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An economic and actuarial analysis of *death bonds*

JOÃO VINÍCIUS DE FRANÇA CARVALHO
UNIVERSITY OF SAO PAULO, BRAZIL

LUÍS EDUARDO AFONSO
UNIVERSITY OF SAO PAULO, BRAZIL

Agenda

- Introduction
- Objectives
- The financial product *death bond*
- Methodology
- Simulations
- *Adverse Selection*: the most lucrative insured
- Final remarks

Introduction

- Life insurance: payment of an ammount to beneficiaries at the end of the year of death of the insured;
- Traditionally, life insurance has been treated as an illiquid asset;
- In some countries, the policies have been negotiated in the secondary market (*death bond*);
- Pricing problem: certain receiving but uncertain execution time;
- Investor's rate of return depends on insured's probability of death.

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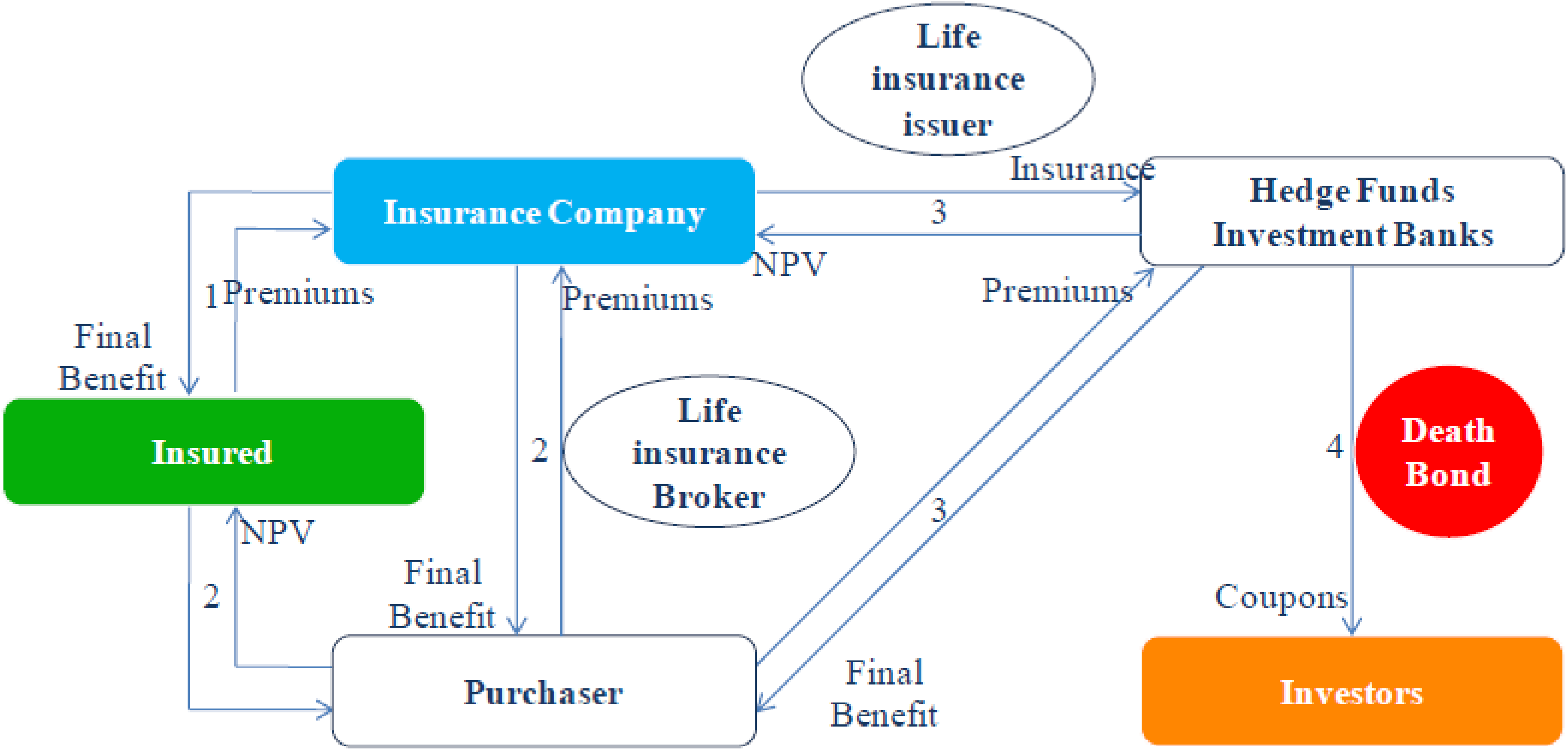
Objectives

- Analyze the feasibility of this market, through simulations of the primary and secondary pricing of such securities;
- Evaluate possible market failures.

