

3rd Edition

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A CAS Exam



Actuarial & Financial Risk Resource Materials Since 1972

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Note: * Not required, but the CAS highly recommends that candidates read these chapters as the candidates will be assumed to be familiar with the material in these chapters.

NOTES

I have been updating this manual since 2014. There have been many syllabus changes since that time, including a major rearrangement of examination topics in the upper exams in 2024. For the current update, I reflected the 2024 syllabus material. This Study Guide is meant to be a supplement to the original material and not a substitute for it.

Beginning with the Fall 2021 Study Kit, the state pages that were contained with prior versions of the NCCI *Experience Rating Plan Manual* are no longer provided. The CAS's official response to this for the Fall 2021 Study Kit is on page B578.

Included in this manual are outlines of Bahnemann Chapters 1-4 that are not required (Chapters 5 and 6 are required). The CAS highly recommends that candidates read Bahnemann Chapters 1-4, as candidates will be assumed to be familiar with the material in these chapters.

When readings have been taken off the syllabus or revised, I retained those questions from past exams that I think are relevant to the current readings, making changes to reflect the then-new syllabus material where appropriate. I also created some questions for some of the then-new material. There are no questions for Bahnemann Chapters 1-4 as they are not required reading on the syllabus. There is a section for Integrative Questions applying to multiple readings that appeared on the 2017, 2018, and 2019 exams, sometimes as the first one or two problems on each exam. As a practical matter, I suggest completing all other questions before answering questions that require material from multiple readings, regardless of where questions are placed in the exam.

Questions and parts of some questions have been taken from material copyrighted by the Casualty Actuarial Society. They are reproduced in this study manual with the permission of the CAS solely to aid students studying for CAS exams. Students may also request past exams directly from the CAS or find them on the CAS website. I am very grateful to the CAS for its cooperation and permission to use this material. The CAS is not responsible for the structure or accuracy of this manual. In some cases, questions and answers have been edited or altered to be more accurate, reflect syllabus changes, or provide a better organized manual. Students should keep in mind that there may be more than one correct way to answer a question even if only one is shown.

Effective with the 2020 exams, the Casualty Actuarial Society no longer provides questions and answers for its exams, so the questions and answers from the 2020 and subsequent exams are not included in this update. Exam questions are identified by numbers in parentheses at the end of each question. Questions have four numbers separated by hyphens. For questions from the exams those numbers represent: the year of the exam, the number of the question, and the points assigned. Questions I added also have four numbers separated by hyphens and reflect: year I added them, the number of the exam (8), the number of the question I added that year, and the points I assigned. The past exam questions that are retained for which I made significant changes so that they reflect the new syllabus material are designated by: the year of the exam, the number of the exam, the number of the question & MTS, and the points assigned. MC indicates that a multiple-choice question has been converted into a true/false question. I did not change the question label for minor changes to reflect the new syllabus material.

I made a conscientious effort to eliminate mistakes and incorrect answers, but a few may remain. I am grateful to students who previously pointed out errors and encourage those who find others to bring them to my attention. If you find any errors, please send them to support@actexmadriver.com. Please check the ACTEX website for corrections subsequent to publication.

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Actuarial Standards Board, "Actuarial Standard of Practice No. 12, Risk Classification (for All Practice Areas)," December 2005, Updated for Deviation Language Effective May 1, 2011

OUTLINE

I. <u>SECTION 1. PURPOSE, SCOPE, CROSS REFERENCES, AND EFFECTIVE DATE</u>

A. <u>Purpose</u> – Provides guidance to actuaries when performing professional services with respect to designing, reviewing, or changing risk classification systems.

B. <u>Scope</u>

- 1. Applies to all actuaries when performing professional services with respect to designing, reviewing, or changing risk classification systems used in connection with financial or personal security systems regarding the classification of individuals or entities into groups intended to reflect the relative likelihood of expected outcomes.
 - a. Expert testimony
 - b. Regulatory activities
 - c. Legislative activities
 - d. Statements concerning public policy
- 2. Also applies when giving advice with respect to a risk classification system.
- 3. Risk classification can affect and be affected by many actuarial activities, such as:
 - a. Setting rates, contributions, reserves, benefits, dividends, or experience refunds
 - b. Analysis or projection of quantitative or qualitative experience or results
 - c. Underwriting actions
 - d. Development assumptions
- 4. Standard applies when activities directly or indirectly involve designing, reviewing, or changing a risk classification system.
- 5. Also applies when performing such activities if those activities directly or indirectly are likely to have a material effect on the intended purpose or expected outcome of the risk classification system.
- 6. Departures from this standard should be disclosed.
- C. <u>Cross References</u>
 - 1. Referenced documents are as amended, restated, or succeeding.
 - 2. If there is a material difference from the originally referenced document, the actuary should consider the guidance in this standard to the extent it is applicable and appropriate.
- D. <u>Effective Date</u> Any professional service commenced on or after May 1, 2006.

