*risks*

*Article*

# Disruption of Life Insurance Profitability in the Aftermath of the COVID-19 Pandemic

**Maria Carannante [1,*,†], Valeria D'Amato [1,†], Paola Fersini [2,†], Salvatore Forte [3,†] and Giuseppe Melisi [4,†]**

[1] Department of Pharmacy, University of Salerno, Via Giovanni Paolo II, 132, 84084 Fisciano, Italy; vdamato@unisa.it
[2] Department of Business and Management, Luiss Guido Carli, Viale Romania, 32, 00197 Rome, Italy; pfersini@luiss.it
[3] Faculty of Law, Giustino Fortunato University, Via Raffaele Delcogliano, 82100 Benevento, Italy; s.forte@unifortunato.eu
[4] Department of Law, Economics, Management and Quantitative Methods, University of Sannio, Piazza Guerrazzi, 82100 Benevento, Italy; gimelisi@unisannio.it
* Correspondence: mcarannante@unisa.it
† These authors contributed equally to this work.

**Abstract:** Life insurance profitability depends on reliable mortality risk projections and pricing. While the COVID-19 pandemic has caused disruptions around the world, this is a temporary mortality shock likely to dissipate. In this paper, we investigate the long-run impact of COVID-19 on life insurance profitability. Due to the long-run dynamics of the mortality characterised by a decreasing effect of the COVID-19 mortality acceleration, we suggest proactive mortality risk management by implementing prompt premium adjustments, in order to increase the resilience of the business.

**Keywords:** SCR; profitability; annuity; mortality projections



**Citation:** Carannante, Maria, Valeria D'Amato, Paola Fersini, Salvatore Forte, and Giuseppe Melisi. 2022. Disruption of Life Insurance Profitability in the Aftermath of the COVID-19 Pandemic. *Risks* 10: 40. https://doi.org/10.3390/risks10020040

Academic Editors: Anna Rita Bacinello and Nadine Gatzert

Received: 8 November 2021
Accepted: 3 February 2022
Published: 11 February 2022



## 1. Introduction

Aside from the social and health consequences of COVID-19, the pandemic has led to economic and market shocks. Interest rates and equity markets have declined, credit spreads have widened, and volatility has increased. The additional volatility in global markets affecting the value of equity, fixed investments, and low interest rate income has led to the need to implement unconventional monetary policy measures, such as negative rates, large asset purchase programmes, forward guidance, and targeted liquidity provision measures (ECB 2021). Likewise, the impact of COVID-19 on the insurance industry risks is becoming severe.

Insurance companies are required to investigate the potential disruption across the business caused by the pandemic. Indeed, the pandemic is likely to disrupt investments, finance, capital, underwriting, claims, and actuarial functions in several business areas. Over the next few months, due to the increasing uncertainty around new business and underwriting, the appetite for new insurance products may decline, as consumers face increasing temporary or permanent unemployment, potential loss of income, and general market volatility. Cash flow expectations over the next years also depend on global equity markets that have seen reduced investment returns. "The insurance sector must deal with challenging market conditions and maintain operations, while at the same time protecting employees and policyholders" (EIOPA 2020a). The decline in asset liquidity and the increase in overdue liabilities may cause a decrease in assets relative to liabilities (EIOPA 2020b).

According to Karlsson (2020), the pandemic may have seriously affected the operation of European insurance companies, by representing a serious threat for the solvency stability. Understanding how the COVID-19 pandemic has affected insurance companies is crucial especially in light of the "double-hit" scenario characterised by a resurgence of the virus, reported by previous stress test exercises by Moody's Analytics (2020). The insurance industry's profitability is linked to operational and financial management both of them suffering the effect of the pandemic. The future financial cash flows could be affected by the uncertainty and pessimism due to the pandemic, the spillover effect of the overall decline in the market, leading to investors' herd behaviour to negative abnormal returns. Conversely, in Farooq et al. (2021), the authors take also into account a possible opposite effect of the COVID-19 outbreak of the increasing demand for insurance contracts and premiums. From the operational management point of view, insurers are responding to the widening pandemic on multiple fronts as health insurance, non-life and life offices, some classes of business being most exposed to coronavirus and adversely impacted. Some business classes are more exposed to the COVID-19 outbreak than the others. The portfolio concentration of higher risk business classes seriously threatens the insurance companies, by suggesting more well-diversified portfolios.

In particular, the health insurance premiums continued to grow steadily after the outbreak as pointed out in Wang et al. (2020) and Nguyen and Vo (2020). In particular, in correspondence to the profound shock to the health care systems due to the surge of COVID-19, major commercial health insurance companies increased operating income from decreased care utilization: for instance UnitedHealth Group, CVS Health Care Benefits Segment, Anthem, and Humana all saw operating earnings over 200% of their 2019 amount, much of which has been attributed to delays in routine care (Bryan and Tsai 2021).

Focusing exclusively on aspects related to non-life insurance, the insurers tried to adapt the policies to the new challenges exposed by the crisis in response to the COVID-19, specifically by providing the business interruption (BI) insurance, the crisis having been reaffirmed the importance of business continuity planning. With regard to property and casualty (P&C), the impact on business and coverage has been profound, estimated at USD 80 to USD 100 billion in the case of business interruption (BI) coverage, a critical area of concern under COVID-19 (Marsh 2021). In general, according to an interesting study by Gründl et al. (2020), the insurance industry alone will not be able to provide sufficient coverage for business interruption losses like those occurring during the COVID-19 crisis, as the markup of a hypothetical insurance contract in the top 20% of the realised price markups of NatCat insurance would lead an expected shortfall of the loss distribution which is about 100 times higher. In the automobile insurance field, reductions in driving and accident claims led to premium refunds early during the pandemic by causing well-documented premium changes (Scism 2020).

