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 **ACTEX**

Exam LTAM Study Manual



Spring 2019 Edition, Volume I

Johnny Li, Ph.D., FSA | Andrew Ng, Ph.D., FSA

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Actuarial & Financial Risk Resource Materials
Since 1972

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Preface

Thank you for choosing ACTEX.

In 2018, the SoA launched Exam LTAM (Long-Term Actuarial Mathematics) to replace Exam MLC (Models for Life Contingencies). Compared to its predecessor, Exam LTAM has a much broader coverage. Topics that are newly introduced include the following:

(1) Structural settlement and health insurance

You are required to know the calculations involved in structural settlements, which are often used in settling personal injury claims arising from motor vehicle accidents and medical malpractice. You also need to understand various types of health insurance, and know how to price them using complex multiple-state models.

(2) Mortality modeling

You are required to know several sophisticated mortality models, including the Lee-Carter model, the Cairns-Blake-Dowd model, the CBD M7 model, and MP-2014. You also need to know how to apply them in life insurance pricing and valuation.

(3) Retirement benefits

You are required to know how to value retiree health benefits. Although the set-up covered in Exam LTAM is a “simplified” one, the calculations are still quite involved.

(4) Estimation of life tables

You are required to know how life tables (and multiple state models) are estimated using advanced statistical methods. Previously, in Exam MLC, candidates were required to know how to apply them only.

In this brand new study manual, four chapters (Chapters 12, 14, 15 and 16; 216 pages in total) are written to cover these new (and very advanced) topics, ensuring you are best prepared for the exam! As a fact, one author (Professor Johnny Li) of this study manual has strong expertise in many of these exam topics. Professor Li published some 60 papers on mortality modeling and 2 books on personal injury claims. He also taught mortality modeling in a SoA live webcast. Some of his previous work has been adopted into the SoA’s study note (LTAM-21-18) for this exam.

Exam LTAM has a very unique format. Among all preliminary exams, Exam LTAM is the only one that includes both multiple-choice and written-answer questions. We know very well that you may be worried about written-answer questions. To help you score the highest mark you can in the written-answer section, this manual contains more than 150 written-answer questions for you to practice. Eight full-length mock exams, written in exactly the same format as that announced in the SoA’s Exam LTAM Introductory Note, are also provided. Many of the written-answer questions in this study manual are highly challenging! We are sorry for giving you a hard time, but we do want you to succeed in the real exam.

The learning outcomes stated in the syllabus of Exam LTAM require candidates to be able to interpret a lot of actuarial concepts. This skill is drilled extensively in our practice problems, which often ask you to interpret a certain actuarial formula or to explain your calculation. Also, in Exam LTAM you may be asked to define or describe a certain product, model or terminology. To help you prepare for this type of questions, Chapters 0 and 16 of this study manual provide you summaries of the definitions and descriptions of various products and terminologies. The summaries are written in a “fact sheet” style so that you can remember the key points more easily.

Proofs and derivations are another key challenge. In Exam LTAM, you are highly likely to be asked to prove or derive something. You are expected to know, for example, how to derive the Kolmogorov forward differential equations for a certain transition probability. In this new study manual, we do teach (and drill) you how to prove or derive important formulas. This is in stark contrast to some other exam prep products in which proofs and derivations are downplayed, if not omitted.

Besides the topics specified in the exam syllabus, you also need to know a range of numerical techniques, for example, Euler’s method and Simpson’s rule, in order to succeed. We know that you may not have even seen these techniques before, so we have prepared a special chapter (Appendix 1) to teach you all of the numerical techniques required for Exam LTAM. In addition, whenever a numerical technique is used, we clearly point out which technique it is, letting you follow our examples and exercises more easily.

We have made our best effort to ensure that all topics in the syllabus are explained and practiced in sufficient depth. For your reference, a detailed mapping between this study manual and the readings in the exam syllabus is provided on pages P-11 to P-14.