II. <u>SECTION 2. DEFINITIONS</u>

- A. <u>Advice</u> An actuary's communication or other work product in oral, written, or electronic form setting forth the actuary's professional opinion or recommendations concerning work that falls within the scope of this standard.
- B. <u>Adverse Selection</u> Actions taken by one party using risk characteristics or other information known to or suspected by that party that cause a financial disadvantage to the financial or personal security system (sometimes referred to as antiselection).
- C. <u>Credibility</u> A measure of the predictive value in a given application that the actuary attaches to a particular body of data (predictive is used here in the statistical sense and not in the sense of predicting the future).
- D. <u>Financial or Personal Security System</u> A private or governmental entity or program that is intended to mitigate the impact of unfavorable outcomes of contingent events. Examples of financial or personal security systems include auto insurance, homeowners insurance, life insurance, and pension plans, where the mitigation primarily takes the form of financial payments; prepaid health plans and continuing care retirement communities, where the mitigation primarily takes the form of direct service to the individual; and other systems, where the mitigation may be a combination of financial payments and direct services.
- E. <u>Homogeneity</u> The degree to which the expected outcomes within a risk class have comparable value.
- F. <u>Practical</u> Realistic in approach, given the purpose, nature, and scope of the assignment and any constraints, including cost and time considerations.
- G. <u>Risk(s)</u> Individuals or entities covered by financial or personal security systems.
- H. <u>Risk Characteristics</u> Measurable or observable factors or characteristics that are used to assign each risk to one of the risk classes of a risk classification system.
- I. <u>Risk Class</u> A set of risks grouped together under a risk classification system.
- J. <u>Risk Classification System</u> A system used to assign risks to groups based upon the expected cost or benefit of the coverage or services provided.

III. SECTION 3. ANALYSIS OF ISSUES AND RECOMMENDED PRACTICES

- A. <u>Introduction</u>
 - 1. Approaches to risk classification can vary significantly.
 - 2. It is appropriate for the actuary to exercise considerably professional judgment.
- B. <u>Considerations in the Selection of Risk Characteristics</u>
 - 1. Relationship of Risk Characteristics and Expected Outcomes
 - a. The actuary should select risk characteristics that are related to expected outcomes.

- b. A relationship exists if it can be shown that the variation in actual or reasonably anticipated experience correlates to the risk characteristic.
- c. To demonstrate a relationship can use:
 - Analysis of available data
 - Clinical experience
 - Expert opinion
- d. Rates are considered to be **equitable (fair)** if the differences in rates reflect material differences in expected cost for risk characteristics.
- e. The actuary should consider the interdependence of risk characteristics and make appropriate adjustments if their impact on the operation of the risk classification system is expected to be material.
- f. It may be appropriate for the actuary to make inferences without specific demonstration. For example, it might not be necessary to demonstrate that persons with seriously impaired, uncorrected vision would represent higher risks as operators of motor vehicles.
- 2. Causality It is not necessary to establish a cause and effect relationship between the risk characteristics and expected outcome.
- 3. Objectivity The actuary should select risk characteristics that are capable of being objectively determined.
- 4. Practicality The actuary's selection of a risk characteristic should reflect the tradeoffs between practical and other relevant considerations such as:
 - a. Cost, time, and effort needed to evaluate the risk characteristic
 - b. The ongoing cost of administration
 - c. The acceptability of the usage of the characteristic
 - d. Potential usage of different characteristics that would produce equivalent results
- 5. Applicable Law The actuary should consider whether compliance with applicable law creates significant limitations on the choice of risk characteristics.
- 6. Industry Practices The actuary should consider usual and customary risk classification practices for the type of financial or personal security system under consideration.
- 7. Business Practices The actuary should consider limitations created by business practices related to the financial or personal security system as known to the actuary and consider whether such limitations are likely to have a significant impact on the risk classification system.

