 2026
Report Date December 1, 2026
Reserve as of December 31, 2026: $15,000
$20,000 paid on March 1, 2027 and the claim is closed.
Claim #6: Accident Date July 1, 2027
Report Date August 1, 2027
$4000 paid September 1, 2027 and the claim is closed.
(a) Determine the written premiums for Calendar Year 2026.
(b) Determine the earned premiums for Calendar Year 2026.
(c) Determine the paid losses for Calendar Year 2026.
(d) Determine the reported losses for Calendar Year 2026.
(e) Determine the paid losses for Accident Year 2026 as of December 31, 2026.
(f) Determine the paid losses for Accident Year 2026 at ultimate.
(g) Determine the reported losses for Accident Year 2026 as of December 31, 2026.
(h) Determine the reported losses for Accident Year 2026 at ultimate.
(i) Determine the written premiums for Policy Year 2026.
(j) Determine the earned premiums for Policy Year 2026, as of December 31, 2026.
(k) Determine the earned premiums for Policy Year 2026 at ultimate.
(l) Determine the paid losses for Policy Year 2026 as of December 31, 2026.
(m) Determine the paid losses for Policy Year 2026 at ultimate.
(n) Determine the reported losses for Policy Year 2026 as of December 31, 2026.
(o) Determine the reported losses for Policy Year 2026 at ultimate.
(p) Determine the paid losses for Report Year 2026 as of December 31, 2026.
(q) Determine the paid losses for Report Year 2026 at ultimate.
(r) Determine the reported losses for Report Year 2026 as of December 31, 2026.
(s) Determine the reported losses for Report Year 2026 at ultimate.

**3.2.** (1.5 points) Given the following information about two lines of insurance:

| Accident Year | Commercial Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2021 | 20,000 | 29,000 | 33,000 | 36,000 |
| 2022 | 22,000 | 32,000 | 37,000 | |
| 2023 | 23,000 | 33,000 | | |
| 2024 | 24,000 | | | |

| Accident Year | Personal Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2021 | 30,000 | 39,000 | 41,000 | 42,000 |
| 2022 | 35,000 | 45,000 | 48,000 | |
| 2023 | 40,000 | 52,000 | | |
| 2024 | 45,000 | | | |

a. (1 point) Based on the data, fully discuss whether it would be appropriate to combine these two lines of business for estimating unpaid claims.
b. (0.5 point) Briefly describe two additional factors that generally should be considered when deciding whether to combine lines of business for estimating unpaid claims.

**3.3.** (1 point) List four key dates for the organization of claim data.

***3.4.*** (2 points) An actuary is considering combining data from private passenger automobile liability insurance with data from commercial automobile liability insurance in order to estimate unpaid claims. Identify and briefly discuss four characteristics of the data that should be considered before combining these lines of business.

**3.5.** (1 point) List four different types of claims data (dollars of loss).
Do not list ways to aggregate data such as Accident Years.

**3.6.** (2 points) Below are four independent scenarios for estimating ultimate losses as of December 31, 2021. For each, briefly explain why the actuary should not use the data described and identify a more appropriate alternative.

a. (0.5 point) Prior to 2020, all policies for a general liability insurer had a $50,000 policy limit. Effective January 1, 2020, all policies were written with a $100,000 policy limit. The actuary intends to use accident year data.

b. (0.5 point) The rate of growth of earned exposures has decreased dramatically over the past two years, which has changed the average accident date significantly. The actuary intends to use accident year data.

c. (0.5 point) An auto liability claim with both bodily injury and property damage payments or case reserves would have counted as two claim counts prior to 2020 and is now recorded as one. The actuary intends to use claim counts as an exposure base.

d. (0.5 point) The insurer writes general liability coverage in one state only. The average severity of litigated claims reported after January 1, 2020 is 70% of the value of claims reported prior to January 1, 2020. The actuary intends to use accident year data.

**3.7.** (1 point) List four different types of claim count data.
Do not list ways to aggregate data such as Accident Years.

**3.8.** (1 point) An insurance company has the following information available for the four different geographic regions within the same line of business:

| | Earned Exposures by Accident Year (000) | | |
|---|---|---|---|
| Region | 2021 | 2022 | 2023 |
| 1 | 31 | 33 | 37 |
| 2 | 6 | 10 | 15 |
| 3 | 3 | 3 | 4 |
| 4 | 19 | 18 | 19 |

| Observed Average Age to Age Paid Claim Development Factors (Age in Months) | | | | | |
|---|---|---|---|---|---|
| Region | 12-24 | 24-36 | 36-48 | 48-60 | 60-Ult |
| 1 | 6.70 | 2.90 | 1.70 | 1.20 | 1.10 |
| 2 | 5.20 | 2.10 | 1.40 | 1.20 | 1.05 |
| 3 | 3.10 | 1.60 | 1.30 | 1.10 | 1.03 |
| 4 | 3.00 | 1.70 | 1.20 | 1.10 | 1.03 |

Justify an appropriate grouping of the regional data for estimating the insurer's unpaid claims for the total book of business.

***3.9.*** (1 point) List four things an actuary should consider when establishing the large claim threshold.

**3.10.** (1.5 points) Compare and contrast Calendar Year data versus Accident Year data versus Policy Year data with respect to:
● The match between premiums/exposures and claims.
● Timeliness.

**3.11.** (2 points) Rick and Morty are actuaries, who are each performing a reserve analysis for a small insurance company. In order to enhance credibility:
● Rick supplements internal data with industry data separately by line of business.
● Morty relies only on internal data, aggregated across all lines of business.
Describe the benefits and deficiencies of each of these two strategies.

**3.12.** (1 point) List four lines of insurance and the corresponding exposure bases.

**3.13.** (1 point) Company A and Company B have recently merged.
Before the merger:
● Both companies are monoline private passenger automobile insurance carriers.
● Both companies use the reported claim development technique to estimate ultimate claims.
After the merger:
● The actuary performing the reserve review has combined the claims data for the two companies.
● The actuary is estimating ultimate claims using the reported claim development technique.
a. (0.5 points) Briefly describe two arguments for the approach taken after the merger.
b. (0.5 points) Briefly describe two potential deficiencies of the approach taken after the merger.

**3.14.** (2 points) Claims data can be aggregated in several different ways:
i. Calendar year
ii. Calendar/accident year
iii. Policy year
iv. Report year
Provide one advantage and one disadvantage of each for use in loss reserving.

**3.15.** (1 point) An insurer writes private passenger automobile liability coverage in two states. Given the following bodily injury (BI) and property damage (PD) information as of December 31, 2024:

| State A: | | | | | State B: | | | |
|---|---|---|---|---|---|---|---|---|
| Accident Year | Earned Exposure | Ultimate Claim Count | | | Accident Year | Earned Exposure | Ultimate Claim Count | |
| | | BI | PD | | | | BI | PD |
| 2022 | 7000 | 45 | 130 | | 2022 | 20,000 | 170 | 600 |
| 2023 | 7500 | 46 | 140 | | 2023 | 20,400 | 180 | 620 |
| 2024 | 8100 | 47 | 150 | | 2024 | 20,900 | 190 | 650 |
| | | | | | | | | |
| Paid Age-to-Ultimate Factors | | | | | Paid Age-to-Ultimate Factors | | | |
| Coverage | 12-to-Ult | 24-to-Ult | 36-to-Ult | | Coverage | 12-to-Ult | 24-to-Ult | 36-to-Ult |
| BI | 4.00 | 1.80 | 1.30 | | BI | 8.00 | 2.30 | 1.50 |
| PD | 1.25 | 1.04 | 1.00 | | PD | 1.37 | 1.08 | 1.00 |
| | | | | | | | | |
| Coverage | Ultimate Severity | | | | Coverage | Ultimate Severity | | |
| BI | 20,000 | | | | BI | 13,000 | | |
| PD | 7,000 | | | | PD | 5,000 | | |

a. (0.5 point) Discuss an argument for performing a bodily injury and property damage combined unpaid claims analysis for state A.
b. (0.5 point) Discuss an argument against performing an all-state combined unpaid claims analysis for bodily injury.

**3.16.** (1 point) List four characteristics to consider when separating data into groups for an analysis of unpaid claims.

**3.17. (6, 11/02, Q.1)** (1 point)
An insurance company has 40 open claims as of December 31, 2000.
Each has the same formula reserve of $6,250.
The following is a breakdown of activity on these claims during the 2001 calendar year.
● 5 claims closed with payment for a total of $80,000 in payments.
● 5 claims closed without payment.
● 5 claims with a partial payment of $2,500 each, with a corresponding reserve decrease on each claim of $2,500.
● 5 claims with a partial payment of $5,000 each, with each of these 5 claims having a reserve increase to $10,000.
● 20 claims remain open with no payment or reserve activity.
● Received unanticipated salvage and subrogation recoveries amounting to $5,000 in total.
What is the reported loss for these 40 claims for calendar year 2001?
A. Less than $30,000
B. At least $30,000, but less than $50,000
C. At least $50,000, but less than $70,000
D. At least $70,000, but less than $90,000
E. At least $90,000

*__3.18.* (6, 11/06, Q.13)__ (2 points)
Briefly describe each phase of the overall approach to a reserve valuation problem.

**3.19. (6, 11/10, Q.13)** (1.5 points) Given the following information about two lines of insurance:

| Accident Year | Commercial Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2006 | 10,000 | 14,000 | 16,800 | 18,480 |
| 2007 | 15,000 | 21,000 | 25,200 | |
| 2008 | 20,000 | 28,000 | | |
| 2009 | 25,000 | | | |

| Accident Year | Personal Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2006 | 10,000 | 12,000 | 13,200 | 13,332 |
| 2007 | 11,000 | 13,200 | 14,520 | |
| 2008 | 12,000 | 14,400 | | |
| 2009 | 13,000 | | | |

a. (1 point) Based on the data, provide two reasons why it would be inappropriate to combine these two lines of business for estimating unpaid claims.
b. (0.5 point) Briefly describe two additional factors that generally should be considered when deciding whether to combine lines of business for estimating unpaid claims.

**3.20. (5, 5/11, Q.21)** (2 points) A large insurer is considering combining data from a long-tailed, low-frequency line of business with data from a short-tailed, high-frequency line of business to estimate unpaid claims. Identify and briefly discuss four characteristics of the data that should be considered before combining these lines of business.

**3.21. (5, 5/12, Q.16)** (2 points) Below are four independent scenarios for estimating ultimate losses as of December 31, 2011. For each, briefly explain why the actuary should not use the data described and identify a more appropriate alternative.

a. (0.5 point) Prior to 2010, all policies for a property insurer had a $1,000 deductible. Effective January 1, 2010, all policies were written with a $5,000 deductible. The actuary intends to use accident year data.

b. (0.5 point) The insurer writes general liability coverage in one state only. The average severity of litigated claims reported after January 1, 2010 is twice the value of claims reported prior to January 1, 2010. The actuary intends to use accident year data.

c. (0.5 point) A general liability claim with both bodily injury and property damage case estimates would have counted as one claim count prior to 2010 and is recorded as two. The actuary intends to use claim counts as an exposure base.

d. (0.5 point) The rate of growth of earned exposures has increased dramatically over the past two years, which has changed the average accident date significantly. The actuary intends to use accident year data.

**3.22. (5, 5/14, Q.12)** (1 point) An insurance company has the following information available for the four different geographic regions within the same line of business:

| | Earned Exposures by Accident Year | | | Ultimate Claim Counts by Accident Year | | |
|---|---|---|---|---|---|---|
| Region | 2011 | 2012 | 2013 | 2011 | 2012 | 2013 |
| 1 | 21,900 | 22,560 | 22,125 | 2,075 | 2,143 | 2,010 |
| 2 | 2,575 | 2,460 | 2,520 | 126 | 124 | 125 |
| 3 | 18,000 | 17,460 | 17,800 | 880 | 895 | 877 |
| 4 | 4,450 | 10,720 | 27,500 | 227 | 580 | 1,330 |

| Observed Average Age to Age Paid Claim Development Factors (Age in Months) | | | | | |
|---|---|---|---|---|---|
| Region | 12-24 | 24-36 | 36-48 | 48-60 | 60-Ult |
| 1 | 7.67 | 3.07 | 1.75 | 1.30 | 1.10 |
| 2 | 3.20 | 1.70 | 1.28 | 1.10 | 1.06 |
| 3 | 3.19 | 1.73 | 1.31 | 1.12 | 1.04 |
| 4 | 4.10 | 2.28 | 1.52 | 1.05 | 1.03 |

Justify an appropriate grouping of the regional data for estimating the insurer's unpaid claims for the total book of business.

**3.23. (5, 11/16, Q.17)** (2 points) Actuary A and Actuary B are each performing a reserve analysis for a small insurance company. To enhance credibility:
● Actuary A relies only on internal data, aggregated across all lines of business.
● Actuary B supplements internal data with industry data separately by line of business.
Describe the benefits and deficiencies of each of these two strategies.

**3.24. (5, 5/18 Makeup, Q.14)** (1 point) Company A and Company B have recently merged.
Before the merger:
● Both companies are monoline homeowners' insurance carriers.
● Both companies use the reported claim development technique to estimate ultimate claims.
After the merger:
● The actuary performing the reserve review has combined the claims data for the two companies.
● The actuary is estimating ultimate claims using the reported claim development technique.
a. (0.5 points) Briefly describe two arguments for the approach taken after the merger.
b. (0.5 points) Briefly describe two potential deficiencies of the approach taken after the merger.

**3.25. (5, 5/19, Q.13)** (1.75 points)
An insurer writes private passenger automobile liability coverage in two states.
Given the following bodily injury (BI) and property damage (PD) information as of December 31, 2018:

| State A: | | | | | State B: | | | |
|---|---|---|---|---|---|---|---|---|
| Accident Year | Earned Exposure | Ultimate Claim Count | | | Accident Year | Earned Exposure | Ultimate Claim Count | |
| | | BI | PD | | | | BI | PD |
| 2016 | 36,000 | 50 | 950 | | 2016 | 100,000 | 1,250 | 5,000 |
| 2017 | 37,800 | 60 | 1,140 | | 2017 | 105,000 | 1,300 | 5,200 |
| 2018 | 41,580 | 72 | 1,368 | | 2018 | 110,250 | 1,375 | 5,500 |
| | | | | | | | | |
| Paid Age-to-Ultimate Factors | | | | | Paid Age-to-Ultimate Factors | | | |
| Coverage | 12-to-Ult | 24-to-Ult | 36-to-Ult | | Coverage | 12-to-Ult | 24-to-Ult | 36-to-Ult |
| BI | 5.00 | 1.50 | 1.20 | | BI | 9.00 | 2.10 | 1.30 |
| PD | 1.20 | 1.01 | 1.00 | | PD | 1.30 | 1.01 | 1.00 |
| | | | | | | | | |
| Coverage | Ultimate Severity | | | | Coverage | Ultimate Severity | | |
| BI | 15,000 | | | | BI | 10,000 | | |
| PD | 5,000 | | | | PD | 2,500 | | |

● There is no exposure, claim count, or severity trend.

a. (0.5 point) Discuss an argument for performing a bodily injury and property damage combined unpaid claims analysis for state A.

b. (0.5 point) Discuss an argument against performing an all-state combined unpaid claims analysis for bodily injury.

c. (0.75 point) Fully evaluate management's assertion that state A should be charged a higher premium than state B for bodily injury coverage due to its higher ultimate severity.

Solutions to Problems:

**3.1.** (a) **$24,000** from Policy C.
(b) $4000 from Policy A, $16,000 from B, and $20,000 from C, for a total of **$40,000**.
(c) $6000 from Claim #1, $2000 from #3, and $7000 from Claim #4, for a total of **$15,000**.
(d) $6000 - $8000 = -$2000 from Claim #1, $10,000 - $5000 = $5000 from Claim #2, $2000 from Claim #3, $7000 from Claim #4, and $15,000 from #5, for a total of **$27,000**.
(e) **$2000** from Claim #3.
(f) $2000 from Claim #3, and $20,000 from #5, for a total of **$22,000**.
(g) $2000 from Claim #3, and $15,000 from #5, for a total of **$17,000**.
(h) $2000 from Claim #3, and $20,000 from #5, for a total of **$22,000**.
(At ultimate the Accident Year paid and reported losses are always equal.)
(i) **$24,000** from Policy C.
(If these policies had been subject to premium audits, then the Policy Year 2006 written premium as of 12/31/06 would have differed from its value at ultimate.)
(j) **$20,000** from Policy C.
(k) **$24,000** from Policy C.
(At ultimate the Policy Year written and earned premiums are always equal.)
(l) **$0**.
(m) $20,000 from Claim #5, and $4000 from Claim #6, for a total of **$24,000**.
(n) **$15,000** from Claim #5.
(o) $20,000 from Claim #5, and $4000 from Claim #6, for a total of **$24,000**.
(At ultimate the Policy Year paid and reported losses are always equal.)
(p) $2000 from Claim #3, and $7000 from Claim #4, for a total of **$9000**.
(q) $2000 from Claim #3, $7000 from Claim #4, and $20,000 from Claim #5, for a total of **$29,000**.
(r) $2000 from Claim #3, $7000 from Claim #4, and $15,000 from Claim #5, for a total of **$24,000**.
(s) $2000 from Claim #3, $7000 from Claim #4, and $20,000 from Claim #5, for a total of **$29,000**.
(At ultimate the Report Year paid and reported losses are always equal.)

**3.2.** (a) Compute loss development factors to 48 months for Commercial Automobile.

| Accident Year | Commercial Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2021 | 20,000 | 29,000 | 33,000 | 36,000 |
| 2022 | 22,000 | 32,000 | 37,000 | |
| 2023 | 23,000 | 33,000 | | |
| 2024 | 24,000 | | | |
| | Age to Age Factors | | | |
| 2021 | 1.450 | 1.138 | 1.091 | |
| 2022 | 1.455 | 1.156 | | |
| 2023 | 1.435 | | | |
| Average | 1.446 | 1.147 | 1.091 | |
| To 48 months | 1.810 | 1.251 | 1.091 | 1.000 |

Compute loss development factors to 48 months for Personal Automobile.

| Accident Year | Personal Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2021 | 30,000 | 39,000 | 41,000 | 42,000 |
| 2022 | 35,000 | 45,000 | 48,000 | |
| 2023 | 40,000 | 52,000 | | |
| 2024 | 45,000 | | | |
| | Age to Age Factors | | | |
| 2021 | 1.300 | 1.051 | 1.024 | |
| 2022 | 1.286 | 1.067 | | |
| 2023 | 1.300 | | | |
| Average | 1.295 | 1.059 | 1.024 | |
| To 48 months | 1.405 | 1.085 | 1.024 | 1.000 |

The development factors differ significantly, and Personal Automobile is growing much faster than Commercial Automobile.
Thus combining the two lines would distort the estimate of unpaid claims.
Also each of the data sets has enough data to be credible.

(b) Possible responses (any two):
● Are there similar similar severities.
● Is there similar adequacy of case reserves.
● Are there similar likelihoods of a claim reopening.
● Consistency of the coverage triggered by the claims in the group (i.e., group claims that will generally be subject to the same or similar laws, policy terms, claims handling, etc.)
● Are there similar reporting patterns.
● Are there similar settlement patterns.
Comment: Similar to 6, 11/10, Q.13.

**3.3.** Possible responses (any four):
● Policy effective dates: beginning and end of the policy effective period
● Accident date
● Report date
● Accounting date: an actuary is estimating the unpaid claims or IBNR for accidents on or prior to this date.
● Valuation date: date as of which the data is valued; transactions after this data are excluded.
Comment: See page 38 of Friedland.

**3.4.** Possible responses (any four):
● Credibility: Is there sufficient volume of data in order to estimate unpaid claims separately for the two sets of data?
● Claim settlement rate: Commercial automobile has a slower settlement rate than private passenger automobile. Differences can distort estimates of unpaid claims, particularly if the lines are growing at different rates.
● Severity: Commercial automobile has higher severity than private passenger automobile. Differences can distort estimates of unpaid claims, particularly if the lines are growing at different rates.
● Case reserve adequacy: Review the case reserve philosophy on each line of business. Differences may affect the results of estimated unpaid claims.
● Reporting patterns: Commercial automobile has a somewhat longer average time to report claims than private passenger automobile. Differences can distort estimates of unpaid claims, particularly if the lines are growing at different rates.
● Homogeneity: The two sets of data are dissimilar; the combined data is heterogeneous.
Comment: Similar to 5, 5/11, Q.21.

**3.5.** Possible responses (any four):
● Incremental paid claims
● Cumulative paid claims
● Paid claims on closed claims
● Paid claims on open claims
● Case outstanding
● Reported claims: sum of cumulative paid claims plus case outstanding
● Incremental reported claims
Comment: See page 30 of Friedland.

**3.6.** (a) Accident years prior to 2020 have a $50,000 policy limit apply, while AY 2021 and subsequent have a $100,000 policy limit apply.
AY10 has a mix of accidents to which different policy limits apply.
Thus we have different development patterns.
I would use **policy year** data; each policy year has only one policy limit that applies.
In order to determine development factors to apply to PY20 and PY21, one would need to somehow adjust upwards the development factors based on older data; perhaps industry benchmarks would help.
(b) In more recent AYs, the average accident date is earlier, and thus there is less expected emergence; using development factors based on historical data would overestimate development of recent AYs.
I would use data by **accident quarters** of a year.
(c) The claim counts would have greatly decreased in 2020 compared to previous, even through there was no change in the exposure to loss. (Some but not all auto liability claims involve both property damage and bodily injury.)
Instead **use earned exposures** (caryears) as an exposure base.
Alternately, one could adjust the claim counts in years prior to 2020 to match the current method of counting claims.
(d) Accident reported prior to January 1, 2020 have a different severity than accident reported after January 1, 2020. AY20 and AY21 each have a mix of such claims, and such mix will change as each accident year matures.
I would use **report year** data; each report year has only one level of severity.
Comment: Similar to 5, 5/12, Q.16.

**3.7.** Possible responses (any four):
- Reported claim counts
- Claim counts on closed with payment
- Claim counts on closed with no payment
- Open claim counts
- Reopened claim counts

Comment: See page 30 of Friedland.

**3.8.** Calculate percentages of ultimate paid:

| Observed Average Age to Age Paid Claim Development Factors (Age in Months) | | | | | |
|---|---|---|---|---|---|
| Region | 12-24 | 24-36 | 36-48 | 48-60 | 60-Ult |
| 1 | 6.70 | 2.90 | 1.70 | 1.20 | 1.10 |
| 2 | 5.20 | 2.10 | 1.40 | 1.20 | 1.05 |
| 3 | 3.10 | 1.60 | 1.30 | 1.10 | 1.03 |
| 4 | 3.00 | 1.70 | 1.20 | 1.10 | 1.03 |
| Cumulative Percentage Paid of Ultimate (Age in Months) | | | | | |
| Region | 12 | 24 | 36 | 48 | 60 |
| 1 | 2.3% | 15.4% | 44.6% | 75.8% | 90.9% |
| 2 | 5.2% | 27.0% | 56.7% | 79.4% | 95.2% |
| 3 | 13.7% | 42.4% | 67.9% | 88.3% | 97.1% |
| 4 | 14.4% | 43.3% | 73.6% | 88.3% | 97.1% |

The percentages for Regions 3 and 4 are similar.
The percentages for Region 1 are very different; Region 1 is big enough to stand on its own.
The percentages for Region 2 are different from the other regions, kind of in between.
I am concerned about the small amount of data for Region 2 in AY21; however, there is more data for AY22 and AY23. Region 2 is growing quickly and is sufficiently different in its development pattern that I would keep it separate; grouping Region 2 is likely to distort the analysis. Region 3 has only a small amount of data, I will group it with similar Region 4.
Grouping: **Region 1 by itself, Region 2 by itself, Regions 3 and 4 together**.
Comment: Similar to 5, 5/14, Q.12.

**3.9.** Possible responses (any four):
- Number of claims over the threshold each year
- Size of claim relative to policy limits
- Size of claim relative to reinsurance limits
- Credibility of internal data regarding large claims
- Availability of relevant external data

Comment: See page 32 of Friedland. Similar to 5, 11/15, Q.15a.

**3.10.** Policy Year data provides the best match between premiums/exposures and claims.
Calendar Year data provides the worst match between premiums/exposures and claims.
Accident Year data has a better match between premiums/exposures and claims than Calendar Year, but not as good a match as Policy Year.
Accident Year data is available sooner than Policy Year, but not as soon as Calendar Year.

**3.11.** Rick's Benefits: Supplementing with industry benchmarks will decrease the effect of random fluctuations in the insurer's internal data. Also the data will be more homogeneous, with long tailed lines kept separate from short tailed lines of business.
Rick's Deficiencies: The claims reporting and settlement processes of this insurer may differ from the industry average, which can be a problem when using external data as does Rick. Also, even within a line of business, this insurer's mix of insureds may differ in some significant way from the industry average, resulting in different patterns of development.
Morty's Benefits: The volume of data will increase, which should decrease the effect of random fluctuations. Incorporating company specific data will reflect that insurer's claims handling practices. Also this would reflect this insurer's mix of business.
Morty's Deficiencies: Different lines of insurance have different reporting and settlement patterns; thus this approach could be problematic if the mix of business is changing over time. This is a small company so aggregating all lines might still not be stable enough to produce an accurate estimate.
Comment: Similar to 5, 11/16, Q.17.

**3.12.** Possible responses (any four):

| Line of Insurance | Exposure |
|---|---|
| U.S. workers compensation | Payroll |
| Automobile liability | Number of vehicles or miles driven |
| General liability for public entities | Population or operating expenditures |
| General liability for corporations | Sales or square footage |
| Hospital professional liability | Average occupied beds and outpatient visits |
| Property | Property values |
| Crime | Number of employees |

Comment: See page 35 of Friedland.
There are other possible responses.

**3.13.** (a) Possible Responses:
- The combined data has more credibility. This is particularly important if one of the two companies is small.
- The actuary is getting a weighted average of the individual company's past development patterns, which is a reasonable estimate of how the combined reported claims will emerge.

(b) Possible Responses (any two):
- The two companies may have had different claims handling techniques, which would lead to different settlement rates. Using combined data would mask this difference.
- The two companies may have had different case reserving philosophies. Using combined data would mask this difference.
- The companies may be growing at different rates. In which case, if their development patterns are different, the historical development patterns of the combined data will not be reflective of the future emergence of reported losses.
- The two companies may have had different percentages of property versus liability losses. This would lead to different development patterns for the two companies. Using combined data would mask this difference.

Comment: Similar to 5, 5/18 Makeup Exam, Q.14.

**3.14.** Advantages of Calendar Year Data (any one):
- There is no future development. The values remains fixed at the end of the calendar year.
- Since insurers conduct financial reporting on a calendar year basis, this data is readily available.

Disadvantage of Calendar Year Data:
- The fixed nature of calendar year data means that it can not be used to measure loss development.

Advantages of Accident Year Data (any one):
- Easy to obtain.
- Easy to understand.
- Represents claims occurring over a shorter time frame than for policy year data. Thus Accident Year data matures more quickly than Policy Year data.
- Numerous industry benchmarks are available.
- Valuable when there is a change due to economic or regulatory forces.
- Valuable when there are major claim events.

Disadvantages of Accident Year Data (any one):
- Mismatch between claims and premiums/exposures.
- Includes claims from policies at more varied times than policy year data.
- For self-insureds with high deductibles, it can mask changes in retention levels and/or changes in insurers or reinsurers.

Advantages of Policy Year Data (any one):
- Match between claims and premiums/exposures.
- Valuable when underwriting or pricing changes occur.
- Useful for self-insureds where only one policy may apply.

Disadvantages of Policy Year Data (any one):
- The extended time frame; a longer time until the ultimate claims can be reliably estimated.
- Can make it difficult to understand and isolate the effect of a catastrophe.
- Can make it difficult to understand and isolate the effect of a major court ruling.

Advantages of Report Year Data (any one):
- The number of claim counts is fixed at the close of the year.
- More stable data than Accident Year data.
- More determinable development patterns than Accident Year data.

Disadvantage of Report Year Data:
- Only measures development on known claims and not pure IBNR.

**3.15.** (a) In State A there is relatively little BI experience; there are many fewer claims than for PD with a higher severity and thus small credibility.
Combining the BI data with the PD data would result in more credibility.
(b) The age-to-age factors differ greatly between the two states.
Also State A has 1.54 times the severity of State B.
Also State A is growing faster than State B.
Comment: Similar to 5, 5/19, Q.13a&b.

**3.16.** Possible responses (any four):
- Credibility: volume of data in each subgroup
- Similar Reporting Patterns
- Similar Settlement Patterns
- Similar Severity
- Similar Adequacy of Case Reserves
- Similar Likelihood of a Claim Reopening
- Consistency of the coverage triggered by the claims in the group (i.e., group claims that will generally be subject to the same or similar laws, policy terms, claims handling, etc.)

Comment: See page 29 of Friedland.
An actuary wants to divide the data into sufficiently homogeneous groups while maintaining sufficient credibility of the data.

**3.17. C.** The case reserves at the beginning of 2001 are: (40)(6250) = $250,000.
Losses paid during 2001: 80,000 + (5)(2500) + (5)(5000) = $117,500.
$5000 in salvage and subrogation in 2001.
The case reserves at the end of 2001 are:
(5)(6250-2500) + (5)(10,000) + (20)(6250) = $193,750.
CY01 reported losses: 117,500 + 193,750 - 250,000 - 5000 = **$56,250**.
Alternately, for the first 5 claims CY01 reported losses: 80,000 - (5)(6250) = $48,750.
For the next 5 claims CY01 reported losses: (5)(-6250) = -$31,250.
For the next 5 claims CY01 reported losses: 0
For the next 5 claims CY01 reported losses: (5) {5000 + (10,000 - 6250)} = $43,750.
For the final 20 claims CY01 reported losses: 0.
$5000 in salvage and subrogation in 2001.
CY01 reported losses: 48,750 - 31,250 + 43,750 - 5000 = **$56,250**.

**3.18.** The four-phase approach to the process of estimating unpaid claims:
- **Exploring the data** to identify its key characteristics and possible anomalies. Balancing data to other verified sources should be undertaken at this point.
- **Applying appropriate techniques for estimating unpaid claims**.
- **Evaluating** the conflicting results of the various methods used, with an attempt to reconcile or explain the different outcomes. At this point, the projected ultimate amounts are evaluated in contexts outside their original frame of analysis.
- **Monitoring** projections of claim development over subsequent calendar periods. Deviations of actual development from projected development of counts or amounts are one of the most useful diagnostic tools in evaluating the accuracy of unpaid claim estimates.

Comment: See Page 27 of Friedland; she is referring to the chapter on loss reserving in Foundations of Casualty Actuarial Science.
The four phases are: review the data, apply the reserving techniques, compare results and choose an indicated reserve, and monitor results.

**3.19.** (a) Compute loss development factors to 48 months for Commercial Automobile.

| Accident Year | Commercial Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2006 | 10,000 | 14,000 | 16,800 | 18,480 |
| 2007 | 15,000 | 21,000 | 25,200 | |
| 2008 | 20,000 | 28,000 | | |
| 2009 | 25,000 | | | |
| | Age to Age Factors | | | |
| 2006 | 1.4 | 1.2 | 1.1 | |
| 2007 | 1.4 | 1.2 | | |
| 2008 | 1.4 | | | |
| Average | 1.4 | 1.2 | 1.1 | |
| To 48 months | 1.848 | 1.32 | 1.1 | 1 |

Compute loss development factors to 48 months for Personal Automobile.

| Accident Year | Personal Auto Property Damage Reported Claims ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2006 | 10,000 | 12,000 | 13,200 | 13,332 |
| 2007 | 11,000 | 13,200 | 14,520 | |
| 2008 | 12,000 | 14,400 | | |
| 2009 | 13,000 | | | |
| | Age to Age Factors | | | |
| 2006 | 1.2 | 1.1 | 1.01 | |
| 2007 | 1.2 | 1.1 | | |
| 2008 | 1.2 | | | |
| Average | 1.2 | 1.1 | 1.01 | |
| To 48 months | 1.3332 | 1.111 | 1.01 | 1 |

The development factors differ significantly, and Commercial Automobile is growing much faster than Personal Automobile.
Thus combining the two lines would distort the estimate of unpaid claims.
Also each of the data sets has enough data to be credible.

(b) Possible responses (any two):
- Are there similar similar severities.
- Is there similar adequacy of case reserves.
- Are there similar likelihoods of a claim reopening.
- Consistency of the coverage triggered by the claims in the group (i.e., group claims that will generally be subject to the same or similar laws, policy terms, claims handling, etc.)
- Are there similar reporting patterns.
- Are there similar settlement patterns.

Comment: Differences in reporting patterns, settlement patterns, and adequacy of case reserves combine to result in different loss development patterns.

**3.20.** Possible responses (any four):
- Credibility: Is there sufficient volume of data in order to estimate unpaid claims separately for the two sets of data?
- Claim settlement rate: The long-tailed line has a slower settlement rate than the short-tailed line. Differences can distort estimates of unpaid claims, particularly if the lines are growing at different rates.
- Severity: Usually long-tailed low-frequency lines have higher severity than short-tailed high frequency lines. Differences can distort estimates of unpaid claims, particularly if the lines are growing at different rates.
- Case reserve adequacy: Review the case reserve philosophy on each line of business. Differences may affect the results of estimated unpaid claims.
- Reporting patterns: The long-tailed line probably has a longer average time to report claims than the short-tailed line. Differences can distort estimates of unpaid claims, particularly if the lines are growing at different rates.
- Homogeneity: The two sets of data are dissimilar; the combined data is heterogeneous.

Comment: The CAS Examiners' Report only contains the first four responses.

**3.21.** (a) Accident years prior to 2010 have a $1000 deductible apply, while AY 2011 and subsequent have a $5000 deductible apply.
AY10 has a mix of accidents to which a $1000 and $5000 deductible apply.
Thus we have different development patterns.
I would use **policy year** data; each policy year has only one deductible that applies.
In order to determine development factors that apply to PY10 and PY11, one would need to adjust older years to a $5000 deductible basis.
(b) Accident reported prior to January 1, 2010 have a different severity than accident reported after January 1, 2010. AY10 and AY11 each have a mix of such claims, and such mix will change as each accident year matures.
I would use **report year** data; each report year has only one level of severity.
(c) The claim counts would have greatly increased in 2010 compared to previous, even through there was no change in the exposure to loss. (Some but not all general liability claims involve both property damage and bodily injury.)
Instead **use earned exposures** (sales or payroll) as an exposure base.
Alternately, one could adjust the claim counts in years prior to 2010 to match the current method of counting claims.
(d) In more recent AYs, the average accident date is later, and thus there is more expected emergence; using development factors based on historical data would underestimate development of recent AYs.
I would use data by **accident quarters** of a year.

**3.22.** Calculate Claim Frequencies (not necessary for full credit):

| | Earned Exposures by Accident Year | | | Ultimate Claim Counts by Accident Year | | |
|---|---|---|---|---|---|---|
| Region | 2011 | 2012 | 2013 | 2011 | 2012 | 2013 |
| 1 | 21,900 | 22,560 | 22,125 | 2,075 | 2,143 | 2,010 |
| 2 | 2,575 | 2,460 | 2,520 | 126 | 124 | 125 |
| 3 | 18,000 | 17,460 | 17,800 | 880 | 895 | 877 |
| 4 | 4,450 | 10,720 | 27,500 | 227 | 580 | 1,330 |
| | Claim Frequency by AY | | | | | |
| Region | 2011 | 2012 | 2013 | | | |
| 1 | 9.5% | 9.5% | 9.1% | | | |
| 2 | 4.9% | 5.0% | 5.0% | | | |
| 3 | 4.9% | 5.1% | 4.9% | | | |
| 4 | 5.1% | 5.4% | 4.8% | | | |

The frequencies for Regions 2, 3, and 4 are similar, while that for Region 1 is much different.
Calculate percentages of ultimate paid:

| Observed Average Age to Age Paid Claim Development Factors (Age in Months) | | | | | |
|---|---|---|---|---|---|
| Region | 12-24 | 24-36 | 36-48 | 48-60 | 60-Ult |
| 1 | 7.67 | 3.07 | 1.75 | 1.30 | 1.10 |
| 2 | 3.20 | 1.70 | 1.28 | 1.10 | 1.06 |
| 3 | 3.19 | 1.73 | 1.31 | 1.12 | 1.04 |
| 4 | 4.10 | 2.28 | 1.52 | 1.05 | 1.03 |
| Cumulative Percentage Paid of Ultimate (Age in Months) | | | | | |
| Region | 12 | 24 | 36 | 48 | 60 |
| 1 | 1.7% | 13.0% | 40.0% | 69.9% | 90.9% |
| 2 | 12.3% | 39.4% | 67.0% | 85.8% | 94.3% |
| 3 | 11.9% | 37.9% | 65.5% | 85.9% | 96.2% |
| 4 | 6.5% | 26.7% | 60.8% | 92.5% | 97.1% |

The percentages for Regions 2 and 3 are similar.
The percentages for Region 1 are very different; Region 1 is big enough to stand on its own.
The percentages for Region 4 are different from the other regions, kind of in between.
I am concerned about the small amount of data for Region 4 in AY11; however, there is more data for AY12 and AY13. Region 4 is growing quickly and is sufficiently different in its development pattern that I would keep it separate; grouping Region 4 is likely to distort the analysis. Region 2 has only a small amount of data, I will group it with similar Region 3.
Grouping: **Region 1 by itself, Regions 2 and 3 together, Region 4 by itself**.
Comment: Even though the frequencies for Regions 2, 3, and 4 are similar, the development pattern for Region 4 is significantly different.