Other distinguishing features of this study manual include:

- All topics in the newest release (as of June 6, 2018) of LTAM-21-18 “Supplementary Note on Long Term Actuarial Mathematics” are fully incorporated into this study manual.
- We use graphics extensively. Graphical illustrations are probably the most effective way to explain formulas involved in Exam LTAM. The extensive use of graphics can also help you remember various concepts and equations.
- A sleek layout is used. The font size and spacing are chosen to let you feel more comfortable in reading. Important equations are displayed in eye-catching boxes.
- Rather than splitting the manual into tiny units, each of which tells you a couple of formulas only, we have carefully grouped the exam topics into 17 chapters and 3 appendices. Such a grouping allows you to more easily identify the linkages between different concepts, which are essential for your success as multiple learning outcomes can be examined in one single exam question.
- Instead of giving you a long list of formulas, we point out which formulas are the most important. Having read this study manual, you will be able to identify the formulas you must remember and the formulas that are just variants of the key ones.

- We do not want to overwhelm you with verbose explanations. Whenever possible, concepts and techniques are demonstrated with examples and integrated into the practice problems.
- We explain multiple-state models in great depth. A solid understanding of multiple-state models is crucially important, because many of the learning objectives in Exam LTAM are related to multiple-state models.
- We teach you how to make tedious retiree health benefit calculations more manageable by using a tabular approach. Also, whenever possible, multiple methods (direct methods and computationally efficient algorithms) are presented.
- We write practice problems and mock exam questions in a similar format to the released exam questions. This arrangement helps you comprehend questions more quickly in the real exam.
- All mock exams in this study manual are based on the newest set of examination tables (the Standard Ultimate Life Table), so in the real exam, you can retrieve values from these tables more quickly.

On page P-15, you will find a flow chart showing how different chapters of this manual are connected to one another. You should first study Chapters 0 to 10 in order. Chapter 0 will give you some background factual information; Chapters 1 to 4 will build you a solid foundation; and Chapters 5 to 10 will get you to the core of the exam. You should then study Chapters 11 to 16 in any order you wish. Immediately after reading a chapter, do all practice problems we provide for that chapter. Make sure that you understand every single practice problem. Finally, work on the mock exams.

Before you begin your study, please download the exam syllabus from the SoA’s website:

<https://www.soa.org/Education/Exam-Req/edu-exam-ltam-detail.aspx>

On the last page of the exam syllabus, you will find a link to Exam LTAM Tables, which are frequently used in the exam. You should keep a copy of the tables, as we are going to refer to them from time to time. You should also check the exam home page periodically for updates, corrections or notices.

If you find a possible error in this manual, please let us know at the “Customer Feedback” link on the ACTEX homepage (www.actexamdriver.com). Any confirmed errata will be posted on the ACTEX website under the “Errata & Updates” link.

Enjoy your study!