The financial product *death bond*



Methodology

- The rate of return depends on the financial amount that an individual has managed to accumulate in the entity in capitalization financial system;
- The premium calculus is set to equalize the amount to be paid with the *expected present value (EPV)* of payments in the future;
- EPV depends on: survival function and interest rate → **actuarial modeling**.

Methodology

- $v = \frac{1}{(1+i)^t}$: financial discount factor;
- l_x e d_x: number of living people aged x and dead persons before achieving $x+1$ years old, respectively, given one survival function;
- ${}_tp_x$: probability of an individual at age x complete age $x+t$ (${}_tq_x = 1 - {}_tp_x$).

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Methodology

- *Pure single premium (PSP)* : $A_x = \sum_{t=0}^{\infty} v^{t+1} {}_t q_x = \frac{1}{l_x} \sum_{t=0}^{\infty} v^{t+1} d_{x+t}$, e
- Let: $D_x = v^x l_x$, $C_x = v^{x+1} d_x$ and $M_x = \sum_{t=0}^{\infty} C_{x+t}$, so:

$$A_x = \sum_{t=0}^{\infty} v^{t+1} {}_t q_x = \frac{1}{v^x l_x} \sum_{t=0}^{\infty} v^{x+t+1} d_{x+t} = \frac{1}{D_x} \sum_{t=0}^{\infty} C_{x+t} = \frac{M_x}{D_x}$$

- *Anniuties*: let $N_x = \sum_{t=0}^{\infty} D_{x+t}$, we get:

$$\ddot{a}_x = \sum_{t=0}^{\infty} v^t {}_t p_x = \sum_{t=0}^{\infty} \frac{D_{x+t}}{D_x} = \frac{1}{D_x} \sum_{t=0}^{\infty} D_{x+t} = \frac{N_x}{D_x}$$

- *Net level annual premium (NLAP)*:

$$\ddot{a}_x P_x = A_x \Leftrightarrow P_x = \frac{A_x}{\ddot{a}_x} = \frac{M_x}{N_x}$$

- Accumulated reserves in *t* years:

$${}_t V_x = A_{x+t} - P_x . \ddot{a}_{x+t} = \frac{M_{x+t} - P_x N_{x+t}}{D_{x+t}}$$

Methodology

- *Paid-up insurance*: allows renegotiation of the value of the benefit, from a reserve already accumulated. The formula is given by:

$$ {}_tW_x = \frac{{}_tV_x}{A_{x+t}} = \frac{A_{x+t} - P_x.\ddot{a}_{x+t}}{A_{x+t}} = 1 - \frac{P_x}{P_{x+t}} $$

- Profitability of the *death bond*:

$$ RR_{x,t,n} = \frac{\left(\frac{K.{}_tW_x}{(1+j)^n}\right) - {}_tV_x}{{}_tV_x} $$