**3.23.** Actuary A Benefits: The volume of data will increase, which should decrease the effect of random fluctuations. Incorporating company specific data will reflect that insurer's claims handling practices. Also this would reflect this insurer's mix of business.
Actuary A Deficiencies: Different lines of insurance have different reporting and settlement patterns; thus this approach could be problematic if the mix of business is changing over time. This is a small company so aggregating all lines might still not be stable enough to produce an accurate estimate.
Actuary B Benefits: Supplementing with industry benchmarks will decrease the effect of random fluctuations in the insurer's internal data. Also the data will be more homogeneous, with long tailed lines kept separate from short tailed lines of business.
Actuary B Deficiencies: The claims reporting and settlement processes of this insurer may differ from the industry average, which can be a problem when using external data as does Actuary B. Also, even within a line of business, this insurer's mix of insureds may differ in some significant way from the industry average, resulting in different patterns of development.

**3.24.** (a) Possible Responses:
- The combined data has more credibility. This is particularly important if one of the two companies is small.
- The actuary is getting a weighted average of the individual company's past development patterns, which is a reasonable estimate of how the combined reported claims will emerge.

(b) Possible Responses (any two):
- The two companies may have had different claims handling techniques, which would lead to different settlement rates. Using combined data would mask this difference.
- The two companies may have had different case reserving philosophies. Using combined data would mask this difference.
- The companies may be growing at different rates. In which case, if their development patterns are different, the historical development patterns of the combined data will not be reflective of the future emergence of reported losses.
- The two companies may have had different percentages of property versus liability losses. This would lead to different development patterns for the two companies. Using combined data would mask this difference.

Comment: For part (a), the CAS Sample Solutions had as a possible response:
**"**Combining the two data sets will produce more stable development factors and results if data was volatile or there were large losses for one of the companies."
I think this is very similar to the idea of more credibility.
"Since homeowners' insurance are typically short tailed, using a reported technique which works with high frequency and low severity claims would be good."
I do not think this has anything to with whether or not one should use merged data;
in both cases the reported claim development technique is to be used.
For part (b), the CAS Sample Solutions had as a possible response:
"If the company has operated in different states and the characteristics of the claims are different due to limits, regulations, the data shouldn't be combined."
I do not think this is likely to be important for homeowners' insurance in most situations.

**3.25.** (a) In State A there is relatively little BI experience; there are many fewer claims than for PD with a higher severity and thus small credibility.
Combining the BI data with the PD data would result in more credibility.
(b) The age-to-age factors differ greatly between the two states.
Also State A has 1.5 times the severity of State B.
Also State A is growing faster than State B.
(c) The estimated BI pure premiums for State A by AY:
(50)(15,000) / 36,000 = 20.83, (60)(15,000) / 37,800 = 23.81, (72)(15,000) / 41,580 = 25.97.
The estimated BI pure premiums for State B by AY:
(1250)(10,000)/100,000 = 125.00, (1300)(10,000)/105,000 = 123.81,
(1375)(10,000)/110,250 = 124.72.
While State A has an estimated higher severity, State B has a much higher frequency.
This results in State B having a much higher pure premium; State B rather than State A has a higher indicated rate for bodily injury coverage.

## *Section 4, Meeting with Management*

A reserving analysis should include both a review of quantitative data and discussions with key members of the claim and underwriting departments.[82] An actuary needs to talk with those involved in the claims and underwriting processes that underlie the data.[83]

An actuary who is an employee of an insurer or reinsurer should be in regular contact with people in all other departments.[84] An outside consulting actuary may have to go through a more formal process.

Understanding the Environment:

An actuary should understand the environment, both internal and external to the insurer. Among those items that can be important:[85]
- Classes of business written or geographical focus.
- Policy provisions such as policy limits and deductibles.
- Reinsurance arrangements including limits and attachment points.[86]
- A change in claims management philosophy that often occur when managerial changes occur.
- Claims processing lags that may occur when a new technology is implemented within an insurer or when claim department staffing is disrupted.[87]
- Changes in the legal and social environment.[88]
- Changes in the economic environment.[89]

Questions for Management:

Friedland presents several list of questions to ask executives of different departments.[90] For your exam, it would not hurt to try to remember a question or two from each of the important categories.

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[82] This applies to both reserving and ratemaking.
[83] For simplicity, Friedland uses “management” to refer to those involved in or in charge of the claims and underwriting processes.
[84] After you work at a company for a while you should have developed a network of people around the company who know they can ask you questions and who you can ask questions of in turn.
[85] See page 44 of Friedland.
[86] An excess of loss reinsurance treaty with an attachment point of $1 million and a limit of $4 million covers the layer from $1 million to $5 million. Such an excess treaty would be denoted $4M xs $1M.
[87] For example in the event of a merger of insurers or a major catastrophe that temporarily overwhelms the claim department’s capacity.
[88] For example, the introduction of no-fault automobile insurance, back-logs in the court systems, new court rulings, or the implementation of tort reform measures.
[89] For example, a change in the rate of inflation or a change in interest rates.
[90] Most are from the paper by Berquist and Sherman, as later supplemented by Richard Sherman.
The loss reserving techniques in the paper by Berquist and Sherman will be discussed in a subsequent section.

Questions for a Claims Executive:

- What specific objectives and guidelines does your department have in setting unpaid case? Are unpaid case established on the basis of what it would cost to settle the case today, or has a provision for inflation between now and the estimated time of settlement of the claim been included in the case outstanding?
- **Have there been any significant changes in the guidelines for setting and reviewing unpaid case during the last five years**?
- Have there been any changes in the definitions of or rules for establishing bulk or formula reserves for reported claims in the last five years?
- Are any special procedures or guidelines applied in the reserving of large or catastrophic claims? If so, please describe.
- **Has the size of the caseload of the average claims adjuster changed significantly in the past several years**?
- When, in the sequence of events, is a claim file established?
- Is a claim file established for each claimant or for each accident? What procedures are followed when there are multiple claimants from the same accident? Is a claim file established for each coverage or for all coverages combined?
- What procedures are followed in recording reopened claims? Are such claims coded to the report date of the original claim or to the date of reopening? How will the reopening of a claim affect aggregate data for paid, open or reported claims and paid, outstanding or incurred losses?
- Have there been any noticeable shifts in the reporting or non-reporting of very small or trivial claims? In the procedures for the recording of such?
- Has there been any shift in emphasis in settling large versus small claims? In the relative proportion of such claims? In attitudes in adjusting such claims?
- Have there been any changes in the guidelines on when to close a claim? For example, is a property damage claim kept open until the associated bodily injury claim is closed, or only until the property damage portion is settled?
- **Have there been any noticeable changes in the rate of settlement of claims recently**?
- Has there been any shift from the employment of company adjusters to independent adjusters? Or vice versa? If so, how has this affected the operations of the claims department?
- Has there been any change in the timing of the payment of allocated loss adjustment expenses? For example, are such payments made as these expenses are accrued (or incurred) or when the claim is closed?
- Has there been any change in the definition and limit for one-shot or fast-track claims in recent years? What is that limit?
- What safeguards against fraudulent claims are now employed? Are any special procedures followed in the event of the filing of apparently questionable or non-meritorious claims? Have these safeguards changed in recent years?
- Have there been any shifts toward (or away from) the more vigorous defense of suits in recent years?
- Could you provide copies of all bulletins to the field issued in the last five years in which details of the changes in claims procedures are provided?
- Could you provide copies of recent claim audits?

- For workers compensation, what mortality table was used (year and general population or disabled lives table) to set the unpaid case for permanently disabled claimants?
- For large open claims, has there been any revision in the reserve since the latest evaluation date of the claims experience?
- **Are unpaid case set at an expected level, the most likely settlement amount, or the minimum possible amount (or some other standard)**?

Questions for an Underwriting Executive:

- **What significant changes have occurred in your company's book of business and mix of business in the past five to seven years**?
  How are the risks insured today different from those of the past?
- Do you underwrite any large risks which are not characteristic of your general book of business?
- **Have any significant changes occurred in your underwriting guidelines in recent years**?
- Has the proportion of business attributable to excess coverages for self-insurers changed in recent years? Can a distribution of such business be obtained by line, retention limit, class, etc.? Is a record of self-insured losses and claims available?
- For how many different programs or types of risk are premium and claims experience tracked and compiled into claim ratio runs?
- Are there any available summaries of the details of excess policies, such as attachment points, exclusions, per occurrence, sunset clauses, aggregate caps, etc.?
- What is the frequency of availability of such experience summaries? How far back are these available?
- How are the new programs priced? If you are relying on another insurer's filings, how similar are the underlying books of business?

Questions for a Data Processing or Accounting Executive:

- Has there been any change in the date on which the books are closed for the quarter? the year?
- How are claim payments handled for claims which have already been paid, but which have not yet been processed to the point where they can be allocated to accident quarter? Are they excluded from the loss history until they are allocated to accident quarter or are they loaded into an arbitrary quarter?
- **Have new data processing systems been implemented in recent years**? Have they had a significant impact on the rate of processing claims or on the length of time required from the reporting to the recording of a claim?
- To what extent have each of the data sources supplied been crosschecked and audited for accuracy and for balancing to overall company statistics? Comment on the degree of accuracy with which each kind of statistic has been properly allocated to accident quarter, to line of business, to size of loss, etc.
- Have there been any changes in coding procedures which would affect the data supplied?
- Would it be possible for partial payments to exceed the case outstanding on a claim? In such an event, what adjustments are made? Are unpaid case taken down by the amount of partial payments?
- How far back can the claims data be actively re-compiled by various key criteria?

- What data elements are available for each claim? For each risk?
- By what key criteria could the historical claims data be freshly compiled? Examples of criteria: size of loss breakdowns, type of claim breakdowns (e.g., liability vs. property for commercial multi-peril or homeowner multi-peril), separate compilations by policy limit, or deductible, or type of claim, or state.
- Can data be compiled either by claimant or occurrence, if multiple claims are established for one occurrence?

Questions for Actuaries Specializing in Ratemaking:[91]

- Have there been any changes in company operations or procedures which have caused you to depart from standard ratemaking procedures? If so, please describe those changes and how they were treated.
- **What data which is currently used for ratemaking purposes could also be used in testing unpaid claims**?
- Have you noted any significant shifts in the composition of business by type of risk or type of claim within the past several years?
- Do you have any of the following sources of information which may be of value in reserve testing:
  a) External economic indices,
  b) Combined claims data for several companies,[92]
  c) Special rating bureau studies,
  d) Changes in state laws or regulations, and
  e) Size of loss or cause of loss studies?
- Could we obtain copies of recent rate filings?
- Were there any changes in statues, court decisions, extent of coverage that necessitated some reflection in the rate analysis?
- How are new programs priced? If you are relying on another insurer's filing, how similar are the underlying books of business?

Questions for In-House Actuaries:[93]

- Could we obtain copies of any and all actuarial studies done by consultants, auditors or internal actuaries?
- What areas of disagreement are there between these different studies?
- What specific background information did you take into account in making your selections?

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[91] At small insurers, an actuary may be involved in both ratemaking and reserving.
[92] For example, data from a rating bureau.
[93] As opposed to Out-House Actuaries.

Questions for Those Managing Reinsurance:[94]

- Please provide details of reinsurance treaties and of reinsurance agreements in general, regarding both assumed and ceded business.
- Please provide details of all reinsurance ceded treaties including:
  - Retention level or quota share percentage
  - Reinsurers involved including participation
  - Details of any sliding scale premium, commission, or profit commission including currently booked amounts
  - Any problems or delays encountered in collecting reinsurance?
- Please provide details of any internal or sister company reinsurance agreements that were not included above (cover notes, relevant amounts, and by-line breakdowns).
- Have you secured the continuation of your reinsurance program for next year?
  - If so, under what terms?

Questions for Senior Management:[95]

Please provide a brief description of the company's operations including:

- An organization chart with recent changes highlighted.
- Details of ownership.
- Description of types of business written including all special programs.
- Description of marketing (i.e., direct writer, independent agent, etc.)

[94] This list of questions was created by Friedland.
[95] This list of questions was created by Friedland.

Problems:

**4.1.** (1 point) An actuary should understand the environment, both internal and external to the insurer. List four important such items.

**4.2.** (0.5 points) Identify two questions to ask the claims department to better understand any operational changes.

**4.3.** (0.5 points) An actuary is estimating ultimate losses.
Identify two questions to ask an underwriting executive.

**4.4.** (0.5 points) An actuary is estimating ultimate losses.
Identify two questions to ask a data processing or accounting executive.

**4.5.** (0.5 points) A consulting actuary is estimating ultimate losses for an insurance company.
Identify two things you would like the senior management of the insurer to provide.

**4.6.** (0.5 points) An actuary is estimating ultimate losses for their insurance company.
Identify two questions to ask fellow actuaries at the company specializing in ratemaking.

**4.7.** (0.5 points) An actuary is estimating ultimate losses for an insurer.
Identify two things to ask those managing reinsurance for the insurer.
(Your responses can be either items you wish to be provided or questions you wish to ask.)

**4.8. (6, 11/06, Q.20)** (1.5 points)
a. (0.5 points) Why is it important for the actuary to engage in discussions with management in business areas, such as claims and underwriting, when performing a reserve analysis?
b. (1 point) A review of the claims data for a company reveals that the time it takes to settle a claim once it has been reported has increased over the last six months.
Identify two questions that you would ask of claims management of that company to better understand this trend.

Solutions to Problems:

**4.1.** Possible responses (any four):
- Classes of business written or geographical focus.
- Policy provisions such as policy limits and deductibles.
- Reinsurance arrangements including limits and attachment points.
- A change in claims management philosophy that often occur when managerial changes occur.
- A new technology is implemented by an insurer.
- When claim department staffing is disrupted.
- Changes in the legal and social environment.
- Changes in the economic environment.

Comment: See page 44 of Friedland.

**4.2.** Possible Responses (any two):
- Has there been a change in case reserving practices?
- Has there been a change in claim closing practices?
- Has there been any changes in the priority given to large versus small claims?
- Has there been a change in how claims closed without payment are recorded in your data?
- Over the historical period has there been social or legal environment changes that would impact the size of claims and/or the reserves set for claims?
- Have there been any significant changes in the guidelines for setting and reviewing case reserves during the last five years?
- Have there been any changes in the definitions of or rules for establishing formula reserves for reported claims in the last five years?
- Have there been any noticeable shifts in the reporting or non-reporting of very small or trivial claims? In the procedures for the recording of such?
- Have there been any shifts toward (or away from) the more vigorous defense of suits in recent years?

Comment: Similar to 5, 5/18 Makeup Exam, Q.20b.
There are other possible responses, see pages 45 to 47 of Friedland.

**4.3.** Possible Responses (any two):
- What significant changes have occurred in your company's book of business and mix of business in the past five to seven years?
  How are the risks insured today different from those of the past?
- Do you underwrite any large risks which are not characteristic of your general book of business?
- Have any significant changes occurred in your underwriting guidelines in recent years?
- Has the proportion of business attributable to excess coverages for self-insurers changed in recent years? Can a distribution of such business be obtained by line, retention limit, class, etc.? Is a record of self-insured losses and claims available?
- For how many different programs or types of risk are premium and claims experience tracked and compiled into claim ratio runs?
- Are there any available summaries of the details of excess policies, such as attachment points, exclusions, per occurrence, sunset clauses, aggregate caps, etc.?
- What is the frequency of availability of such experience summaries?
  How far back are these available?
- How are the new programs priced? If you are relying on another insurer's filings, how similar are the underlying books of business?

**4.4.** Possible Responses (any two):
- Has there been any change in the date on which the books are closed for the quarter? the year?
- How are claim payments handled for claims which have already been paid, but which have not yet been processed to the point where they can be allocated to accident quarter? Are they excluded from the loss history until they are allocated to accident quarter or are they loaded into an arbitrary quarter?
- Have new data processing systems been implemented in recent years? Have they had a significant impact on the rate of processing claims or on the length of time required from the reporting to the recording of a claim?
- To what extent have each of the data sources supplied been crosschecked and audited for accuracy and for balancing to overall company statistics? Comment on the degree of accuracy with which each kind of statistic has been properly allocated to accident quarter, to line of business, to size of loss, etc.
- Have there been any changes in coding procedures which would affect the data supplied?
- Would it be possible for partial payments to exceed the case outstanding on a claim? In such an event, what adjustments are made? Are unpaid case taken down by the amount of partial payments?
- How far back can the claims data be actively re-compiled by various key criteria?
- What data elements are available for each claim? For each risk?
- By what key criteria could the historical claims data be freshly compiled? Examples of criteria: size of loss breakdowns, type of claim breakdowns (e.g., liability vs. property for commercial multi-peril or homeowner multi-peril), separate compilations by policy limit, or deductible, or type of claim, or state.
- Can data be compiled either by claimant or occurrence, if multiple claims are established for one occurrence?

**4.5.** Possible Responses (any two):
- An organization chart with recent changes highlighted.
- Details of ownership.
- Description of types of business written including all special programs.
- Description of marketing (i.e., direct writer, independent agent, etc.)

**4.6.** Possible Responses (any two):
- Have there been any changes in company operations or procedures which have caused you to depart from standard ratemaking procedures? If so, please describe those changes and how they were treated.
- What data which is currently used for ratemaking purposes could also be used in testing unpaid claims?
- Have you noted any significant shifts in the composition of business by type of risk or type of claim within the past several years?
- Do you have any of the following sources of information which may be of value in reserve testing such as external economic indices, combined claims data for several companies, special rating bureau studies, changes in state laws or regulations, and size of loss or cause of loss studies?
- Could we obtain copies of recent rate filings?
- Were there any changes in statues, court decisions, extent of coverage that necessitated some reflection in the rate analysis?
- How are new programs priced? If you are relying on another insurer's filing, how similar are the underlying books of business?

**4.7.** Possible Responses (any two):
- Please provide details of reinsurance treaties and of reinsurance agreements in general, regarding both assumed and ceded business.
- Please provide details of all reinsurance ceded treaties including:
  - Retention level or quota share percentage
  - Reinsurers involved including participation
  - Details of any sliding scale premium, commission, or profit commission including currently booked amounts
  - Any problems or delays encountered in collecting reinsurance?
- Please provide details of any internal or sister company reinsurance agreements that were not included above (cover notes, relevant amounts, and by-line breakdowns).
- Have you secured the continuation of your reinsurance program for next year? If so, under what terms?

**4.8.** (a) Any changes made to claims department processes could affect claim closure patterns, case reserve adequacy, etc.
It is important to talk with underwriting so that you know about any changes in the mix of business, changes in underwriting guidelines, pricing, etc. These could affect loss emergence, frequency, severity, loss ratios, etc.
(b) Possible responses (any two):
● Has the caseload per claim department adjuster changed?
● Has there been a change in priorities as far as settling large claims versus small claims?
● Have there been any shifts toward the more vigorous defense of suits?
● Has there been a change in philosophy regarding trivial or very small claims?
Comment: At pages 45 to 47 of Friedland, there are many other sample questions to ask claims management, but in part (b) I have only included items that might affect the settlement rate.

## Section 5, The Development Triangle

Development triangles are the workhorses of reserving analysis. They come in many varieties.

An Example of a Development Triangle of Paid Claims:

Most commonly, development triangles involve accident years.
The following paid data is as of December 31, 2024:

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 105 | 235 | 437 | 625 |
| 2022 | 110 | 397 | 635 | |
| 2023 | 116 | 486 | | |
| 2024 | 146 | | | |

Data periods such as accident years are measured from their start.
Thus AY21 at 12 months is as of December 31, 2021.
AY21 at the maturity age of 24 months is as of December 31, 2022.
$105,000 has been paid for AY21 by December 31, 2021. This is usually called first report.
$235,000 has been paid for AY21 by December 31, 2022. This is usually called second report.
$437,000 has been paid for AY21 by December 31, 2023. This is usually called third report.

This triangle only goes out to 48 months.[96] This is common in exam question.
If an exam question were to say that there is no development beyond 48 months, this means that 48 months is "ultimate"; ultimate means that there are no more claims transactions beyond that point in time.[97] **An actuary should analyze development until there are no more changes in the quantity of interest**.

Besides cumulative data, actuaries also work with incremental data.[98]
In the above triangle, the amount paid for AY21 in 2022 is: 235,000 - 105,000 = $130,000.

Exercise: For the above example, determine the incremental paid claims.
[Solution: We take differences:

| Accident Year | Incremental Paid Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 105 | 130 | 202 | 188 |
| 2022 | 110 | 287 | 238 | |
| 2023 | 116 | 370 | | |
| 2024 | 146 | | | |

Comment: One could recover the cumulative triangle from the incremental triangle. ]

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[96] In practical applications, there could be additional columns: 60 months, 72 months, etc.
[97] Ultimate is an actuarial concept rather than being based on any language in the insurance policy.
[98] In exam questions, assume claims data is cumulative rather than incremental, unless stated otherwise.

105,000 is paid on AY21 claims during 2021. 130,000 is paid on AY21 claims during 2022.
202,000 is paid on AY21 claims during 2023. 188,000 is paid on AY21 claims during 2024.

Assuming that 48 months is ultimate, then the Calendar Year 2024 paid losses are the sum of incremental amounts: (1000)(146 + 370 + 238 + 188) = $942,000.[99]
In general, **Calendar Years are represented by southwest to northeast diagonals**.
Note that CY24 starts at AY24 and then goes diagonally upwards and to the right.

In the above example, **each row represents an Accident Year**. We could have more rows.
Each row shows the development of an AY, in other words the change in values over time.
**Each column in the claim development triangle represents a maturity age**.

The columns could be instead at: 6 months, 18 months, 30 months, etc.
Sometimes the columns will be instead at: 6 months, 12 months, 18 months, etc.
Sometimes rather than Accident Years the data could be arranged in Accident Half-Years or Accident Quarter-Years.

Rather than Accident Years, data can be arranged by:
- Policy year.
- Report year.[100]
- Underwriting year[101]
- Treaty year[102]
- Fiscal year[103]

An Example of a Development Triangle of Case Outstanding:

The following case reserves are as of December 31, 2024:

| Accident Year | Case Outstanding ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 52 | 220 | 179 | 0 |
| 2022 | 60 | 127 | 69 | |
| 2023 | 73 | 77 | | |
| 2024 | 92 | | | |

Assuming that 48 months is ultimate, then the total case reserves as of December 31, 2024 is:
(1000)(92 + 77 + 69 + 0) = $238,000.

As with the previous example, we could have more columns, different columns, more rows, different time periods such as Accident Half-Years or Policy Years.

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[99] In general, AYs prior to 2021 could contribute paid losses to CY24.
[100] Report Years are commonly used with data from claims-made policies.
[101] Underwriting year is similar to a Policy Year, but is a term used by reinsurers.
[102] Treaty year is defined as a period of twelve months covered by a reinsurance treaty or contract.
[103] For example, for a self-insured entity a Fiscal year could run from April 1 to March 31.

An Example of a Development Triangle of Reported Claims:

**Reported Claims = Paid Claims + Case Outstanding**. Adding up the two previous cumulative triangles, the following reported claims are as of December 31, 2024:

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 157 | 455 | 616 | 625 |
| 2022 | 170 | 524 | 704 | |
| 2023 | 189 | 563 | | |
| 2024 | 146 | | | |

Calendar Year reported claims are: Paid Claims + Change in Case Reserves.
Assuming 48 months is ultimate, CY24 paid claims were $942,000.

Exercise: Assuming 48 months is ultimate, determine the CY24 reported losses.
[Solution: The change in case reserves is:
(0 - 179) + (69 - 127) + (77 -73) + 92 = -141 thousand.
Thus the CY24 reported losses are: $942,000 - $141,000 = $801,000. ]

In the above triangle of reported claims, the development is positive. However, it would have been negative if and when the reduction in case reserves was more than the increase in paid losses.

Exercise: For the above example, determine the incremental reported claims.
[Solution: We take differences:

| Accident Year | Incremental Reported Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 157 | 298 | 161 | 9 |
| 2022 | 170 | 354 | 180 | |
| 2023 | 189 | 374 | | |
| 2024 | 146 | | | |

Comment: An actuary is more likely to work with an incremental paid triangle.]

Besides triangles of claims, actuaries work with triangles of Allocated Loss Adjustment Expense, as well as triangles of claim counts.[104]

[104] Sometimes ALAE is included with losses.

Examples of Triangles of Claim Counts:

When the claimant or someone else notifies the insurer of a claim then it becomes a reported claim.[105] Reported claim counts as of December 31, 2024:

| Accident Year | Reported Claim Counts as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 803 | 1085 | 1300 | 1301 |
| 2022 | 821 | 1114 | 1292 | |
| 2023 | 850 | 1131 | | |
| 2024 | 892 | | | |

When a claim is settled it becomes a closed claim count.[106]
Closed claim counts as of December 31, 2024:[107]

| Accident Year | Closed Claim Counts as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 496 | 794 | 1152 | 1301 |
| 2022 | 524 | 831 | 1178 | |
| 2023 | 550 | 882 | | |
| 2024 | 583 | | | |

Until a claim is settled, a reported claim is considered an open claim.
Open Claim Counts = Reported Claim Counts - Closed Claim Counts.[108]

| Accident Year | Open Claim Counts as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 307 | 291 | 148 | 0 |
| 2022 | 297 | 283 | 114 | |
| 2023 | 300 | 249 | | |
| 2024 | 309 | | | |

[105] Details may differ slightly between insurers. For example, a claim may be considered reported when a claims handler pays an amount and/or opens a claims file.
[106] Sometimes a closed claim will be reopened. For example, a claims handler may think all payments have been made on a workers compensation claim. Thus the claim handler closes the claim. However, if the worker subsequently reinjures his back and has to spend some more time off from work, then the claim will be reopened.
[107] Some insurers will not include a claim closed without payment as a closed claim.
In that case, the actuary would want to have separate triangles of claim counts closed with and without payment.
[108] Assuming that closed claim counts include claims closed without payment.

Examples of Triangles of Severities:

Actuaries are interested in various average sizes.
For example, an actuary can take the ratio of paid claims to closed claims.[109]

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 105 | 235 | 437 | 625 |
| 2022 | 110 | 397 | 635 | |
| 2023 | 116 | 486 | | |
| 2024 | 146 | | | |
| AY | Closed Claim Counts as of (months) | | | |
| 2021 | 496 | 794 | 1152 | 1301 |
| 2022 | 524 | 831 | 1178 | |
| 2023 | 550 | 882 | | |
| 2024 | 583 | | | |
| AY | Severity of Closed Claims | | | |
| 2021 | $212 | $296 | $379 | $480 |
| 2022 | $210 | $478 | $539 | |
| 2023 | $211 | $551 | | |
| 2024 | $250 | | | |
| AY | Incremental Severity of Closed Claims | | | |
| 2021 | $212 | $436 | $564 | $1,262 |
| 2022 | $210 | $935 | $686 | |
| 2023 | $211 | $1,114 | | |
| 2024 | $250 | | | |

One can also calculate the incremental severity of closed claims:[110]

$$\frac{\text{Amount Paid During the Calendar Year for the AY}}{\text{Number of Claims Closed During the Calendar Year for the AY}}.$$

For example, (1000)(235 - 105)/(794 - 496) = $436.

[109] For these ratios to be meaningful, partial payments have to be either absent or insignificant.
[110] An unusual pattern of incremental severity of closed claims may warrant further investigation.

An actuary can also take the ratio of case outstanding to open claims:[111]

| Accident Year | Case Outstanding ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 52 | 220 | 179 | 0 |
| 2022 | 60 | 127 | 69 | |
| 2023 | 73 | 77 | | |
| 2024 | 92 | | | |
| AY | Open Claim Counts as of (months) | | | |
| 2021 | 307 | 291 | 148 | 0 |
| 2022 | 297 | 283 | 114 | |
| 2023 | 300 | 249 | | |
| 2024 | 309 | | | |
| AY | Average Case Reserve | | | |
| 2021 | $169 | $756 | $1,209 | n/a |
| 2022 | $202 | $449 | $605 | |
| 2023 | $243 | $309 | | |
| 2024 | $298 | | | |

Also, an actuary can take the ratio of reported claims to reported claim counts:

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 157 | 455 | 616 | 625 |
| 2022 | 170 | 524 | 704 | |
| 2023 | 189 | 563 | | |
| 2024 | 146 | | | |
| AY | Reported Claim Counts as of (months) | | | |
| 2021 | 803 | 1085 | 1300 | 1301 |
| 2022 | 821 | 1114 | 1292 | |
| 2023 | 850 | 1131 | | |
| 2024 | 892 | | | |
| AY | Average Reported Claims | | | |
| 2021 | $196 | $419 | $474 | $480 |
| 2022 | $207 | $470 | $545 | |
| 2023 | $222 | $498 | | |
| 2024 | $164 | | | |

[111] An unusual pattern of average case reserves may warrant further investigation.

An Example of Constructing Triangles:[112]

Given the following information as of December 31, 2023:

| Claim ID | Accident Date | Report Date | 2021 Transactions | | 2022 Transactions | | 2023 Transactions | |
|---|---|---|---|---|---|---|---|---|
| | | | Cal.Yr. Paid | Ending Case O/S | Cal.Yr. Paid | Ending Case O/S | Cal.Yr. Paid | Ending Case O/S |
| 1 | January 4, 2021 | July 1, 2021 | 420 | 0 | 0 | 0 | 0 | 0 |
| 2 | August 17, 2021 | October 2, 2021 | 300 | 600 | 0 | 700 | 260 | 440 |
| 3 | November 6, 2021 | February 15, 2022 | | | 810 | 0 | 0 | 0 |
| 4 | March 14, 2022 | April 16, 2022 | | | 350 | 600 | 800 | 0 |
| 5 | June 15, 2022 | June 8, 2022 | | | 730 | 0 | 0 | 0 |
| 6 | July 31, 2022 | October 23, 2022 | | | 0 | 900 | 400 | 300 |
| 7 | December 10, 2022 | May 19, 2023 | | | | | 470 | 500 |
| 8 | April 18, 2023 | June 13, 2023 | | | | | 930 | 0 |
| 9 | May 22, 2023 | July 23, 2023 | | | | | 180 | 150 |
| 10 | October 25, 2023 | December 27, 2023 | | | | | 0 | 400 |

Let us construct a triangle of cumulative paid claims.
AY21: claims 1 to 3. AY22: claims 4 to 7. AY23: claims 8 to 10.

| Accident Year | Cumulative Paid Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | $720 | $1,530 | $1,790 |
| 2022 | $1,080 | $2,750 | |
| 2023 | $1,110 | | |

For AY21: 420 + 300 = 720. 720 + 810 = 1530. 1530 + 260 = 1790.

[112] See Tables 5 to 12 in Chapter 5 of Friedland.

Exercise: Construct triangles of case outstanding and reported losses.
[Solution: For AY22 Case Outstanding @ 12 months: 600 + 900 = 1500.

| Accident Year | Case Outstanding as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | $600 | $700 | $440 |
| 2022 | $1,500 | $800 | |
| 2023 | $550 | | |
| AY | Cumulative Reported Claims as of (months) | | |
| 2021 | $1,320 | $2,230 | $2,230 |
| 2022 | $2,580 | $3,550 | |
| 2023 | $1,660 | | |

The reported losses are the paid claims plus case outstanding. ]

Exercise: Construct triangles of reported, closed, and open claim counts.
[Solution:

| Accident Year | Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 2 | 3 | 3 |
| 2022 | 3 | 4 | |
| 2023 | 3 | | |
| AY | Closed Claim Counts as of (months) | | |
| 2021 | 1 | 2 | 2 |
| 2022 | 1 | 2 | |
| 2023 | 1 | | |
| AY | Open Claim Counts as of (months) | | |
| 2021 | 1 | 1 | 1 |
| 2022 | 2 | 2 | |
| 2023 | 2 | | |

Open claim counts = Reported claim counts - Closed claim counts. ]

Short-tail Versus Long-tail Lines of Property/Casualty Insurance:

Long-tail lines take longer for all claims to be settled and paid than short-tail lines of insurance. There is no universally used dividing line between the two.[113]

Good examples of short-tail lines are: Health Insurance and Automobile Collision Insurance.

Good examples of long-tail lines are: General Liability and Medical Malpractice.[114]

Loss Reserves are both more important and harder to properly estimate for long-tail lines of insurance.

When the actuary works with loss development triangles, there needs to be included more columns when working on long-tail lines than when working on short-tail lines.[115]

Some Details With Respect To Claim Count Data:

It is important that the actuary understands how claim count data is recorded, since this can differ between insurers.[116]

- Does the insurer of an automobile accident with payments for multiple coverages or to multiple parties count it as one claim or multiple claims?[117]
- How does the insurer treat reopened claims?[118]
  Are they coded as a new claim or is a previously closed claim reopened?
- Does the insurer include claims closed with no payment (CNP) in the reported and closed claim count triangles?
- Some insurers include claims with no case outstanding and no payments in the definition of reported claim counts, while other insurers define reported claim counts as only those claims with a positive case reserve and/or with a claim payment.[119]
- How are claims classified that have only ALAE payments and no claim payment?

"A change in the definition of claim counts can have a significant consequence on the results of diagnostic analyses using claim counts and on estimation techniques that rely on the number of claims. It is also important that the actuary is aware of differences between the insurer's definition of claim counts and any external benchmarks that would be used for comparison purposes."[120]

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[113] Some actuaries would add a third category: medium-tail lines.
[114] Claims involving injury and liability tend to be long term, because it is more complex to determine and agree on the amount of loss for personal injury, and because there are more likely to be lengthy legal disputes regarding liability.
[115] Some of Friedland's examples go out to a maturity of 120 months.
[116] Consulting actuaries have to stay on their toes!
[117] For example there may be payment for both bodily injury and physical damage.
There may be multiple claimants injured or whose property was damaged in one accident.
[118] Reopened claims are important for Workers' Compensation Insurance.
[119] The former type of insurer may record a claim as reported whenever a claims handler opens a claim file.
[120] Quoted from page 73 of Friedland.

Problems:

**5.1.** (3 points) Given the following information:

| Claim | Accident Date | Report Date | Evaluation Date | Outstanding Case Reserve | Cumulative Paid Claims |
|---|---|---|---|---|---|
| 1 | February 1, 2021 | August 1, 2021 | December 31, 2021 | $1,500 | $700 |
| | | | December 31, 2022 | $800 | $1,100 |
| | | | December 31, 2023 | $300 | $1,800 |
| 2 | July 1, 2022 | February 14, 2023 | December 31, 2023 | $500 | $0 |
| 3 | June 5, 2021 | October 20, 2021 | December 31, 2021 | $1,000 | $0 |
| | | | May 30, 2022 | $1,000 | $600 |
| | | | December 31, 2022 | $2,500 | $900 |
| | | | December 31, 2023 | $1,200 | $1,300 |
| 4 | April 13, 2023 | April 15, 2023 | December 31, 2023 | $3,400 | $200 |
| 5 | March 4, 2022 | October 17, 2022 | December 31, 2022 | $5,000 | $2,000 |
| | | | December 31, 2023 | $800 | $3,000 |
| 6 | November 6, 2021 | November 11, 2021 | November 24, 2021 | $4,000 | $0 |
| | | | December 31, 2021 | $0 | $2,100 |

a. (0.75 points)
Construct the annual paid claim development triangle for accident years 2021 through 2023.
b. (0.75 points)
Construct the annual reported claim development triangle for accident years 2021 through 2023.
c. (0.75 points)
Construct the annual paid claim development triangle for report years 2021 through 2023.
d. (0.75 points)
Construct the annual reported claim development triangle for report years 2021 through 2023.

**5.2.** (1 point) Given the following data, valued as of December 31, 2016:

| Cumulative Paid Losses ($000) | | | | | |
|---|---|---|---|---|---|
| Accident Year | Age of Development in Months | | | | |
| | 12 | 24 | 36 | 48 | 60 |
| 2012 | 200 | 300 | 350 | 400 | 420 |
| 2013 | 230 | 340 | 400 | 460 | |
| 2014 | 240 | 360 | 430 | | |
| 2015 | 260 | 400 | | | |
| 2016 | 290 | | | | |

There is no paid development beyond 60 months.
Calculate the value of 2016 calendar year paid losses.