Syllabus Reference

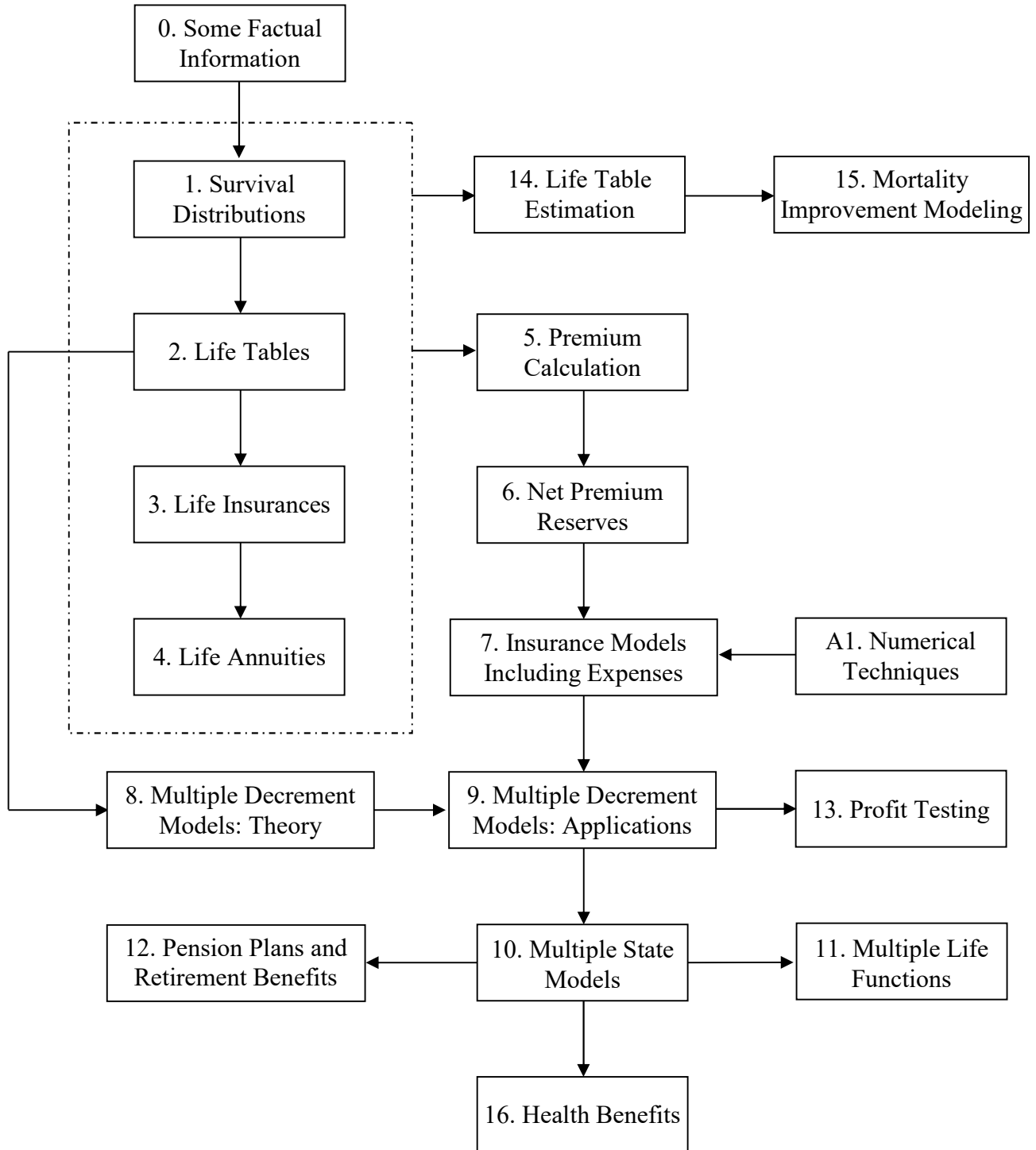
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Flow Chart



Chapter 0 Some Factual Information

This chapter serves as a summary of Chapter 1 in AMLCR. It contains descriptions of various life insurance products and pension plans. There is absolutely no mathematics in this chapter.

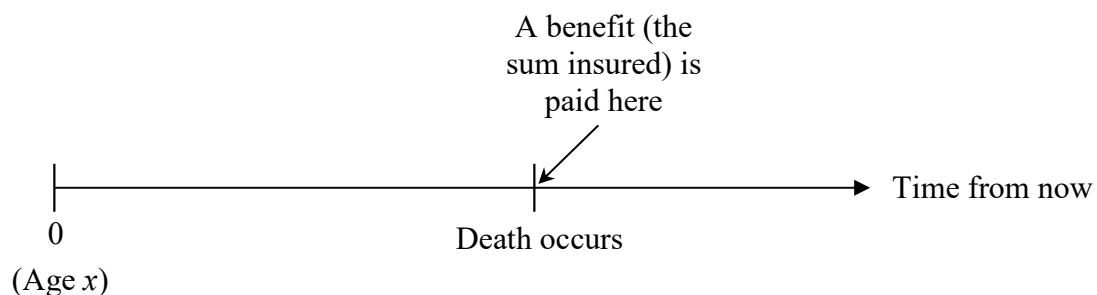
You should know (and remember) the information presented in this chapter, because in the written answer questions, you may be asked to define or describe a certain pension plan or life insurance policy. Most of the materials in this chapter are presented in a “fact sheet” style so that you can remember the key points more easily.