- C. <u>Considerations in Establishing Risk Classes</u>
 - 1. Intended Use
 - a. A risk classification system should be appropriate for the intended use.
 - b. Different sets of risk classes may be appropriate for different purposes.
 - 2. Actuarial Considerations
 - a. Adverse Selection
 - Likely to occur if the variation in expected outcomes within a risk class is too great.
 - To the extent practical, the actuary should establish risk classes such that each has sufficient homogeneity with respect to the expected outcomes to satisfy the purpose for which the risk classification system is intended.
 - b. Credibility
 - It is desirable that risk classes be large enough to allow credible statistical inferences regarding expected outcomes.
 - When this is not possible, the actuary should balance considerations of predictability with considerations of homogeneity.
 - The actuary should use professional judgement to achieve this balance.
 - 3. Other Considerations The actuary should:
 - a. comply with the applicable law;
 - b. consider industry practices for that type of financial or personal security system as known to the actuary; and
 - c. consider limitations created by business practices of the financial or personal security system as known to the actuary.
 - 4. Reasonableness of results The actuary should consider the reasonableness of results that proceed from the intended use of the risk classes such as:
 - a. consistency of the patterns of rates;
 - b. consistency of values; and
 - c. consistency of factors among risk classes.

D. <u>Testing the Risk Classification System</u>

- 1. Upon the establishment of the risk classification system and upon subsequent review, the actuary should, if appropriate, test the long-term viability of the financial or personal security system.
- 2. When performing such tests subsequent to the establishment of the risk classification system, the actuary should evaluate emerging experience and determine whether there is any significant need for change.
- 3. Effect of Adverse Selection
 - a. Can potentially threaten the long-term viability of a financial or personal security system.
 - b. If the effects of adverse selection are expected to be material, the actuary should, when practical, estimate the potential impact and recommend appropriate measures to mitigate the risk.
- 4. Risk Classes Used for Testing
 - a. The actuary should consider using a different set of risk classes for testing long-term viability than was used as the basis for determining the assigned values.
 - b. This is likely to improve the meaningfulness of the tests.
- 5. Effect of Changes The actuary should consider testing the effects of changes:
 - a. if the risk classification system has changed; or
 - b. business or industry practices have changed.
- 6. Quantitative Analyses Depending on the purpose, nature, and scope of the assignment, the actuary should consider performing quantitative analyses of the impact of the following to the extent they are generally known and reasonably available to the actuary:
 - a. significant limitations due to compliance with applicable law;
 - b. significant departures from industry practices;
 - c. significant limitations created by business practices of the financial or personal security system;
 - d. any changes in the risk classes or the assigned values based upon the actuary's determination that experience indicates a significant need for a change; and
 - e. any expected material effects of adverse selection.
- E. <u>Reliance on Data or Other Information Supplied by Others</u> Refer to ASOP No. 23, *Data Quality*.

F. <u>Documentation</u>

- 1. The actuary should document the assumptions and methodologies used in designing, reviewing, or changing a risk classification system in compliance with the requirements of ASOP No. 41, *Actuarial Communications*.
- 2. The actuary should also prepare and retain documentation to demonstrate compliance with the disclosure requirements in Section 4.1 of this standard.

IV. SECTION 4. COMMUNICATIONS AND DISCLOSURES

A. <u>Communications and Disclosures (Section 4.1)</u>

- 1. When issuing actuarial communications under this standard, the actuary should comply with ASOP Nos. 23 and 41.
- 2. In addition, the actuarial communications should disclose any known significant impact resulting from the following to the extent they are generally known and reasonably available to the actuary:
 - a. significant limitations due to compliance with applicable law;
 - b. significant departures from industry practices;
 - c. significant limitations created by business practices related to the financial or personal security system;
 - d. a determination by the actuary that experience indicates a significant need or change, such as changes in the risk classes or the assigned values; and
 - e. expected material effects of adverse selection;
 - f. the disclosure in ASOP No. 41, section 4.2, if any material assumption or method was prescribed by applicable law (statutes, regulations, and other legally binding authority);
 - g. the disclosure in ASOP No. 41, section 4.3, if the actuary states reliance on other sources and thereby disclaims responsibility for any material assumption or method selected by a party other than the actuary; and
 - h. the disclosure in ASOP No. 41, section 4.4, if, in the actuary's professional judgment, the actuary has otherwise deviated materially from the guidance of this ASOP.
- 3. The actuarial communications should also disclose any recommendations developed by the actuary to mitigate the potential impact of adverse selection.