**5.3.** (1.25 points) Given the following claim detail (000s):

| Claim | Accident Date | Paid During 2018 | Case Reserve at Year End 2018 | Paid During 2019 | Case Reserve at Year End 2019 | Paid During 2020 | Case Reserve at Year End 2020 |
|---|---|---|---|---|---|---|---|
| 1 | April 6, 2018 | $330 | $210 | $280 | $0 | $0 | $0 |
| 2 | August 14, 2018 | $110 | $400 | $0 | $400 | $200 | $250 |
| 3 | October 19, 2018 | | | $90 | $70 | $60 | $30 |
| 4 | January 25, 2019 | | | $300 | $300 | $180 | $100 |
| 5 | September 1, 2019 | | | $220 | $400 | $300 | $0 |
| 6 | December 7, 2019 | | | $0 | $200 | $90 | $150 |
| 7 | May 11, 2020 | | | | | $130 | $350 |
| 8 | July 23, 2020 | | | | | $400 | $800 |

Construct the cumulative accident year reported loss development triangle as of December 31, 2010.

**5.4.** (0.25 points) Terry Dactyl is an actuary. Terry is preforming a loss reserving analysis. Out to what maturity should Terry takes this analysis?

**5.5.** (1.25 points) Given the following information:

| Accident Year | Cumulative Paid Loss ($ million) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2016 | 150 | 400 | 560 | 630 |
| 2017 | 170 | 450 | 610 | |
| 2018 | 180 | 470 | | |
| 2019 | 200 | | | |

| Accident Year | Case Outstanding ($ million) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2016 | 480 | 290 | 190 | 90 |
| 2017 | 500 | 310 | 200 | |
| 2018 | 530 | 330 | | |
| 2019 | 570 | | | |

a. (0.25 point) Calculate reported claims for accident year 2017 as of December 31, 2019.
b. (0.5 point) Calculate paid claims for calendar year 2019.
c. (0.5 point) Calculate the change in case reserves for calendar year 2019.

***5.6.*** (0.75 point) Given the following information:

| Accident Year | Cumulative Reported Claims ($million) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 132 | 165 | 181 | 185 |
| 2022 | 134 | 170 | 187 | |
| 2023 | 140 | 179 | | |
| 2024 | 143 | | | |

● The insurer began operating January 1, 2021.
Calculate reported claims for each of the calendar years 2021, 2022, 2023, and 2024.

**5.7.** (1.5 points) Given the following information:

| | | 2023 Transactions | | 2024 Transactions | | 2025 Transactions | |
|---|---|---|---|---|---|---|---|
| Claim ID | Accident Date | Calendar Year Payments | Ending Case O/S | Calendar Year Payments | Ending Case O/S | Calendar Year Payments | Ending Case O/S |
| 1 | February 5, 2023 | 100 | 350 | 250 | 100 | 100 | --- |
| 2 | June 21, 2023 | 50 | 250 | 125 | 350 | 400 | --- |
| | | | | | | | |
| 3 | May 17, 2024 | | | 200 | 150 | 150 | 150 |
| 4 | November 15, 2024 | | | 100 | 550 | 450 | 300 |
| | | | | | | | |
| 5 | July 23, 2025 | | | | | 250 | 650 |

a. (0.75 point) Construct an accident year cumulative paid claims triangle.
b. (0.75 point) Construct an accident year cumulative reported claims triangle.

**5.8.** (1.75 points)

Claim#1
January 14, 2022 Accident occurs
May 11, 2022 Claim is reported and opened with initial case outstanding of $15,000
August 21, 2022 A payment of $3,000 is made and case outstanding is reduced to $13,000
March 15, 2023 Claim is closed with an additional payment of $10,000
April 1, 2023 A deductible amount of $2,500 is recovered on the claim

Claim#2
December 1, 2022 Accident occurs
January 15, 2023 Claim is reported and opened with initial case outstanding of $7,000
January 31, 2024 Case outstanding is reduced to $4000
February 20, 2024 Claim is closed with a total payment of $6,000

Claim#3
November 1, 2023 Accident occurs
November 3, 2023 Claim is reported and opened with initial case outstanding of $8,000
January 30, 2024 Claim is closed without payment

Claim#4
July 5, 2024 Accident occurs
July 8, 2024 Claim is reported and opened with initial case outstanding of $20,000

Using the claims data above, build the following cumulative development triangles with annual December 31 valuations:

i. Report year reported claims net of any recoveries
ii. Accident year paid claims net of any recoveries

**5.9.** (1 point) Given the following information:

| Accident Year | Cumulative Paid Claims ($ million) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2020 | 20 | 31 | 33 | 34 |
| 2021 | 22 | 34 | 37 | 39 |
| 2022 | 23 | 36 | 38 | |
| 2023 | 25 | 39 | | |
| 2024 | 26 | | | |

| Accident Year | Case Outstanding ($ million) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2020 | 10 | 2 | 1 | 0 |
| 2021 | 11 | 3 | 2 | 0 |
| 2022 | 12 | 4 | 3 | |
| 2023 | 13 | 5 | | |
| 2024 | 14 | | | |

● There is no development beyond 48 months.
Determine the Calendar Year 2024 reported claims.

**5.10.** (2 points) Given the following information:

| Claim ID | Accident Date | Report Date | 2021 Transactions | | 2022 Transactions | | 2033 Transactions | |
|---|---|---|---|---|---|---|---|---|
| | | | Cal.Yr. Paid | Ending Case O/S | Cal.Yr. Paid | Ending Case O/S | Cal.Yr. Paid | Ending Case O/S |
| 1 | March 13, 2021 | July 11, 2021 | 400 | 0 | 0 | 0 | 0 | 0 |
| 2 | September 8, 2021 | October 12, 2021 | 300 | 600 | 0 | 600 | 250 | 150 |
| 3 | December 21, 2021 | February 5, 2022 | | | 700 | 0 | 0 | 0 |
| 4 | March 11, 2022 | April 21, 2022 | | | 400 | 200 | 350 | 0 |
| 5 | June 5, 2022 | August 19, 2022 | | | 500 | 0 | 0 | 0 |
| 6 | September 10, 2022 | October 3, 2022 | | | 0 | 400 | 300 | 200 |
| 7 | December 22, 2022 | March 1, 2023 | | | | | 800 | 450 |
| 8 | April 2, 2023 | June 8, 2023 | | | | | 450 | 250 |
| 9 | May 18, 2023 | July 13, 2023 | | | | | 500 | 0 |
| 10 | November 22, 2023 | December 7, 2023 | | | | | | 900 |
| 11 | October 20, 2023 | January 24, 2024 | | | | | | |

● Reported claims are closed when case outstanding equals 0.

Create the following cumulative annual triangles organized by accident year:

i. paid claims
ii. reported claims
iii. reported claim count
iv. closed claim count

**5.11.** (1.5 points) Given the following:

| Claim ID | Accident Date | Transaction Date | Amount Paid on Transaction Date ($) | Ending Case Outstanding ($) |
|---|---|---|---|---|
| A | March 30, 2021 | May 24, 2021 | 0 | 2000 |
| | | July 11, 2022 | 0 | 3000 |
| | | April 3, 2023 | 3500 | 0 |
| B | July 28, 2021 | November 29, 2021 | 500 | 1500 |
| | | January 6, 2022 | 900 | 1000 |
| | | October 14, 2022 | 700 | 500 |
| C | May 21, 2022 | June 25, 2022 | 0 | 4000 |
| | | February 8, 2023 | 2000 | 3000 |
| | | December 22, 2023 | 3000 | 0 |
| D | August 11, 2022 | August 15, 2022 | 4000 | 9000 |
| | | September 17, 2023 | 5000 | 2000 |

a. (0.5 point) Calculate calendar year 2021 reported claims.
b. (0.5 point) Calculate calendar year 2022 reported claims.
c. (0.5 point) Calculate calendar year 2023 reported claims.

**5.12. (6, 11/07, Q.7)** (1 point)
Given the following data, valued as of December 31, 2006 (amount in $000):

| Cumulative Paid Losses | | | | | |
|---|---|---|---|---|---|
| Accident Year | Age of Development in Months | | | | |
| | 12 | 24 | 36 | 48 | 60 |
| 2002 | 100 | 150 | 175 | 200 | 210 |
| 2003 | 110 | 130 | 150 | 155 | |
| 2004 | 90 | 120 | 130 | | |
| 2005 | 105 | 130 | | | |
| 2006 | 100 | | | | |

Calculate the value of 2006 calendar year paid losses.

**5.13. (6, 11/10, Q.10)** (1.75 points) Given the following information:

| Accident Year | Cumulative Paid Loss ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2006 | 75,000 | 212,500 | 288,000 | 337,000 |
| 2007 | 50,000 | 165,000 | 310,000 | |
| 2008 | 115,000 | 238,000 | | |
| 2009 | 85,000 | | | |

| Accident Year | Case Outstanding ($000) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2006 | 188,000 | 115,000 | 74,000 | 35,000 |
| 2007 | 175,000 | 94,000 | 45,000 | |
| 2008 | 115,000 | 238,000 | | |
| 2009 | 208,000 | | | |

a. (0.25 point) Calculate reported claims for accident year 2007 as of December 31, 2009.
b. (0.5 point) Calculate paid claims for calendar year 2009.
c. (0.5 point) Calculate the change in case reserves for calendar year 2009.
d. (0.5 point)
Briefly describe two benefits of organizing data for reserving on an accident year basis.

**5.14. (5, 5/11, Q.22)** (2.25 points) Given the following claim detail (000s):

| Claim | Accident Date | Paid During 2008 | Case Reserve at Year End 2008 | Paid During 2009 | Case Reserve at Year End 2009 | Case Paid During 2010 | Reserve at Year End 2010 |
|---|---|---|---|---|---|---|---|
| 1 | March 3, 2008 | $225 | $190 | $250 | $0 | $0 | $0 |
| 2 | July 18, 2008 | $150 | $500 | $0 | $500 | $230 | $270 |
| 3 | December 1, 2008 | | | $105 | $75 | $75 | $25 |
| 4 | March 1, 2009 | | | $200 | $200 | $150 | $100 |
| 5 | October 3, 2009 | | | $320 | $280 | $200 | $0 |
| 6 | November 3, 2009 | | | $0 | $100 | $50 | $100 |
| 7 | April 12, 2010 | | | | | $45 | $55 |
| 8 | June 28, 2010 | | | | | $500 | $500 |

a. (1.25 points) Construct the cumulative accident year reported loss development triangle as of December 31, 2010.
b. {0.5 point) Describe a situation in which it is preferable to use accident year data for estimating unpaid claims rather than report year data.
c. (0.5 point) Describe a situation in which it is preferable to use report year data for estimating unpaid claims rather than policy year data.

**5.15. (5, 11/13, Q.14)** (2 points) Given the following information:

| Claim ID | Accident Date | Report Date | Incremental Payments in Calendar Year | | |
|---|---|---|---|---|---|
| | | | 2010 | 2011 | 2012 |
| 1 | June 15, 2010 | July 1, 2010 | $100 | $400 | $0 |
| 2 | December 15, 2010 | January 15, 2011 | $0 | $300 | $150 |
| 3 | April 1, 2011 | May 1, 2011 | | $200 | $200 |
| 4 | November 15, 2011 | January 1, 2012 | | $0 | $500 |
| 5 | April 1, 2012 | May 1, 2012 | | | $200 |

a. (0.5 point)
Construct an annual incremental accident year paid loss triangle as of December 31, 2012.
b. (0.5 point)
Construct an annual cumulative report year paid loss triangle as of December 31, 2012.
c. (0.5 point) Assess whether an accident year approach or a report year approach is more appropriate for reserving auto liability insurance.
d. (0.5 point) Assess whether annual or quarterly triangles are more appropriate for a small company selling a long-tailed line of business.

**5.16. (5, 11/15, Q.16)** (2.75 points)

Claim#1

| | |
|---|---|
| January 4, 2012 | Accident occurs |
| May 1, 2012 | Claim is reported and opened with initial case outstanding of $5,000 |
| December 1, 2012 | A payment of $2,000 is made and case outstanding is reduced to $4,000 |
| January 15, 2013 | Claim is closed with an additional payment of $8,000 |
| June 1, 2013 | A deductible amount of $1,000 is recovered on the claim |

Claim#2

| | |
|---|---|
| December 1, 2012 | Accident occurs |
| January 15, 2013 | Claim is reported and opened with initial case outstanding of $1,000 |
| January 31, 2014 | Case outstanding is reduced to $500 |
| February 20, 2014 | Claim is closed with a total payment of $3,000 |

Claim#3

| | |
|---|---|
| November 1, 2013 | Accident occurs |
| November 3, 2013 | Claim is reported and opened with initial case outstanding of $10,000 |
| January 30, 2014 | Claim is closed without payment |

Claim#4

| | |
|---|---|
| July 15, 2014 | Accident occurs |
| July 17, 2014 | Claim is reported and opened with initial case outstanding of $3,000 |

a. (1.75 points) Using the claims data above, build the following cumulative development triangles with annual December 31 valuations:
   i. Report year reported claims net of any recoveries
   ii. Accident year paid claims net of any recoveries

b. (1 point) Briefly discuss one advantage and one disadvantage of using each of the data aggregation methods in part a. above when performing an unpaid claim analysis.

**5.17. (SOA GIRR, 11/20, Q.1)** (4 points)
You are given the following information for a line of business that started in 2016:

| Accident Year | Reported Claims (000) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2016 | 12,800 | 16,380 | 18,350 | 19,080 |
| 2017 | 13,700 | 17,810 | 19,590 | |
| 2018 | 15,200 | 19,150 | | |
| 2019 | 14,800 | | | |

| Accident Year | Paid Claims (000) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2016 | 9,730 | 14,580 | 17,430 | 18,300 |
| 2017 | 9,450 | 15,320 | 18,410 | |
| 2018 | 10,940 | 16,090 | | |
| 2019 | 11,100 | | | |

| Accident Year | Case Estimates (000) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2016 | 3,070 | 1,800 | 920 | 380 |
| 2017 | 4,250 | 2,490 | 1,140 | |
| 2018 | 4,260 | 2,980 | | |
| 2019 | 3,620 | | | |

(a) (1 point) Identify the inconsistencies in the data triangles.

(b) (0.5 points) Provide one potential cause for the data issue identified in part (a).

QUESTION CONTINUED ON THE NEXT PAGE

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You are provided with the following additional transactions from a single claim that occurred on March 1, 2017 and was not included in the above data:

| | Transaction Description | Transaction Date | Case Estimate | Indemnity Payment | ALAE Payment |
|---|---|---|---|---|---|
| 1 | Open new claim file | May 1, 2017 | 42,000 | 0 | 0 |
| 2 | Payment on reported claim file | Dec. 1, 2017 | 30,000 | 10,000 | 1,000 |
| 3 | Payment on reported claim file | Jun. 1, 2018 | 20,000 | 12,000 | 2,000 |

(c) (1.5 points) Construct revised paid claims and case estimates triangles incorporating this additional information.

(d) (1 point) Calculate the calendar year 2018 reported claims using the revised triangles from part (c).

**5.18. (SOA GIRR, 11/22, Q.18)** (5 points) You are given the following claims-made data for Nurses Professional Liability coverage from the claims department.

| Report Year | Nurses - Professional Liability Incremental Paid Claims (000) During Calendar Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| 2015 | 330 | 1,380 | 1,315 | 577 | 118 | 21 | 5 |
| 2016 | | 351 | 1,855 | 1,479 | 428 | 91 | 8 |
| 2017 | | | 436 | 1,489 | 1,252 | 933 | 168 |
| 2018 | | | | 423 | 1,592 | 1,182 | 670 |
| 2019 | | | | | 449 | 1,675 | 1,540 |
| 2020 | | | | | | 354 | 1,709 |
| 2021 | | | | | | | 584 |

| Case Estimates (000) at Evaluation Date | | | | | | | |
|---|---|---|---|---|---|---|---|
| Report Year | Dec. 31, 2015 | Dec. 31, 2016 | Dec. 31, 2017 | Dec. 31, 2018 | Dec. 31, 2019 | Dec. 31, 2020 | Dec. 31, 2021 |
| 2015 | 1,169 | 1,368 | 362 | 116 | 21 | 5 | 0 |
| 2016 | | 1,321 | 1,348 | 222 | 94 | 23 | 16 |
| 2017 | | | 1,456 | 1,378 | 689 | 177 | 18 |
| 2018 | | | | 1,404 | 1,349 | 520 | 203 |
| 2019 | | | | | 1,247 | 1,701 | 553 |
| 2020 | | | | | | 1,543 | 1,711 |
| 2021 | | | | | | | 1,350 |

(a) (1 point) Construct a cumulative reported claim development triangle by report year.

(b) (0.5 points) Calculate the calendar year 2020 reported claims for the coverage above.

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You are subsequently informed that the following six claim transactions were not captured in the previous dataset.

| Trans. # | Transaction Date | Transaction Description | Occurrence Date | Report Date | Change in Case Estimate (000) | Indemnity Payment (000) |
|---|---|---|---|---|---|---|
| 1 | Aug. 5, 2019 | subrogation recovery | May 6, 2017 | July 2, 2018 | | -15 |
| 2 | Dec. 19, 2019 | payment on reported claim file | Mar. 1, 2016 | Aug. 27, 2017 | -45 | 45 |
| 3 | Dec. 28, 2019 | open and close new claim file | Oct. 17, 2018 | Dec. 23, 2019 | | 10 |
| 4 | Jan. 28, 2020 | payment & change in case estimate | Aug. 1, 2015 | Nov. 28, 2016 | -20 | 15 |
| 5 | Feb. 4, 2021 | open new claim file | Sept. 12, 2020 | Feb. 3, 2021 | 30 | |
| 6 | May 11, 2021 | payment on reported claim file with no change in case estimate | June 14, 2017 | Apr. 19, 2020 | | 5 |

(c) (3 points) Update the reported claim development triangle from part (a) to include the missing claim transactions.

You are given the following carried IBNR reserves for the Nurses coverage above:

| IBNR Reserves (000) | |
|---|---|
| December 31, 2020 | 3,900 |
| December 31, 2021 | 4,100 |

(d) (0.5 points) Calculate the calendar year 2021 incurred claims.

**5.19. (SOA GIRR, 5/24, Q.13)** (5 points) You are given the following data for a line of business:

| Accident Year | Reported Claims | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 |
| 2015 | 2,073,186 | 2,977,355 | 3,689,430 | 4,344,924 | 4,635,919 | 4,691,541 |
| 2016 | 2,214,894 | 3,167,365 | 4,021,756 | 4,613,081 | 4,945,867 | 5,014,244 |
| 2017 | 2,339,966 | 3,357,699 | 4,299,159 | 4,992,272 | 5,303,741 | 5,364,852 |
| 2018 | 2,442,143 | 3,577,869 | 4,576,972 | 5,228,180 | 5,653,369 | 5,760,949 |
| 2019 | 2,592,402 | 3,757,301 | 4,853,532 | 5,625,219 | 6,054,505 | |
| 2020 | 2,817,613 | 4,182,588 | 5,212,351 | 6,024,272 | | |
| 2021 | 3,075,951 | 4,425,866 | 5,613,235 | | | |
| 2022 | 3,232,412 | 4,682,692 | | | | |
| 2023 | 3,554,432 | | | | | |

| Accident Year | Cumulative Paid Claims | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 |
| 2015 | 1,286,342 | 2,412,544 | 3,380,499 | 4,184,900 | 4,587,477 | 4,691,541 |
| 2016 | 1,419,281 | 2,553,776 | 3,692,376 | 4,472,461 | 4,899,904 | 5,014,244 |
| 2017 | 1,474,216 | 2,703,709 | 3,940,993 | 4,833,876 | 5,248,486 | 5,364,852 |
| 2018 | 1,470,542 | 2,889,545 | 4,189,625 | 5,064,468 | 5,604,641 | 5,760,949 |
| 2019 | 1,607,264 | 2,999,878 | 4,445,019 | 5,419,708 | 5,967,598 | |
| 2020 | 1,747,620 | 3,387,292 | 4,766,703 | 5,724,228 | | |
| 2021 | 1,964,983 | 3,552,637 | 5,155,384 | | | |
| 2022 | 1,980,306 | 3,785,833 | | | | |
| 2023 | 2,247,631 | | | | | |

There is no development beyond 72 months.

Question continued on the next page

(a) (1.5 points) Determine the change in case estimates during calendar year 2023.
(b) (1.5 points) Determine the claims paid during calendar year 2023.

You are given the following claims information regarding two claims for a different line of business:

- Claim #4400 is a claim file from an accident that occurred on March 1, 2021 and was reported to the insurer on October 1, 2021. The claim file originally closed in 2022 but was later reopened in 2023. The company does not treat such claims as a new claim, but as reopening the original claim file.
- Claim #5500 is a claim file from an accident that occurred on July 1, 2021 and was reported to the insurer on February 1, 2022. The adjuster set an initial case estimate of 12,000. Upon further investigation, on February 1, 2023 this claim was found to not be covered under the insurance policy purchased by the insured, and the claim file was closed with no claim payments made.

(c) (1 point) Construct two reported count triangles that reflect the development on these two claim files over time. Make sure to correctly label your triangles.
(d) (1 point) Construct two closed count triangles that reflect the development on these two claim files over time. Make sure to correctly label your triangles.
Note: I have rewritten this past exam question.

Solutions to Problems:

**5.1.** Claims 1, 3, and 6 are in AY21. Claims 2 and 5 are in AY22. Claim 4 is in AY23.

| a. | Cumulative Paid Claims | | | |
|---|---|---|---|---|
| | AY | 12 | 24 | 36 |
| | 2021 | $2,800 | $4,100 | $5,200 |
| | 2022 | $2,000 | $3,000 | |
| | 2023 | $200 | | |
| | | | | |
| b. | Cumulative Reported Claims | | | |
| | AY | 12 | 24 | 36 |
| | 2021 | $5,300 | $7,400 | $6,700 |
| | 2022 | $7,000 | $4,300 | |
| | 2023 | $3,600 | | |

For example, for AY21 @ 3rd report: 1800 + 1300 + 2100 = $5200.
5200 + 300 + 1200 + 0 = $6700.
Claims 1, 3, and 6 are in RY21. Claim 5 is in RY22. Claims 2 and 4 is in RY23.

| c. | Cumulative Paid Claims | | | |
|---|---|---|---|---|
| | RY | 12 | 24 | 36 |
| | 2021 | $2,800 | $4,100 | $5,200 |
| | 2022 | $2,000 | $3,000 | |
| | 2023 | $200 | | |
| | | | | |
| d. | Cumulative Reported Claims | | | |
| | RY | 12 | 24 | 36 |
| | 2021 | $5,300 | $7,400 | $6,700 |
| | 2022 | $7,000 | $3,800 | |
| | 2023 | $4,100 | | |

Comment: My parts a&b are similar to 5, 5/18 Makeup Exam, Q.15a&b

**5.2.** Add up the incremental paid losses along the latest diagonal.
CY16 paid: (1000) {290 + (400-260) + (430-360) + (460-400) + (420-400)} = **$580,000**.
Alternately, cumulative paid as of December 31, 2015: 260 + 360 + 400 + 400 = 1420.
Cumulative paid as of December 31, 2016: 290 + 400 + 330 + 460 + 420 = 2000.
CY16 paid: (1000)(2000 - 1420) = **$580,000**.
Comment: Similar to 6, 11/07, Q.7.

**5.3.** AY18: Claims 1 to 3. AY19: Claims 4 to 6. AY20: Claims 7 and 8.
Cumulative Reported Claims = Cumulative Paid Claims + Case Reserves at Year End.
For AY18, 330 + 110 + 210 + 400 = $1050.
330 + 110 + 280 + 90 + 400 + 70 = $1280.
330 + 110 + 280 + 90 + 200 + 60 + 250 + 30 = $1350.

| Accident Year | Cumulative Reported Claims (000s) | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2018 | $1,050 | $1,280 | $1,350 |
| 2019 | $1,420 | $1,340 | |
| 2020 | $1,680 | | |

Comment: Similar to 5, 5/11, Q.22a.

**5.4.** If possible, Terry should analyze development out to the point at which the development ceases (i.e., until the selected development factors are equal to 1.000).

**5.5.** (a) 610 + 200 = **$810 million**.
(b) Add up the incremental paid claims along a diagonal:
200 + (470 - 180) + (610 - 450) + (630 - 560) = **$720 million**.
(c) Add up the changes in case outstanding along a diagonal:
570 + (330 -530) + (200 - 310) + (90 - 190) = **$160 million**.
Comment: Similar to 6, 11/10, Q.10.

**5.6.** The CY reported claims are the sum of incremental reported claims along a diagonal.

| Accident Year | Incremental Reported Claims ($million) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 132 | 33 | 16 | 4 |
| 2022 | 134 | 36 | 17 | |
| 2023 | 140 | 39 | | |
| 2024 | 143 | | | |

CY21: $**132 million**.
CY22: 134 + 33 = **$177 million**.
CY23: 140 + 36 + 16 = **$192 million**.
CY24: 143 + 39 + 17 + 4 = **$203 million**.
Comment: Similar to 5, 5/16, Q.15a.

**5.7.** (a) AY23 at the end of 2023: 100 + 50 = 150.
AY23 at the end of 2024: 150 + 250 + 125 = 525.
AY23 at the end of 2025: 525 + 100 + 400 = 1025.
AY24 at the end of 2024: 200 + 100 = 300.
AY24 at the end of 2025: 300 + 150 + 450 = 900.
AY25 at the end of 2025: 250.

| | Cumulative Paid Loss through Month | | |
|---|---|---|---|
| Accident Year | 12 | 24 | 36 |
| | | | |
| 2023 | 150 | 525 | 1025 |
| 2024 | 300 | 900 | |
| 2025 | 250 | | |

(b) Add the case reserves to the previous determined cumulative paid triangle:
AY23 at the end of 2023: 150 + 350 + 250 = 750.
AY23 at the end of 2024: 525 + 100 + 350 = 975.
AY23 at the end of 2025: 1025 + 0 + 0 = 1025.
AY24 at the end of 2024: 300 + 150 + 550 = 1000.
AY24 at the end of 2025: 900 + 150 + 300 = 1350.
AY25 at the end of 2025: 250 + 650 = 900.

| | Cumulative Reported Loss through Month | | |
|---|---|---|---|
| Accident Year | 12 | 24 | 36 |
| | | | |
| 2023 | 750 | 975 | 1025 |
| 2024 | 1000 | 1350 | |
| 2025 | 900 | | |

Comment: Similar to 5, 11/16, Q16a&b.

**5.8.** i. Claim #1 is reported in 2022, so all of its activity goes into RY22.
Reported claims as of 12/31/22: 3000 + 13,000 = 16,000.
Reported claims as of 12/31/23: 3000 + 10,000 - 2500 =10,500.
Claims #2 and #3 are reported in 2023, so all of their activity goes into RY23.
Reported claims as of 12/31/23: 7000 + 8000 = 15,000.
Reported claims as of 12/31/24: 6000 + 0 = 6,000.
Claim #4 is reported in 2024, so all of its activity goes into RY24.
Reported claims as of 12/31/24: 20,000.

| | Reported Claims Net of Any Recoveries | | |
|---|---|---|---|
| Report Year | 12 Months | 24 Months | 36 Months |
| 2022 | 16,000 | 10,500 | 10,500 |
| 2023 | 15,000 | 6,000 | |
| 2024 | 20,000 | | |

ii. Claims #1 and #2 involve accidents in 2022, so all of their activity goes into AY22.
Paid as of 12/31/22: 3000.
Paid as of 12/31/23: 3000 + 10,000 - 2500 = 10,500.
Paid as of 12/31/24: 10,500 + 6000 = 16,500.
Claim #3 involves an accidents in 2023, so all of its activity goes into AY13.
Paid as of 12/31/23: 0.
Paid as of 12/31/24: 0.
Claim #4 involves an accidents in 2024, so all of its activity goes into AY14.
Paid as of 12/31/24: 0.

| | Paid Claims Net of Any Recoveries | | |
|---|---|---|---|
| Accident Year | 12 Months | 24 Months | 36 Months |
| 2022 | 3,000 | 10,500 | 16,500 |
| 2023 | 0 | 0 | |
| 2024 | 0 | | |

Comment: Similar to 5, 11/15, Q.16a.

**5.9.** The CY24 paid claims: 26 + (39-25) + (38-36) + (39-37) = $44 million.
The case outstanding at the end of 2023: 13 + 4 + 2 + 0 = $19 million,
The case outstanding at the end of 2024: 14 + 5 + 3 + 0 = $22 million
The CY24 reported claims: 44 + 22 - 19 = **$47 million**.
Comment: CY reported claims = CY paid + change in case reserves.

**5.10.** AY21: claims 1 to 3. AY22: claims 4 to 7. AY23: claims 8 to 11.

| Accident Year | Cumulative Paid Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 700 | 1400 | 1650 |
| 2022 | 900 | 1550 | |
| 2023 | 950 | | |

| Accident Year | Cumulative Reported Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 1300 | 2000 | 1800 |
| 2022 | 1500 | 2200 | |
| 2023 | 2100 | | |

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 2 | 3 | 3 |
| 2022 | 3 | 4 | |
| 2023 | 3 | | |

| Accident Year | Cumulative Closed Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 1 | 2 | 2 |
| 2022 | 1 | 2 | |
| 2023 | 1 | | |

Comment: Similar to 5, 11/14, Q.14a.

**5.11.** (a) Claim A: 2000. Claim B: 500 + 1500 = 2000. Total = 2000 + 2000 = **4000**.
(b) Claim A: 3000 - 2000 = 1000. Claim B: 900 + 700 + (500 - 1500) = 600.
Claim C: 4000. Claim D: 4000 + 9000 = 13,000.
Total = 1000 + 600 + 4000 + 13,000 = **18,600**.
(c) Claim A: 3500 - 3000 = 500. Claim B: 0.
Claim C: 2000 + 3000 - 4000 = 1000. Claim D: 5000 + (2000-9000) = -2000.
Total = 500 + 0 + 1000 - 2000 = **-500**.
Comment: Similar to 5, 11/18, Q.15a&c.
CY reported claims = CY paid + change in case reserves.

**5.12.** Add up the incremental paid losses along the latest diagonal.
CY06 paid: (1000) {100 + (130-105) + (130-120) + (155-150) + (210-200)} = **$150,000**.
Alternately, cumulative paid as of December 31, 2005: 105 + 120 + 150 + 200 = 575.
Cumulative paid as of December 31, 2006: 100 + 130 + 130 + 155 + 210 = 725.
CY06 paid: (1000)(725 - 575) = **$150,000**.
Comment: One has to assume that there is no paid development beyond 60 months.

**5.13.** (a) 310,000+ 45,000 = **$355,000 thousand**.
(b) Add up the incremental paid claims along a diagonal:
85,000 + (238,000 - 115,000) + (310,000 - 165,000) + (337,000 - 288,000)
= **$402,000 thousand**.
(c) Add up the changes in case outstanding along a diagonal:
208,000 + (238,000 -115,000) + (45,000 - 94,000) + (35,000 - 74,000) = **$243,000 thousand**.
(d) Advantages of Accident Year Data (any two):
- Easy to obtain.
- Easy to understand.
- Represents claims occurring over a shorter time frame than for policy year data.
  Thus Accident Year data matures more quickly than Policy Year data.
- Numerous industry benchmarks are available.
- Valuable when there is a change due to economic or regulatory forces.
- Valuable when there are major claim events.

**5.14.** (a) AY08: Claims 1 to 3. AY09: Claims 4 to 6. AY10: Claims 7 and 8.
Cumulative Reported Claims = Cumulative Paid Claims + Case Reserves at Year End.
For example, 225 + 150 + 190 + 500 = $1065.
225 + 150 + 250 + 105 + 230 + 75 + 270 + 25 = $1330.

| Accident Year | Cumulative Reported Claims (000s) | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2008 | $1,065 | $1,305 | $1,330 |
| 2009 | $1,100 | $1,120 | |
| 2010 | $1,100 | | |

(b) With report year data, unpaid claims are Incurred but not enough reported (IBNER), with no pure IBNR. Thus it is preferable to use accident year data when one wishes to estimate pure IBNR as well as the other components of unpaid claims.
Alternately, AY data is widely used to estimate unpaid claims. Therefore there are many industry benchmarks and data based on AY aggregation. When the actuary wants to use such benchmarks or industry data, then it is preferable to use internal AY data as well.
(c) When you are working with claims-made policies, it makes sense to use report year data, since claims-made policies operate on report years and have no pure IBNR at year end.
Alternately, when there is a signifiant change in the legal or social climate such that the average severity tracks more with the report date rather than the occurrence/accident date of the incident.

**5.15.** a. Claims 1 and 2 are in AY11. Claims 3 and 4 are in AY12. Claim 5 is in AY13.

| Accident Year | Incremental Paid Claims | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2010 | $100 | $700 | $150 |
| 2011 | $200 | $700 | |
| 2012 | $200 | | |

b. For example, 100 + 700 + 150 = 950.

| Accident Year | Cumulative Paid Claims | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2010 | $100 | $800 | $950 |
| 2011 | $200 | $900 | |
| 2012 | $200 | | |

c. A report year approach is more appropriate for claims made policies.
If applied to reserving auto liability insurance, one would not get an estimate of the pure IBNR.
An accident year approach is more appropriate for reserving auto liability insurance, and commonly used.
Alternately, accident year is more common but report year is more appropriate if a change in social or legal climate causes severity to correlate more with report date than accident date.
d. While it is always better to have access to more information, for a small company writing a long-tailed line of business quarterly triangles would not add to the accuracy of an estimate of ultimate losses. Since the data takes a long time to develop, annual data is more than sufficient. Since this is small company, there will be random fluctuations in quarterly data which may add uncertainty to the estimates of ultimate. Also a small company would probably prefer to avoid the expense of obtaining and maintaining data on a quarterly basis.
Comment: The second solution shown for part (c) was taken from CAS Examiner's Report. The CAS Examiner's Report had one of two responses for part (d) "Use quarterly: the change in exposures and reporting pattern will shift the average accident date within an accident year and disturb development factors." However, this does not seem to relate to the situation presented.

**5.16.** (a) i. Claim #1 is reported in 2012, so all of its activity goes into RY12.
Reported claims as of 12/31/12: 4000 + 2000 = 6000.
Reported claims as of 12/31/13: 2000 + 8000 - 1000 = 9000.
Claims #2 and #3 are reported in 2013, so all of their activity goes into RY13.
Reported claims as of 12/31/13: 1000 + 10,000 = 11,000.
Reported claims as of 12/31/14: 3000 + 0 = 3,000.
Claim #4 is reported in 2014, so all of its activity goes into RY14.
Reported claims as of 12/31/14: 3000.

| | Reported Claims Net of Any Recoveries | | |
|---|---|---|---|
| Report Year | 12 Months | 24 Months | 36 Months |
| 2012 | 6,000 | 9,000 | 9,000 |
| 2013 | 11,000 | 3,000 | |
| 2014 | 3,000 | | |

ii. Claims #1 and #2 involve accidents in 2012, so all of their activity goes into AY12.
Paid as of 12/31/12: 2000.
Paid as of 12/31/13: 2000 + 8000 - 1000 = 9,000.
Paid as of 12/31/14: 2000 + 8000 - 1000 + 3000 = 12,000
Claim #3 involves an accidents in 2013, so all of its activity goes into AY13.
Paid as of 12/31/13: 0.
Paid as of 12/31/14: 0.
Claim #4 involves an accidents in 2014, so all of its activity goes into AY14.
Paid as of 12/31/14: 0.

| | Paid Claims Net of Any Recoveries | | |
|---|---|---|---|
| Accident Year | 12 Months | 24 Months | 36 Months |
| 2012 | 2,000 | 9,000 | 12,000 |
| 2013 | 0 | 0 | |
| 2014 | 0 | | |

(b) Report Year Advantages (any one):
- Claim counts are fixed at the end of the year.
- Useful for working with claims-made policies.
- More stable data and more readily determinable development patterns.
- Only settlement lag, no report lag in estimates.
- Appropriate when there is a change in social or legal climate that causes severity to be more correlated with reported date than accident date.
- Easier to see effects of laws which will predominantly show up when a claim is reported.

Report Year Disadvantages (any one):
- Only measures development on known claims and not pure IBNR; other techniques would have to be used in order to estimate pure IBNR.
- Not as commonly used, and thus less benchmark data is available.

Accident Year Advantages (any one):
- Easy to understand and collect data.
- It is a common aggregation method with a lot of benchmarks available.
- Data readily available sooner than policy year aggregation.
- Useful if there is a change in economic or regulatory forces.
- Valuable when there is a major claim event such as a catastrophe.
- It is a common aggregation method with a lot of benchmarks available.