Many of the policies and plans mentioned in this chapter will be discussed in detail in later parts of this study guide.

0.1 Traditional Life Insurance Contracts

Whole life insurance

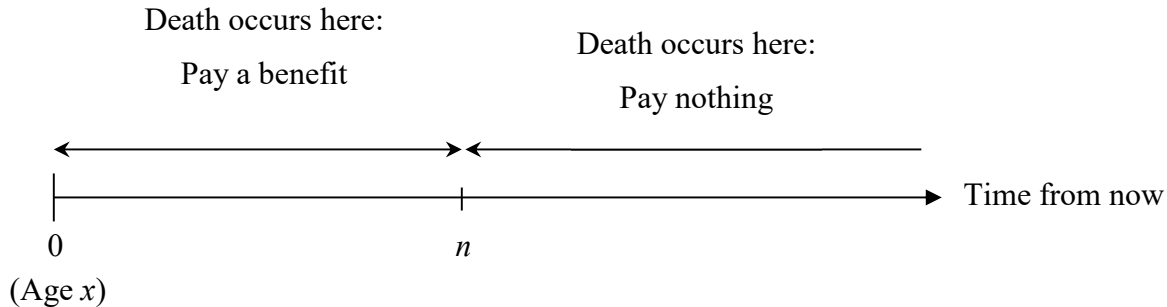
A whole life insurance pays a benefit on the death of the policyholder whenever it occurs. The following diagram illustrates a whole life insurance sold to a person age x .



The amount of benefit is often referred to as the *sum insured*. The policyholder, of course, has to pay the “price” of policy. In insurance context, the “price” of a policy is called the *premium*, which may be payable at the beginning of the policy, or periodically throughout the life time of the policy.

Term life insurance

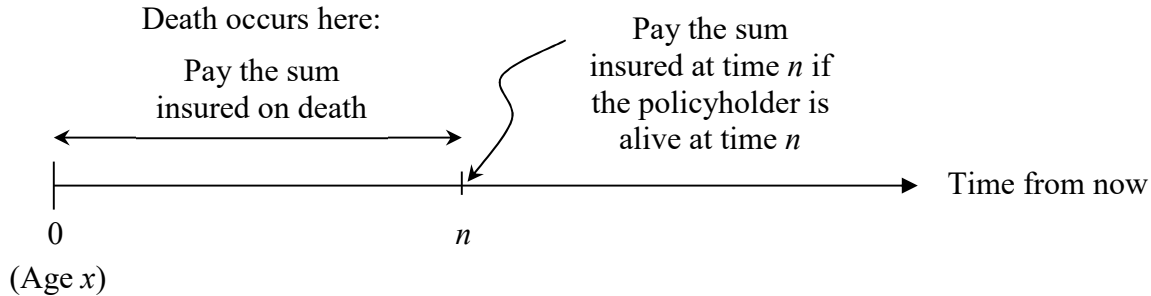
A term life insurance pays a benefit on the death of the policyholder, provided that death occurs before the end of a specified term.



The time point n in the diagram is called the *term* or the *maturity date* of the policy.

Endowment insurance

An endowment insurance offers a benefit paid either on the death of the policyholder or at the end of a specified term, whichever occurs earlier.



These three types of traditional life insurance will be discussed in Chapter 3 of this study guide.