PAST CAS EXAMINATION AND NEW QUESTIONS

1. The Supreme Court's decision in the *Norris* case eliminated the use of sex as a rating variable in pensions. Discuss the potential implications of this decision on automobile insurance classification in the context of the considerations in the selection of risk characteristics discussed in ASOP 12.

(84–9–9 & MTS–3)

2. A property insurance company is considering adding a new classification rating variable to its homeowners insurance program based on an individual risk's actual loss experience over the past five-year period as follows:

Class A – no claims Class B – one or two claims Class C – three or more claims

Considering the considerations in the selection of risk characteristics discussed in ASOP 12, would you recommend the addition of this new classification? Why or why not?

(96–9–48b & MTS–1.5)

3. As the personal lines actuary for the department of insurance in the state of Crazyfornia, you have been asked by the state's insurance commissioner to comment on Proposition 99.

Proposition 99 – The ratemaking for personal automobile insurance should be based on a new classification system using the following six criteria:

- a) Insureds are to be classified based on nationality.
- b) Insureds are to be classified based on the ability to pass an annual random drug test.
- c) Insureds are to be classified based on whether they can pass a comprehensive, individually administered eight-hour driving test every year.
- d) Insureds are to be classified based on their weights.
- e) Insureds are to be classified as either good eyesight or bad eyesight. Each eye doctor can have his/her own definition of good/bad eyesight.
- f) Insureds are to be classified as right-handed or left-handed.

For each criterion, identify which one of the considerations in the selection of risk characteristics discussed in ASOP 12 is violated. You may not use the same consideration for more than two criteria.

(97–9–48 & MTS–0.5/0.5/0.5/0.5/0.5/0.5)

- 1. ASOP 12 lists the following considerations in the selection of risk characteristics:
 - 1) There should be a relationship between the risk characteristics and the expected outcome.
 - 2) The risk characteristics should be objective.
 - 3) The risk characteristics should reflect the tradeoff between practicality and other considerations.
 - 4) Risk characteristics should comply with applicable law.
 - 5) The actuary should consider industry practices in selecting risk characteristics.
 - 6) The actuary should consider business practices in selecting risk characteristics.

If the *Norris* case were applied to automobile insurance, it would violate 1) because the risk classification system would not reflect expected costs as males would be undercharged and females overcharged as one relevant cost-related factor would be disregarded. The resulting risk classification would meet considerations 2), 3), and 4). It would not meet 5) or 6).

- 2. See #1 for the list of considerations.
 - 1) The proposed system would not reflect cost differences among risks or distinguish among risks on cost-based factors because past loss experience may not be a good indicator of future loss experience.
 - 2) The system could be applied objectively.
 - 3) The new system would entail extra costs without comparable benefits. In addition, public acceptability would be questionable, given the random penalties the system would produce.
 - 4) Whether the new system complies with the applicable law would have to be determined for each state.
 - 5) The new system is not current industry practice, which could be an advantage or disadvantage.
 - 6) The new system is not current business practice and would add expense.

On balance, I would not recommend the new classification.

- 3. See #1 for the list of considerations.
 - a. Need one of these. It is not objective (2). It does not comply with applicable law (4).
 - b. Need one of these. There may not be a relationship between the risk characteristic and the expected outcome (1). There is not practical due to the added expense (3). It may not comply with applicable law; this would have to be determined for each state (4).
 - c. It is not practical due to the added expense (3).
 - d. There probably is not a relationship between the risk characteristic and the expected outcome (1).
 - e. It is not objective (2).
 - f. There is no relationship between the risk characteristic and the expected outcome (1).

Robert A. Bailey and LeRoy J. Simon, "An Actuarial Note on the Credibility of Experience of a Single Private Passenger Car" Discussion by W. J. Hazam, *PCAS* XLVI, 1959, pp. 159–64; XLVII, 1960, pp. 150–52

<u>OUTLINE</u>

I. <u>INTRODUCTION</u>

A. <u>The Problem</u>

What credibility should be assigned to the accident experience of an automobile in determining its liability premium?

B. <u>The Authors' Solution</u>

Automobiles are divided by class, reflecting use and driver characteristics, and by subclass, reflecting claim experience over three years. Their claim frequency per \$1,000 of premium for two subsequent years was then compiled and each class's frequency was compared to the average. Credibility equals the ratio of the future relative frequency less unity to the past relative frequency less unity.