Accident Year Disadvantages (any one):
- Potential mismatch between losses and exposures/premium.
- Includes claims from policies underwritten and priced at more varied times than policy year data.
- It may mask the changes in policy limits and/or deductibles that could have an effect on claim development patterns.

Comment: For part (b), see Chapter 3 of Friedland.

**5.17.** (a) The most recent diagonal (corresponding to the most recent CY) does not reconcile, since Reported claims > Paid claims + Case estimates.
For example, 14,800 > 14,720 = 11,100 + 3620.

(b) There are either paid claims or case estimates missing from the latest calendar year.

(c) Everything from this claim goes in AY17.
As of 12 months there is 30,000 in case estimates and 11,000 in paid claims.
As of 24 months there is 20,000 in case estimates and 11,000 + 14,000 = 25,000 paid.
As of 36 months there is still 20,000 in case estimates and 25,000 paid.

| Accident Year | Revised Paid Claims (000) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2016 | 9,730 | 14,580 | 17,430 | 18,300 |
| 2017 | **9,461** | **15,345** | **18,435** | |
| 2018 | 10,940 | 16,090 | | |
| 2019 | 11,100 | | | |

| Accident Year | Revised Case Estimates (000) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2016 | 3,070 | 1,800 | 920 | 380 |
| 2017 | **4,280** | **2,510** | **1,160** | |
| 2018 | 4,260 | 2,980 | | |
| 2019 | 3,620 | | | |

(d) 10,940 + (15,345-9461) + (17,430-14,580) + 4260 + (2510-4280) + (920-1800)
= **21,234** thousand.

**5.18.** (a) 330 + 1169 = 1499. 330 + 1380 + 1368 = 3078.

| Report Year | Nurses - Professional Liability Incremental Paid Claims (000) During Calendar Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| 2015 | 330 | 1,380 | 1,315 | 577 | 118 | 21 | 5 |
| 2016 | | 351 | 1,855 | 1,479 | 428 | 91 | 8 |
| 2017 | | | 436 | 1,489 | 1,252 | 933 | 168 |
| 2018 | | | | 423 | 1,592 | 1,182 | 670 |
| 2019 | | | | | 449 | 1,675 | 1,540 |
| 2020 | | | | | | 354 | 1,709 |
| 2021 | | | | | | | 584 |
| Case Estimates (000) at Evaluation Date | | | | | | | |
| Report Year | Dec. 31, 2015 | Dec. 31, 2016 | Dec. 31, 2017 | Dec. 31, 2018 | Dec. 31, 2019 | Dec. 31, 2020 | Dec. 31, 2021 |
| 2015 | 1,169 | 1,368 | 362 | 116 | 21 | 5 | 0 |
| 2016 | | 1,321 | 1,348 | 222 | 94 | 23 | 16 |
| 2017 | | | 1,456 | 1,378 | 689 | 177 | 18 |
| 2018 | | | | 1,404 | 1,349 | 520 | 203 |
| 2019 | | | | | 1,247 | 1,701 | 553 |
| 2020 | | | | | | 1,543 | 1,711 |
| 2021 | | | | | | | 1,350 |
| | Cumulative Reported Claims By Report Year Lag | | | | | | |
| Report Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2015 | 1499 | 3078 | 3387 | 3718 | 3741 | 3746 | 3746 |
| 2016 | 1672 | 3554 | 3907 | 4207 | 4227 | 4228 | |
| 2017 | 1892 | 3303 | 3866 | 4287 | 4296 | | |
| 2018 | 1827 | 3364 | 3717 | 4070 | | | |
| 2019 | 1696 | 3825 | 4217 | | | | |
| 2020 | 1897 | 3774 | | | | | |
| 2021 | 1934 | | | | | | |

(b) We add to the incremental paid claims the changes in case reserves.
21 + 91 + 933 + 1182 + 1675 + 354
+ (5 - 21) + (23 - 94) + (177 - 689) + (520 - 1349) + (1701 - 1247) + 1543 = **4825**.
(c) Transaction #1: RY18, lag 1, -15 paid and reported.
Transaction #2: RY17, lag 2, no change in reported.
Transaction #3: RY19, lag 0, 10 paid and reported.
Transaction #4: RY16, lag 4, -5 reported.
Transaction #5: RY21, lag 0, 30 reported.
Transaction #6: RY20, lag 1, 5 paid and reported.

| | Unadjusted Cumulative Reported Claims By Report Year Lag | | | | | | |
|---|---|---|---|---|---|---|---|
| RY | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2015 | 1499 | 3078 | 3387 | 3718 | 3741 | 3746 | 3746 |
| 2016 | 1672 | 3554 | 3907 | 4207 | 4227 | 4228 | |
| 2017 | 1892 | 3303 | 3866 | 4287 | 4296 | | |
| 2018 | 1827 | 3364 | 3717 | 4070 | | | |
| 2019 | 1696 | 3825 | 4217 | | | | |
| 2020 | 1897 | 3774 | | | | | |
| 2021 | 1934 | | | | | | |
| RY | Adjustments to Cumulative Reported Claims By Report Year Lag | | | | | | |
| 2015 | | | | | | | |
| 2016 | | | | | -5 | -5 | |
| 2017 | | | | | | | |
| 2018 | | -15 | -15 | -15 | | | |
| 2019 | 10 | 10 | 10 | | | | |
| 2020 | | 5 | | | | | |
| 2021 | 30 | | | | | | |
| RY | Adjusted Cumulative Reported Claims By Report Year Lag | | | | | | |
| 2015 | 1499 | 3078 | 3387 | 3718 | 3741 | 3746 | 3746 |
| 2016 | 1672 | 3554 | 3907 | 4207 | 4222 | 4223 | |
| 2017 | 1892 | 3303 | 3866 | 4287 | 4296 | | |
| 2018 | 1827 | 3349 | 3702 | 4055 | | | |
| 2019 | 1706 | 3835 | 4227 | | | | |
| 2020 | 1897 | 3779 | | | | | |
| 2021 | 1964 | | | | | | |

(d) CY21 incurred claims = CY 21 change in reported claims + CY21 change in IBNR =
1964 + (3779 - 1897) + (4227 - 3835) + (4055 - 3702) + (4296 - 4287) + (4223 - 4222)
+ (3746 - 3746) + (4100 - 3900) = **4801**.

**5.19.** (a) The case reserves are the difference between the reported and paid claims.

| Accident Year | Reported Claims | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 |
| 2015 | 2,073,186 | 2,977,355 | 3,689,430 | 4,344,924 | 4,635,919 | 4,691,541 |
| 2016 | 2,214,894 | 3,167,365 | 4,021,756 | 4,613,081 | 4,945,867 | 5,014,244 |
| 2017 | 2,339,966 | 3,357,699 | 4,299,159 | 4,992,272 | 5,303,741 | 5,364,852 |
| 2018 | 2,442,143 | 3,577,869 | 4,576,972 | 5,228,180 | 5,653,369 | 5,760,949 |
| 2019 | 2,592,402 | 3,757,301 | 4,853,532 | 5,625,219 | 6,054,505 | |
| 2020 | 2,817,613 | 4,182,588 | 5,212,351 | 6,024,272 | | |
| 2021 | 3,075,951 | 4,425,866 | 5,613,235 | | | |
| 2022 | 3,232,412 | 4,682,692 | | | | |
| 2023 | 3,554,432 | | | | | |
| AY | Cumulative Paid Claims | | | | | |
| 2015 | 1,286,342 | 2,412,544 | 3,380,499 | 4,184,900 | 4,587,477 | 4,691,541 |
| 2016 | 1,419,281 | 2,553,776 | 3,692,376 | 4,472,461 | 4,899,904 | 5,014,244 |
| 2017 | 1,474,216 | 2,703,709 | 3,940,993 | 4,833,876 | 5,248,486 | 5,364,852 |
| 2018 | 1,470,542 | 2,889,545 | 4,189,625 | 5,064,468 | 5,604,641 | 5,760,949 |
| 2019 | 1,607,264 | 2,999,878 | 4,445,019 | 5,419,708 | 5,967,598 | |
| 2020 | 1,747,620 | 3,387,292 | 4,766,703 | 5,724,228 | | |
| 2021 | 1,964,983 | 3,552,637 | 5,155,384 | | | |
| 2022 | 1,980,306 | 3,785,833 | | | | |
| 2023 | 2,247,631 | | | | | |
| AY | Case Reserves | | | | | |
| 2015 | 786,844 | 564,811 | 308,931 | 160,024 | 48,442 | 0 |
| 2016 | 795,613 | 613,589 | 329,380 | 140,620 | 45,963 | 0 |
| 2017 | 865,750 | 653,990 | 358,166 | 158,396 | 55,255 | 0 |
| 2018 | 971,601 | 688,324 | 387,347 | 163,712 | 48,728 | 0 |
| 2019 | 985,138 | 757,423 | 408,513 | 205,511 | 86,907 | |
| 2020 | 1,069,993 | 795,296 | 445,648 | 300,044 | | |
| 2021 | 1,110,968 | 873,229 | 457,851 | | | |
| 2022 | 1,252,106 | 896,859 | | | | |
| 2023 | 1,306,801 | | | | | |

The case reserves at the end of CY22:
1,252,106 + 873,229 + 445,648 + 205,511 + 48,728 = 2,825,222.
The case reserves at the end of CY23:
1,306,801 + 896,859 + 457,851 + 300,044 + 86,907 = 3,048,462
Change in case reserves during CY23: 3,048,462 - 2,825,222= **223,240**.
(b) The paid claims at the end of CY22:
1,980,306 + 3,552,637 + 4,766,703 + 5,419,708 + 5,604,641 + 5,364,852 = 26,688,847.
The paid claims at the end of CY23:
2.247,631 + 3,785,833 + 5,155,384 + 5,724,228 + 5,967,598 + 5,760,949 = 28,641,623.
Claims paid in CY23: 28,641,623 - 26,688,847 = **1,952,776**.
(c) Claim #4400 is in AY2021 and is reported in 2021.

| AY | Reported Counts | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 1 | 1 | 1 |

Claim #5500 is in AY2021 and is reported in 2022.

| AY | Reported Counts | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 0 | 1 | 1 |

(d) Claim #4400 is in AY2021. Closed in 2022, but reopened in 2023.

| AY | Closed Counts | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 0 | 1 | 0 |

Claim #5500 is in AY2021 and is closed (with no payment) in 2023.

| AY | Closed Counts | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 0 | 0 | 1 |

Alternately, the insurer may not include claims closed without payment in its closed claim counts. In which case, it may have a separate triangle for claims closed without payment.

| AY | Closed Counts | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 0 | 0 | 0 |
| AY | Closed Without Payment Counts | | |
| 2021 | 0 | 0 | 1 |

Comment: Some insurers include claims closed without payment (CNP) counts in their reported claim counts, but not in their closed claim counts.

## Section 6, The Development Triangle as a Diagnostic Tool

As has been discussed previously, the actuary needs to meet with management and discuss what is going on with the insurer. For the loss reserving actuary it is particularly important to talk to the management and staff about any changes in the claims handling process.

This chapter discusses how to use data to alert the actuary to changes in the claims environment. This can be due to changes in either the insurer's operations or in the external environment.

The first purpose is to see whether or not changes implemented by claims management have had their intended effect. The second purpose is to alert the actuary to changes which will alter the estimate of ultimate claims and to suggest which loss reserving techniques would be most appropriate to use.[121]

The actuary should start by looking for any anomalies in claims triangles and claim count triangles that were discussed in the previous section.[122]

*Claims Ratios*:[123]

The actuary can take the ratio of a claims triangle to either earned premium or on-level earned premium. The claims can be either reported or paid. The actuary is looking for anything unusual.

| Accident Year | Ratio of Paid Claims to On-Level Earned Premium | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 26.2% | 49.1% | 83.6% |
| 2022 | 21.2% | 51.6% | |
| 2023 | 25.7% | | |
| AY | Ratio of Reported Claims to On-Level Earned Premium | | |
| 2021 | 42.2% | 70.0% | 93.2% |
| 2022 | 59.0% | 68.7% | |
| 2023 | 68.5% | | |

The paid ratio for AY22 at first report seems unusual compared to the two other years.
The reported ratios at first report for the AYs are very different from each other.[124]
These warrant further investigation by the actuary.

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[121] Many different loss reserving techniques will be discussed in subsequent sections.
[122] This applies to ratemaking as well as loss reserving.
[123] See Tables 4, 5, and 7 in Friedland.
[124] In practical applications the actuary would examine a triangle with many more rows.

Ratio of Paid to Reported Claims:[125]

**The triangle of the ratio of Paid claims to Reported claims can reveal a change in case reserve adequacy or settlement patterns.**

If for example these ratios at early maturities have increased, then the numerator of paid claims has increased and/or the denominator of reported claims has decreased. This could indicate either that more claims are being paid sooner or that case reserves have been weakened.[126]

Further analysis would be needed to see which if either of these is occurring.

Also it may be due to the type of claims changing, due to changes in the mix of business being written. It may be due to changes in the claims department; for example the insurer may be concentrating on closing large claims earlier.

Exercise: Discuss the following information:

| Accident Year | Cumulative Paid Claims as of (months) ($000) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 400 | 800 | 1100 |
| 2022 | 500 | 900 | |
| 2023 | 600 | | |
| AY | Cumulative Reported Claims as of (months) ($000) | | |
| 2021 | 900 | 1300 | 1500 |
| 2022 | 1200 | 1600 | |
| 2023 | 1600 | | |
| AY | Ratio | | |
| 2021 | 0.444 | 0.615 | 0.733 |
| 2022 | 0.417 | 0.563 | |
| 2023 | 0.375 | | |

[Solution: Looking down the column for 12 months, the ratios of paid to reported claims have decreased. This could be due to either a slowing of the settlement rate, or a strengthening of case reserves. ]

[125] See Table 6 in Friedland.

[126] It could also be the case that it is taking longer for claims to be reported. This could be due to internal reasons such as taking more time to get into the computer data base and/or taking more time for a claim file to be opened.

Ratio of Closed-to-Reported Claim Counts:

As discussed previously, different insurers define claim counts differently. It is important for the actuary to know how claims counts are defined and to check whether there has been any change in the way claim counts are defined.

**The triangle of the ratio of Closed Claims Counts to Reported Claims Counts can reveal a change in settlement rate.** For example:

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 200 | 240 | 250 |
| 2022 | 230 | 280 | |
| 2023 | 270 | | |
| AY | Cumulative Closed Claim Counts as of (months) | | |
| 2021 | 100 | 150 | 210 |
| 2022 | 115 | 190 | |
| 2023 | 160 | | |
| AY | Ratio | | |
| 2021 | 0.500 | 0.625 | 0.840 |
| 2022 | 0.500 | 0.679 | |
| 2023 | 0.593 | | |

Looking down the columns, the ratios seem to have increased in calendar year 2023.
The settlement rate seems to have increased.

Friedland mentions a number of internal and external forces that may affect these ratios:

- Change in the guidelines for the establishment of a claim.
- Introduction of a new call center to handle claims.[127]
- Decrease in the statute of limitations, which often accompanies major tort reform.
- A hurricane may temporarily limit an insurer's operations with telephone and computer system shutdowns, resulting in a one-time blip with a decrease in the ratio of closed-to-reported claim counts.
- Restructuring of the claim field offices, such as through the merging of existing offices or the addition of new offices.
- Delegation of a higher limit for settlement of claims to a Third Party Administrator.

As will be discussed in subsequent sections, one can use the triangle of reported claim counts in order to estimate ultimate claim counts. Then:
Disposal Rates = (Cumulative Closed Claim Counts) ÷ (Ultimate Claim Counts).

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[127] This could affect both reported and closed claim counts.

Severities:[128]

One can calculate triangles of several average sizes:
average reported claims, average paid claims, and average case outstanding.

- Average reported claim: $\frac{\text{reported claims}}{\text{reported claim counts}}$.

- Average closed claim: $\frac{\text{paid claims}}{\text{closed claim counts}}$.

- Average case outstanding: $\frac{\text{reported claims - paid claims}}{\text{reported claim counts - closed claim counts}}$.

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 400 | 800 | 1100 |
| 2022 | 500 | 900 | |
| 2023 | 600 | | |
| AY | Cumulative Closed Claim Counts as of (months) | | |
| 2021 | 100 | 150 | 210 |
| 2022 | 115 | 190 | |
| 2023 | 160 | | |
| AY | Average Paid Claim | | |
| 2021 | $4,000 | $5,333 | $5,238 |
| 2022 | $4,348 | $4,737 | |
| 2023 | $3,750 | | |

For these severities to be meaningful there should be at most insignificant partial payments. Partial payments would create a mismatch between paid claims and closed claim counts.

Going down the columns one would expect the severities to increase in line with the rate of inflation for the given line of insurance.[129] If this is not the observed pattern, the actuary should investigate further.

As will be discussed in subsequent sections, some reserving techniques use an annual severity trend; the triangle of average paid claims can be used to select this trend.

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[128] See Tables 11 to 14 in Friedland.
[129] In practical applications the actuary would examine a triangle with many more rows.

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 900 | 1300 | 1500 |
| 2022 | 1200 | 1600 | |
| 2023 | 1600 | | |
| AY | Cumulative Reported Claim Counts as of (months) | | |
| 2021 | 200 | 240 | 250 |
| 2022 | 230 | 280 | |
| 2023 | 270 | | |
| AY | Average Reported Claim | | |
| 2021 | $4,500 | $5,417 | $6,000 |
| 2022 | $5,217 | $5,714 | |
| 2023 | $5,926 | | |
| AY | Cumulative Paid Claims ($000) as of (months) | | |
| 2021 | 400 | 800 | 1100 |
| 2022 | 500 | 900 | |
| 2023 | 600 | | |
| AY | Cumulative Closed Claim Counts as of (months) | | |
| 2021 | 100 | 150 | 210 |
| 2022 | 115 | 190 | |
| 2023 | 160 | | |
| AY | Average Case Outstanding | | |
| 2021 | $5,000 | $5,556 | $10,000 |
| 2022 | $6,087 | $7,778 | |
| 2023 | $9,091 | | |

For example, the average case reserve for AY21 at first report is:
(1000)(900 - 400) / (200 - 100) = $5000.

This triangle of averages of case outstanding seems to indicate that case reserves have been strengthened. However, the actuary has to determine how much of the increase in the average case reserve is truly due to a systemic change in adequacy and how much may be due to change in the mix of claims. In general, **the triangle of averages of case outstanding can be used to try to detect any change in the adequacy of case reserves.**

The presence or absence of a very large claim can distort triangles of severities. An actuary could remove any such very large claims and treat them separately. Instead, an actuary can work with limited claims; then an estimate of ultimate limited claims would have be translated somehow back to an unlimited basis.

Conclusions:

**The actuary should look at more than one diagnostic tool before drawing conclusions**.[130]

"Exploring the data begins by understanding the trends and changes affecting the database. Understanding the data is a prerequisite to estimating sound loss reserves. This exploration will help the analyst select appropriate loss reserving methods and interpret the results of the methods."[131]

Management may inform the actuary of operational changes in the claims process. However, the actuary needs to examine data in order to confirm whether or not management's plans have had the intended effect.

"**Without some form of verification, management's assertion of changes in the strength of case outstanding or changes in the rate of claims settlement could lead to inaccurate estimates of unpaid claims by the actuary**."

"Understanding the data is a complex process that requires the input of many people and ultimately requires the judgment of the actuary to interpret the findings from both quantitative and qualitative information."

*Importance Recognizing Changes in Insurer Operations*:[132]

"The financial condition of an insurance company can not be adequately assessed without sound loss reserve estimates.

A large number of numerical examples will be provided to demonstrate the techniques.

The common methods assume that an insurance company's historical experience can be used to project the future. But in today's business environment, an insurance company's operations are frequently changing. The loss reserve analyst needs to recognize and make adjustments for the changes. Based on experience and judgment, an actuary's opinion will always play a key role in interpreting the results of the numerical techniques. It is important for an actuary to learn about the organization and understand the data before embarking on the task of estimating the loss reserve."

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[130] On an exam questions, you are often asked to draw conclusions based solely on the limited information provided.

[131] Quoted from "Loss Reserving", by Ronald F. Wiser, revised and updated by Jo Ellen Cockley and Andrea Gardner, Chapter 5 of Foundations of Actuarial Science, not on the syllabus.

[132] Quoted from "Loss Reserving", by Ronald F. Wiser, revised and updated by Jo Ellen Cockley and Andrea Gardner, Chapter 5 of Foundations of Actuarial Science, not on the syllabus.

*Data Analysis*:[133]

"Before the analyst begins to project immature loss data to ultimate loss estimates, it is important to review the data. The objective of this review is to understand the data in terms of:
1. rate of development,
2. smoothness of development,
3. presence of large losses, and
4. volume of data.

Review of the data will allow the analyst to form conclusions about:
1. appropriate projection methodologies,
2. anomalies in the data, and
3. appropriate questions to ask management concerning issues that manifest themselves in the data, that will further the analyst's understanding of the book of business that generated the data."

[133] Quoted from "Loss Reserving", by Ronald F. Wiser, revised and updated by Jo Ellen Cockley and Andrea Gardner, Chapter 5 of Foundations of Actuarial Science, not on the syllabus.

Problems:

**6.1.** (2 points) The following data reflects an insurance company's recent claims experience:

| Reported Claims ($000) as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 33,000 | 41,000 |
| 2022 | 39,000 | 47,000 |
| 2023 | 37,000 | 45,000 |
| 2024 | 36,000 | |

| Paid Claims ($000) as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 10,000 | 20,000 |
| 2022 | 13,000 | 24,000 |
| 2023 | 16,000 | 29,000 |
| 2024 | 15,000 | |

| Reported Claim Counts as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 1,900 | 2,200 |
| 2022 | 2,100 | 2,400 |
| 2023 | 1,800 | 1,900 |
| 2024 | 1,900 | |

| Closed Claim Counts as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 270 | 1,000 |
| 2022 | 300 | 1,100 |
| 2023 | 360 | 1,000 |
| 2024 | 450 | |

Use two different diagnostics to assess whether any changes have been made to the company's claims department.

**6.2.** (1.25 points) Given the following information:

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 6,400 | 6,800 | 7,000 |
| 2022 | 5,900 | 6,200 | |
| 2023 | 4,600 | | |

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 6,900 | 7,300 | 7,400 |
| 2022 | 6,400 | 7,200 | |
| 2023 | 5,300 | | |

| Accident Year | Open Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 122 | 85 | 35 |
| 2022 | 126 | 104 | |
| 2023 | 115 | | |

Create two diagnostic triangles and discuss whether there have been any changes in case reserve adequacy.

**6.3.** (2 points) Given the following data for a small insurance company:

| Cumulative Closed Claim Counts | | | | | Earned Exposures |
|---|---|---|---|---|---|
| Accident Year | Age of Development in Months | | | | |
| | 12 | 24 | 36 | 48 | |
| 2020 | 240 | 380 | 450 | 480 | 30,000 |
| 2021 | 250 | 400 | 460 | | 31,000 |
| 2022 | 240 | 350 | | | 32,000 |
| 2023 | 210 | | | | 33,000 |

a. (1.5 points) Explain any aspects of the data that may be the result of operational changes within the company.
b. (0.5 point) Explain how such a change might affect ultimate loss indications derived from the corresponding paid loss triangle.

**6.4.** (1 point) The paid losses for the most recent accident year at first report are significantly larger than previous accident years at first report.
Other than inflation, list two possible reasons for this.

**6.5.** (2 points) Given the following information as of December 31, 2023:

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 2,200 | 4,000 | 6,100 |
| 2022 | 2,200 | 4,300 | |
| 2023 | 2,300 | | |

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 5,000 | 7,300 | 7,800 |
| 2022 | 4,900 | 6,800 | |
| 2023 | 4,800 | | |

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 202 | 207 | 210 |
| 2022 | 196 | 201 | |
| 2023 | 199 | | |

| Accident Year | Open Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 152 | 98 | 32 |
| 2022 | 146 | 75 | |
| 2023 | 137 | | |

- Reported claim counts exclude claims closed without payment.
- Historical claim cost inflation is 0%.

Calculate the closed to reported claim count ratio triangle and the average case outstanding triangle and briefly describe what the triangles suggest about changes in:

i. Settlement rates

ii. Case reserve adequacy

**6.6.** (1 point) Given the following information as of December 31, 2024:

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 10,000 | 15,000 | 18,000 | 19,800 |
| 2022 | 11,000 | 16,500 | 19,800 | |
| 2023 | 11,650 | 14,900 | | |
| 2024 | 10,500 | | | |

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 5,800 | 11,000 | 16,000 | 19,100 |
| 2022 | 6,400 | 12,000 | 18,500 | |
| 2023 | 6,800 | 13,100 | | |
| 2024 | 7,300 | | | |

Produce a diagnostic that shows an operational change in the insurer's history.
Briefly describe a scenario that could result in the observed diagnostic.

**6.7.** (1 point) Given the following information as of December 31, 2024:

| Accident Year | Cumulative Closed Claim Counts as of (months) | | | | Ultimate Claim Counts |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | |
| 2020 | 1,210 | 1,350 | 1,400 | 1,430 | 1,480 |
| 2021 | 1,240 | 1,360 | 1,410 | 1,480 | 1,500 |
| 2022 | 1,250 | 1,370 | 1,470 | | 1,510 |
| 2023 | 1,270 | 1,450 | | | 1,530 |
| 2024 | 1,400 | | | | 1,600 |

Calculate a diagnostic triangle and briefly discuss the results.

***6.8.*** (1.5 points) An insurance company faces the following scenarios:
- For property claims, the insurer instituted a new program that maintains recently retired claims adjusters on standby in case of a catastrophe.
- For liability claims, a law was passed that will increase the statute of limitations on reporting a claim.

a. (1 point) For each scenario above, explain the effect on the case outstanding triangle.
b. (0.5 point) Briefly describe two additional scenarios that could cause a change in the ratio of closed to reported claim counts.

***6.9.*** (2 points) Given the following information for an insurer:

| Accident Year | Cumulative Paid Loss + ALAE ($000) as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,100 | 1,450 | 1,550 | 1,660 | 1,680 |
| 2021 | 1,180 | 1,700 | 1,750 | 1,870 | |
| 2022 | 1,270 | 1,880 | 2,050 | | |
| 2023 | 1,300 | 1,710 | | | |
| 2024 | 1,320 | | | | |

| Accident Year | Cumulative Reported Loss + ALAE ($000) as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,400 | 1,600 | 1,670 | 1,690 | 1,710 |
| 2021 | 1,500 | 1,850 | 1,880 | 1,900 | |
| 2022 | 1,570 | 2,030 | 2,100 | | |
| 2023 | 1,650 | 1,900 | | | |
| 2024 | 1,800 | | | | |

| Accident Year | Cumulative Closed Claim Counts as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 720 | 1,220 | 1,330 | 1,430 | 1,460 |
| 2021 | 760 | 1,240 | 1,350 | 1,430 | |
| 2022 | 750 | 1,230 | 1,330 | | |
| 2023 | 780 | 1,210 | | | |
| 2024 | 810 | | | | |

| Accident Year | Cumulative Reported Claim Counts as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,200 | 1,350 | 1,400 | 1,450 | 1,470 |
| 2021 | 1,260 | 1,380 | 1,420 | 1,440 | |
| 2022 | 1,250 | 1,370 | 1,350 | | |
| 2023 | 1,300 | 1,290 | | | |
| 2024 | 1,170 | | | | |

a. (1.5 points) Calculate a diagnostic triangle in order to determine whether the adequacy of case reserves has changed. Briefly discuss the result.

b. (0.5 point) Calculate a diagnostic triangle in order to determine whether the settlement rate has changed. Briefly discuss the result.

**6.10.** (1 point) Given the following information:

| Accident Year | Cumulative Closed Claim Counts as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | Ultimate |
| 2020 | 113 | 139 | 169 | 177 | 178 |
| 2021 | 112 | 138 | 161 | | 176 |
| 2022 | 113 | 133 | | | 177 |
| 2023 | 108 | | | | 183 |

Determine whether there has been a change in the rate of settling claims.

**6.11.** (1 point) Given the following data as of December 31, 2024:

| Accident Year | Case Outstanding ($million) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 104 | 102 | 70 | 19 |
| 2022 | 98 | 129 | 72 | |
| 2023 | 118 | 137 | | |
| 2024 | 121 | | | |

| Accident Year | Open Claim Counts as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 3700 | 4600 | 2100 | 510 |
| 2022 | 3400 | 4200 | 1900 | |
| 2023 | 3300 | 4100 | | |
| 2024 | 3200 | | | |

● Selected annual severity trend is 6%.
Evaluate whether there has been a change in the adequacy of case outstanding over the experience period.

**6.12.** (5 points) Given the following information:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 300 | 500 | 700 | 900 |
| 2020 | 300 | 500 | 700 | |
| 2021 | 300 | 500 | | |
| 2022 | 300 | | | |
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 500 | 700 | 900 | 900 |
| 2020 | 500 | 700 | 900 | |
| 2021 | 500 | 700 | | |
| 2022 | 500 | | | |
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 800 | 1100 | 1400 | 1500 |
| 2020 | 800 | 1100 | 1400 | |
| 2021 | 800 | 1100 | | |
| 2022 | 800 | | | |
| Closed Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 600 | 900 | 1200 | 1500 |
| 2020 | 600 | 900 | 1200 | |
| 2021 | 600 | 900 | | |
| 2022 | 600 | | | |

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| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 100 | 170 | 230 | 300 |
| 2020 | 100 | 170 | 230 | |
| 2021 | 100 | 170 | | |
| 2022 | 100 | | | |
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 190 | 270 | 290 | 300 |
| 2020 | 190 | 270 | 290 | |
| 2021 | 190 | 270 | | |
| 2022 | 190 | | | |
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 270 | 370 | 470 | 500 |
| 2020 | 270 | 370 | 470 | |
| 2021 | 270 | 370 | | |
| 2022 | 270 | | | |
| Closed Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 200 | 300 | 400 | 500 |
| 2020 | 200 | 300 | 400 | |
| 2021 | 200 | 300 | | |
| 2022 | 200 | | | |

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● Both Company A and Company B write primary automobile insurance policies.
● On December 31, 2022, the two merge to form Company C.

a. (3 points) Calculate three key diagnostics that an actuary would review to determine whether to combine historical data for Company A and Company B.

b. (1 point) Assume the mix of business is comparable (i.e. similar limits, classes, territories, etc.) for Company A and Company B. Argue whether or not it is appropriate to combine the historical data to estimate unpaid claims for accident years 2022 and prior as of December 31, 2022 for Company C.

c. (1 point) Assume that Company C's claims department will adopt Company A's claims practices. Argue whether or not it is appropriate to combine historical data to estimate ultimate claims for accident year 2023 as of December 31, 2023 for Company C.

**6.13.** (1 point)
Given the following data for an insurance company evaluated as of December 31, 2023:

| Average Case Outstanding | | | | | | Average Reported Claims | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Accident Year | | | | | | Accident Year | | | | |
| | 12 | 24 | 36 | 48 | | | 12 | 24 | 36 | 48 |
| 2020 | 1100 | 2000 | 2200 | 2300 | | 2020 | 800 | 1450 | 1980 | 2140 |
| 2021 | 1160 | 2100 | 2420 | | | 2021 | 840 | 1520 | 2080 | |
| 2022 | 1220 | 2310 | | | | 2022 | 890 | 1600 | | |
| 2023 | 1350 | | | | | 2023 | 930 | | | |

● Industry average claim cost trend = 5%.
Discuss the above data.

**6.14.** (2.5 points) Given the following information for a line of business:
- No reported claims development past 36 months.
- Annual claim severity trend = +4%.

| Accident Year | Cumulative Paid Claims ($000s) | | | Cumulative Closed Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2020 | 11,200 | 15,400 | 18,300 | 135 | 175 | 199 |
| 2021 | 12,200 | 17,000 | | 136 | 179 | |
| 2022 | 13,500 | | | 140 | | |

| Accident Year | Cumulative Reported Claims ($000s) | | | Cumulative Reported Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2020 | 14,800 | 17,100 | 18,500 | 178 | 196 | 200 |
| 2021 | 15,500 | 18,000 | | 179 | 199 | |
| 2022 | 16,500 | | | 183 | | |

Hans Down is a reserving actuary.
Fully discuss the things Hans should consider in deciding between using either the paid or the reported claim development method to estimate ultimate claims for this line of business.
Which of the two methods should Hans use?

**6.15.** (1.5 points)
a. (0.5 point) Identify two changes in an insurance company's internal environment that could distort the paid or reported development patterns.
b. (1 point) Briefly describe how each change identified in part a. above may be observed in a diagnostic triangle.

**6.16.** (1.5 points) Given the following:

| Reported Claims ($000) as of (months) | | | | | |
|---|---|---|---|---|---|
| Accident Year | 12 | 24 | 36 | 48 | 60 |
| 2020 | 2,380 | 2,600 | 2,670 | 2,760 | 2,790 |
| 2021 | 2,500 | 2,910 | 2,980 | 3,000 | |
| 2022 | 2,570 | 3,030 | 3,100 | | |
| 2023 | 2,650 | 2,700 | | | |
| 2024 | 2,410 | | | | |

| Reported Claim Counts as of (months) | | | | | |
|---|---|---|---|---|---|
| Accident Year | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,200 | 1,350 | 1,400 | 1,460 | 1,470 |
| 2021 | 1,260 | 1,380 | 1,420 | 1,450 | |
| 2022 | 1,250 | 1,370 | 1,430 | | |
| 2023 | 1,300 | 1,290 | | | |
| 2024 | 1,370 | | | | |

| Paid Claims ($000) as of (months) | | | | | |
|---|---|---|---|---|---|
| Accident Year | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,700 | 2,060 | 2,250 | 2,620 | 2,700 |
| 2021 | 1,780 | 2,300 | 2,550 | 2,910 | |
| 2022 | 1,870 | 2,420 | 2,600 | | |
| 2023 | 1,900 | 2,450 | | | |
| 2024 | 1,820 | | | | |

| Closed Claim Counts as of (months) | | | | | |
|---|---|---|---|---|---|
| Accident Year | 12 | 24 | 36 | 48 | 60 |
| 2020 | 720 | 1,220 | 1,330 | 1,440 | 1,450 |
| 2021 | 760 | 1,240 | 1,350 | 1,430 | |
| 2022 | 750 | 1,230 | 1,320 | | |
| 2023 | 780 | 1,210 | | | |
| 2024 | 810 | | | | |

Compute the triangle of average case outstanding. Discuss the result.

**6.17.** (10 points) You are given the following information:

| Accident Year | Reported Claims ($000) as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 58,641 | 74,804 | 77,323 | 77,890 | 80,728 | 82,280 | 82,372 |
| 2020 | 63,732 | 79,512 | 83,680 | 85,366 | 88,152 | 87,413 | |
| 2021 | 51,779 | 68,175 | 69,802 | 69,694 | 70,041 | | |
| 2022 | 40,143 | 67,978 | 75,144 | 77,947 | | | |
| 2023 | 55,665 | 80,296 | 87,961 | | | | |
| 2024 | 43,401 | 57,547 | | | | | |
| 2025 | 28,800 | | | | | | |

| Accident Year | Paid Claims ($000) as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 22,603 | 40,064 | 54,301 | 64,114 | 71,257 | 75,950 | 78,224 |
| 2020 | 22,054 | 43,970 | 58,737 | 71,841 | 78,076 | 81,287 | |
| 2021 | 20,166 | 39,147 | 51,319 | 60,417 | 66,402 | | |
| 2022 | 19,297 | 37,355 | 50,391 | 62,347 | | | |
| 2023 | 20,555 | 42,898 | 62,832 | | | | |
| 2024 | 17,001 | 33,568 | | | | | |
| 2025 | 11,346 | | | | | | |

| Accident Year | Reported Claim Counts as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 32,751 | 41,201 | 41,618 | 41,755 | 41,773 | 41,774 | 41,774 |
| 2020 | 33,736 | 39,528 | 39,926 | 40,044 | 40,072 | 40,072 | |
| 2021 | 27,067 | 32,740 | 33,084 | 33,183 | 33,209 | | |
| 2022 | 24,928 | 29,796 | 30,074 | 30,169 | | | |
| 2023 | 25,229 | 31,930 | 32,281 | | | | |
| 2024 | 17,632 | 21,801 | | | | | |
| 2025 | 15,609 | | | | | | |

Question continued on the next page

| Accident Year | Claim Counts Closed With Payment as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 23,355 | 31,940 | 33,288 | 33,860 | 34,091 | 34,247 | 34,294 |
| 2020 | 22,662 | 30,294 | 31,588 | 32,129 | 32,323 | 32,433 | |
| 2021 | 18,951 | 25,197 | 26,214 | 26,582 | 26,777 | | |
| 2022 | 16,631 | 22,894 | 23,806 | 24,229 | | | |
| 2023 | 17,381 | 24,581 | 25,765 | | | | |
| 2024 | 12,666 | 16,669 | | | | | |
| 2025 | 10,592 | | | | | | |

| Accident Year | Claim Counts Closed Without Payment as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 2,646 | 6,285 | 6,935 | 7,240 | 7,353 | 7,393 | 7,412 |
| 2020 | 3,142 | 6,529 | 7,053 | 7,308 | 7,411 | 7,465 | |
| 2021 | 2,752 | 5,366 | 5,840 | 6,050 | 6,185 | | |
| 2022 | 2,343 | 4,744 | 5,132 | 5,400 | | | |
| 2023 | 2,238 | 4,666 | 5,375 | | | | |
| 2024 | 1,749 | 3,458 | | | | | |
| 2025 | 1,246 | | | | | | |

Create each of the following diagnostic triangles and briefly comment on them.
(a) Paid Claims as a percent of Reported Claims.
(b) The average open claim, and the changes from the previous Accident Year.
(c) The average closed claim (defined as the ratio of paid claims to the claim counts closed with payment), and the changes from the previous Accident Year.
(d) For an AY, the ratio of closed claim counts (either with or without payment) to reported claim counts.
(e) For an AY, the ratio of claims counts closed in a year (either with or without payment) to the claim counts open at the start of that year.
(f) The ratio of the incremental claim counts closed without payment to the incremental claim counts closed with payment.