Participating (with profit) insurance

Any premium collected from the policyholder will be invested, for example, in the bond market. In a participating insurance, the profits earned on the invested premiums are shared with the policyholder. The profit share can take different forms, for example, cash dividends, reduced premiums or increased sum insured. You need not know the detail of this product.



0.2 Modern Life Insurance Contracts

Modern life insurance products are usually more flexible and often involve an investment component. The table below summarizes the features of several modern life insurance products.

Product	Features
Universal life insurance	<ul style="list-style-type: none"> – Combines investment and life insurance – Premiums are flexible, as long as the accumulated value of the premiums is enough to cover the cost of insurance
Unitized with-profit insurance	<ul style="list-style-type: none"> – Similar to traditional participating insurance – Premiums are used to purchase shares of an investment fund. – The income from the investment fund increases the sum insured.
Equity-linked insurance	<ul style="list-style-type: none"> – The benefit is linked to the performance of an investment fund. – Examples: equity-indexed annuities (EIA), unit-linked policies, segregated fund policies, variable annuity contracts – Usually, investment guarantees are provided.

We will not discuss these policies in detail because it is out of the scope of this exam.



0.3 Underwriting

Underwriting refers to the process of collecting and evaluating information such as age, gender, smoking habits, occupation and health history. The purposes of this process are:

- To classify potential policyholders into broadly homogeneous risk categories
- To determine if additional premium has to be charged.

The following table summarizes a typical categorization of potential policyholders.

Category	Characteristics
Preferred lives	Have very low mortality risk
Normal lives	Have some risk but no additional premium has to be charged
Rated lives	Have more risk and additional premium has to be charged
Uninsurable lives	Have too much risk and therefore not insurable

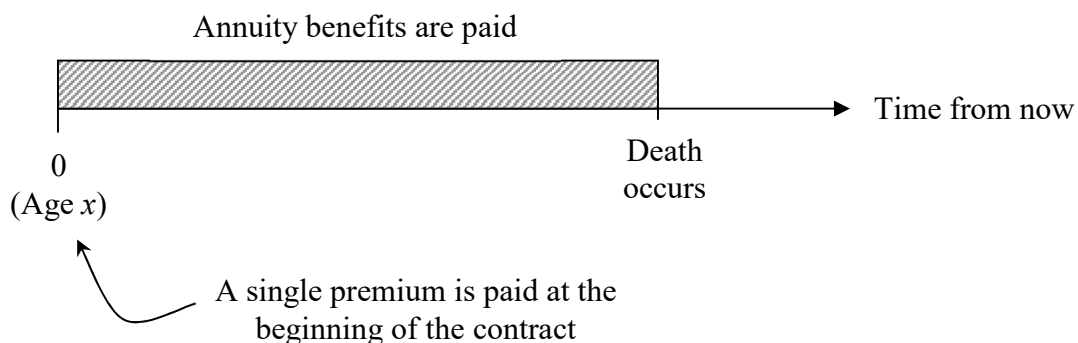
Underwriting is an important process, because with no (or insufficient) underwriting, there is a risk of adverse selection; that is, the insurance products tend to attract high risk individuals, leading to excessive claims. In Chapter 2, we will introduce the select-and-ultimate table, which is closely related to underwriting.

0.4 Life Annuities

A life annuity is a benefit in the form of a regular series of payments, conditional on the survival of the policyholder. There are different types of life annuities.