C. <u>Symbols</u>

- 1. A subclass with three or more accident-free years
- 2. B subclass with no accident-free years
- 3. m claim frequency of a class
- 4. N radix, number of persons in the population
- 5. R ratio of actual to expected losses
- 6. X subclass with only two accident-free years
- 7. Y subclass with only one accident-free year
- 8. Z credibility

II. <u>THE AUTHORS' APPROACH</u>

- A. <u>Determination of Subclass Relative Frequency</u>
 - 1. Convert each subclass's earned premium to earned premium at rates for subclass B
 - 2. Divide the earned premium by \$1,000
 - 3. Divide the number of claims by the premium in 2.
 - 4. Take the ratio of subclass frequency to the average frequency for all classes
 - 5. Compute the relative frequency for the following classes:
 - a. A
 - b. (A + X)
 - c. (A + X + Y)
- B. <u>Determination of Accident-Free Credibilities</u>
 - 1. One-year credibility equals unity minus the relative frequency for (A + X + Y)
 - 2. Two-year credibility equals unity minus the relative frequency for (A + X)
 - 3. Three-year credibility equals unity minus the relative frequency for A
- C. Determination of Credibility for Risks Having at Least One Accident in the Last Year
 - 1. Calculate past relative frequency for these risks
 - a. Assume Poisson applies with average frequency m
 - b. Determine the percentage of persons with at least one claim, unity minus the percentage of persons with no claims, i.e., $(1 e^{-m})$
 - c. Average frequency for those with at least one claim

$$AF = \frac{m}{1 - e^{-m}}$$

- d. Substitute actual frequency for m
- e. Relative frequency

$$RF = \frac{1}{1 - e^{-m}}$$

- 2. Determine the future relative frequency for this group of risks
- 3. Apply the following formula:

$$Z = \frac{Future Relative Frequency - 1.0}{Past Relative Frequency - 1.0}$$

III. <u>PERSPECTIVE</u>

A. <u>The Authors' Major Conclusions for Canadian Private Passenger Cars</u>

- 1. One-year experience has significant and measurable credibility for experience rating, ranging from .038 to .071 for a subclass
- 2. In a highly refined private passenger rating system reflecting inherent hazard, the accuracy of a merit rating plan would be low, but if there is a wider range of hazard, credibility would be larger
- 3. Adding a second year's experience to one year's will increase credibility by two-fifths; adding a third year's experience to two years' will increase credibility by one-sixth
- B. <u>Other Comments</u>
 - 1. Class 1 (no male operator under 25) is the least homogeneous and thus its subclasses have the most credibility
 - 2. Credibility also increases with size
- C. <u>Reasons That Credibility Does Not Vary in Proportion to Time</u>
 - 1. An individual's accident propensity changes over time
 - 2. The population of a class changes as individuals enter and leave
 - 3. Individuals within a class have different accident propensities, which are markedly skewed
 - 4. In the credibility formula, Z is not exactly proportionate to n

D. <u>Use of Premium as a Base Rather Than Car-Years</u>

- 1. According to the authors, this avoids the maldistribution created by having territories with higher claim frequencies produce more X, Y, and B risks and higher territorial premiums
- 2. According to Hazam, this eliminates maldistribution only if both of the following two conditions are met:
 - a. High-frequency territories are also high-premium territories
 - b. Territorial differentials are proper

E. <u>Use of Losses Rather Than Claim Counts</u>

- 1. Accident frequency used to reduce chance variations caused by claim size variations
- 2. But subclass B risks have a consistently higher-than-average severity and subclass A risks have one that is lower than average
- 3. This consistency is the reason that using losses instead of counts produces an increase in credibility

F. <u>Hazam's Conclusions</u>

- 1. Credibility is measurable and significant
- 2. But not large enough to justify the credits now offered by many U.S. plans
- 3. May, however, reduce the gap by also taking into account conviction frequencies

G. <u>Comparison with Dropkin</u>

- 1. Use of accidents rather than violations
- 2. Emphasis on the results accomplished rather than on the limits of segregation
- 3. Their levels of data
 - a. Possible levels of data
 - 1) Class
 - 2) Subdivision of class by violations or accidents
 - 3) Individual drivers
 - b. Bailey and Simon
 - 1) Weight class and subclass data to get a better predictor of future experience
 - 2) Subclass has some credibility and thus is somewhat homogeneous
 - 3) Refer to subclass data as individual experience
 - c. Dropkin
 - 1) Separates class data into subclasses
 - 2) Still finds subclasses heterogeneous and overlapping
 - 3) Implies that further segregation needed so that subclass experience approximates that of the individual

PAST CAS EXAMINATION QUESTIONS

A. <u>The Credibility Equation</u>

A1. Bailey and Simon in their paper, "An Actuarial Note on the Credibility of a Single Private Passenger Car" computed credibilities for accident-free risks based upon the commonly used experience rating formula, Modification = Z(R) + (1 - Z) where Z is the credibility factor and R is the ratio of actual losses to expected losses. Given the following information and using Bailey and Simon's technique, compute the credibilities for automobiles with at least one, two, and three years, respectively of accident-free driving.