***6.18*.** (1 point) Given the following for an insurance company:

| Accident Year | Average Case Outstanding ($000) on Large Claims as of (months) | | | | Average Case Outstanding ($) on Small Claims as of (months) | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 12 | 24 | 36 | 48 |
| 2021 | 600 | 710 | 760 | 850 | 2700 | 3100 | 4500 | 5000 |
| 2022 | 640 | 740 | 900 | | 2800 | 3300 | 4700 | |
| 2023 | 660 | 900 | | | 2900 | 3400 | | |
| 2024 | 810 | | | | 3000 | | | |

- Annual severity trend is 5%.
- Large claims are defined as greater than or equal to $250,000 in reported claims and small claims are defined as less than $250,000 in reported claims.

Fully discuss the above information.

**6.19. (6, 11/06, Q.2)** (1.5 points) (1 point) Which triangle will best help identify whether case reserve inadequacy is present in the latest accident year?
A. Closed Claim Counts as a Percent of Open Claim Counts Triangle
B. Cumulative Reported Loss Triangle
C. Average Paid Loss Triangle
D. Open Claim Counts Triangle
E. Paid Loss as a Percentage of Reported Loss Triangle

**6.20. (6, 11/07, Q.40)** (2 points) Given the following data for an insurance company:

| Cumulative Closed Claim Counts | | | | | Earned Exposures |
|---|---|---|---|---|---|
| Accident Year | Age of Development in Months | | | | |
| | 12 | 24 | 36 | 48 | |
| 2003 | 120 | 170 | 195 | 200 | 20,000 |
| 2004 | 115 | 170 | 210 | | 20,500 |
| 2005 | 120 | 195 | | | 21,000 |
| 2006 | 160 | | | | 21,250 |

a. (1.5 points) Explain any aspects of the data that may be the result of operational changes within the company.
b. (0.5 point) Explain how such a change might affect ultimate loss indications derived from the corresponding paid loss triangle.

**6.21. (6, 11/10, Q.15)** (1.75 points) Given the following claim detail ($000):

| Claim | Accident Date | Paid During 2007 | Case Reserve at 12/31/07 | Paid During 2008 | Case Reserve at 12/31/08 | Paid During 2009 | Case Reserve at 12/31/09 |
|---|---|---|---|---|---|---|---|
| 1 | January 1, 2007 | 75 | 250 | 50 | 250 | 300 | 0 |
| 2 | July 1, 2007 | 25 | 250 | 50 | 200 | 200 | 0 |
| 3 | January 1, 2008 | | | 0 | 500 | 50 | 600 |
| 4 | July 1, 2008 | | | 100 | 50 | 100 | 0 |
| 5 | January 1, 2009 | | | | | 105 | 645 |

a. (0.5 point) Construct an accident year cumulative paid loss triangle.
b. (0.5 point) Construct an accident year cumulative reported loss triangle.
c. (0.75 point) Perform a diagnostic test to determine whether the data suggests a speed-up in claim payments.

**6.22. (5, 5/11, Q.23)** (1 point) Given the following data as of December 31, 2010:

| Accident Year | Reported Claims (000s) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2007 | $500 | $554 | $586 | $592 |
| 2008 | $448 | $470 | $512 | |
| 2009 | $312 | $346 | | |
| 2010 | $426 | | | |

| Accident Year | Paid Claims (000s) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2007 | $85 | $200 | $500 | $570 |
| 2008 | $81 | $225 | $472 | |
| 2009 | $59 | $175 | | |
| 2010 | $85 | | | |

Fully discuss whether the data indicates a speed-up in claim closure.

**6.23. (5, 5/12, Q.23)** (1.5 points) An insurance company faces the following scenarios:
- For property claims, a new claims processing system is implemented that will result in claims closing faster.
- For liability claims, a tort reform change is passed that will reduce the statute of limitations on reporting a claim.

a. (1 point) For each scenario above, explain the effect on the average case outstanding triangle.
b. (0.5 point) Briefly describe two additional scenarios that could cause a change in the ratio of closed to reported claim counts.

**6.24. (5, 5/13, Q.20)** (3 points) Given the following information for a line of business:
- Assume no reported claims development past 36 months.
- Annual claim severity trend = +5%.
- Paid claim development method ultimate loss for accident year 2012 = $10,275,000.
- Reported claim development method ultimate loss for accident year 2012 = $9,650,000.

| Accident Year | Cumulative Paid Claims ($000s) | | | Cumulative Closed Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 2,100 | 6,410 | 8,300 | 35 | 75 | 99 |
| 2011 | 2,210 | 7,000 | | 35 | 80 | |
| 2012 | 2,550 | | | 40 | | |

| Accident Year | Cumulative Reported Claims ($000s) | | | Cumulative Reported Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 5,300 | 7,810 | 8,500 | 80 | 98 | 100 |
| 2011 | 5,500 | 8,130 | | 79 | 97 | |
| 2012 | 6,000 | | | 82 | | |

| Accident Year | Outstanding Claims ($000s) | | | Outstanding Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 3,200 | 1,400 | 200 | 45 | 23 | 1 |
| 2011 | 3,290 | 1,130 | | 44 | 17 | |
| 2012 | 3,450 | | | 42 | | |

Fully discuss the considerations in deciding between using the paid or the reported claim development method to estimate ultimate claims for this line of business, and recommend an ultimate loss estimate for accident year 2012.

**6.25. (5, 11/13, Q.15)** (4.5 points) Given the following information:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 400 | 2,400 | 9,600 | 12,000 |
| 2010 | 400 | 2,400 | 9,600 | |
| 2011 | 400 | 2,400 | | |
| 2012 | 400 | | | |
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 800 | 4,800 | 12,800 | 14,400 |
| 2010 | 800 | 4,800 | 12,800 | |
| 2011 | 800 | 4,800 | | |
| 2012 | 800 | | | |
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 2,000 | 3,000 | 3,000 | 3,000 |
| 2010 | 2,000 | 3,000 | 3,000 | |
| 2011 | 2,000 | 3,000 | | |
| 2012 | 2,000 | | | |
| Closed Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 1,000 | 1,500 | 2,000 | 2,500 |
| 2010 | 1,000 | 1,500 | 2,000 | |
| 2011 | 1,000 | 1,500 | | |
| 2012 | 1,000 | | | |

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| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 12 | 45 | 176 | 230 |
| 2010 | 4 | 39 | 192 | |
| 2011 | 6 | 51 | | |
| 2012 | 8 | | | |
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 50 | 144 | 264 | 278 |
| 2010 | 34 | 144 | 288 | |
| 2011 | 34 | 147 | | |
| 2012 | 40 | | | |
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 40 | 60 | 60 | 60 |
| 2010 | 40 | 60 | 60 | |
| 2011 | 40 | 60 | | |
| 2012 | 40 | | | |
| Closed Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 20 | 30 | 40 | 50 |
| 2010 | 20 | 30 | 40 | |
| 2011 | 20 | 30 | | |
| 2012 | 20 | | | |

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- Both Company A and Company B write primary auto liability policies.
- On December 31, 2012, the two merge to form Company C.

*a. (1 point) According to the Statement of Principles Regarding Property and Casualty Loss and Loss Adjustment Expense Reserves, discuss two actuarial considerations for designing a reserve study for Company C.*

b. (1.5 points) Calculate three key diagnostics that an actuary would review to determine whether to combine historical data for Company A and Company B.

c. (1 point) Assume the mix of business is comparable (i.e. similar limits, classes, territories, etc.) for Company A and Company B. Argue whether or not it is appropriate to combine the historical data to estimate unpaid claims for accident years 2012 and prior as of December 31, 2012 for Company C.

d. (1 point) Assume that Company C's claims department will adopt Company A's claims practices. Argue whether or not it is appropriate to combine historical data to estimate unpaid claims for accident year 2013 as of December 31, 2013 for Company C.

Note: The Standard of Practice referenced in part (a) is in Appendix A of Friedland, but is no longer on the syllabus of your exam.

**6.26. (5, 11/14, Q.14)** (3 points) Given the following information:

| Claim ID | Accident Date | Report Date | 2011 Transactions | | 2012 Transactions | | 2013 Transactions | |
|---|---|---|---|---|---|---|---|---|
| | | | Cal.Yr. Paid | Ending Case O/S | Cal.Yr. Paid | Ending Case O/S | Cal.Yr. Paid | Ending Case O/S |
| 1 | March 3, 2011 | July 1, 2011 | 260 | 0 | 0 | 0 | 0 | 0 |
| 2 | September 18, 2011 | October 2, 2011 | 200 | 500 | 0 | 500 | 230 | 270 |
| 3 | December 1, 2011 | February 15, 2012 | | | 620 | 0 | 0 | 0 |
| 4 | March 1, 2012 | April 1, 2012 | | | 200 | 200 | 400 | 0 |
| 5 | June 15, 2012 | September 9, 2012 | | | 460 | 0 | 0 | 0 |
| 6 | September 30, 2012 | October 20, 2012 | | | 0 | 400 | 700 | 400 |
| 7 | December 12, 2012 | March 11, 2013 | | | | | 300 | 230 |
| 8 | April 12, 2013 | June 18, 2013 | | | | | 400 | 200 |
| 9 | May 28, 2013 | July 23, 2013 | | | | | 600 | 300 |
| 10 | November 12, 2013 | December 5, 2013 | | | | | | 100 |
| 11 | October 30, 2013 | January 31, 2014 | | | | | | |

● Reported claims are closed when case outstanding equals 0.

a. (2 points) Create the following cumulative annual triangles organized by accident year:
   i. paid claims
   ii. reported claims
   iii. reported claim count
   iv. closed claim count

b. (1 point) Use the triangles produced in part a. above to generate one additional triangle to show that an operational change took place during the experience period. Identify and briefly describe an operational change consistent with the data.

**6.27. (5, 5/17, Q.15)** (2.25 points) Given the following information as of December 31, 2016:

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 1,150 | 2,250 | 3,000 |
| 2015 | 1,250 | 2,400 | |
| 2016 | 1,550 | | |

| Accident Year | Cumulative Reported Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 5,150 | 7,200 | 8,000 |
| 2015 | 4,800 | 6,700 | |
| 2016 | 4,750 | | |

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 102 | 107 | 108 |
| 2015 | 96 | 101 | |
| 2016 | 99 | | |

| Accident Year | Open Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 52 | 28 | 12 |
| 2015 | 46 | 25 | |
| 2016 | 42 | | |

- Reported claim counts exclude claims closed without payment.
- Historical claim cost inflation is 0%.

a. (0.75 point) Calculate the paid to reported claim ratio triangle and briefly describe what it suggests about changes in:
   i. Settlement rates
   ii. Case reserve adequacy

b. (1.5 points) Calculate the closed to reported claim count ratio triangle and the average case outstanding triangle and briefly describe what the triangles suggest about changes in:
   i. Settlement rates
   ii. Case reserve adequacy

**6.28. (5, 11/19, Q.17)** (2.25 points)

a. (0.75 point) Identify three changes in an insurance company's internal environment that could distort the paid or reported development patterns.

b. (1.5 points) Briefly describe how each change identified in part a. above may be observed in a diagnostic triangle.

**6.29. (SOA GIRR, 5/20, Q.3)** (4 points)

You are analyzing the following data triangles for the purpose of investigative testing:

| Data Triangle | |
|---|---|
| A | Ratios of paid claims to reported claims |
| B | Average reported claims |
| C | Average paid claims |
| D | Ratios of closed counts to reported counts |
| E | Average case estimates |

(a) (1 point) Describe the expected pattern in a stable environment for each of:
(i) Data triangle A
(ii) Data triangle B

(b) (1 point) Describe a limitation when analyzing data triangle A.

(c) (0.5 points) Explain why it is preferable to use paid claims on closed counts when analyzing data triangle C.

You have analyzed data triangles A and D, and neither are showing stable patterns.

(d) (1 point) Describe what an unstable pattern could indicate for each of:
(i) Data triangle A
(ii) Data triangle D

In reviewing data triangle E, you have noticed a material increase in the averages for a recent accident year.

(e) (0.5 points) Describe one possible cause of this anomaly in data triangle E.

**6.30. (SOA GIRR, 5/21, Q.2)** (4 points) You are given the following development triangles for investigative analysis on a book of business:

| Accident Year | Ratios of Closed Counts to Reported Counts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 |
| 2012 | 0.882 | 0.865 | 0.895 | 0.897 | 0.911 | 0.956 | 0.975 | 1.000 | 1.000 |
| 2013 | 0.882 | 0.865 | 0.895 | 0.897 | 0.911 | 0.956 | 0.975 | 1.000 | |
| 2014 | 0.882 | 0.865 | 0.895 | 0.897 | 0.911 | 0.951 | 0.976 | | |
| 2015 | 0.882 | 0.865 | 0.895 | 0.897 | 0.894 | 0.951 | | | |
| 2016 | 0.882 | 0.865 | 0.895 | 0.864 | 0.894 | | | | |
| 2017 | 0.882 | 0.865 | 0.825 | 0.864 | | | | | |
| 2018 | 0.882 | 0.774 | 0.825 | | | | | | |
| 2019 | 0.711 | 0.774 | | | | | | | |
| 2020 | 0.711 | | | | | | | | |

| Accident Year | Average Reported Claims | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 |
| 2012 | 882 | 1,135 | 1,382 | 1,564 | 1,709 | 1,792 | 1,856 | 1,875 | 1,875 |
| 2013 | 882 | 1,135 | 1,382 | 1,564 | 1,709 | 1,792 | 1,856 | 1,875 | |
| 2014 | 882 | 1,135 | 1,647 | 1,823 | 1,964 | 2,046 | 2,108 | | |
| 2015 | 882 | 1,135 | 1,382 | 1,564 | 1,709 | 1,793 | | | |
| 2016 | 882 | 1,135 | 1,382 | 1,564 | 1,709 | | | | |
| 2017 | 882 | 1,135 | 1,381 | 1,564 | | | | | |
| 2018 | 882 | 1,135 | 1,381 | | | | | | |
| 2019 | 882 | 1,135 | | | | | | | |
| 2020 | 882 | | | | | | | | |

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| Accident Year | Average Paid Claims | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 |
| 2012 | 625 | 1,055 | 1,324 | 1,500 | 1,667 | 1,678 | 1,731 | 1,744 | 1,800 |
| 2013 | 625 | 1,055 | 1,323 | 1,500 | 1,667 | 1,678 | 1,731 | 1,744 | |
| 2014 | 625 | 1,055 | 1,323 | 1,500 | 1,667 | 1,669 | 1,731 | | |
| 2015 | 625 | 1,055 | 1,323 | 1,500 | 1,658 | 1,669 | | | |
| 2016 | 625 | 1,055 | 1,323 | 1,491 | 1,657 | | | | |
| 2017 | 625 | 1,055 | 1,316 | 1,491 | | | | | |
| 2018 | 625 | 1,048 | 1,316 | | | | | | |
| 2019 | 620 | 1,048 | | | | | | | |
| 2020 | 620 | | | | | | | | |

| Accident Year | Ratios of Paid Claims to Reported Claims | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 |
| 2012 | 0.625 | 0.804 | 0.857 | 0.861 | 0.889 | 0.895 | 0.909 | 0.930 | 0.960 |
| 2013 | 0.625 | 0.804 | 0.857 | 0.861 | 0.889 | 0.895 | 0.909 | 0.930 | |
| 2014 | 0.625 | 0.804 | 0.719 | 0.739 | 0.773 | 0.776 | 0.802 | | |
| 2015 | 0.625 | 0.804 | 0.857 | 0.861 | 0.867 | 0.884 | | | |
| 2016 | 0.625 | 0.804 | 0.857 | 0.824 | 0.867 | | | | |
| 2017 | 0.625 | 0.804 | 0.786 | 0.824 | | | | | |
| 2018 | 0.625 | 0.714 | 0.786 | | | | | | |
| 2019 | 0.500 | 0.714 | | | | | | | |
| 2020 | 0.500 | | | | | | | | |

- The annual claims trend is 0% and experience has generally been stable.

Accident Year 2014 seems to show an anomaly.

(a) (1.5 points) Provide one possible interpretation of this anomaly. Justify your interpretation.

(b) (1 point) Identify another anomaly from the diagnostics.

(c) (1.5 points) Provide one possible interpretation of the anomaly you identified in part (b). Justify your interpretation.

**6.31. (SOA GIRR, 11/21, Q.16)** (7 points)
(a) (0.5 points) Define “maturity age” in the context of a claim development triangle.

You are given the following claim information.

| Claim ID | Incremental Paid Claims | | | | | |
|---|---|---|---|---|---|---|
| | 2018H1 | 2018H2 | 2019H1 | 2019H2 | 2020H1 | 2020H2 |
| Occurrence Year: 2018 | | | | | | |
| 1 | 0 | 100 | 250 | 0 | 0 | 75 |
| 2 | 50 | | | | | |
| 3 | | | | 0 | 55 | 0 |
| 4 | | | | | | |
| Occurrence Year: 2019 | | | | | | |
| 5 | | | 190 | 0 | 30 | |
| 6 | | | | 0 | 0 | |
| 7 | | | 75 | 0 | 0 | 185 |
| Occurrence Year: 2020 | | | | | | |
| 8 | | | | | 0 | 0 |
| 9 | | | | | 0 | 100 |
| 10 | | | | | 0 | 175 |

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| Claim ID | Case Estimates at the End of Each Half Year | | | | | |
|---|---|---|---|---|---|---|
| | 2018H1 | 2018H2 | 2019H1 | 2019H2 | 2020H1 | 2020H2 |
| Occurrence Year: 2018 | | | | | | |
| 1 | 150 | 200 | 75 | 75 | 75 | 0 |
| 2 | 0 | | | | | |
| 3 | | | | 315 | 260 | 260 |
| 4 | | | | | 75 | 90 |
| Occurrence Year: 2019 | | | | | | |
| 5 | | | 35 | 35 | 0 | |
| 6 | | | | 225 | 0 | |
| 7 | | | 0 | 0 | 225 | 0 |
| Occurrence Year: 2020 | | | | | | |
| 8 | | | | | 250 | 65 |
| 9 | | | | | 25 | 0 |
| 10 | | | | | 275 | 0 |

(b) (3 points) Construct a development triangle of cumulative reported claims, by accident year, with maturity ages 6, 12, 18, 24, 30 and 36 months.

The above claim information provides claims from the following three lines of business:

- Medical malpractice
- Workers' compensation
- Automobile physical damage

(c) (1.5 points) Select which line of business was the likely source for each of the following claims, providing a justification for each selection:

(i) Claim 2
(ii) Claim 3
(iii) Claim 7

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You are given the following general liability development triangle for investigative analysis.

| Accident Year | Reported Pure Premiums | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 |
| 2013 | 199 | 295 | 394 | 471 | 545 | 586 | 620 | 637 |
| 2014 | 196 | 293 | 393 | 469 | 544 | 626 | 618 | |
| 2015 | 170 | 257 | 344 | 419 | 485 | 521 | | |
| 2016 | 168 | 258 | 346 | 424 | 494 | | | |
| 2017 | 178 | 280 | 377 | 468 | | | | |
| 2018 | 190 | 300 | 408 | | | | | |
| 2019 | 202 | 321 | | | | | | |
| 2020 | 271 | | | | | | | |

(d) (1 point) Identify two anomalies relating to this triangle.

(e) (1 point) Describe a business, operational, or environmental change that could cause each of the anomalies identified in part (d).

**6.32. (SOA GIRR, 5/22, Q.2)** (7 points)
You are given the following claim information evaluated as of December 31, 2021.

| Accident Year | Reported Claims (000) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2018 | 1,196 | 1,525 | 1,638 | 1,723 |
| 2019 | 1,269 | 1,607 | 1,908 | |
| 2020 | 1,294 | 1,707 | | |
| 2021 | 1,451 | | | |

| Accident Year | Reported Counts | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2018 | 230 | 250 | 260 | 265 |
| 2019 | 235 | 255 | 265 | |
| 2020 | 231 | 251 | | |
| 2021 | 234 | | | |

The reported claims include ALAE.
You are also informed that the following six claim transactions were not captured in the triangles due to a system error.

| Trans # | Claim ID | Transaction Date | Transaction Description | Occurrence Date | Case Estimate (000) | Indemnity Payment (000) | ALAE Payment (000) |
|---|---|---|---|---|---|---|---|
| 1 | 1020 | May 17, 2019 | Open new claim file | Apr. 27, 2018 | 10 | 5 | |
| 2 | 1377 | Nov. 3, 2019 | Open & close new claim file | Sep. 15, 2019 | | 50 | 25 |
| 3 | 1944 | Jan. 2, 2021 | Close reported claim file | Sep. 15, 2019 | -25 | 10 | 5 |
| 4 | 2135 | Feb. 28, 2021 | Change in case estimate | Jan. 6, 2020 | 65** | | |
| 5 | 2260 | Apr. 24, 2021 | Open new claim file | Feb. 3, 2018 | 20 | | |
| 6 | 2260 | June 5, 2021 | Close reported claim file | Feb. 3, 2018 | -20 | | 20 |

** Represents an increase of 65 over the previous case estimate.

(a) (4 points) Update both development triangles shown above to include the claim transactions not captured due to the system error.

(b) (0.5 points) Determine calendar year 2021 reported claims.

Accident year 2021 paid claims and ALAE evaluated as of December 31, 2021, were 800,000.

(c) (0.5 points) Determine case reserves as of December 31, 2021, for accident year 2021 only.

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You are subsequently given a variety of corrected claim and count triangles and have been asked to conduct investigative tests.

(d) (1 point) Describe the investigative tests you would recommend using for the following independent situations:

(i) The claim department implemented a new definition of claims to distinguish between reported incidents that are valid claims and incidents not covered under the insurance policy.

(ii) The claim department implemented a new initiative to increase their use of partial settlements.

During investigative testing, you observe an increase in average reported claims, with changes greater than the rate of trend going down each column (from accident year to accident year). However, the reported counts are stable.

(e) (1 point) Provide two examples of company operational changes that could cause an increase in average reported claims without affecting reported counts.

Note: I have slightly rewritten this past exam question.

**6.33. (SOA GIRR, 11/22, Q.7)** (4 points)
You are given the following information for an investigative analysis:

| Accident Year | Reported Claim Frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 |
| 2014 | 0.017 | 0.018 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 |
| 2015 | 0.018 | 0.019 | 0.019 | 0.019 | 0.019 | 0.018 | 0.018 | |
| 2016 | 0.017 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | | |
| 2017 | 0.018 | 0.019 | 0.020 | 0.020 | 0.019 | | | |
| 2018 | 0.015 | 0.016 | 0.017 | 0.018 | | | | |
| 2019 | 0.015 | 0.015 | 0.016 | | | | | |
| 2020 | 0.014 | 0.015 | | | | | | |
| 2021 | 0.013 | | | | | | | |

You noticed that the claim frequency has been decreasing since accident year 2018.
(a) (1 point) Describe two operational changes that could have caused this decrease.

(b) (0.5 points) Describe one external environmental change that could have caused this decrease.

You are given the following diagnostic triangle for a different line of business:

| Accident Year | Ratios of Paid Claims to Reported Claims | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 |
| 2014 | 0.205 | 0.363 | 0.454 | 0.575 | 0.670 | 0.829 | 0.902 | 0.960 |
| 2015 | 0.187 | 0.357 | 0.425 | 0.570 | 0.667 | 0.813 | 0.868 | |
| 2016 | 0.213 | 0.367 | 0.442 | 0.559 | 0.656 | 0.772 | | |
| 2017 | 0.198 | 0.359 | 0.438 | 0.551 | 0.614 | | | |
| 2018 | 0.196 | 0.373 | 0.447 | 0.490 | | | | |
| 2019 | 0.190 | 0.365 | 0.375 | | | | | |
| 2020 | 0.203 | 0.295 | | | | | | |
| 2021 | 0.150 | | | | | | | |

(c) (0.5 points) Identify a change in pattern in this triangle.

(d) (1 point) Describe two possible operational changes that could have caused the pattern change identified in part (c).

(e) (1 point) Describe an additional test to further investigate the change in pattern identified in part (c).

**6.34. (SOA GIRR, 5/23, Q.13)** (5 points) You are estimating ultimate claims for a medium-tailed line of business evaluated as of December 31, 2022. Your reserving software produces the following preliminary estimates based on a simple application of the development method:

| Accident Year | Reported Claims | | | | | | Ultimate Claims |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | |
| 2017 | 4,490,119 | 6,618,441 | 8,018,024 | 9,424,347 | 9,996,330 | 10,121,653 | 10,248,547 |
| 2018 | 4,892,866 | 6,982,903 | 8,630,338 | 10,114,249 | 10,671,269 | | 10,940,516 |
| 2019 | 5,116,047 | 7,389,572 | 9,267,893 | 10,572,454 | | | 11,466,607 |
| 2020 | 5,687,200 | 8,006,857 | 10,230,447 | | | | 12,900,933 |
| 2021 | 6,277,173 | 9,059,236 | | | | | 14,220,841 |
| 2022 | 6,920,495 | | | | | | 15,636,155 |

| Accident Year | Paid Claims | | | | | | Ultimate Claims |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | |
| 2017 | 1,950,824 | 4,523,911 | 6,506,781 | 8,594,540 | 9,886,911 | 10,121,653 | 10,361,968 |
| 2018 | 2,077,925 | 4,668,120 | 7,007,477 | 9,239,820 | 10,671,269 | | 11,184,014 |
| 2019 | 2,061,272 | 4,882,698 | 7,493,669 | 10,572,454 | | | 12,771,843 |
| 2020 | 2,431,961 | 5,348,691 | 8,813,923 | | | | 14,375,085 |
| 2021 | 2,726,683 | 6,334,322 | | | | | 15,811,681 |
| 2022 | 2,996,405 | | | | | | 17,138,313 |

| Accident Year | Reported Counts | | | | | | Ultimate Counts |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | |
| 2017 | 1,193 | 1,488 | 1,670 | 1,850 | 1,921 | 1,935 | 1,949 |
| 2018 | 1,204 | 1,523 | 1,701 | 1,864 | 1,941 | | 1,969 |
| 2019 | 1,229 | 1,515 | 1,738 | 1,874 | | | 1,977 |
| 2020 | 1,236 | 1,554 | 1,753 | | | | 2,023 |
| 2021 | 1,278 | 1,576 | | | | | 2,053 |
| 2022 | 1,273 | | | | | | 2,068 |

Question continued on the next page.

| Accident Year | Closed Counts | | | | | | Ultimate Counts |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | |
| 2017 | 616 | 1,070 | 1,401 | 1,715 | 1,910 | 1,935 | 1,960 |
| 2018 | 614 | 1,096 | 1,427 | 1,729 | 1,941 | | 1,992 |
| 2019 | 623 | 1,086 | 1,463 | 1,874 | | | 2,151 |
| 2020 | 627 | 1,117 | 1,566 | | | | 2,227 |
| 2021 | 648 | 1,211 | | | | | 2,307 |
| 2022 | 696 | | | | | | 2,365 |

The annual claim severity trend for this line of business is 6.2%.

As part of your claims analysis, you are conducting various investigative tests for evaluating potential changes in case reserve adequacy and/or claim settlement patterns.

(a) (2.5 points) Analyze this data for evidence of a change in case reserve adequacy, using two different investigative tests. Justify your conclusion.

Your colleague reviewed the triangle of reported claim ratios for this line of business. The most recent diagonal showed a significant increase and your colleague concluded that this is clear evidence of an increase in case outstanding adequacy.

(b) (0.5 points) Critique your colleague's conclusion.

The ratios of paid to reported claims is one investigative test used to determine if there is evidence of a change in claim settlement patterns.

(c) (0.5 points) Describe why an increase in the most recent diagonal of the ratios of paid to reported claims triangle may not give a clear indication of such a change.

(d) (1.5 points) Analyze this data for evidence of a change in claim settlement patterns, using an investigative test other than the test described in part (c). Justify your conclusion.

**6.35. (SOA GIRR, 5/24, Q.2)** (5 points) You are estimating ultimate claims as of December 31, 2023 for a line of business that has seasonality.

| Accident Half-Year | Reported Claims | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 |
| 2020-1 | 1,778,236 | 1,817,664 | 1,906,195 | 1,918,947 | 1,938,911 | 1,949,451 | 1,951,269 | 1,951,269 |
| 2020-2 | 1,801,831 | 1,896,710 | 1,942,431 | 1,969,627 | 1,990,982 | 2,002,627 | 2,004,998 | |
| 2021-1 | 1,930,879 | 1,983,793 | 2,069,155 | 2,084,933 | 2,109,125 | 2,121,231 | | |
| 2021-2 | 1,944,003 | 2,034,385 | 2,091,282 | 2,125,691 | 2,146,588 | | | |
| 2022-1 | 2,075,131 | 2,126,932 | 2,205,071 | 2,220,455 | | | | |
| 2022-2 | 2,137,034 | 2,253,530 | 2,273,987 | | | | | |
| 2023-1 | 2,243,409 | 2,283,355 | | | | | | |
| 2023-2 | 2,451,221 | | | | | | | |

There is no development after 48 months.

(a) (2.5 points) Calculate the ultimate claims for accident year 2023 using the development method. Justify your selections.
(b) (1 point) Calculate the accident year 2023 expected reported claims from December 31, 2023 to June 30, 2024.
Note: Parts (c) and (d) of this past exam question are not on the syllabus of your exam.

**6.36. (SOA GIRR, 5/25, Q.1)** (5 points)
You are analyzing development triangles for investigative testing purposes.
(a) (1 point) State two purposes for conducting investigative testing with development triangles.

You are given:

| Accident Year | Ratio of Paid Claims to Reported Claims | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 0.498 | 0.705 | 0.839 | 0.923 | 0.989 |
| 2021 | 0.502 | 0.710 | 0.835 | 0.913 | |
| 2022 | 0.514 | 0.705 | 0.812 | | |
| 2023 | 0.499 | 0.655 | | | |
| 2024 | 0.462 | | | | |

| Accident Year | Ratio of Closed Counts to Reported Counts | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 0.581 | 0.710 | 0.792 | 0.848 | 0.889 |
| 2021 | 0.591 | 0.716 | 0.789 | 0.847 | |
| 2022 | 0.576 | 0.709 | 0.790 | | |
| 2023 | 0.587 | 0.715 | | | |
| 2024 | 0.581 | | | | |

- The annual claim severity trend is 5%.

(b) (1 point) Describe the pattern (row or column) you would expect to observe in each of these triangles if the line of business is in a stable environment.
(c) (2 points) Evaluate each triangle to determine if this line of business likely does or does not represent a stable line of business.
(d) (0.5 points) State what a triangle of ratios of closed counts with no payments to total closed counts would help identify.

You are also analyzing a triangle of average paid claims, which is calculated as paid claims divided by closed counts.

(e) (0.5 points) Describe a data adjustment needed to ensure this test would provide consistency between the payments in the numerator and the counts in the denominator.

**6.37. (SOA GI101, 7/26, Q.3)** (3 points) You are conducting investigative tests for line of business A to determine if there has been a change in the settlement patterns or adequacy of case estimates over the experience period.

(a) (0.5 points) Describe how an increase in the claim settlement rate (with no other material changes) is likely to affect a triangle with ratios of paid claims to reported claims.

Your colleague reviewed changes in the average case estimate triangle for line of business B. They commented that estimates increase down each column of the triangle consistently with the rate of inflation. They concluded that case adequacy has increased.

(b) (1 point) Assess your colleague's conclusion.

Another colleague is evaluating a triangle of reported claim ratios and has noticed a significant increase in the latest diagonal. They have commented that this is likely due to a rate decrease.

(c) (0.5 points) Assess your colleague's conclusion.

(d) (1 point) Describe two other possible reasons for this increase that are different from your colleague's conclusion.

Solutions to Problems:

**6.1.** Determine the ratio of Paid to Reported Claims:

| Reported Claims ($000) as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 33,000 | 41,000 |
| 2022 | 39,000 | 47,000 |
| 2023 | 37,000 | 45,000 |
| 2024 | 36,000 | |
| Paid Claims ($000) as of (months) | | |
| Accident Year | 12 | 24 |
| 2021 | 10,000 | 20,000 |
| 2022 | 13,000 | 24,000 |
| 2023 | 16,000 | 29,000 |
| 2024 | 15,000 | |
| Ratio | | |
| 2021 | 30.30% | 48.78% |
| 2022 | 33.33% | 51.06% |
| 2023 | 43.24% | 64.44% |
| 2024 | 41.67% | |

The ratios are increasing. This may be due to a speed up in claim settlement and/or a weakening of case reserves. (As seen subsequently, there is a speed up but the adequacy of case reserves remained about the same.)

Determine the ratio of Closed Counts to Reported Counts:

| Reported Claim Counts as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 1,900 | 2,200 |
| 2022 | 2,100 | 2,400 |
| 2023 | 1,800 | 1,900 |
| 2024 | 1,900 | |
| Closed Claim Counts as of (months) | | |
| Accident Year | 12 | 24 |
| 2021 | 270 | 1,000 |
| 2022 | 300 | 1,100 |
| 2023 | 360 | 1,000 |
| 2024 | 450 | |
| Ratio | | |
| 2021 | 14.21% | 45.45% |
| 2022 | 14.29% | 45.83% |
| 2023 | 20.00% | 52.63% |
| 2024 | 23.68% | |

The ratios for AY13 and AY14 at first report are larger than before, as is the ratio for AY13 at second report. This indicates a speed up in claim settlement.

Determine the severity of Reported Claims:

| Reported Claims ($000) as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 33,000 | 41,000 |
| 2022 | 39,000 | 47,000 |
| 2023 | 37,000 | 45,000 |
| 2024 | 36,000 | |
| Reported Claim Counts as of (months) | | |
| Accident Year | 12 | 24 |
| 2021 | 1,900 | 2,200 |
| 2022 | 2,100 | 2,400 |
| 2023 | 1,800 | 1,900 |
| 2024 | 1,900 | |
| Severity | | |
| 2021 | $17,368 | $18,636 |
| 2022 | $18,571 | $19,583 |
| 2023 | $20,556 | $23,684 |
| 2024 | $18,947 | |

There is some increase in severities. This may be due to reserve strengthening. (As seen subsequently, the adequacy of case reserves remained about the same.)

Determine the severity of Closed Claims:

| Paid Claims ($000) as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 10,000 | 20,000 |
| 2022 | 13,000 | 24,000 |
| 2023 | 16,000 | 29,000 |
| 2024 | 15,000 | |
| Closed Claim Counts as of (months) | | |
| Accident Year | 12 | 24 |
| 2021 | 270 | 1,000 |
| 2022 | 300 | 1,100 |
| 2023 | 360 | 1,000 |
| 2024 | 450 | |
| Severity | | |
| 2021 | $37,037 | $20,000 |
| 2022 | $43,333 | $21,818 |
| 2023 | $44,444 | $29,000 |
| 2024 | $33,333 | |

The severities are increasing at second report. This may indicate that the insurer is concentrating on closing larger claims more quickly.