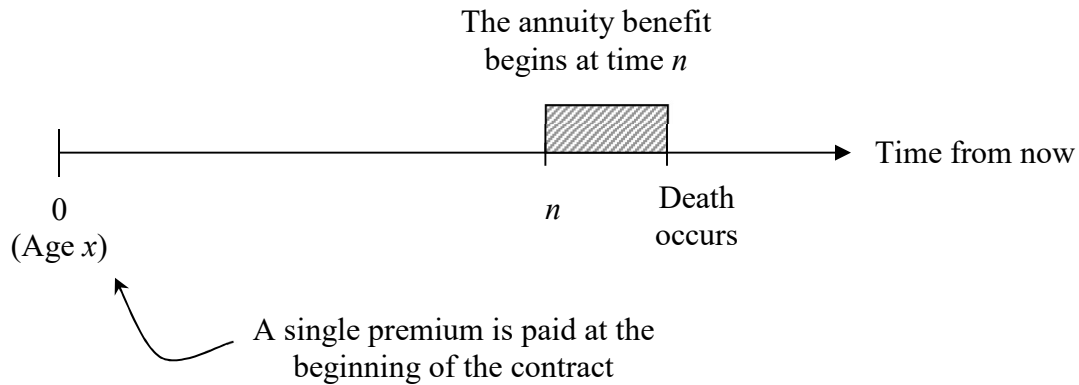
Single premium immediate annuity (SPIA)

The annuity benefit of a SPIA commences as soon as the contract is written. The policyholder pays a single premium at the beginning of the contract.



Single premium deferred annuity (SPDA)

The annuity benefit of a SPDA commences at some future specified date (say n years from now). The policyholder pays a single premium at the beginning of the contract.



Regular Premium Deferred Annuity (RPDA)

An RPDA is identical to a SPDA except that the premiums are paid periodically over the deferred period (i.e., before time n).

These three annuity types will be discussed in greater depth in Chapter 4 of this study guide.

Some life annuities are issued to two lives (a husband and wife). These life annuities can be classified as follows.

Joint life annuity	The annuity benefit ceases on the first death of the couple.
Last survivor annuity	The annuity benefit ceases on the second death of the couple.
Reversionary annuity	The annuity benefit begins on the first death of the couple, and ceases on the second death.

These annuities will be discussed in detail in Chapter 11 of this study guide.



0.5 Pensions

A pension provides a lump sum and/or annuity benefit upon an employee's retirement. In the following table, we summarize a typical classification of pension plans:

<p>Defined contribution (DC) plans</p>	<p>The retirement benefit from a DC plan depends on the accumulation of the deposits made by the employ and employee over the employee's working life time.</p>
<p>Defined benefit (DB) plans</p>	<p>The retirement benefit from a DB plan depends on the employee's service and salary.</p> <p>Final salary plan: the benefit is a function of the employee's final salary.</p> <p>Career average plan: the benefit is a function of the average salary over the employee's entire career in the company.</p>

Pension plans will be discussed in detail in Chapter 12 of this study guide.

**Exercise 0**

1. (Exam LTAM Sample 1.1) Which of the following is not true with regard to underwriting?
 - (A) Life insurance policies are typically underwritten to prevent adverse selection.
 - (B) The distribution method affects the level of underwriting.
 - (C) Single premium immediate annuities are typically underwritten to prevent adverse selection.
 - (D) Underwriting may result in an insured life being classified as a rated life due to the insured's occupation or hobby.
 - (E) A pure endowment does not need to be underwritten to prevent adverse selection.

2. (Exam LTAM Sample 1.2) Over the last 30 years, life insurance products and the management of the associated risks have radically changed and become more complex. Which of the following is not a reason for this change?
 - (A) More sophisticated policyholders.
 - (B) More competition among life insurance companies.
 - (C) More computational power.
 - (D) More complex risk management techniques.
 - (E) Separation of the savings elements and the protection elements of life insurance products.

Solutions to Exercise 0

1. (C) is incorrect. If the mortality rate of the insured is higher than expected, the number of payment from the annuity will be smaller than expected. This means the insurance company would benefit. Therefore, the policy needs no underwriting.

(B) is correct because for some direct marketed products with small death benefits, the actuary can assume a higher-than-normal mortality to partially offset the extra mortality that results in limited underwriting. This saves the cost of selling the business.
2. (E) is incorrect. In the past 30 years, new products such as universal life insurance, unitized with-profit insurance and equity-linked insurance contain savings, investment and protection components (such as guarantees). These products are designed to compete with investment products offer by other financial institutions.