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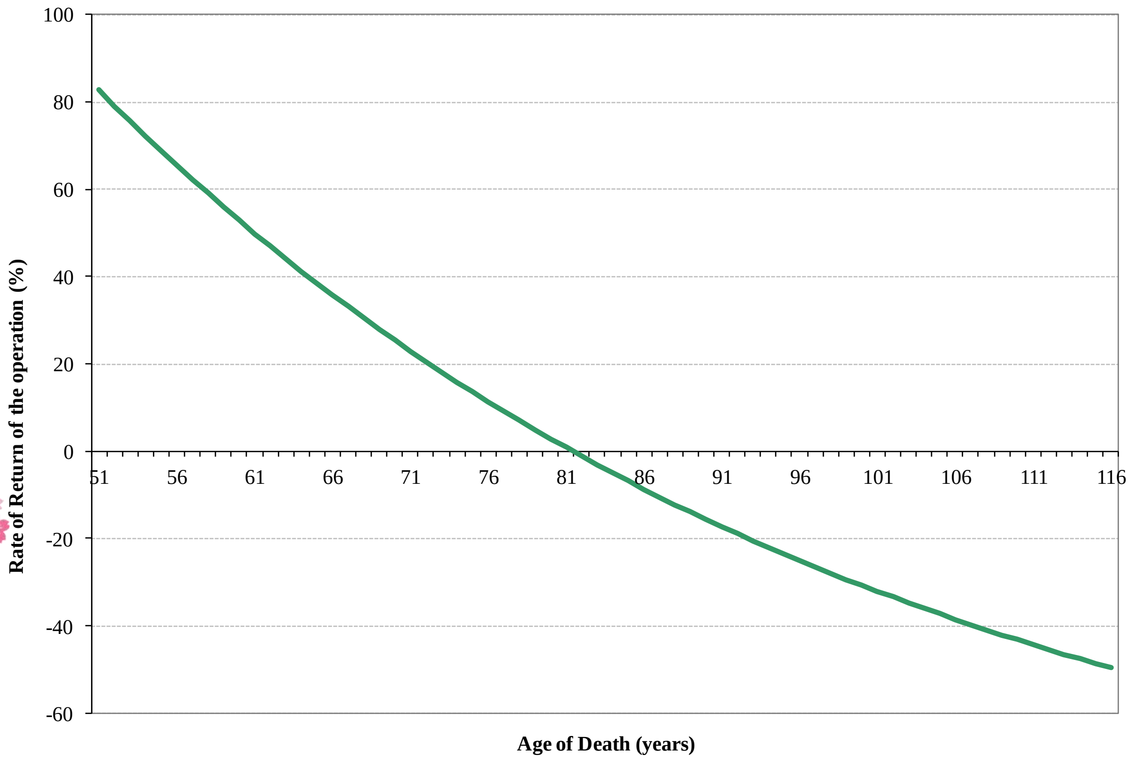
Methodology

- Expected rate of return ($ERR_{x,t,n}$):

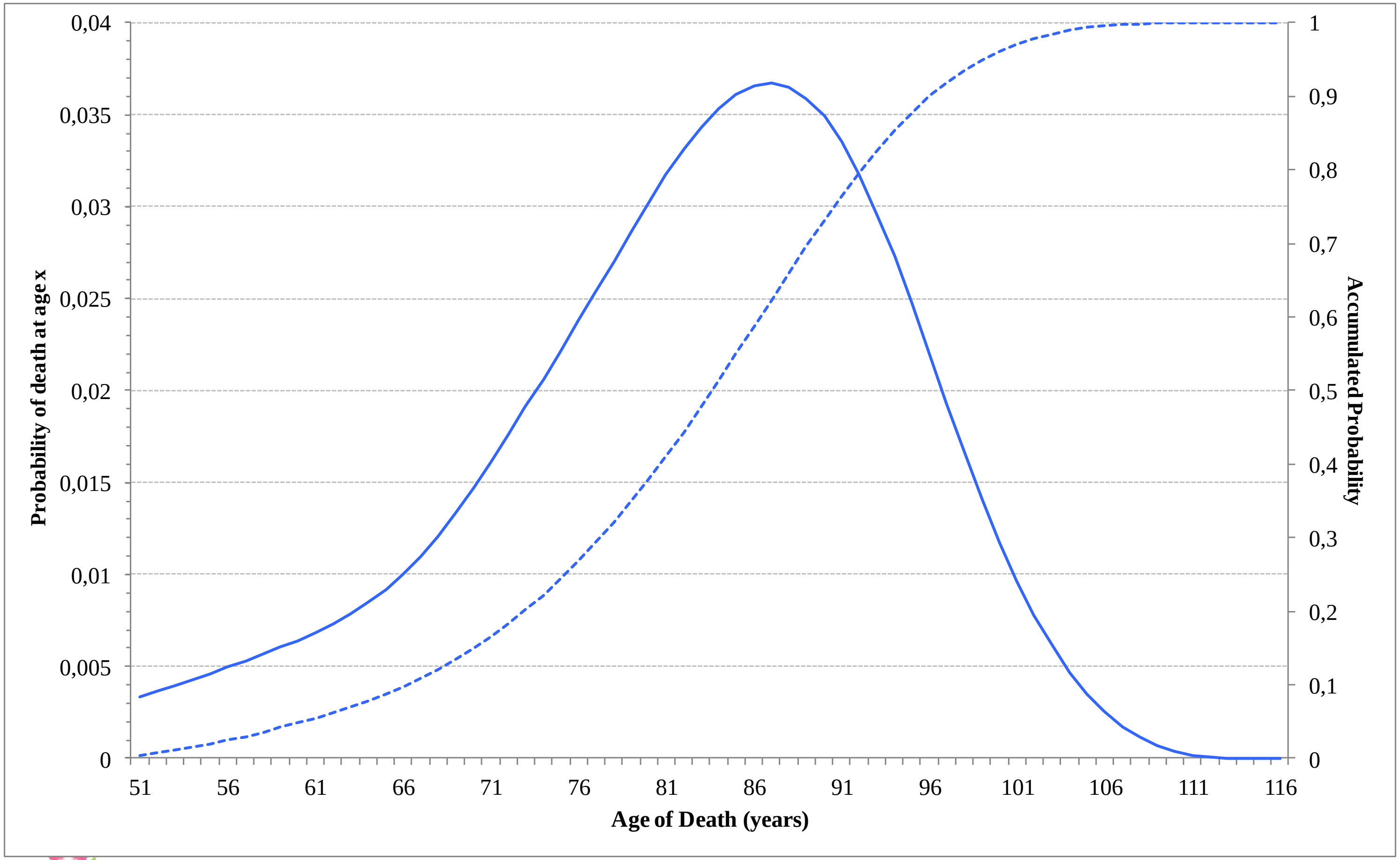
$$ERR_{x,t,n} = \frac{\sum_{n=t}^{\infty}\left\{ q_{x+n}\prod_{i=t}^{n-1}\left(p_{x+i}\right)\left[\frac{\left(\frac{K\cdot{}_tW_x}{(1+j)^n}\right)-{}_tV_x}{{}_tV_x}\right]\right\}}{\sum_{n=t}^{\infty}\left[q_{x+n}\prod_{i=t}^{n-1}\left(p_{x+i}\right)\right]}$$