Determine the severity of Case Reserves:

| Reported Claims ($000) as of (months) | | |
|---|---|---|
| Accident Year | 12 | 24 |
| 2021 | 33,000 | 41,000 |
| 2022 | 39,000 | 47,000 |
| 2023 | 37,000 | 45,000 |
| 2024 | 36,000 | |
| Paid Claims ($000) as of (months) | | |
| 2021 | 10,000 | 20,000 |
| 2022 | 13,000 | 24,000 |
| 2023 | 16,000 | 29,000 |
| 2024 | 15,000 | |
| Case Reserves ($000) | | |
| 2021 | 23,000 | 21,000 |
| 2022 | 26,000 | 23,000 |
| 2023 | 21,000 | 16,000 |
| 2024 | 21,000 | |
| Reported Claim Counts as of (months) | | |
| 2021 | 1,900 | 2,200 |
| 2022 | 2,100 | 2,400 |
| 2023 | 1,800 | 1,900 |
| 2024 | 1,900 | |
| Closed Claim Counts as of (months) | | |
| 2021 | 270 | 1,000 |
| 2022 | 300 | 1,100 |
| 2023 | 360 | 1,000 |
| 2024 | 450 | |
| Open Claim Counts | | |
| 2021 | 1,630 | 1,200 |
| 2022 | 1,800 | 1,300 |
| 2023 | 1,440 | 900 |
| 2024 | 1,450 | |
| Average Case Reserves | | |
| 2021 | $14,110 | $17,500 |
| 2022 | $14,444 | $17,692 |
| 2023 | $14,583 | $17,778 |
| 2024 | $14,483 | |

The average case reserves are about level.
This indicates no significant change in the adequacy of case reserves.
Comment: Similar to 5, 5/15, Q.16a.
Exam questions tend to have less ambiguity in the diagnostics.

**6.2.** Case Outstanding Severity = $\frac{\text{Reported Claims - Paid Claims}}{\text{Open Claim Counts}}$.

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 6,400 | 6,800 | 7,000 |
| 2022 | 5,900 | 6,200 | |
| 2023 | 4,600 | | |
| AY | Cumulative Reported Claims ($000) as of (months) | | |
| 2021 | 6,900 | 7,300 | 7,400 |
| 2022 | 6,400 | 7,200 | |
| 2023 | 5,300 | | |
| AY | Open Claim Counts as of (months) | | |
| 2021 | 122 | 85 | 35 |
| 2022 | 126 | 104 | |
| 2023 | 115 | | |
| AY | Case Outstanding Severity | | |
| 2021 | $4,098 | $5,882 | $11,429 |
| 2022 | $3,968 | $9,615 | |
| 2023 | $6,087 | | |
| AY | Ratio of Paid to Reported Claims | | |
| 2021 | 0.928 | 0.932 | 0.946 |
| 2022 | 0.922 | 0.861 | |
| 2023 | 0.868 | | |

The case outstanding severities on the latest diagonal are significantly larger, indicating that there has a recent strengthening of case reserves.
Going down the columns, the ratios of paid to reported claims are decreasing, indicating that there may have been a recent strengthening of case reserves.
Comment: Similar to 5, 5/16, Q.21a.
Instead of the ratio of paid to reported (or its inverse), one could calculate the ratio of case reserves to reported claims, or the ratio of case reserves to paid claims.

**6.3.** (a) Calculate age to age factors. Calculate the frequencies.

| Cumulative Closed Claim Counts | | | | | Earned Exposures |
|---|---|---|---|---|---|
| Accident Year | Age of Development in Months | | | | |
| | 12 | 24 | 36 | 48 | |
| 2020 | 240 | 380 | 450 | 480 | 30,000 |
| 2021 | 250 | 400 | 460 | | 31,000 |
| 2022 | 240 | 350 | | | 32,000 |
| 2023 | 210 | | | | 33,000 |
| AY | Age to Age Factors | | | | |
| 2020 | 1.583 | 1.184 | 1.067 | | |
| 2021 | 1.600 | 1.150 | | | |
| 2022 | 1.458 | | | | |
| AY | Closed Claim Frequencies | | | | |
| 2020 | 0.80% | 1.27% | 1.50% | 1.60% | |
| 2021 | 0.81% | 1.29% | 1.48% | | |
| 2022 | 0.75% | 1.09% | | | |
| 2023 | 0.64% | | | | |

The age to age factors have decreased along the latest diagonal.
This indicates an decrease in the settlement rate.
The closed claim frequencies have decreased for AY23 at first report and AY22 at second report compared to prior AYs. This is probably due to an decrease in the settlement rate.
There may have been a decrease in the number of claims adjusters.
(b) Recently, a smaller percentage of ultimate losses will be paid than historically. Therefore, the paid factors to ultimate based on historical data will be too small to apply to recent data,
The ultimate losses would be **underestimated**.
Comment: Similar to 6, 11/07, Q.40**.**

**6.4.** Any two of the following:
- an increase in the claim settlement rate
- deteriorating loss experience
- a significant increase in exposure
- a law change (affecting Workers Compensation)
- an increase in the policy coverage provided (higher limits of coverage)
- a single unusually large claim was paid
- an unusual event caused a large number of claims (a large Winter storm or a catastrophe)
- a new judicial decision (affecting liability insurance)
- a change in the mix of business being written
- changing third party administrators
- an error in the data

Comment: There are probably other reasonable responses.
Each of these reasons would be dealt with somewhat differently by a reserving actuary.

**6.5.** i. For example, 1 - 152/202 = 0.248.

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 202 | 207 | 210 |
| 2022 | 196 | 201 | |
| 2023 | 199 | | |
| AY | Open Claim Counts as of (months) | | |
| 2021 | 152 | 98 | 32 |
| 2022 | 146 | 75 | |
| 2023 | 137 | | |
| AY | Ratio of Closed to Reported Claim Counts | | |
| 2021 | 0.248 | 0.527 | 0.848 |
| 2022 | 0.255 | 0.627 | |
| 2023 | 0.312 | | |

The ratios of closed to reported claim counts at given maturities are increasing.
This indicates an increase in the claim settlement rate.

ii. For example, (1000)(5000 - 2200)/152 = $18,421.

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2021 | 2,200 | 4,000 | 6,100 |
| 2022 | 2,200 | 4,300 | |
| 2023 | 2,300 | | |
| AY | Cumulative Reported Claims ($000) as of (months) | | |
| 2021 | 5,000 | 7,300 | 7,800 |
| 2022 | 4,900 | 6,800 | |
| 2023 | 4,800 | | |
| AY | Open Claim Counts as of (months) | | |
| 2021 | 152 | 98 | 32 |
| 2022 | 146 | 75 | |
| 2023 | 137 | | |
| AY | Average Case Outstanding | | |
| 2021 | $18,421 | $33,673 | $53,125 |
| 2022 | $18,493 | $33,333 | |
| 2023 | $18,248 | | |

We are told inflation is 0%. At a given maturity we see close to constant average case outstanding. This is consistent with no change in case reserve adequacy.
Comment: Similar to 5, 5/17, Q.15b.

**6.6.** The ratio of paid to reported claims has increased in CY24.

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 5,800 | 11,000 | 16,000 | 19,100 |
| 2022 | 6,400 | 12,000 | 18,500 | |
| 2023 | 6,800 | 13,100 | | |
| 2024 | 7,300 | | | |
| Accident Year | Cumulative Reported Claims ($000) as of (months) | | | |
| 2021 | 10,000 | 15,000 | 18,000 | 19,800 |
| 2022 | 11,000 | 16,500 | 19,800 | |
| 2023 | 11,650 | 14,900 | | |
| 2024 | 10,500 | | | |
| Accident Year | Ratio of Paid to Reported Claims | | | |
| 2021 | 0.580 | 0.733 | 0.889 | 0.965 |
| 2022 | 0.582 | 0.727 | 0.934 | |
| 2023 | 0.584 | 0.879 | | |
| 2024 | 0.695 | | | |

Case reserves may have been weakened.
Alternately, the rate of settling claims may have increased.
Comment: Similar to 5, 11/17, Q.19b.

**6.7.** Calculate disposal rates: (Cumulative Closed Claim Counts) ÷ (Ultimate Claim Counts).

| Accident Year | Cumulative Closed Claim Counts as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | Ultimate |
| 2020 | 1,210 | 1,350 | 1,400 | 1,430 | 1,480 |
| 2021 | 1,240 | 1,360 | 1,410 | 1,480 | 1,500 |
| 2022 | 1,250 | 1,370 | 1,470 | | 1,510 |
| 2023 | 1,270 | 1,450 | | | 1,530 |
| 2024 | 1,400 | | | | 1,600 |
| AY | Disposal Rate | | | | |
| 2020 | 81.8% | 91.2% | 94.6% | 96.6% | |
| 2021 | 82.7% | 90.7% | 94.0% | 98.7% | |
| 2022 | 82.8% | 90.7% | 97.4% | | |
| 2023 | 83.0% | 94.8% | | | |
| 2024 | 87.5% | | | | |

The disposal rates along the latest diagonal are higher, indicating an increase in the rate of settling claims.
Comment: Similar to 5, 5/18, Q.21.

**6.8.** (a) A large catastrophe results in a large influx of claims, creating a temporary slowdown in the ability to handle and close claims. However, this new program should alleviate that problem. In case of a catastrophe, there will be fewer open claims at a given maturity than would have been the case previously, so the case outstanding triangle will have smaller amounts.
The new statute of limitations may cause some claims to be reported later than they would have been, increasing the case outstanding amounts at these later maturities.
The new statute of limitations may cause some claims to be reported that would not have otherwise been reported in time, and thus not covered. This would cause the case outstanding amounts at these later maturities to be more than previously.
There will be a longer time until claim counts and claims are at ultimate.
(b) Possible responses (any two):
- A new claims processing system is implemented that will result in claims closing faster; the ratio goes up.
- The claims department hires additional claims adjusters in order to try to close claims more quickly; the ratio goes up.
- Change in the guidelines for the establishment of a claim.
- Restructuring of the claim field offices, such as through the merging of existing offices or the addition of new offices.
- Introduction of a new call center to handle claims; the ratio goes down.
- A decision to fight more claims in court will result is a decrease of closed to reported claim counts; the ratio goes down.

Comment: Similar to 5, 5/12, Q.23.

**6.9.** (a) Calculate the average case reserve per open claim.

| Accident Year | Cumulative Reported Loss + ALAE ($000) as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,400 | 1,600 | 1,670 | 1,690 | 1,710 |
| 2021 | 1,500 | 1,850 | 1,880 | 1,900 | |
| 2022 | 1,570 | 2,030 | 2,100 | | |
| 2023 | 1,650 | 1,900 | | | |
| 2024 | 1,800 | | | | |
| AY | Cumulative Paid Loss + ALAE ($000) as of (months) | | | | |
| 2020 | 1,100 | 1,450 | 1,550 | 1,660 | 1,680 |
| 2021 | 1,180 | 1,700 | 1,750 | 1,870 | |
| 2022 | 1,270 | 1,880 | 2,050 | | |
| 2023 | 1,300 | 1,710 | | | |
| 2024 | 1,320 | | | | |
| AY | Case Reserves ($000) as of (months) | | | | |
| 2020 | 300 | 150 | 120 | 30 | 30 |
| 2021 | 320 | 150 | 130 | 30 | |
| 2022 | 300 | 150 | 50 | | |
| 2023 | 350 | 190 | | | |
| 2024 | 480 | | | | |
| AY | Cumulative Reported Claim Counts as of (months) | | | | |
| 2020 | 1,200 | 1,350 | 1,400 | 1,450 | 1,470 |
| 2021 | 1,260 | 1,380 | 1,420 | 1,440 | |
| 2022 | 1,250 | 1,370 | 1,350 | | |
| 2023 | 1,300 | 1,290 | | | |
| 2024 | 1,170 | | | | |
| AY | Cumulative Closed Claim Counts as of (months) | | | | |
| 2020 | 720 | 1,220 | 1,330 | 1,430 | 1,460 |
| 2021 | 760 | 1,240 | 1,350 | 1,430 | |
| 2022 | 750 | 1,230 | 1,330 | | |
| 2023 | 780 | 1,210 | | | |
| 2024 | 810 | | | | |
| AY | Average Case Reserve per Open Claim | | | | |
| 2020 | $625 | $1,154 | $1,714 | $1,500 | $3,000 |
| 2021 | $640 | $1,071 | $1,857 | $3,000 | |
| 2022 | $600 | $1,071 | $2,500 | | |
| 2023 | $673 | $2,375 | | | |
| 2024 | $1,333 | | | | |

The average case reserves along the latest diagonal are much larger; there appears to have been reserve strengthening.

(b) Compare closed claim counts to reported claim counts.

| Accident Year | Cumulative Reported Claim Counts as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 1,200 | 1,350 | 1,400 | 1,450 | 1,470 |
| 2021 | 1,260 | 1,380 | 1,420 | 1,440 | |
| 2022 | 1,250 | 1,370 | 1,350 | | |
| 2023 | 1,300 | 1,290 | | | |
| 2024 | 1,170 | | | | |
| AY | Cumulative Closed Claim Counts as of (months) | | | | |
| 2020 | 720 | 1,220 | 1,330 | 1,430 | 1,460 |
| 2021 | 760 | 1,240 | 1,350 | 1,430 | |
| 2022 | 750 | 1,230 | 1,330 | | |
| 2023 | 780 | 1,210 | | | |
| 2024 | 810 | | | | |
| AY | Ratio of Closed Counts over Reported Counts | | | | |
| 2020 | 0.600 | 0.904 | 0.950 | 0.986 | 0.993 |
| 2021 | 0.603 | 0.899 | 0.951 | 0.993 | |
| 2022 | 0.600 | 0.898 | 0.985 | | |
| 2023 | 0.600 | 0.938 | | | |
| 2024 | 0.692 | | | | |

Along the latest diagonal the ratio of paid claim counts to reported claim counts is higher; there appears to be an increase in settlement rate.

Comment: Similar to 5, 5/18 Makeup, Q.20a.

In part (a), if one calculated the ratio of paid claims to reported claims, one could not determine whether there was a change in the adequacy of case reserves or a change in settlement rate.

In part (b), one could instead use the triangle of reported claim counts to estimated ultimate claim counts and then calculate disposal rates: (closed claim counts) / (ultimate claim counts).

**6.10.** Calculate disposal rates: (Cumulative Closed Claim Counts) ÷ (Ultimate Claim Counts).

| Accident Year | Cumulative Closed Claim Counts as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | Ultimate |
| 2020 | 113 | 139 | 169 | 177 | 178 |
| 2021 | 112 | 138 | 161 | | 176 |
| 2022 | 113 | 133 | | | 177 |
| 2023 | 108 | | | | 183 |
| AY | Disposal Rate | | | | |
| 2020 | 63.5% | 78.1% | 94.9% | 99.4% | |
| 2021 | 63.6% | 78.4% | 91.5% | | |
| 2022 | 63.8% | 75.1% | | | |
| 2023 | 59.0% | | | | |

The disposal rates along the latest diagonal are lower, indicating a decrease in the rate of settling claims.

Comment: Similar to 5, 5/18 Makeup, Q.21.

The ultimate claim counts were probably estimated from a triangle of reported claims counts.

**6.11.** Compute the average case outstanding values and trend them to 2024.

| Accident Year | Case Outstanding ($million) as of (months) | | | |
|---|---|---|---|---|
| | 12 | 24 | 36 | 48 |
| 2021 | 104 | 102 | 70 | 19 |
| 2022 | 98 | 129 | 72 | |
| 2023 | 118 | 137 | | |
| 2024 | 121 | | | |
| | | | | |
| Accident Year | Open Claim Counts as of (months) | | | |
| 2021 | 3700 | 4600 | 2100 | 510 |
| 2022 | 3400 | 4200 | 1900 | |
| 2023 | 3300 | 4100 | | |
| 2024 | 3200 | | | |
| | | | | |
| Accident Year | Average Case Outstanding | | | |
| 2021 | 28,108 | 22,174 | 33,333 | 37,255 |
| 2022 | 28,824 | 30,714 | 37,895 | |
| 2023 | 35,758 | 33,415 | | |
| 2024 | 37,813 | | | |
| | | | | |
| Accident Year | Average Case Outstanding Trended to 2024 | | | |
| 2021 | 33,477 | 26,409 | 39,701 | 44,371 |
| 2022 | 32,386 | 34,511 | 42,579 | |
| 2023 | 37,903 | 35,420 | | |
| 2024 | 37,813 | | | |

In the triangle of the trended average case outstanding, the latest two diagonals are larger than prior (we can compare for 12 and 24 months). Thus there has been an increase in the adequacy of case outstanding over the experience period.
Comment: Similar to 5, 11/18, Q.20a.

**6.12.** (a) Compute paid loss development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 300 | 500 | 700 | 900 |
| 2020 | 300 | 500 | 700 | |
| 2021 | 300 | 500 | | |
| 2022 | 300 | | | |
| AY | Age to Age Factors | | | |
| 2019 | 1.667 | 1.400 | 1.286 | |
| 2020 | 1.667 | 1.400 | | |
| 2021 | 1.667 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 100 | 170 | 230 | 300 |
| 2020 | 100 | 170 | 230 | |
| 2021 | 100 | 170 | | |
| 2022 | 100 | | | |
| AY | Age to Age Factors | | | |
| 2019 | 1.700 | 1.353 | 1.304 | |
| 2020 | 1.700 | 1.353 | | |
| 2021 | 1.700 | | | |

The paid loss development factors similar between the two companies.

Compute reported loss development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 500 | 700 | 900 | 900 |
| 2020 | 500 | 700 | 900 | |
| 2021 | 500 | 700 | | |
| 2022 | 500 | | | |
| AY | Age to Age Factors | | | |
| 2019 | 1.400 | 1.286 | 1.000 | |
| 2020 | 1.400 | 1.286 | | |
| 2021 | 1.400 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 190 | 270 | 290 | 300 |
| 2020 | 190 | 270 | 290 | |
| 2021 | 190 | 270 | | |
| 2022 | 190 | | | |
| AY | Age to Age Factors | | | |
| 2019 | 1.421 | 1.074 | 1.034 | |
| 2020 | 1.421 | 1.074 | | |
| 2021 | 1.421 | | | |
| Average | 1.421 | 1.074 | 1.034 | |

The reported loss development factors differ between the two companies.

Compute the ratios of paid to reported claims for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 300 | 500 | 700 | 900 |
| 2020 | 300 | 500 | 700 | |
| 2021 | 300 | 500 | | |
| 2022 | 300 | | | |
| AY | Reported Losses ($000s) | | | |
| 2019 | 500 | 700 | 900 | 900 |
| 2020 | 500 | 700 | 900 | |
| 2021 | 500 | 700 | | |
| 2022 | 500 | | | |
| AY | Ratio | | | |
| 2019 | 60.0% | 71.4% | 77.8% | 100.0% |
| 2020 | 60.0% | 71.4% | 77.8% | |
| 2021 | 60.0% | 71.4% | | |
| 2022 | 60.0% | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 100 | 170 | 230 | 300 |
| 2020 | 100 | 170 | 230 | |
| 2021 | 100 | 170 | | |
| 2022 | 100 | | | |
| AY | Reported Losses ($000s) | | | |
| 2019 | 190 | 270 | 290 | 300 |
| 2020 | 190 | 270 | 290 | |
| 2021 | 190 | 270 | | |
| 2022 | 190 | | | |
| AY | Ratio | | | |
| 2019 | 52.6% | 63.0% | 79.3% | 100.0% |
| 2020 | 52.6% | 63.0% | 79.3% | |
| 2021 | 52.6% | 63.0% | | |
| 2022 | 52.6% | | | |

The ratios of paid to reported claims differ between the two companies.

Compute the ratios of closed to reported claim counts for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 800 | 1100 | 1400 | 1500 |
| 2020 | 800 | 1100 | 1400 | |
| 2021 | 800 | 1100 | | |
| 2022 | 800 | | | |
| AY | Closed Counts | | | |
| 2019 | 600 | 900 | 1200 | 1500 |
| 2020 | 600 | 900 | 1200 | |
| 2021 | 600 | 900 | | |
| 2022 | 600 | | | |
| AY | Ratio | | | |
| 2019 | 75.0% | 81.8% | 85.7% | 100.0% |
| 2020 | 75.0% | 81.8% | 85.7% | |
| 2021 | 75.0% | 81.8% | | |
| 2022 | 75.0% | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 270 | 370 | 470 | 500 |
| 2020 | 270 | 370 | 470 | |
| 2021 | 270 | 370 | | |
| 2022 | 270 | | | |
| AY | Closed Counts | | | |
| 2019 | 200 | 300 | 400 | 500 |
| 2020 | 200 | 300 | 400 | |
| 2021 | 200 | 300 | | |
| 2022 | 200 | | | |
| AY | Ratio | | | |
| 2019 | 74.1% | 81.1% | 85.1% | 100.0% |
| 2020 | 74.1% | 81.1% | 85.1% | |
| 2021 | 74.1% | 81.1% | | |
| 2022 | 74.1% | | | |

The ratios of closed to reported claim counts are very similar for the two companies.

Compute the severity of paid losses for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 300 | 500 | 700 | 900 |
| 2020 | 300 | 500 | 700 | |
| 2021 | 300 | 500 | | |
| 2022 | 300 | | | |
| AY | Closed Counts | | | |
| 2019 | 600 | 900 | 1200 | 1500 |
| 2020 | 600 | 900 | 1200 | |
| 2021 | 600 | 900 | | |
| 2022 | 600 | | | |
| AY | Severity | | | |
| 2019 | $500 | $556 | $583 | $600 |
| 2020 | $500 | $556 | $583 | |
| 2021 | $500 | $556 | | |
| 2022 | $500 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 100 | 170 | 230 | 300 |
| 2020 | 100 | 170 | 230 | |
| 2021 | 100 | 170 | | |
| 2022 | 100 | | | |
| AY | Closed Counts | | | |
| 2019 | 200 | 300 | 400 | 500 |
| 2020 | 200 | 300 | 400 | |
| 2021 | 200 | 300 | | |
| 2022 | 200 | | | |
| AY | Severity | | | |
| 2019 | $500 | $567 | $575 | $600 |
| 2020 | $500 | $567 | $575 | |
| 2021 | $500 | $567 | | |
| 2022 | $500 | | | |
| Average | $500 | $567 | $575 | $600 |

The paid severities are very similar for the two companies.

Compute the severity of case reserves for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 300 | 500 | 700 | 900 |
| 2020 | 300 | 500 | 700 | |
| 2021 | 300 | 500 | | |
| 2022 | 300 | | | |
| AY | Reported Losses ($000s) | | | |
| 2019 | 500 | 700 | 900 | 900 |
| 2020 | 500 | 700 | 900 | |
| 2021 | 500 | 700 | | |
| 2022 | 500 | | | |
| AY | Reported Counts | | | |
| 2019 | 800 | 1100 | 1400 | 1500 |
| 2020 | 800 | 1100 | 1400 | |
| 2021 | 800 | 1100 | | |
| 2022 | 800 | | | |
| AY | Closed Counts | | | |
| 2019 | 600 | 900 | 1200 | 1500 |
| 2020 | 600 | 900 | 1200 | |
| 2021 | 600 | 900 | | |
| 2022 | 600 | | | |
| AY | Average Case Reserve | | | |
| 2019 | $1,000 | $1,000 | $1,000 | |
| 2020 | $1,000 | $1,000 | $1,000 | |
| 2021 | $1,000 | $1,000 | | |
| 2022 | $1,000 | | | |

For example, ($500,000 - $300,000) / (800 - 600) = $1000.

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 100 | 170 | 230 | 300 |
| 2020 | 100 | 170 | 230 | |
| 2021 | 100 | 170 | | |
| 2022 | 100 | | | |
| AY | Reported Losses ($000s) | | | |
| 2019 | 190 | 270 | 290 | 300 |
| 2020 | 190 | 270 | 290 | |
| 2021 | 190 | 270 | | |
| 2022 | 190 | | | |
| AY | Reported Counts | | | |
| 2019 | 270 | 370 | 470 | 500 |
| 2020 | 270 | 370 | 470 | |
| 2021 | 270 | 370 | | |
| 2022 | 270 | | | |
| AY | Closed Counts | | | |
| 2019 | 200 | 300 | 400 | 500 |
| 2020 | 200 | 300 | 400 | |
| 2021 | 200 | 300 | | |
| 2022 | 200 | | | |
| AY | Average Case Reserve | | | |
| 2019 | $1,286 | $1,429 | $857 | |
| 2020 | $1,286 | $1,429 | $857 | |
| 2021 | $1,286 | $1,429 | | |
| 2022 | $1,286 | | | |

For example, ($190,000 - $100,000) / (270 - 200) = $1286.
The average case reserves are different for the two companies.

Compute closed claim count development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Closed Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 600 | 900 | 1200 | 1500 |
| 2020 | 600 | 900 | 1200 | |
| 2021 | 600 | 900 | | |
| 2022 | 600 | | | |
| AY | Age to Age Factors | | | |
| 2019 | 1.500 | 1.333 | 1.250 | |
| 2020 | 1.500 | 1.333 | | |
| 2021 | 1.500 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Closed Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2019 | 200 | 300 | 400 | 500 |
| 2020 | 200 | 300 | 400 | |
| 2021 | 200 | 300 | | |
| 2022 | 200 | | | |
| AY | Age to Age Factors | | | |
| 2019 | 1.500 | 1.333 | 1.250 | |
| 2020 | 1.500 | 1.333 | | |
| 2021 | 1.500 | | | |
| Average | 1.500 | 1.333 | 1.250 | |

The closed claim count development factors are the same for the two companies.

Compute reported claim count development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Reported Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 800 | 1100 | 1400 | 1500 |
| 2010 | 800 | 1100 | 1400 | |
| 2011 | 800 | 1100 | | |
| 2012 | 800 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 1.375 | 1.273 | 1.071 | |
| 2010 | 1.375 | 1.273 | | |
| 2011 | 1.375 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Reported Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 270 | 370 | 470 | 500 |
| 2010 | 270 | 370 | 470 | |
| 2011 | 270 | 370 | | |
| 2012 | 270 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 1.370 | 1.270 | 1.064 | |
| 2010 | 1.370 | 1.270 | | |
| 2011 | 1.370 | | | |

The reported claim count development factors are very similar for the two companies.

(b) The paid loss development factors are similar between the two companies.
The reported loss development factors differ between the two companies.
The ratios of paid to reported claims differ between the two companies.
The ratios of closed to reported claim counts are very similar for the two companies.
The paid severities are very similar for the two companies.
The average case reserves are different for the two companies.
The closed claim count development factors are the same for the two companies.
The reported claim count development factors are very similar for the two companies.

It is not appropriate to combine the historical data. Even though the counts for both companies develop in a similar manner, losses do not. The average case reserves are very different; the two companies seem to have very different case reserving philosophies. Combining the historical data will distort the estimates of ultimate losses.

(c) If Company C adopts Company A's claim practices, then the historical development pattern for Company B will not apply going forward. (Eventually all of the data will reflect Company A's claim practices, but that will take a good number of years.) It would be appropriate to combine A and B only if you adjust company B's historical data. Due to the difference in the severity of case reserves between the two companies, it would be better to apply paid reserving techniques to the combined data.
Comment: Similar to 5, 11/13, Q.15b&c&d.
In part (a), only calculate three diagnostics.
Your answer to part (b) will depend somewhat on which diagnostics you calculated in part (b).

**6.13**. It is common for the average case outstanding to be higher than the average reported values, because companies typically close small claims earlier, leaving the larger claims open to influence the average case outstanding.
While the average reported claims are increasing at close to the industry average rate, the average case outstanding is growing significantly faster along the latest diagonal.

| Average Case Outstanding | | | | | Trends in Average Case Outstanding | | | |
|---|---|---|---|---|---|---|---|---|
| Accident Year | 12 | 24 | 36 | | Accident Years | 12 | 24 | 36 |
| 2020 | 1100 | 2000 | 2200 | | 2021 ÷ 2020 | 1.055 | 1.050 | 1.100 |
| 2021 | 1160 | 2100 | 2420 | | 2022 ÷ 2021 | 1.052 | 1.100 | |
| 2022 | 1220 | 2310 | | | 2022 ÷ 2021 | 1.107 | | |
| 2023 | 1350 | | | | | | | |

| Average Reported Claims | | | | | Trends in Average Reported Claims | | | |
|---|---|---|---|---|---|---|---|---|
| Accident Year | 12 | 24 | 36 | | Accident Years | 12 | 24 | 36 |
| 2020 | 800 | 1450 | 1980 | | 2021 ÷ 2020 | 1.050 | 1.048 | 1.051 |
| 2021 | 840 | 1520 | 2080 | | 2022 ÷ 2021 | 1.060 | 1.053 | |
| 2022 | 890 | 1600 | | | 2022 ÷ 2021 | 1.045 | | |
| 2023 | 930 | | | | | | | |

Since reported claims equal paid plus case outstanding, one possibility is that claims are being paid faster, so that the case outstanding is a smaller portion of the reported losses; the smaller percent of claims that have yet to be paid are on average bigger.
Comment: Similar to 5, 5/19, Q.14.

**6.14**. Calculate the average closed claim:

| Accident Year | Cumulative Paid Claims ($000s) | | | Cumulative Closed Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2020 | 11,200 | 15,400 | 18,300 | 135 | 175 | 199 |
| 2021 | 12,200 | 17,000 | | 136 | 179 | |
| 2022 | 13,500 | | | 140 | | |
| AY | Average Closed Claim | | | Change | | |
| 2020 | $82,963 | $88,000 | $91,960 | | | |
| 2021 | $89,706 | $94,972 | | 8.1% | 7.9% | |
| 2022 | $96,429 | | | 7.5% | | |

The average closed claim increased by more than the given 4% severity trend.

Calculate the ratio of closed claim count to reported claim count:

| Accident Year | Cumulative Reported Claim Count | | | Cumulative Closed Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2020 | 178 | 196 | 200 | 135 | 175 | 199 |
| 2021 | 179 | 199 | | 136 | 179 | |
| 2022 | 183 | | | 140 | | |
| AY | Ratio | | | | | |
| 2020 | 0.758 | 0.893 | 0.995 | | | |
| 2021 | 0.760 | 0.899 | | | | |
| 2022 | 0.765 | | | | | |

Down the columns, the ratios are relatively stable.

Calculate the average reported claim:

| Accident Year | Cumulative Reported Claims ($000s) | | | Cumulative Reported Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2020 | 14,800 | 17,100 | 18,500 | 178 | 196 | 200 |
| 2021 | 15,500 | 18,000 | | 179 | 199 | |
| 2022 | 16,500 | | | 183 | | |
| AY | Average Reported Claim | | | Change | | |
| 2020 | $83,146 | $87,245 | $92,500 | | | |
| 2021 | $86,592 | $90,452 | | 4.1% | 3.7% | |
| 2022 | $90,164 | | | 4.1% | | |

Down the columns, the average reported claim is increasing by about 4% per year.
This matches the given annual severity trend.

Given the above diagnostics, the reported claim development method is preferable to the paid claim development method.
Comment: Similar to 5, 5/13, Q.20.

**6.15. (**a) Possible responses (any two):
- Increase (or decrease) in case reserve adequacy
- Increase (or decrease) in settlement rate, speedup (or slowdown) in case settlement
- Paying out claims faster
- Prioritization of large vs small claims
- Change in mix of business
- Change in policy limits or change the deductible offered
- Change in underwriting rules
- Change in reporting process, such as introducing a new call center
- Growing or shrinking in the book of business that change the average accident date
- Reinsurance program change
- Change in subrogation procedures to increase recoveries
- Company implements a new rule requiring insured to report claims faster
- Take a more aggressive litigative stance on claims
- Start a fraud detection department
- Change in how claims are processed, such as introducing new technology
- Increased risk control (safety programs)

(b). Responses for "Increase in case reserve adequacy":
- A triangle of case outstanding ÷ open claim count will show an increase down columns.
- The paid-to-reported ratio would decrease going down columns of the triangle.

Responses for "Increase in settlement rate" / "Paying out claims faster":
- Could result in an increase in disposal rate.
- The paid to reported triangle would increase down the columns.
- The closed-to-reported claim count triangle will show an increasing trend down the columns.

Responses for "Prioritization of large vs small claims":
- # Closed ÷ # reported triangle would observe a decrease in early maturities.
- Average paid severity (or incremental paid severity) would increase at early maturities since smaller claims are not being closed as quickly as previously.
- Average case outstanding decreases at later maturities down the column since fewer large claims compared to other claims are left open.

Response for "Change in Mix of Business", "Change in underwriting rules":
- Look at triangles separated by mix of business; check whether there is a change in the percentages for the different types of business.

Response for "Change in policy limits or change the deductible":
- Check average paid severity to see if there is a change. (Higher policy limits will tend to increase severity, while higher deductibles will tend to decrease severity.)

Responses for "Change in reporting process, such as introducing a new call center":
- Changes in claim reporting pattern can be assessed using the age-to-age development factors of reported claim counts and ratio of reported claim count to exposure. An increase in these ratios across years would imply faster claim reporting.
- Look at the ratios of reported loss to on-level premium. If reporting speeds up this could lead to an increase in the first column of the triangle.

Comment: Similar to 5, 11/19, Q.17.

**6.16.** Calculate the average case reserve per open claim.

| Accident Year | Reported Claims ($000) as of (months) | | | | |
|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 |
| 2020 | 2,380 | 2,600 | 2,670 | 2,760 | 2,790 |
| 2021 | 2,500 | 2,910 | 2,980 | 3,000 | |
| 2022 | 2,570 | 3,030 | 3,100 | | |
| 2023 | 2,650 | 2,700 | | | |
| 2024 | 2,410 | | | | |
| AY | Paid Claims ($000) as of (months) | | | | |
| 2020 | 1,700 | 2,060 | 2,250 | 2,620 | 2,700 |
| 2021 | 1,780 | 2,300 | 2,550 | 2,910 | |
| 2022 | 1,870 | 2,420 | 2,600 | | |
| 2023 | 1,900 | 2,450 | | | |
| 2024 | 1,820 | | | | |
| AY | Case Reserves ($000) as of (months) | | | | |
| 2020 | 680 | 540 | 420 | 140 | 90 |
| 2021 | 720 | 610 | 430 | 90 | |
| 2022 | 700 | 610 | 500 | | |
| 2023 | 750 | 250 | | | |
| 2024 | 590 | | | | |
| AY | Reported Claim Counts as of (months) | | | | |
| 2020 | 1,200 | 1,350 | 1,400 | 1,460 | 1,470 |
| 2021 | 1,260 | 1,380 | 1,420 | 1,450 | |
| 2022 | 1,250 | 1,370 | 1,430 | | |
| 2023 | 1,300 | 1,290 | | | |
| 2024 | 1,370 | | | | |
| AY | Closed Claim Counts as of (months) | | | | |
| 2020 | 720 | 1,220 | 1,330 | 1,440 | 1,450 |
| 2021 | 760 | 1,240 | 1,350 | 1,430 | |
| 2022 | 750 | 1,230 | 1,320 | | |
| 2023 | 780 | 1,210 | | | |
| 2024 | 810 | | | | |
| AY | Average Case Reserve per Open Claim | | | | |
| 2020 | $1,417 | $4,154 | $6,000 | $7,000 | $4,500 |
| 2021 | $1,440 | $4,357 | $6,143 | $4,500 | |
| 2022 | $1,400 | $4,357 | $4,545 | | |
| 2023 | $1,442 | $3,125 | | | |
| 2024 | $1,054 | | | | |

The average case reserves along the latest diagonal are smaller than prior, indicating that case reserves have been weakened.
Comment: Similar to 5, 11/19, Q.21.

**6.17.** (a)

| Accident Year | Reported Claims ($000) as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 58,641 | 74,804 | 77,323 | 77,890 | 80,728 | 82,280 | 82,372 |
| 2020 | 63,732 | 79,512 | 83,680 | 85,366 | 88,152 | 87,413 | |
| 2021 | 51,779 | 68,175 | 69,802 | 69,694 | 70,041 | | |
| 2022 | 40,143 | 67,978 | 75,144 | 77,947 | | | |
| 2023 | 55,665 | 80,296 | 87,961 | | | | |
| 2024 | 43,401 | 57,547 | | | | | |
| 2025 | 28,800 | | | | | | |
| AY | Paid Claims ($000) as of (months) | | | | | | |
| 2019 | 22,603 | 40,064 | 54,301 | 64,114 | 71,257 | 75,950 | 78,224 |
| 2020 | 22,054 | 43,970 | 58,737 | 71,841 | 78,076 | 81,287 | |
| 2021 | 20,166 | 39,147 | 51,319 | 60,417 | 66,402 | | |
| 2022 | 19,297 | 37,355 | 50,391 | 62,347 | | | |
| 2023 | 20,555 | 42,898 | 62,832 | | | | |
| 2024 | 17,001 | 33,568 | | | | | |
| 2025 | 11,346 | | | | | | |
| AY | Ratio of Paid Claims to Reported Claims | | | | | | |
| 2019 | 38.5% | 53.6% | 70.2% | 82.3% | 88.3% | 92.3% | 95.0% |
| 2020 | 34.6% | 55.3% | 70.2% | 84.2% | 88.6% | 93.0% | |
| 2021 | 38.9% | 57.4% | 73.5% | 86.7% | 94.8% | | |
| 2022 | 48.1% | 55.0% | 67.1% | 80.0% | | | |
| 2023 | 36.9% | 53.4% | 71.4% | | | | |
| 2024 | 39.2% | 58.3% | | | | | |
| 2025 | 39.4% | | | | | | |

This statistic tests the consistency of the development of paid and reported losses. It also may give warning of changes in case reserve inadequacies. In this case, AY22 is inconsistent with history. The high ratio at age 12 months indicates that the case reserve portion of the 1997 accident year reported losses at that age was much weaker than it was historically.