		Earned Premium	Number	Claim Frequency	Relative
Years Since	Earned	at Present	of Claims	per \$1,000	Claim
Last Accident	Car Years	<u>Rates (\$000)</u>	Incurred	of Premiums	Frequency
3	2,757	159,108	217,151	1.365	.920
2	131	7,910	13,792	1.744	1.175
1	164	9,862	19,346	1.962	1.322
None	274	17,226	37.730	2.190	1.476
Total	3,326	194,106	288,019	1.484	1.000
(75S–9a–2a–	6)				

A2. You have been asked to develop a compensation experience rating plan for one-employee manufacturing risks. For ease of administration, it has been decided that only one year's claim experience will be utilized. The table below gives the last calendar year's experience sorted by the time elapsed since the previous claim.

Years Since	Earned	Number of
Latest Claim	Employee Years	Incurred Claims
0	25,000	7,500
1	75,000	7,500
2 or more	300,000	15,000
Total	400,000	30,000

Determine the amount of credibility that can be assigned to one year's claim experience. (77–9–13–5)

A3. a. From the information below on a particular class of private passenger automobile business, determine the experience rating credibility of the experience of one private passenger car for one year.

Years Since			
Most Recent	Earned Car	Number of	Claim
Accident	Years	Claims	Frequency
0	50,000	9,000	.180
1	50,000	7,500	.150
2	50,000	6,500	.130
3	50,000	6,000	.120
4	<u>800,000</u>	<u>56,000</u>	.070
Total	1,000,000	85,000	.085

b. Assuming the Poisson distribution represents the risk distribution and using the additional information and notations below, set up the final equation you would use to confirm your answer above for the credibility of one year's experience.

N - total number of cars insured x - claim frequency of class Ne^{-x} - number of cars having no claim last year. (78–9–8–4/4)

A1. 1) Calculate future absolute claim frequencies:

FACF = (Number of Claims Incurred)/(Earned Premium at Present Rates) FACF₁ = $\frac{217,151 + 13,792 + 19,346}{159,108 + 7,910 + 9,862} = 1.415$ FACF₂ = $\frac{217,151 + 13,792}{159,108 + 7,910} = 1.383$ FACF₃ = $\frac{217,151}{159,108} = 1.365$

2) Calculate future relative claim frequencies:

3) Calculate credibilities:

- A2. 1) Calculate future absolute claim frequencies: $FACF_1 = \frac{Number of Claims Incurred}{Earned Employee Years} = \frac{7,500 + 15,000}{75,000 + 300,000} = .060$ $FACF_{Overall} = 30,000/400,000 = .075$
 - 2) Calculate the future relative claim frequency:

 $FRCF_1 = FACF_1/FACF_{Overall} = .060/.075 = .800$

3) Calculate the credibility:

 $Z = 1 - FRCF_1 = 1 - .800 = .200$, pp. 159–60.

a. 1) Calculate the future absolute claim frequency:

FACF = (Number of Claims)/(Earned Car Years) FACF₁ = $\frac{7,500 + 6,500 + 6,000 + 56,000}{50,000 + 50,000 + 50,000 + 800,000} = .080$

- Calculate the future relative claim frequency:
 FRCF₁ = FACF₁/FACF_{Overall} = .080/.085 = .941
- 3) Calculate the credibility: $Z_1 = 1 - FRCF_1 = 1 - .941 = .059$, pp. 159–60.
- b. 1) Calculate the future relative claim frequency: $FRCF_0 = FACF_0/FACF_{Overall} = .180/.085 = 2.118$
 - 2) Since the past relative claim frequency equals $1/(1 e^{-x})$ or $1/(1 e^{-.085})$, we get the following equation:

$$FRCF_0 = 2.118 = \frac{Z_0}{1 - e^{-.085}} + (1 - Z_0) \qquad Z_0 = \frac{(1.118)(1 - e^{-.085})}{e^{-.085}} = .099, \text{ pp. 159-160, 164.}$$

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