Simulations

Gender (M/F)	M
Age at hiring (x, in years)	35
Number of *NLAP* paid (t, in years)	15
Age at negotiation ($x + t$, in years)	50
Financial discount (per year)	2%
Accumulated Reserve (${}_tV_x$)	R$ 21,654.58
Capital (K)	R$ 100,000.00
Paid-up insurance ($K.{}_tW_x$)	R$ 40.352,28



Simulations



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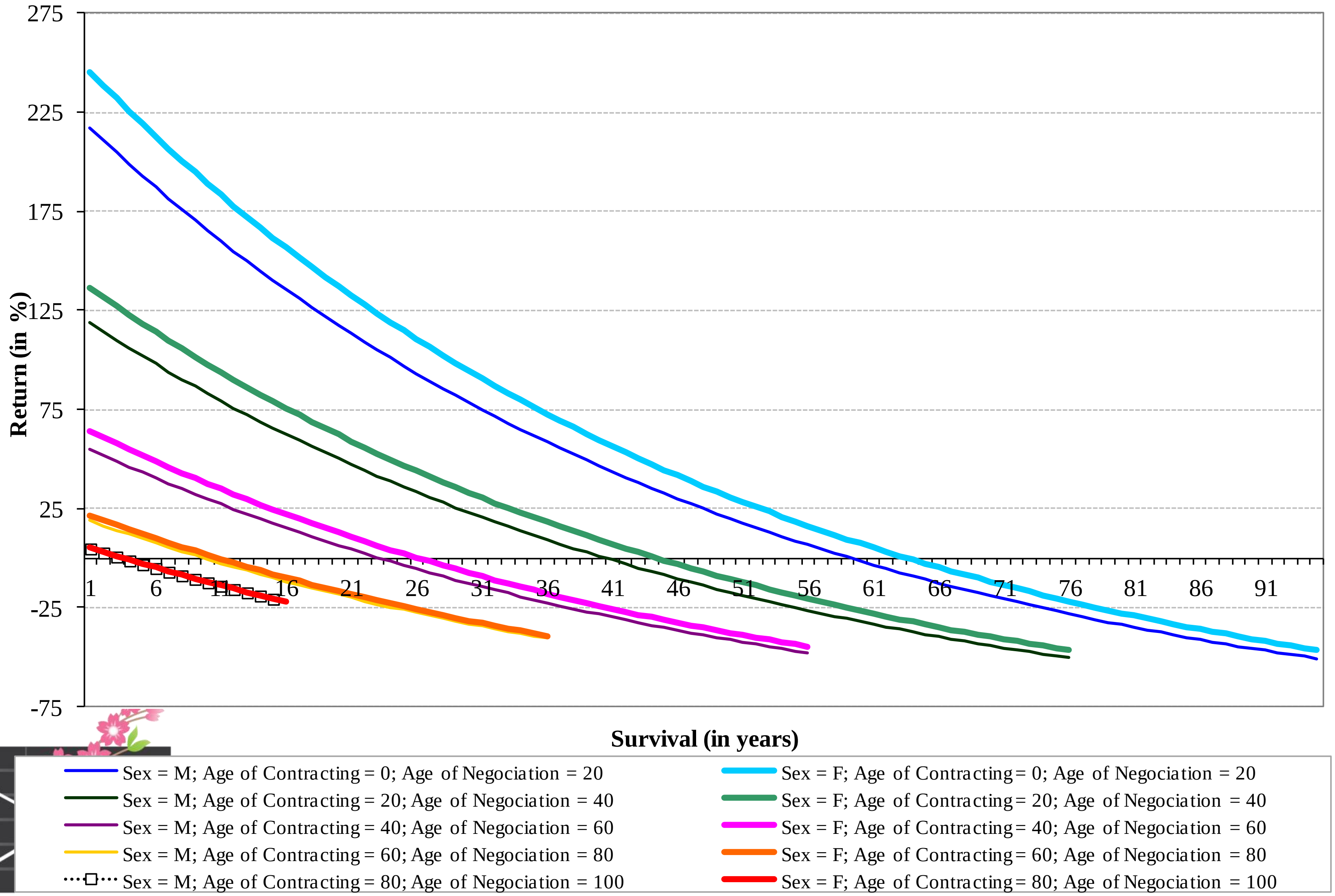
Simulations



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Simulations

Age at negociation	Gender	
	M	F
20	0,000009% (32,99%)	0,000032% (30,46%)
40	0,000009% (27,11%)	0,000033% (25,63%)
60	0,000010% (20,21%)	0,000035% (20,01%)
80	0,000018% (11,76%)	0,000051% (12,04%)
100	0,000381% (4,47%)	0,000803% (4,71%)

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Adverse Selection: the most lucrative insured

- Information asymmetries: the investor can incorrectly estimate the ERR;
- *Adverse Selection:* (institution) has less information that the agent (insured), with a unilateral change of behavior → the investor would be more interested in individuals the insured with higher probability of death;
- A hypothetical way to select these policyholders: finding them with their diseases already diagnosed;
- *Mortality Proxy*: medical literature (Eurocare project) for diagnosis of cancer.

Adverse Selection: the most lucrative insured

Category of probability	Average point of category	Men	Women	Total
≥80%	90%	2%	5%	4%
60–79%	70%	31%	45%	38%
40–59%	50%	25%	23%	24%
20–39%	30%	10%	12%	11%
<20%	10%	32%	14%	23%
Total		100%	100%	100%
Average probability of surviving 5 anos		**42,2%**	**52,5%**	**47,8%**

Age at negotiation	Gender	
	M	F
20	185,57% (12,64%)	203,25% (16,35%)
40	96,91% (8,71%)	107,39% (11,18%)
60	39,67% (6,18%)	44,29% (7,78%)
80	7,00% (4,73%)	6,66% (5,75%)
100	-5,65% (4,17%)	-7,77% (4,97%)

Final remarks (I)

- The first comparisons between the main factors for pricing, gender and age, evidence that initially this is a low attractive investment;

- Regardless of gender, the older is the insured, the higher is the rate, as also there is higher interest in women's lives than in men’s;

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Final remarks (II)

- Increasing probability of premature death: high attractiveness of the product by the investors (evidence of strong adverse selection);
- For future studies, it is possible to think of the analysis for other types of diseases or in the more refined modeling of the curve of probability of death, as well as other possibilities of adverse selection.

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