(b) For example, 32,751 - 23,355 - 2646 = 6,750.

| Accident Year | Reported Claim Counts as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 32,751 | 41,201 | 41,618 | 41,755 | 41,773 | 41,774 | 41,774 |
| 2020 | 33,736 | 39,528 | 39,926 | 40,044 | 40,072 | 40,072 | |
| 2021 | 27,067 | 32,740 | 33,084 | 33,183 | 33,209 | | |
| 2022 | 24,928 | 29,796 | 30,074 | 30,169 | | | |
| 2023 | 25,229 | 31,930 | 32,281 | | | | |
| 2024 | 17,632 | 21,801 | | | | | |
| 2025 | 15,609 | | | | | | |
| AY | Claim Counts Closed With Payment as of (months) | | | | | | |
| 2019 | 23,355 | 31,940 | 33,288 | 33,860 | 34,091 | 34,247 | 34,294 |
| 2020 | 22,662 | 30,294 | 31,588 | 32,129 | 32,323 | 32,433 | |
| 2021 | 18,951 | 25,197 | 26,214 | 26,582 | 26,777 | | |
| 2022 | 16,631 | 22,894 | 23,806 | 24,229 | | | |
| 2023 | 17,381 | 24,581 | 25,765 | | | | |
| 2024 | 12,666 | 16,669 | | | | | |
| 2025 | 10,592 | | | | | | |
| AY | Claim Counts Closed Without Payment as of (months) | | | | | | |
| 2019 | 2,646 | 6,285 | 6,935 | 7,240 | 7,353 | 7,393 | 7,412 |
| 2020 | 3,142 | 6,529 | 7,053 | 7,308 | 7,411 | 7,465 | |
| 2021 | 2,752 | 5,366 | 5,840 | 6,050 | 6,185 | | |
| 2022 | 2,343 | 4,744 | 5,132 | 5,400 | | | |
| 2023 | 2,238 | 4,666 | 5,375 | | | | |
| 2024 | 1,749 | 3,458 | | | | | |
| 2025 | 1,246 | | | | | | |
| AY | Open Claim Counts as of (months) | | | | | | |
| 2019 | 6,750 | 2,976 | 1,395 | 655 | 329 | 134 | 68 |
| 2020 | 7,932 | 2,705 | 1,285 | 607 | 338 | 174 | |
| 2021 | 5,364 | 2,177 | 1,030 | 551 | 247 | | |
| 2022 | 5,954 | 2,158 | 1,136 | 540 | | | |
| 2023 | 5,610 | 2,683 | 1,141 | | | | |
| 2024 | 3,217 | 1,674 | | | | | |
| 2025 | 3,771 | | | | | | |

| Accident Year | Reported Claims ($000) as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 58,641 | 74,804 | 77,323 | 77,890 | 80,728 | 82,280 | 82,372 |
| 2020 | 63,732 | 79,512 | 83,680 | 85,366 | 88,152 | 87,413 | |
| 2021 | 51,779 | 68,175 | 69,802 | 69,694 | 70,041 | | |
| 2022 | 40,143 | 67,978 | 75,144 | 77,947 | | | |
| 2023 | 55,665 | 80,296 | 87,961 | | | | |
| 2024 | 43,401 | 57,547 | | | | | |
| 2025 | 28,800 | | | | | | |
| AY | Paid Claims ($000) as of (months) | | | | | | |
| 2019 | 22,603 | 40,064 | 54,301 | 64,114 | 71,257 | 75,950 | 78,224 |
| 2020 | 22,054 | 43,970 | 58,737 | 71,841 | 78,076 | 81,287 | |
| 2021 | 20,166 | 39,147 | 51,319 | 60,417 | 66,402 | | |
| 2022 | 19,297 | 37,355 | 50,391 | 62,347 | | | |
| 2023 | 20,555 | 42,898 | 62,832 | | | | |
| 2024 | 17,001 | 33,568 | | | | | |
| 2025 | 11,346 | | | | | | |
| AY | Case Reserves ($000) as of (months) | | | | | | |
| 2019 | 36,038 | 34,740 | 23,022 | 13,776 | 9,471 | 6,330 | 4,148 |
| 2020 | 41,678 | 35,542 | 24,943 | 13,525 | 10,076 | 6,126 | |
| 2021 | 31,613 | 29,028 | 18,483 | 9,277 | 3,639 | | |
| 2022 | 20,846 | 30,623 | 24,753 | 15,600 | | | |
| 2023 | 35,110 | 37,398 | 25,129 | | | | |
| 2024 | 26,400 | 23,979 | | | | | |
| 2025 | 17,454 | | | | | | |
| AY | Open Claim Counts as of (months) | | | | | | |
| 2019 | 6,750 | 2,976 | 1,395 | 655 | 329 | 134 | 68 |
| 2020 | 7,932 | 2,705 | 1,285 | 607 | 338 | 174 | |
| 2021 | 5,364 | 2,177 | 1,030 | 551 | 247 | | |
| 2022 | 5,954 | 2,158 | 1,136 | 540 | | | |
| 2023 | 5,610 | 2,683 | 1,141 | | | | |
| 2024 | 3,217 | 1,674 | | | | | |
| 2025 | 3,771 | | | | | | |
| AY | Average Open Claim | | | | | | |
| 2019 | 5,339 | 11,673 | 16,503 | 21,032 | 28,787 | 47,239 | 61,000 |
| 2020 | 5,254 | 13,139 | 19,411 | 22,282 | 29,811 | 35,207 | |
| 2021 | 5,894 | 13,334 | 17,945 | 16,837 | 14,733 | | |
| 2022 | 3,501 | 14,190 | 21,790 | 28,889 | | | |
| 2023 | 6,258 | 13,939 | 22,024 | | | | |
| 2024 | 8,206 | 14,324 | | | | | |
| 2025 | 4,628 | | | | | | |

| Accident Year | Average Open Claim as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 5,339 | 11,673 | 16,503 | 21,032 | 28,787 | 47,239 | 61,000 |
| 2020 | 5,254 | 13,139 | 19,411 | 22,282 | 29,811 | 35,207 | |
| 2021 | 5,894 | 13,334 | 17,945 | 16,837 | 14,733 | | |
| 2022 | 3,501 | 14,190 | 21,790 | 28,889 | | | |
| 2023 | 6,258 | 13,939 | 22,024 | | | | |
| 2024 | 8,206 | 14,324 | | | | | |
| 2025 | 4,628 | | | | | | |
| AY | Change From Previous Accident Year | | | | | | |
| 2019 | -1.6% | 12.6% | 17.6% | 5.9% | 3.6% | -25.5% | |
| 2020 | 12.2% | 1.5% | -7.6% | -24.4% | -50.6% | | |
| 2021 | -40.6% | 6.4% | 21.4% | 71.6% | | | |
| 2022 | 78.7% | -1.8% | 1.1% | | | | |
| 2023 | 31.1% | 2.8% | | | | | |
| 2025 | -43.6% | | | | | | |
| Average | 6.0% | 4.3% | 8.1% | 17.7% | -23.5% | -25.5% | |

The average case reserves at earlier reports may be increasing at a somewhat similar rate to inflation. However, there are unusual swings from one AY to the next, particularly at first report. This warrants further investigation.

(c)

| Accident Year | Paid Claims ($000) as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 22,603 | 40,064 | 54,301 | 64,114 | 71,257 | 75,950 | 78,224 |
| 2020 | 22,054 | 43,970 | 58,737 | 71,841 | 78,076 | 81,287 | |
| 2021 | 20,166 | 39,147 | 51,319 | 60,417 | 66,402 | | |
| 2022 | 19,297 | 37,355 | 50,391 | 62,347 | | | |
| 2023 | 20,555 | 42,898 | 62,832 | | | | |
| 2024 | 17,001 | 33,568 | | | | | |
| 2025 | 11,346 | | | | | | |
| AY | Claim Counts Closed With Payment as of (months) | | | | | | |
| 2019 | 23,355 | 31,940 | 33,288 | 33,860 | 34,091 | 34,247 | 34,294 |
| 2020 | 22,662 | 30,294 | 31,588 | 32,129 | 32,323 | 32,433 | |
| 2021 | 18,951 | 25,197 | 26,214 | 26,582 | 26,777 | | |
| 2022 | 16,631 | 22,894 | 23,806 | 24,229 | | | |
| 2023 | 17,381 | 24,581 | 25,765 | | | | |
| 2024 | 12,666 | 16,669 | | | | | |
| 2025 | 10,592 | | | | | | |
| AY | Average Closed Claim | | | | | | |
| 2019 | 968 | 1,254 | 1,631 | 1,894 | 2,090 | 2,218 | 2,281 |
| 2020 | 973 | 1,451 | 1,859 | 2,236 | 2,415 | 2,506 | |
| 2021 | 1,064 | 1,554 | 1,958 | 2,273 | 2,480 | | |
| 2022 | 1,160 | 1,632 | 2,117 | 2,573 | | | |
| 2023 | 1,183 | 1,745 | 2,439 | | | | |
| 2024 | 1,342 | 2,014 | | | | | |
| 2025 | 1,071 | | | | | | |
| AY | Change From Previous Accident Year | | | | | | |
| 2020 | 0.6% | 15.7% | 14.0% | 18.1% | 15.6% | 13.0% | |
| 2021 | 9.3% | 7.0% | 5.3% | 1.6% | 2.7% | | |
| 2022 | 9.0% | 5.0% | 8.1% | 13.2% | | | |
| 2023 | 1.9% | 7.0% | 15.2% | | | | |
| 2024 | 13.5% | 15.4% | | | | | |
| 2025 | -20.2% | | | | | | |
| Average | 2.4% | 10.0% | 10.7% | 11.0% | 9.1% | 13.0% | |

It is useful to compare the annual increases in open case reserves to these increases in closed claim amounts. In this case it appears that the claim department reserves are not keeping pace with inflationary increases in settlements. There is something unusual going on with AY25 at first report; both the number of claims closed with payment and the average size are way down from the previous AYs. There may be a serious backlog in settling claims for AY25.

(d) (23,355 + 2646)/32,751 = 79.4%.

| Accident Year | Reported Claim Counts as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 32,751 | 41,201 | 41,618 | 41,755 | 41,773 | 41,774 | 41,774 |
| 2020 | 33,736 | 39,528 | 39,926 | 40,044 | 40,072 | 40,072 | |
| 2021 | 27,067 | 32,740 | 33,084 | 33,183 | 33,209 | | |
| 2022 | 24,928 | 29,796 | 30,074 | 30,169 | | | |
| 2023 | 25,229 | 31,930 | 32,281 | | | | |
| 2024 | 17,632 | 21,801 | | | | | |
| 2025 | 15,609 | | | | | | |
| AY | Claim Counts Closed With Payment as of (months) | | | | | | |
| 2019 | 23,355 | 31,940 | 33,288 | 33,860 | 34,091 | 34,247 | 34,294 |
| 2020 | 22,662 | 30,294 | 31,588 | 32,129 | 32,323 | 32,433 | |
| 2021 | 18,951 | 25,197 | 26,214 | 26,582 | 26,777 | | |
| 2022 | 16,631 | 22,894 | 23,806 | 24,229 | | | |
| 2023 | 17,381 | 24,581 | 25,765 | | | | |
| 2024 | 12,666 | 16,669 | | | | | |
| 2025 | 10,592 | | | | | | |
| AY | Claim Counts Closed Without Payment as of (months) | | | | | | |
| 2019 | 2,646 | 6,285 | 6,935 | 7,240 | 7,353 | 7,393 | 7,412 |
| 2020 | 3,142 | 6,529 | 7,053 | 7,308 | 7,411 | 7,465 | |
| 2021 | 2,752 | 5,366 | 5,840 | 6,050 | 6,185 | | |
| 2022 | 2,343 | 4,744 | 5,132 | 5,400 | | | |
| 2023 | 2,238 | 4,666 | 5,375 | | | | |
| 2024 | 1,749 | 3,458 | | | | | |
| 2025 | 1,246 | | | | | | |
| AY | Closed Claim Counts as a Percent of Reported Claim Counts | | | | | | |
| 2019 | 79.4% | 92.8% | 96.6% | 98.4% | 99.2% | 99.7% | 99.8% |
| 2020 | 76.5% | 93.2% | 96.8% | 98.5% | 99.2% | 99.6% | |
| 2021 | 80.2% | 93.4% | 96.9% | 98.3% | 99.3% | | |
| 2022 | 76.1% | 92.8% | 96.2% | 98.2% | | | |
| 2023 | 77.8% | 91.6% | 96.5% | | | | |
| 2024 | 81.8% | 92.3% | | | | | |
| 2025 | 75.8% | | | | | | |

This is a monitor on closing activities. There is relatively steady performance of this ratio as of 12 and 24 months of development for accident years 2019 to 2024. Note the slightly lower closing ratio on the 2025 accident year. This should be explored with the claims department. (On a property line this could be the result of a catastrophe in December, but in a liability line it would indicate potential processing problems.)

(e) {(31,940 - 23,355) + (6285 - 2646)}/6750 = 181.1%.

| Accident Year | Claim Counts Closed With Payment as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 23,355 | 31,940 | 33,288 | 33,860 | 34,091 | 34,247 | 34,294 |
| 2020 | 22,662 | 30,294 | 31,588 | 32,129 | 32,323 | 32,433 | |
| 2021 | 18,951 | 25,197 | 26,214 | 26,582 | 26,777 | | |
| 2022 | 16,631 | 22,894 | 23,806 | 24,229 | | | |
| 2023 | 17,381 | 24,581 | 25,765 | | | | |
| 2024 | 12,666 | 16,669 | | | | | |
| 2025 | 10,592 | | | | | | |
| AY | Claim Counts Closed Without Payment as of (months) | | | | | | |
| 2019 | 2,646 | 6,285 | 6,935 | 7,240 | 7,353 | 7,393 | 7,412 |
| 2020 | 3,142 | 6,529 | 7,053 | 7,308 | 7,411 | 7,465 | |
| 2021 | 2,752 | 5,366 | 5,840 | 6,050 | 6,185 | | |
| 2022 | 2,343 | 4,744 | 5,132 | 5,400 | | | |
| 2023 | 2,238 | 4,666 | 5,375 | | | | |
| 2024 | 1,749 | 3,458 | | | | | |
| 2025 | 1,246 | | | | | | |
| AY | Open Claim Counts as of (months) | | | | | | |
| 2019 | 6,750 | 2,976 | 1,395 | 655 | 329 | 134 | 68 |
| 2020 | 7,932 | 2,705 | 1,285 | 607 | 338 | 174 | |
| 2021 | 5,364 | 2,177 | 1,030 | 551 | 247 | | |
| 2022 | 5,954 | 2,158 | 1,136 | 540 | | | |
| 2023 | 5,610 | 2,683 | 1,141 | | | | |
| 2024 | 3,217 | 1,674 | | | | | |
| 2025 | 3,771 | | | | | | |
| AY | Ratio of Incremental Closed Claim Counts to Open Claim Counts at Beginning of the Year | | | | | | |
| 2019 | | 181.1% | 67.1% | 62.9% | 52.5% | 59.6% | 49.3% |
| 2020 | | 138.9% | 67.2% | 61.9% | 48.9% | 48.5% | |
| 2021 | | 165.2% | 68.5% | 56.1% | 59.9% | | |
| 2022 | | 145.5% | 60.2% | 60.8% | | | |
| 2023 | | 171.6% | 70.6% | | | | |
| 2024 | | 177.6% | | | | | |

There is some deterioration in claims performance in calendar year 2024. Only 60.2% of the claims occurring in 2022 that were open at 12/31/2023 were closed during the 2024 calendar year. Some level of recovery is evident during calendar year 2025 when 60.8% of 2022 occurrences that were open at 12/31/2024 were closed in the calendar year. However, the analyst might surmise that the closing activity on the 2024 inventory may have slipped in order to allow the catch up activity on the older inventories. These indications of processing problems should be probed with questions for claims management.

(f) 2646/23,355 = 11.3%. (6285 - 2646)/(31,940 - 23,355) = 42.4%.

| Accident Year | Claim Counts Closed With Payment as of (months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 |
| 2019 | 23,355 | 31,940 | 33,288 | 33,860 | 34,091 | 34,247 | 34,294 |
| 2020 | 22,662 | 30,294 | 31,588 | 32,129 | 32,323 | 32,433 | |
| 2021 | 18,951 | 25,197 | 26,214 | 26,582 | 26,777 | | |
| 2022 | 16,631 | 22,894 | 23,806 | 24,229 | | | |
| 2023 | 17,381 | 24,581 | 25,765 | | | | |
| 2024 | 12,666 | 16,669 | | | | | |
| 2025 | 10,592 | | | | | | |
| AY | Claim Counts Closed Without Payment as of (months) | | | | | | |
| 2019 | 2,646 | 6,285 | 6,935 | 7,240 | 7,353 | 7,393 | 7,412 |
| 2020 | 3,142 | 6,529 | 7,053 | 7,308 | 7,411 | 7,465 | |
| 2021 | 2,752 | 5,366 | 5,840 | 6,050 | 6,185 | | |
| 2022 | 2,343 | 4,744 | 5,132 | 5,400 | | | |
| 2023 | 2,238 | 4,666 | 5,375 | | | | |
| 2024 | 1,749 | 3,458 | | | | | |
| 2025 | 1,246 | | | | | | |
| AY | Incremental Counts Without Payment to Incremental Counts With Payment | | | | | | |
| 2019 | 11.3% | 42.4% | 48.2% | 53.3% | 48.9% | 25.6% | 40.4% |
| 2020 | 13.9% | 44.4% | 40.5% | 47.1% | 53.1% | 49.1% | |
| 2021 | 14.5% | 41.9% | 46.6% | 57.1% | 69.2% | | |
| 2022 | 14.1% | 38.3% | 42.5% | 63.4% | | | |
| 2023 | 12.9% | 33.7% | 59.9% | | | | |
| 2024 | 13.8% | 42.7% | | | | | |
| 2025 | 11.8% | | | | | | |

This measures the percent of claims being denied. This could reflect how strict the claims handlers are being, how many frivolous claims are being filed, etc.
The variation at later reports could be due to random fluctuation on a small number of incremental claim counts. However, the AY23 values at 24 and 36 months should be investigated further with the claims department.

Comment: Adapted from “Loss Reserving”, by Ronald F. Wiser, revised and updated by Jo Ellen Cockley and Andrea Gardner, Chapter 5 of Foundations of Actuarial Science.
There are other reasonable things that could be said about each diagnostic triangle.

**6.18.** For large claims, on the latest diagonal the average case reserves are larger than prior by more than would be expected due to inflation. It appear that these case reserves have been strengthened. This is not the case for the small claims.
Perhaps the company hired additional claims handling personnel to increase the case reserve adequacy on large claims. Perhaps the company instructed its claims handlers to review the claim files of large claims more frequently. Perhaps the company made an increased effort to settle its large claims, and those that they were unable to settle were more serious on average.
Comment: Similar to 5, 5/19, Q.22.

**6.19. E.** If the paid loss is an increasing percentage of the reported losses down the columns of the triangle, this tends to indicate that the case reserves have been weakened.
Comment: If the closed claim count is an increasing percentage of the open claim count down the columns of the triangle, this tends to indicate that the settlement rate has increased.
The other three triangles each by themselves are not useful diagnostic tools, although the actuary should examine them for any anomalies.

**6.20.** (a) Calculate age to age factors. Calculate the frequencies.

| Cumulative Closed Claim Counts | | | | | Earned Exposures |
|---|---|---|---|---|---|
| Accident Year | Age of Development in Months | | | | |
| | 12 | 24 | 36 | 48 | |
| 2003 | 120 | 170 | 195 | 200 | 20,000 |
| 2004 | 115 | 170 | 210 | | 20,500 |
| 2005 | 120 | 195 | | | 21,000 |
| 2006 | 160 | | | | 21,250 |
| AY | Age to Age Factors | | | | |
| 2003 | 1.417 | 1.147 | 1.026 | | |
| 2004 | 1.478 | 1.235 | | | |
| 2005 | 1.625 | | | | |
| AY | Closed Claim Frequencies | | | | |
| 2003 | 0.60% | 0.85% | 0.98% | 1.00% | |
| 2004 | 0.56% | 0.83% | 1.02% | | |
| 2005 | 0.57% | 0.93% | | | |
| 2006 | 0.75% | | | | |

The age to age factors have increased along the latest diagonal.
This indicates an increase in the settlement rate.
The closed claim frequencies have increased for AY06 at first report and AY05 at second report compared to prior AYs. This is probably due to an increase in the settlement rate.
The claims management may have put in place an initiative to close claims sooner.
(b) Recently, a larger percentage of ultimate losses will be paid than historically. Therefore, the paid factors to ultimate based on historical data will be too large to apply to recent data,
The ultimate losses would be **overestimated**.

**6.21.** (a) Claims #1 and #2 are in AY07. Claims #3 and #4 are in AY08. Claim #5 is in AY09.

| Accident Year | Cumulative Paid Claims ($000) | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2007 | 100 | 200 | 700 |
| 2008 | 100 | 250 | |
| 2009 | 105 | | |

(b) Cumulative Reported Claims = Cumulative Paid Claims + Case Reserves at End of Year.

| Accident Year | Cumulative Reported Claims ($000) | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2007 | 600 | 650 | 700 |
| 2008 | 650 | 850 | |
| 2009 | 750 | | |

(c) Take the ratio of paid to reported claims:

| Accident Year | Cumulative Paid Claims ($000) | | |
|---|---|---|---|
| | 12 Months | 24 Months | 36 Months |
| 2007 | 100 | 200 | 700 |
| 2008 | 100 | 250 | |
| 2009 | 105 | | |
| AY | Cumulative Reported Claims ($000) | | |
| 2007 | 600 | 650 | 700 |
| 2008 | 650 | 850 | |
| 2009 | 750 | | |
| AY | Ratios | | |
| 2007 | 0.167 | 0.308 | 1.000 |
| 2008 | 0.154 | 0.294 | |
| 2009 | 0.140 | | |

The paid to reported ratios at first report are declining, providing slight evidence of a slow-down in claim payments. (This could instead be caused by an increase in case reserve adequacy.)
Alternately, AY07 has 2 reported claims, both closed at 3rd report.
AY08 has 2 reported claims, one of which is closed at 2nd report.
This provides very slight evidence of a speed-up in claim payments.
Comment: There is far too little data to perform a meaningful diagnostic test.

**6.22.** Take the ratio of paid claims to reported claims.

| Accident Year | Reported Claims (000s) | | | |
|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 48 Months |
| 2007 | $500 | $554 | $586 | $592 |
| 2008 | $448 | $470 | $512 | |
| 2009 | $312 | $346 | | |
| 2010 | $426 | | | |
| AY | Paid Claims (000s) | | | |
| 2007 | $85 | $200 | $500 | $570 |
| 2008 | $81 | $225 | $472 | |
| 2009 | $59 | $175 | | |
| 2010 | $85 | | | |
| AY | Ratio | | | |
| 2007 | 0.170 | 0.361 | 0.853 | 0.963 |
| 2008 | 0.181 | 0.479 | 0.922 | |
| 2009 | 0.189 | 0.506 | | |
| 2010 | 0.200 | | | |

Looking down the columns, the ratios have increased.
This may be due to a speed-up in claim closure (an increase in the numerator),
a weakening in case reserves (a decrease in the denominator), or both.

**6.23.** (a) Once the new processing system takes effect, there will be fewer open claims at a given maturity than previously, so the case outstanding triangle will have smaller amounts. The average case reserve will stay the same, unless the new system has a different effect on larger more complicated claims than smaller simpler claims.
The new statute of limitations may cause some claims to be reported sooner than they would have been, increasing the case outstanding amounts at these earlier maturities. If these are larger more complicated claims, then the average case reserve will increase at these earlier maturities.
The new statute of limitations may cause some claims to not be reported and thus not covered. This would cause the case outstanding amounts at these later maturities to be less than previously. If these are larger more complicated claims, then the average case reserve will be less than previously.
(b) Possible responses (any two):
- The claims department hires additional claims adjusters in order to try to close claims more quickly; the ratio goes up.
- Change in the guidelines for the establishment of a claim.
- Restructuring of the claim field offices, such as through the merging of existing offices or the addition of new offices.
- Introduction of a new call center to handle claims; the ratio goes down.
- A large catastrophe results in a large influx of claims, creating a temporary slowdown in the ability to handle and close claims; the ratio goes down.
- A decision to fight more claims in court will result is a decrease of closed to reported claim counts; the ratio goes down.

Comment: In part (b), mention additional scenarios that affect the settlement rate.

**6.24**. Calculate the average case reserves:

| Accident Year | Outstanding Claims ($000s) | | | Outstanding Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 3,200 | 1,400 | 200 | 45 | 23 | 1 |
| 2011 | 3,290 | 1,130 | | 44 | 17 | |
| 2012 | 3,450 | | | 42 | | |
| AY | Average Case Reserves | | | Change | | |
| 2010 | $71,111 | $60,870 | $200,000 | | | |
| 2011 | $74,773 | $66,471 | | 5.1% | 9.2% | |
| 2012 | $82,143 | | | 9.9% | | |

82,143/74,773 = 1.099. 66,471/60,870 = 1.092. Along the latest diagonal, the average case reserves increased by more than the 5% severity trend.

Calculate the average closed claim:

| Accident Year | Cumulative Paid Claims ($000s) | | | Cumulative Closed Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 2,100 | 6,410 | 8,300 | 35 | 75 | 99 |
| 2011 | 2,210 | 7,000 | | 35 | 80 | |
| 2012 | 2,550 | | | 40 | | |
| AY | Average Closed Claim | | | Change | | |
| 2010 | $60,000 | $85,467 | $83,838 | | | |
| 2011 | $63,143 | $87,500 | | 5.2% | 2.4% | |
| 2012 | $63,750 | | | 1.0% | | |

Along the latest diagonal, the average closed claim increased by less than the 5% severity trend.

Calculate the ratio of closed claim count to reported claim count:

| Accident Year | Cumulative Reported Claim Count | | | Cumulative Closed Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 80 | 98 | 100 | 35 | 75 | 99 |
| 2011 | 79 | 97 | | 35 | 80 | |
| 2012 | 82 | | | 40 | | |
| AY | Ratio | | | | | |
| 2010 | 0.438 | 0.765 | 0.990 | | | |
| 2011 | 0.443 | 0.825 | | | | |
| 2012 | 0.488 | | | | | |

The ratios have increased, indicating that the settlement rate has increased.

Calculate the average reported claim:

| Accident Year | Cumulative Reported Claims ($000s) | | | Cumulative Reported Claim Count | | |
|---|---|---|---|---|---|---|
| | 12 Months | 24 Months | 36 Months | 12 Months | 24 Months | 36 Months |
| 2010 | 5,300 | 7,810 | 8,500 | 80 | 98 | 100 |
| 2011 | 5,500 | 8,130 | | 79 | 97 | |
| 2012 | 6,000 | | | 82 | | |
| AY | Average Reported Claim | | | Change | | |
| 2010 | $66,250 | $79,694 | $85,000 | | | |
| 2011 | $69,620 | $83,814 | | 5.1% | 5.2% | |
| 2012 | $73,171 | | | 5.1% | | |

Down the columns, the average reported claim is increasing by about 5% per year.
This matches the given annual severity trend.
Given the above diagnostics, the reported claim development method is preferable to the paid claim development method; estimated ultimate loss for accident year 2012 of **$9,650,000**.
Comment: We were asked to choose between the two methods. In a practical application, the behavior of the severity of case reserves and the change in settlement rates would each warrant further investigation. Somehow the paid losses plus case reserves combine to produce average reported losses that increase at the 5% inflation rate.
From the CAS Examiner's Report: "Candidates were supposed to evaluate Average Paid (and/or Outstanding) and Average Reported trends and compare them to the known severity trend of 5%. They should have noticed the increase in paid severity and that reported trends matched the 5% severity trend. From there they were to conclude to use the reported method and not the paid. This conclusion should have been reached by evaluating changes (or lack of change) in both case adequacy and settlement rates."

**6.25.** (a) Possible Responses (any two):
● Differences in payment pattern: If the two company's differing structures, claims handling, etc. lead to differences in how claims are paid, then combining the data for both into one reserve study could lead to distortions.
● Relative size of the two companies: If one company is much larger than the other, the distortions caused by the combined analysis could be immaterial.
● Operational: The actuary needs to look at how each company sets case reserves, rate of claim closure, emphasis in settling large vs. small claims, etc. These factors impact the results of various reserving techniques and can possibly distort them.
● Changes in book of business: The actuary should look at policy limits, types of insured, etc. to determine differences between the two companies and changes over time that could influence how the data is combined or what reserving techniques are used.
● Homogeneity: The actuary needs to check if the data for Company A and B have similar characteristics.
● Credibility: Is there are enough data in Company C to obtain credible and reliable results.

(b) Compute paid loss development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 400 | 2,400 | 9,600 | 12,000 |
| 2010 | 400 | 2,400 | 9,600 | |
| 2011 | 400 | 2,400 | | |
| 2012 | 400 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 6.000 | 4.000 | 1.250 | |
| 2010 | 6.000 | 4.000 | | |
| 2011 | 6.000 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 12 | 45 | 176 | 230 |
| 2010 | 4 | 39 | 192 | |
| 2011 | 6 | 51 | | |
| 2012 | 8 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 3.750 | 3.911 | 1.307 | |
| 2010 | 9.750 | 4.923 | | |
| 2011 | 8.500 | | | |
| Average | 7.333 | 4.417 | 1.307 | |

The paid loss development factors differ between the two companies.

Compute reported loss development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 800 | 4,800 | 12,800 | 14,400 |
| 2010 | 800 | 4,800 | 12,800 | |
| 2011 | 800 | 4,800 | | |
| 2012 | 800 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 6.000 | 2.667 | 1.125 | |
| 2010 | 6.000 | 2.667 | | |
| 2011 | 6.000 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Reported Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 50 | 144 | 264 | 278 |
| 2010 | 34 | 144 | 288 | |
| 2011 | 34 | 147 | | |
| 2012 | 40 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 2.880 | 1.833 | 1.053 | |
| 2010 | 4.235 | 2.000 | | |
| 2011 | 4.324 | | | |
| Average | 3.813 | 1.917 | 1.053 | |

The reported loss development factors differ between the two companies.

Compute the ratios of paid to reported claims for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 400 | 2,400 | 9,600 | 12,000 |
| 2010 | 400 | 2,400 | 9,600 | |
| 2011 | 400 | 2,400 | | |
| 2012 | 400 | | | |
| AY | Reported Losses ($000s) | | | |
| 2009 | 800 | 4,800 | 12,800 | 14,400 |
| 2010 | 800 | 4,800 | 12,800 | |
| 2011 | 800 | 4,800 | | |
| 2012 | 800 | | | |
| AY | Ratio | | | |
| 2009 | 50.0% | 50.0% | 75.0% | 83.3% |
| 2010 | 50.0% | 50.0% | 75.0% | |
| 2011 | 50.0% | 50.0% | | |
| 2012 | 50.0% | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 12 | 45 | 176 | 230 |
| 2010 | 4 | 39 | 192 | |
| 2011 | 6 | 51 | | |
| 2012 | 8 | | | |
| AY | Reported Losses ($000s) | | | |
| 2009 | 50 | 144 | 264 | 278 |
| 2010 | 34 | 144 | 288 | |
| 2011 | 34 | 147 | | |
| 2012 | 40 | | | |
| AY | Ratio | | | |
| 2009 | 24.0% | 31.3% | 66.7% | 82.7% |
| 2010 | 11.8% | 27.1% | 66.7% | |
| 2011 | 17.6% | 34.7% | | |
| 2012 | 20.0% | | | |

The ratios of paid to reported claims differ between the two companies.

Compute the ratios of closed to reported claim counts for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 2,000 | 3,000 | 3,000 | 3,000 |
| 2010 | 2,000 | 3,000 | 3,000 | |
| 2011 | 2,000 | 3,000 | | |
| 2012 | 2,000 | | | |
| AY | Closed Counts | | | |
| 2009 | 1,000 | 1,500 | 2,000 | 2,500 |
| 2010 | 1,000 | 1,500 | 2,000 | |
| 2011 | 1,000 | 1,500 | | |
| 2012 | 1,000 | | | |
| AY | Ratio | | | |
| 2009 | 50.0% | 50.0% | 66.7% | 83.3% |
| 2010 | 50.0% | 50.0% | 66.7% | |
| 2011 | 50.0% | 50.0% | | |
| 2012 | 50.0% | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Reported Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 40 | 60 | 60 | 60 |
| 2010 | 40 | 60 | 60 | |
| 2011 | 40 | 60 | | |
| 2012 | 40 | | | |
| AY | Closed Counts | | | |
| 2009 | 20 | 30 | 40 | 50 |
| 2010 | 20 | 30 | 40 | |
| 2011 | 20 | 30 | | |
| 2012 | 20 | | | |
| AY | Ratio | | | |
| 2009 | 50.0% | 50.0% | 66.7% | 83.3% |
| 2010 | 50.0% | 50.0% | 66.7% | |
| 2011 | 50.0% | 50.0% | | |
| 2012 | 50.0% | | | |

The ratios of closed to reported claim counts are the same for the two companies.

Compute the severity of paid losses for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 400 | 2,400 | 9,600 | 12,000 |
| 2010 | 400 | 2,400 | 9,600 | |
| 2011 | 400 | 2,400 | | |
| 2012 | 400 | | | |
| AY | Closed Counts | | | |
| 2009 | 1,000 | 1,500 | 2,000 | 2,500 |
| 2010 | 1,000 | 1,500 | 2,000 | |
| 2011 | 1,000 | 1,500 | | |
| 2012 | 1,000 | | | |
| AY | Severity | | | |
| 2009 | $400 | $1,600 | $4,800 | $4,800 |
| 2010 | $400 | $1,600 | $4,800 | |
| 2011 | $400 | $1,600 | | |
| 2012 | $400 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 12 | 45 | 176 | 230 |
| 2010 | 4 | 39 | 192 | |
| 2011 | 6 | 51 | | |
| 2012 | 8 | | | |
| AY | Closed Counts | | | |
| 2009 | 20 | 30 | 40 | 50 |
| 2010 | 20 | 30 | 40 | |
| 2011 | 20 | 30 | | |
| 2012 | 20 | | | |
| AY | Severity | | | |
| 2009 | $600 | $1,500 | $4,400 | $4,600 |
| 2010 | $200 | $1,300 | $4,800 | |
| 2011 | $300 | $1,700 | | |
| 2012 | $400 | | | |
| Average | $375 | $1,500 | $4,600 | $4,600 |

The paid severities are similar for the two companies.
(There is random fluctuation for Company B.)

Compute the severity of case reserves for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 400 | 2,400 | 9,600 | 12,000 |
| 2010 | 400 | 2,400 | 9,600 | |
| 2011 | 400 | 2,400 | | |
| 2012 | 400 | | | |
| AY | Reported Losses ($000s) | | | |
| 2009 | 800 | 4,800 | 12,800 | 14,400 |
| 2010 | 800 | 4,800 | 12,800 | |
| 2011 | 800 | 4,800 | | |
| 2012 | 800 | | | |
| AY | Reported Counts | | | |
| 2009 | 2,000 | 3,000 | 3,000 | 3,000 |
| 2010 | 2,000 | 3,000 | 3,000 | |
| 2011 | 2,000 | 3,000 | | |
| 2012 | 2,000 | | | |
| AY | Closed Counts | | | |
| 2009 | 1,000 | 1,500 | 2,000 | 2,500 |
| 2010 | 1,000 | 1,500 | 2,000 | |
| 2011 | 1,000 | 1,500 | | |
| 2012 | 1,000 | | | |
| AY | Average Case Reserve | | | |
| 2009 | $400 | $1,600 | $3,200 | $4,800 |
| 2010 | $400 | $1,600 | $3,200 | |
| 2011 | $400 | $1,600 | | |
| 2012 | $400 | | | |

For example, ($800,000 - $400,000) / (2000 - 1000) = $400.

| COMPANY B | | | | |
|---|---|---|---|---|
| Paid Losses ($000s) | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 12 | 45 | 176 | 230 |
| 2010 | 4 | 39 | 192 | |
| 2011 | 6 | 51 | | |
| 2012 | 8 | | | |
| AY | Reported Losses ($000s) | | | |
| 2009 | 50 | 144 | 264 | 278 |
| 2010 | 34 | 144 | 288 | |
| 2011 | 34 | 147 | | |
| 2012 | 40 | | | |
| AY | Reported Counts | | | |
| 2009 | 40 | 60 | 60 | 60 |
| 2010 | 40 | 60 | 60 | |
| 2011 | 40 | 60 | | |
| 2012 | 40 | | | |
| AY | Closed Counts | | | |
| 2009 | 20 | 30 | 40 | 50 |
| 2010 | 20 | 30 | 40 | |
| 2011 | 20 | 30 | | |
| 2012 | 20 | | | |
| AY | Average Case Reserve | | | |
| 2009 | $1,900 | $3,300 | $4,400 | $4,800 |
| 2010 | $1,500 | $3,500 | $4,800 | |
| 2011 | $1,400 | $3,200 | | |
| 2012 | $1,600 | | | |

For example, ($50,000 - $12,000) / (40 - 20) = $400.
The average case reserves are very different for the two companies.

Compute closed claim count development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Closed Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 1,000 | 1,500 | 2,000 | 2,500 |
| 2010 | 1,000 | 1,500 | 2,000 | |
| 2011 | 1,000 | 1,500 | | |
| 2012 | 1,000 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 1.500 | 1.333 | 1.250 | |
| 2010 | 1.500 | 1.333 | | |
| 2011 | 1.500 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Closed Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 20 | 30 | 40 | 50 |
| 2010 | 20 | 30 | 40 | |
| 2011 | 20 | 30 | | |
| 2012 | 20 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 1.500 | 1.333 | 1.250 | |
| 2010 | 1.500 | 1.333 | | |
| 2011 | 1.500 | | | |
| Average | 1.500 | 1.333 | 1.250 | |

The closed claim count development factors are the same for the two companies.

Compute reported claim count development factors for each of the two companies:

| COMPANY A | | | | |
|---|---|---|---|---|
| Reported Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 2,000 | 3,000 | 3,000 | 3,000 |
| 2010 | 2,000 | 3,000 | 3,000 | |
| 2011 | 2,000 | 3,000 | | |
| 2012 | 2,000 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 1.500 | 1.000 | 1.000 | |
| 2010 | 1.500 | 1.000 | | |
| 2011 | 1.500 | | | |

| COMPANY B | | | | |
|---|---|---|---|---|
| Reported Claim Counts | | | | |
| AY | 12 | 24 | 36 | 48 |
| 2009 | 40 | 60 | 60 | 60 |
| 2010 | 40 | 60 | 60 | |
| 2011 | 40 | 60 | | |
| 2012 | 40 | | | |
| AY | Age to Age Factors | | | |
| 2009 | 1.500 | 1.000 | 1.000 | |
| 2010 | 1.500 | 1.000 | | |
| 2011 | 1.500 | | | |
| Average | 1.500 | 1.000 | 1.000 | |

The reported claim count development factors are the same for the two companies.

(c) The paid loss development factors differ between the two companies.
The reported loss development factors differ between the two companies.
The ratios of paid to reported claims differ between the two companies.
The ratios of closed to reported claim counts are the same for the two companies.
The paid severities are similar for the two companies.
(There is random fluctuation for Company B.)
The average case reserves are very different for the two companies.
The closed claim count development factors are the same for the two companies.
The reported claim count development factors are the same for the two companies.

It is not appropriate to combine the historical data. Even though the counts for both companies develop in a similar manner, losses do not. The average case reserves are very different; the two companies seem to have very different case reserving philosophies. Combining the historical data will distort the estimates of ultimate losses.
Alternately, it is appropriate to combine the historical data. The settlement rates are the same. Even though there is a difference in loss development patterns, the very small size of Company B relative to Company A will make any distortion in estimates of ultimate losses immaterial.
Due to the vast difference in the severity of case reserves between the two companies, it would be better to apply paid reserving techniques to the combined data.

(d) If Company C adopts Company A's claim practices, then the historical development pattern for Company B will not apply going forward. (Eventually all of the data will reflect Company A's claim practices, but that will take a good number of years.) It would be appropriate to combine A and B only if you adjust company B's historical data. Due to the vast difference in the severity of case reserves between the two companies, it would be better to apply paid reserving techniques to the combined data. In any case, Company B is very small relative to Company A, so that any potential distortion in estimates of ultimate losses will be small.
Comment: The Standard of Practice referenced in part (a) is in Appendix A of Friedland, but is no longer on the syllabus.
In part (b), only calculate three diagnostics.
Your answer to part (c) will depend somewhat on which diagnostics you calculated in part (b).
Part (b) seems like a lot of work for the assigned points.

**6.26.** (a) AY11: claims 1 to 3. AY12: claims 4 to 7. AY13: claims 8 to 11.

| Accident Year | Cumulative Paid Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 460 | 1080 | 1310 |
| 2012 | 660 | 2060 | |
| 2013 | 1000 | | |

| Accident Year | Cumulative Reported Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 960 | 1580 | 1580 |
| 2012 | 1260 | 2460 | |
| 2013 | 1600 | | |

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 2 | 3 | 3 |
| 2012 | 3 | 4 | |
| 2013 | 3 | | |

| Accident Year | Cumulative Closed Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 1 | 2 | 2 |
| 2012 | 1 | 2 | |
| 2013 | 0 | | |

(b) Take the ratio of Closed Claim Counts over Reported Claim Counts:

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 2 | 3 | 3 |
| 2012 | 3 | 4 | |
| 2013 | 3 | | |
| AY | Cumulative Closed Claim Counts as of (months) | | |
| 2011 | 1 | 2 | 2 |
| 2012 | 1 | 2 | |
| 2013 | 0 | | |
| AY | Ratio | | |
| 2011 | 0.500 | 0.667 | 0.667 |
| 2012 | 0.333 | 0.500 | |
| 2013 | 0.000 | | |

The settlement rate seems to have slowed.

Alternately, the average case outstanding:

| Accident Year | Cumulative Open Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 1 | 1 | 1 |
| 2012 | 2 | 2 | |
| 2013 | 3 | | |
| AY | Case Outstanding as of (months) | | |
| 2011 | 500 | 500 | 270 |
| 2012 | 600 | 400 | |
| 2013 | 600 | | |
| AY | Severity | | |
| 2011 | 500 | 500 | 270 |
| 2012 | 300 | 200 | |
| 2013 | 200 | | |

The case reserves seem to have weakened.

Alternately, take the ratio of Paid Claim over Reported Claims:

| Accident Year | Cumulative Paid Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 460 | 1080 | 1310 |
| 2012 | 660 | 2060 | |
| 2013 | 1000 | | |
| AY | Cumulative Reported Claims as of (months) | | |
| 2011 | 960 | 1580 | 1580 |
| 2012 | 1260 | 2460 | |
| 2013 | 1600 | | |
| AY | Ratio | | |
| 2011 | 0.479 | 0.684 | 0.829 |
| 2012 | 0.524 | 0.837 | |
| 2013 | 0.625 | | |

The ratio of paid to reported claims has increased. This could be due to either an increase in payments or a reduction in case reserve adequacy.

Alternately, the average paid claim:

| Accident Year | Cumulative Paid Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 460 | 1080 | 1310 |
| 2012 | 660 | 2060 | |
| 2013 | 1000 | | |
| AY | Cumulative Closed Claim Counts as of (months) | | |
| 2011 | 1 | 2 | 2 |
| 2012 | 1 | 2 | |
| 2013 | 0 | | |
| AY | Severity | | |
| 2011 | 460 | 540 | 655 |
| 2012 | 660 | 1030 | |
| 2013 | n/a | | |

The average paid claim is increasing. This could be due to either an increase in payments or a change in the type of claim that is being closed.

Alternately, the average reported claim:

| Accident Year | Cumulative Reported Claims as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2011 | 960 | 1580 | 1580 |
| 2012 | 1260 | 2460 | |
| 2013 | 1600 | | |
| AY | Cumulative Reported Claim Counts as of (months) | | |
| 2011 | 2 | 3 | 3 |
| 2012 | 3 | 4 | |
| 2013 | 3 | | |
| AY | Severity | | |
| 2011 | 480 | 527 | 527 |
| 2012 | 420 | 615 | |
| 2013 | 533 | | |

The average reported claim is increasing. This could be due to either an increase in payments or case reserve adequacy. (A separate analysis of average case reserves shows that the case reserve adequacy seems to be decreasing.)

Comment: There is too little data to show whether there has been an operational change.

**6.27.** (a) The ratios at given maturities are increasing.

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 1,150 | 2,250 | 3,000 |
| 2015 | 1,250 | 2,400 | |
| 2016 | 1,550 | | |
| AY | Cumulative Reported Claims ($000) as of (months) | | |
| 2014 | 5,150 | 7,200 | 8,000 |
| 2015 | 4,800 | 6,700 | |
| 2016 | 4,750 | | |
| AY | Ratio of Paid to Reported Claims | | |
| 2014 | 22.3% | 31.3% | 37.5% |
| 2015 | 26.0% | 35.8% | |
| 2016 | 32.6% | | |

i. Claim settlement rates increasing would be one explanation.
ii. Case reserve adequacy decreasing would be one explanation.

(b) i. For example, (102 - 52)/102 = 1 - 52/102 = 0.490.

| Accident Year | Cumulative Reported Claim Counts as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 102 | 107 | 108 |
| 2015 | 96 | 101 | |
| 2016 | 99 | | |
| AY | Open Claim Counts as of (months) | | |
| 2014 | 52 | 28 | 12 |
| 2015 | 46 | 25 | |
| 2016 | 42 | | |
| AY | Ratio of Closed to Reported Claim Counts | | |
| 2014 | 0.490 | 0.738 | 0.889 |
| 2015 | 0.521 | 0.752 | |
| 2016 | 0.576 | | |

The ratios of closed to reported claim counts at given maturities are increasing.
This indicates an increase in the claim settlement rate.

ii. For example, (1000)(5150 - 1150)/52 = 76,923.
The average case outstanding is fairly stable for different maturities.

| Accident Year | Cumulative Paid Claims ($000) as of (months) | | |
|---|---|---|---|
| | 12 | 24 | 36 |
| 2014 | 1,150 | 2,250 | 3,000 |
| 2015 | 1,250 | 2,400 | |
| 2016 | 1,550 | | |
| AY | Cumulative Reported Claims ($000) as of (months) | | |
| 2014 | 5,150 | 7,200 | 8,000 |
| 2015 | 4,800 | 6,700 | |
| 2016 | 4,750 | | |
| AY | Open Claim Counts as of (months) | | |
| 2014 | 52 | 28 | 12 |
| 2015 | 46 | 25 | |
| 2016 | 42 | | |
| AY | Average Case Outstanding | | |
| 2014 | $76,923 | $176,786 | $416,667 |
| 2015 | $77,174 | $172,000 | |
| 2016 | $76,190 | | |

We are told inflation is 0%. At a given maturity we see close to constant average case outstanding. This is consistent with no change in case reserve adequacy.
Comment: In answering part (a) you were not supposed to peek ahead to part (b).

**6.28. (**a) Possible responses (any three):
- Increase (or decrease) in case reserve adequacy
- Increase (or decrease) in settlement rate; speedup (or slowdown) in case settlement
- Prioritization of large vs small claims
- Change in mix of business
- Change in policy limits or change in the deductibles offered
- Change in underwriting rules
- Change in reporting process, such as introducing a new call center
- Growing or shrinking of the book of business that changes the average accident date
- Reinsurance program change
- Change in subrogation procedures to increase recoveries
- Company implements a new rule requiring insured to report claims faster
- Take a more aggressive litigative stance on claims
- Start a fraud detection department
- Change in how claims are processed, such as introducing new technology
- Increased risk control (safety programs)

(b). Responses for “Increase in case reserve adequacy”:
- A triangle of case outstanding ÷ open claim count will show an increase down columns.
- The paid-to-reported ratio would decrease going down columns of the triangle.

Responses for “Increase in settlement rate”:
- Would result in an increase in disposal rate.
- The paid to reported triangle would increase down the columns.
- The closed-to-reported claim count triangle will show an increasing trend down the columns.

Responses for “Prioritization of large vs small claims”:
- # Closed ÷ # reported triangle would observe a decrease in early maturities.
- Average paid severity (or incremental paid severity) would increase at early maturities since smaller claims are not being closed as quickly as previously.
- Average case outstanding decreases at later maturities down the column since fewer large claims compared to other claims are left open.

Response for “Change in Mix of Business”, “Change in underwriting rules”:
- Look at triangles separated by mix of business; check whether there is a change in the percentages for the different types of business.

Response for “Change in policy limits or change in the deductibles offered”:
- Check average paid severity to see if there is a change. (Higher policy limits will tend to increase severity, while higher deductibles will tend to decrease severity.)

Responses for “Change in reporting process, such as introducing a new call center”:
- Changes in claim reporting pattern can be assessed using the age-to-age development factors of reported claim counts and ratio of reported claim count to exposure. An increase in these ratios across years would imply faster claim reporting.
- Look at the ratios of reported loss to on-level premium. If reporting speeds up this could lead to an increase in the first column of the triangle.

Responses for "Growing book of business that changes the average accident date":
- Look at reported claim count triangle – one might see claims count development factors increase in the first period due to shifting of average accident date to later in the year.
- Start by looking at the paid or reported claim age to age development factor triangles. LDFs will be distorted and likely increasing because the average accident date is shifting towards the end of the period; the first report will contain less losses than historically since on average claims that had less time to develop.
- Compare disposal rates by quarter to annual disposal rates; for early reports the quarterly disposal rates should be much less affected than the annual disposal rates by an increase in the average accident date.

Response for "Reinsurance program change":
- Look at ratio of net to gross reported claim triangle; check if the ratio is changing significantly from prior years.

Responses for "Change in subrogation procedures to increase recoveries":
- The ratios of reported subrogation to reported claims showing an increase down a column would be an indicator of increased subrogation.
- A triangle of salvage and subrogation to paid losses can be created to observe any changes to the recoveries.

Response for "Company implements a new rule requiring insured to report claims faster":
- Would see a higher ratio of reported counts per exposure at earlier maturities.

Responses for "Take a more aggressive litigative stance on claims":
- Split claim counts into two triangles, those that go through litigation versus those that do not. One would expect to see a larger percentage of claims going though litigation.
- Look at the ratios of closed to reported claim counts. If more claims are being taken to court, they will not be closed as quickly so ratios down the columns of the triangle should decrease.
- Look at the ratio of the paid to reported losses (not including ALAE). One would expect this triangle to show lower values down the columns.
- Look at the ratio of paid ALAE to paid claims. One would expect this triangle to show higher values down the columns due to more money being spent on lawyers, etc. (ALAE).

Responses for "Start a fraud detection department":
- Look at the ratio of claim counts without payment ÷ reported claim counts. If this change had a positive impact, one would expect the latest diagonal to show an increase versus historical ratios.
- Look at the ratio of reported claims to earned premium. If this change had a positive impact, one would expect this ratio to decrease down the columns of the triangle.

Responses for "Change in how claims are processed, such as introducing new technology":
- Look at the ratio of # closed ÷ # reported. If the new claim system speeds up the claim settlement rate, one would expect ratios to increase down the columns of the triangle.
- If the new claim system speeds up the claim settlement rate, one would expect an increase in the disposal rates shown in the triangle.

Response for "Introduction of Safety Programs":
- More safety programs can lead to better loss experience. Look at the triangle of the ratio of reported claims to earned premium to see if this decreases over time

Comment: An exam question with an enormous variety of possible full credit answers.
In part (a) list only three, without having answers that are too similar to each other.
Your responses to part (b) should depend on your responses to part (a).
You might choose responses to part (a) for which you have a good response to part (b).

**6.29.** (a) (i) Expect the ratios to increase across each row and the ratios to be stable down each column.
(ii) Expect the averages to increase somewhat across each row in a similar pattern; larger claims take longer to be reported and individual claims increase on average with lag.
Expect the averages to increase down each column due to inflation.
(b) The ratios of paid clams to reported claims can change either due to changes in the strength of case reserves, and/or due to a change in the settlement rate.
(c) While there may be some partial payments on open claims, for most lines of insurance, most payments are on claims that have been closed; therefore, using closed counts in the denominator results in a good match with the numerator. If one used instead reported counts in the denominator, then there would not be a good match with the numerator.
(d) (i) A change in the strength of case reserves and/or a change in the settlement rate.
(ii) A change in the settlement rate. Alternately, instead there could be a change in the average time to report and/or process a claim.
(e) The insurer has strengthened its case reserves.
Alternately, an unusually large claim has been reported and has yet to be closed.

**6.30.** (a) The average reported claims for AY14 at 36 months and later maturities are significantly larger than surrounding years. Note that this anomaly is not seen for the average paid claims. (The anomaly for reported claims affects the ratio of paid to reported claims.)
Thus the average case reserves are unusually large.
There was one unusually large AY14 claim reported by 36 months that has yet to be paid.
Its very large case reserve raised the average, without significantly affecting the number of reported claim counts.
(b) Along the latest two diagonals (CYs), the ratios of closed to reported counts are lower and the ratios of paid to reported claims are lower than in previous years.
(c) There has been a slowing down of the rate at which claims are settled/closed.
This would reduce both the number of closed claims and the amount of paid claims, without affecting the number of reported claims or the amount of reported claims.

**6.31.** (a) "The age (or maturity) is generally measured in terms of the time from the start of the cohort period. For example, the age of the 2006 accident year valued at year-end 2006 is 12 months (from the start of the accident year). Similarly, the age of the 2006 accident year valued at year end 2007 is 24 months (from the start of the accident year)."
The maturity age refers to the time interval from the beginning of the experience period to the valuation date of the claims.

(b) Reported Claims = case reserves + cumulative paid.

| Accident Year | Case Reserves | | | | | |
|---|---|---|---|---|---|---|
| | 6 | 12 | 18 | 24 | 30 | 36 |
| 2019 | 150 | 200 | 75 | 390 | 410 | 350 |
| 2020 | 35 | 260 | 225 | 0 | | |
| 2021 | 550 | 65 | | | | |
| AY | Cumulative Paid Claims | | | | | |
| 2019 | 50 | 150 | 400 | 400 | 455 | 530 |
| 2020 | 265 | 265 | 295 | 480 | | |
| 2021 | 0 | 275 | | | | |
| AY | Reported Claims | | | | | |
| 2019 | **200** | **350** | **475** | **790** | **865** | **880** |
| 2020 | **300** | **525** | **520** | **480** | | |
| 2021 | **550** | **340** | | | | |

(c) (i) Claim 2 is paid quickly with no case reserve; Automobile Physical Damage.
(ii) Claim 3 has a reporting delay and remains open at 36 months;
most likely Medical Malpractice.
(iii) Claim 7 is reopened after an initial payment and is then closed at 24 months;
Workers' Compensation.

(d)

| Accident Year | Reported Pure Premiums | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 |
| 2013 | 199 | 295 | 394 | 471 | 545 | 586 | 620 | 637 |
| 2014 | 196 | 293 | 393 | 469 | 544 | 626 | 618 | |
| 2015 | 170 | 257 | 344 | 419 | 485 | 521 | | |
| 2016 | 168 | 258 | 346 | 424 | 494 | | | |
| 2017 | 178 | 280 | 377 | 468 | | | | |
| 2018 | 190 | 300 | 408 | | | | | |
| 2019 | 202 | 321 | | | | | | |
| 2020 | 271 | | | | | | | |
| AY | Age to Age Factors | | | | | | | |
| 2013 | 1.482 | 1.336 | 1.195 | 1.157 | 1.075 | 1.058 | 1.027 | |
| 2014 | 1.495 | 1.341 | 1.193 | 1.160 | 1.151 | 0.987 | | |
| 2015 | 1.512 | 1.339 | 1.218 | 1.158 | 1.074 | | | |
| 2016 | 1.536 | 1.341 | 1.225 | 1.165 | | | | |
| 2017 | 1.573 | 1.346 | 1.241 | | | | | |
| 2018 | 1.579 | 1.360 | | | | | | |
| 2019 | 1.589 | | | | | | | |
| AY | Year to Year Changes in Pure Premiums | | | | | | | |
| 2014 | -1.5% | -0.7% | -0.3% | -0.4% | -0.2% | 6.8% | -0.3% | |
| 2015 | -13.3% | -12.3% | -12.5% | -10.7% | -10.8% | -16.8% | | |
| 2016 | -1.2% | 0.4% | 0.6% | 1.2% | 1.9% | | | |
| 2017 | 6.0% | 8.5% | 9.0% | 10.4% | | | | |
| 2018 | 6.7% | 7.1% | 8.2% | | | | | |
| 2019 | 6.3% | 7.0% | | | | | | |
| 2020 | 34.2% | | | | | | | |

Any two of the following:
- Reported pure premium development is increasing over time; age to age factors increase down each column.
- Reported pure premiums for AY20 at 12 months are much larger than for AY19.
- Reported pure premiums decreased in AYs 2013-2016, then increased in AY17 and subsequent accident years.
- Reported pure premium for AY14 increased significantly at 72 months, then decreased at 84 months; the AY factor for 48 to 60 months of 1.151 is large, while the 60 to 72 months factor of 0.987 is small.

(e) Only one possible reason is needed for each item you gave in part (d).
- Reported pure premium development is increasing over time.
  - ○ Change in case reserve adequacy.
  - ○ Change in claim settlement patterns.
  - ○ Change in the type of insureds.
- Reported pure premiums for AY20 at 12 months are much larger than for AY19.
  - ○ Increase in case reserve adequacy at first report.
  - ○ Increase in the rate of settling claims.
  - ○ A large unusual claim or a catastrophe occurred in AY20.
- Reported pure premiums decreased in AYs 2013-2016, then increased in AY17 and subsequent accident years.
  - ○ Changes in policy terms (e.g., limits, deductibles.)
  - ○ Changes in the type of insureds in the book of business.
- Reported pure premium for AY14 increased significantly at 72 months, then decreased at 84 months.
  - o The reporting of a large claim whose initial case reserve was then reduced.
  - o The reporting of a large claim, which was subsequently reduced by subrogation.

Comment: There are other possible answers to part (e).

**6.32.** (a) Transaction #1 goes in AY18.
At 24 months add 15 to the reported claims and 1 to the reported counts.
These changes follow through to later reports.
Transaction #2 goes in AY19.
At 12 months add 75 to the reported claims and 1 to the reported counts.
These changes follow through to later reports.
Transaction #3 goes in AY19.
At 36 months subtract 10 from the reported claims.
Transaction #4 goes in AY20.
At 24 months add 65 to the reported claims.
Transaction #5 goes in AY18.
At 48 months add 20 to the reported claims and 1 to the reported counts.
Transaction #6 goes in AY18.
At 48 months no change to the reported claims and to the reported counts
The revised data:

| Accident Year | Reported Claims (000) | | | | | Accident Year | Reported Counts | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | | | 12 | 24 | 36 | 48 |
| 2018 | 1,196 | 1,540 | 1,653 | 1,758 | | 2018 | 230 | 251 | 261 | 267 |
| 2019 | 1,344 | 1,682 | 1,973 | | | 2019 | 236 | 256 | 266 | |
| 2020 | 1,294 | 1,772 | | | | 2020 | 231 | 251 | | |
| 2021 | 1,451 | | | | | 2021 | 234 | | | |

(b) 1451 + (1772 - 1294) + (1973 - 1682) + (1758 - 1653) = **2325**.
(c) 1,451,000 - 800,000 = **651,000**.
(d) (i) Ratios of closed without payment counts to closed counts.
(ii) Any one of the following:
- Ratios of paid claims to reported claims
- Average paid claims (paid claims divided by closed counts)
- Average paid claims on closed with payment counts (paid claims divided by counts closed with payment)

(e) Any two of the following:
- Case reserve strengthening
- Increase in policy limits
- Expanded coverage
- Increase in defense costs, e.g., increased use of outside counsel
- A change in the mix of business towards classes with higher average severity without a change in average frequency

**6.33.** (a) Any two of the following:
- A systems change which slows down the reporting of claims.
- A change in the definition of claim counts could cause a decrease in frequency.
- Stricter underwriting of risks written by the insurer.

(b) Any one of the following:
- Legislative change implementing tort reform which reduces the number of claims filed.
- A court interpretation clarifying (confirming) a coverage exclusion
- If this is private passenger auto insurance, a decrease in the average miles driven due to increasing gas prices.
- If this is workers compensation insurance, implementing measures to increase workplace safety.

(c) There is a significant decrease in the ratios along the latest diagonal.
(d) Any one of the following:
The insurer is strengthening case reserves.
The insurer is settling claims more slowly.
(e) Change in case adequacy could be confirmed by evaluating average case reserves to see if there is a significant increase along the most recent diagonal.
Change in claim settlement rate could be confirmed by evaluating the ratios of closed to reported counts to see if there is a significant decrease along the latest diagonal.
Comment: There are other possible answers to parts (a) and (b).

**6.34.** (a) Along the latest diagonal, the increase in case reserves is much larger than the 6.2% severity trend. There has been an increase in case reserve adequacy.

| Accident Year | Reported Claims | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 |
| 2017 | 4,490,119 | 6,618,441 | 8,018,024 | 9,424,347 | 9,996,330 | 10,121,653 |
| 2018 | 4,892,866 | 6,982,903 | 8,630,338 | 10,114,249 | 10,671,269 | |
| 2019 | 5,116,047 | 7,389,572 | 9,267,893 | 10,572,454 | | |
| 2020 | 5,687,200 | 8,006,857 | 10,230,447 | | | |
| 2021 | 6,277,173 | 9,059,236 | | | | |
| 2022 | 6,920,495 | | | | | |
| AY | Paid Claims | | | | | |
| 2017 | 1,950,824 | 4,523,911 | 6,506,781 | 8,594,540 | 9,886,911 | 10,121,653 |
| 2018 | 2,077,925 | 4,668,120 | 7,007,477 | 9,239,820 | 10,671,269 | |
| 2019 | 2,061,272 | 4,882,698 | 7,493,669 | 10,572,454 | | |
| 2020 | 2,431,961 | 5,348,691 | 8,813,923 | | | |
| 2021 | 2,726,683 | 6,334,322 | | | | |
| 2022 | 2,996,405 | | | | | |
| AY | Reported Counts | | | | | |
| 2017 | 1,193 | 1,488 | 1,670 | 1,850 | 1,921 | 1,935 |
| 2018 | 1,204 | 1,523 | 1,701 | 1,864 | 1,941 | |
| 2019 | 1,229 | 1,515 | 1,738 | 1,874 | | |
| 2020 | 1,236 | 1,554 | 1,753 | | | |
| 2021 | 1,278 | 1,576 | | | | |
| 2022 | 1,273 | | | | | |
| AY | Closed Counts | | | | | |
| 2017 | 616 | 1,070 | 1,401 | 1,715 | 1,910 | 1,935 |
| 2018 | 614 | 1,096 | 1,427 | 1,729 | 1,941 | |
| 2019 | 623 | 1,086 | 1,463 | 1,874 | | |
| 2020 | 627 | 1,117 | 1,566 | | | |
| 2021 | 648 | 1,211 | | | | |
| 2022 | 696 | | | | | |
| AY | Average Case Reserves | | | | | |
| 2017 | 4,401 | 5,011 | 5,618 | 6,147 | 9,947 | |
| 2018 | 4,771 | 5,421 | 5,923 | 6,477 | | |
| 2019 | 5,041 | 5,844 | 6,452 | | | |
| 2020 | 5,345 | 6,083 | 7,575 | | | |
| 2021 | 5,636 | 7,466 | | | | |
| 2022 | 6,801 | | | | | |
| AY | Change in Average Case Reserves | | | | | |
| 2018 | 8.4% | 8.2% | 5.4% | 5.4% | | |
| 2019 | 5.7% | 7.8% | 8.9% | | | |
| 2020 | 6.0% | 4.1% | 17.4% | | | |
| 2021 | 5.4% | 22.7% | | | | |
| 2022 | 20.7% | | | | | |

Along the latest diagonal, for the first three entries, the increase in average reported claim is larger than the 6.2% severity trend.
There seems to have been an increase in case reserve adequacy.

| Accident Year | Reported Claims | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 |
| 2017 | 4,490,119 | 6,618,441 | 8,018,024 | 9,424,347 | 9,996,330 | 10,121,653 |
| 2018 | 4,892,866 | 6,982,903 | 8,630,338 | 10,114,249 | 10,671,269 | |
| 2019 | 5,116,047 | 7,389,572 | 9,267,893 | 10,572,454 | | |
| 2020 | 5,687,200 | 8,006,857 | 10,230,447 | | | |
| 2021 | 6,277,173 | 9,059,236 | | | | |
| 2022 | 6,920,495 | | | | | |
| AY | Reported Counts | | | | | |
| 2017 | 1,193 | 1,488 | 1,670 | 1,850 | 1,921 | 1,935 |
| 2018 | 1,204 | 1,523 | 1,701 | 1,864 | 1,941 | |
| 2019 | 1,229 | 1,515 | 1,738 | 1,874 | | |
| 2020 | 1,236 | 1,554 | 1,753 | | | |
| 2021 | 1,278 | 1,576 | | | | |
| 2022 | 1,273 | | | | | |
| AY | Average Reported Claim | | | | | |
| 2017 | 3,764 | 4,448 | 4,801 | 5,094 | 5,204 | 5,231 |
| 2018 | 4,064 | 4,585 | 5,074 | 5,426 | 5,498 | |
| 2019 | 4,163 | 4,878 | 5,333 | 5,642 | | |
| 2020 | 4,601 | 5,152 | 5,836 | | | |
| 2021 | 4,912 | 5,748 | | | | |
| 2022 | 5,436 | | | | | |
| AY | Change in Average Reported Claim | | | | | |
| 2018 | 8.0% | 3.1% | 5.7% | 6.5% | 5.7% | |
| 2019 | 2.4% | 6.4% | 5.1% | 4.0% | | |
| 2020 | 10.5% | 5.6% | 9.4% | | | |
| 2021 | 6.7% | 11.6% | | | | |
| 2022 | 10.7% | | | | | |

(b) The case strengthening could cause the most recent diagonal of claims ratios to increase. However, a deterioration in claims experience could also cause the increase.
(c) An increase in the most recent diagonal of the ratios of paid to reported claims triangle can be caused by an increase in the settlement rate. However, it can also be caused by a decrease in the overall adequacy of case reserves.

(d) The ratios along the latest diagonal are significantly higher, indicating an increase in the claim settlement rate.

| AY | Reported Counts | | | | | |
|---|---|---|---|---|---|---|
| 2017 | 1,193 | 1,488 | 1,670 | 1,850 | 1,921 | 1,935 |
| 2018 | 1,204 | 1,523 | 1,701 | 1,864 | 1,941 | |
| 2019 | 1,229 | 1,515 | 1,738 | 1,874 | | |
| 2020 | 1,236 | 1,554 | 1,753 | | | |
| 2021 | 1,278 | 1,576 | | | | |
| 2022 | 1,273 | | | | | |
| AY | Closed Counts | | | | | |
| 2017 | 616 | 1,070 | 1,401 | 1,715 | 1,910 | 1,935 |
| 2018 | 614 | 1,096 | 1,427 | 1,729 | 1,941 | |
| 2019 | 623 | 1,086 | 1,463 | 1,874 | | |
| 2020 | 627 | 1,117 | 1,566 | | | |
| 2021 | 648 | 1,211 | | | | |
| 2022 | 696 | | | | | |
| AY | Ratio of Closed Counts to Reported Counts | | | | | |
| 2017 | 51.6% | 71.9% | 83.9% | 92.7% | 99.4% | 100.0% |
| 2018 | 51.0% | 72.0% | 83.9% | 92.8% | 100.0% | |
| 2019 | 50.7% | 71.7% | 84.2% | 100.0% | | |
| 2020 | 50.7% | 71.9% | 89.3% | | | |
| 2021 | 50.7% | 76.8% | | | | |
| 2022 | 54.7% | | | | | |

**6.35.** (a) Select separate age-to-age factors for the halves of the year up to 30 months.

| Accident Half-Year | Reported Claims | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 |
| 2020-1 | 1,778,236 | 1,817,664 | 1,906,195 | 1,918,947 | 1,938,911 | 1,949,451 | 1,951,269 | 1,951,269 |
| 2020-2 | 1,801,831 | 1,896,710 | 1,942,431 | 1,969,627 | 1,990,982 | 2,002,627 | 2,004,998 | |
| 2021-1 | 1,930,879 | 1,983,793 | 2,069,155 | 2,084,933 | 2,109,125 | 2,121,231 | | |
| 2021-2 | 1,944,003 | 2,034,385 | 2,091,282 | 2,125,691 | 2,146,588 | | | |
| 2022-1 | 2,075,131 | 2,126,932 | 2,205,071 | 2,220,455 | | | | |
| 2022-2 | 2,137,034 | 2,253,530 | 2,273,987 | | | | | |
| 2023-1 | 2,243,409 | 2,283,355 | | | | | | |
| 2023-2 | 2,451,221 | | | | | | | |
| | Age to Age Factors | | | | | | | |
| 2020-1 | 1.0222 | 1.0487 | 1.0067 | 1.0104 | 1.0054 | 1.0009 | 1.0000 | |
| 2020-2 | 1.0527 | 1.0241 | 1.0140 | 1.0108 | 1.0058 | 1.0012 | | |
| 2021-1 | 1.0274 | 1.0430 | 1.0076 | 1.0116 | 1.0057 | | | |
| 2021-2 | 1.0465 | 1.0280 | 1.0165 | 1.0098 | | | | |
| 2022-1 | 1.0250 | 1.0367 | 1.0070 | | | | | |
| 2022-2 | 1.0545 | 1.0091 | | | | | | |
| 2023-1 | 1.0178 | | | | | | | |
| AHY-1 Avg | 1.0231 | 1.0428 | 1.0071 | 1.0110 | | | | |
| AHY-2 Avg | 1.0512 | 1.0204 | 1.0152 | 1.0103 | | | | |
| Average | 1.0351 | 1.0316 | 1.0103 | 1.0107 | 1.0057 | 1.0011 | 1.0000 | |
| AHY-1 Age to Age | 1.0231 | 1.0428 | 1.0071 | 1.0110 | 1.0057 | 1.0011 | 1.0000 | |
| AHY-1 To Ult. | 1.0936 | 1.0689 | 1.0250 | 1.0178 | 1.0067 | 1.0011 | 1.0000 | |
| AHY-2 Age to Age | 1.0512 | 1.0204 | 1.0152 | 1.0103 | 1.0057 | 1.0011 | 1.0000 | |
| AHY-2 To Ult. | 1.1077 | 1.0537 | 1.0326 | 1.0171 | 1.0067 | 1.0011 | 1.0000 | |

Estimated AY23 ultimate: (1.0689)(2,283,355) + (1.1077)(2,451,221) = **5,155,896**.
(b) AY23 expected reported claims from December 31, 2023 to June 30, 2024:
(1.0428 - 1)(2,283,355) + (1.0512 - 1)(2,451,221) = **223,230**.

**6.36.** (a) Any two of the following:
- to review the reasonableness of management's assertions regarding company operations.
- to determine if the qualitative information gathered is consistent with patterns observed in the quantitative data.
- help identify the need for additional data and information.
- provides a means for the documentation required about the data and information gathering phase of actuarial work.

(b) In the triangle of ratios of paid claims to reported claims, down any singe column I would expect to see similar values.
In the triangle of ratios of closed counts to reported counts, down any singe column I would expect to see similar values.
(c) In the triangle of ratios of paid claims to reported claims, the values along the latest diagonal (CY24) are smaller. This line of business likely not stable.
In the triangle of ratios of closed counts to reported counts, down any singe column there are similar values. There is no indication of instability from this triangle.
(d) If the values down a single column are changing, then there is a change in the percent of claims that are being closed without payment. This could indicate either a change in how claims are being handled/settled or in the types of claims being made.
(e) The numerator includes payments on open and closed claims, while the denominator only includes counts of claims that have closed.
Therefore, any partial payments would need to be removed from the numerator.
Comment: Some lines of insurance, such as Workers Compensation, have more partial payments than others.

**6.37.** (a) This would show up as an increase of the ratio of the paid to reported claims triangle in the diagonal corresponding to the calendar year where the change occurred.
(b) Case estimates are expected to increase with the rate of inflation. Therefore, a change that is consistent with the rate of inflation is not indicative of a change in case adequacy.
**I disagree with my colleague's conclusion**.
(c) A rate decrease will cause reported claim ratios to increase, but the effect would be in the latest AY, in other words row of the triangle not the latest diagonal.
**I disagree with my colleague's conclusion**.
(d) Increase in case reserve adequacy (strengthening of case estimates).
Legislative or judicial change increasing the value of open claims.