The uncertain mortality and morbidity events related to COVID-19 are also affecting the life insurance and annuity business. Mortality improvements over the past several years have been muted, likely to continue mainly as a combined effect of the temporary mortality shock due to the pandemic. Indeed, the debate is ongoing on how temporarily stressed mortality rates change post-COVID-19 mortality rates (Andresson and Lindholm 2021) and the mortality term structure (Milesky 2021; Spiegelhalter 2020).

The scarce literature on the topic enlightens that life insurance companies have been forced to significantly adjust life insurance premiums or offerings to account for the increased mortality risk (Pułanska 2021).

Harris et al. (2021) suggest minimal observable premium adjustments through February 2021. They find evidence that premiums raised "for unhealthy older smokers, and policies offered to individuals age 75 and above were differentially removed from the market". Overall, small adjustments in the life business offering correspond to increases in mortality risk perceived from insurers as modest in the short run, by implicitly assuming no effects in the long-run perspective. To the best of our knowledge, in light of the mortality stress temporariness, the academic literature has not extensively focused on the possible changes in profitability margins for life insurance companies.

The novelty of our research properly consists in examining the long-run impact of COVID-19 on life insurance profitability. We suggest connecting the profitability analysis to the temporary excess of deaths due to the COVID-19 which will be softened in the long run by the structural improvements of longevity projections (Carannante et al. 2021b).

Actuarial assumptions and forecasting are crucial for an effective mortality risk management strategy and preserving the expected cash flows over the coming years. Understanding the impact of future structural improvement scenarios, as well as increased short-term mortality combined with heightened attention to social and health care improvements in the longer term will allow life insurance offices to maintain profitability. In other words, proactive mortality risk management, which requires revising mortality assumptions to make timely decisions in reserves and forecasting, will enable the insurance industry to build resilience and tackle the immediate challenge of positioning the business for the future. The remainder of the paper is structured as follows. In Section 2, we introduce the issue of profitability, define profit resilience in life insurance, and how to quantify it with particular reference to annuity contracts. Section 3 details the numerical applications, focusing on the mortality, financial, and cash flow aspects. Section 4 concludes.

## 2. Profit Resilience in Annuity

We analyse the expected profit of a variable immediate annuity contract.

The general actuarial model used for the evaluation of the insurance contract and to estimate the future cash flows belongs to the life insurance methodologies, which represent the actuarial practice in many countries, according to a time-discrete approach, which, see Olivieri and Pitacco (2015).

The contract under consideration is an immediate single premium annuity with a revalued instalment for an individual of age $x$ at time 0 in which the contract is underwritten. Obviously, since it is an immediate annuity, the single premium is the only possible alternative. In this case, in order to implement the profit-sharing mechanism that prevails in the Italian market, we implement an actuarial model with cliquet guarantees with annual returns recognised to policyholders depending only on the most recent performance of an investment portfolio. The contract valuation can the be reduced to that of a sequence of one-year forward-start options, see Bacinello (2001, 2003a, 2003b).

To assess the effects depending on age, we consider policyholders aged 20, 40, and 60. In the case of an annuity, the instalment is constant and the pure premium for an individual at age $x$ is given by:

$$P_x = R \cdot \sum_{t=1}^{\omega-x-1} \frac{l_{x+t}}{l_x} \cdot (1+i)^{-t} \quad (1)$$

where:
$P_x$ is the pure premium based on the first-order mortality basis table;
$R$ is the constant instalment paid by the insurance company during the policyholder's life with a value agreed at contract time;
$l_x$ is the number of policyholders at age $x$ deduced by the first-order mortality basis table used to compute the pure premium;
$i$ is the technical rate;
$\omega$ is the extreme age, thus $\omega - 1$ is the last age for a policyholder and $l_\omega = 0$.

Since we consider a variable annuity, the pure premium is defined as:

$$P_x = R_0 \cdot \sum_{t=1}^{\omega-x-1} \frac{l_{x+t}}{l_x} \cdot (1+i)^{-t} \quad (2)$$

where:
$R_0$ is the first instalment defined at contract time.

The following instalments are variable based on segregated fund returns with the following formula:

$$R_t = R_{t-1} \cdot (1 + r_t) \tag{3}$$

where:
$R_t$ is the instalment at time $t$ if the policyholder is alive;
$R_{t-1}$ is the instalment at time $t-1$ if the policyholder is alive;
$r_t$ is the downgraded rate of return used to vary the rate based on the segregated fund return rate using the following formula:

$$r_t = \max\left(\frac{g_t - i - mt}{1 + i},\ mg\right) \tag{4}$$

where:
$g_t$ is the segregated fund return rate for the period $(t-1, t)$ recognised at time $t$;
$mt$ is the rate retained by the insurance company on the segregated fund return;
$mg$ is the minimum guaranteed rate of the segregated fund.

Once the pure premium and method of variation of the instalment are determined, the expenses loaded premium at age $x$ can be calculated:

$$PT_x = \frac{P_x \cdot (1 + \alpha)}{(1 - \beta)} \tag{5}$$

where:
$\alpha$ is the loading rate of the annuity payment;
$\beta$ is the loading rate of the administrative costs.

The expected profit is defined as:

$$E(U)_{x,k} = PT_{x,k} - BE_{x,k} - CoC_{x,k} \tag{6}$$

where:
$E(U)_{x,k}$ is the present expected profit at time $k$ when the contract is purchased by an individual at age $x$;
$PT_{x,k}$ is the expenses loaded premium at time $k$ for a policyholder at age $x$; $BE_{x,k}$ is the best estimate of the contract liability a time $k$ for a policyholder at age $x$ according to Solvency II principles, by considering the financial options and guarantees to include in the insurance contract;
$CoC_{x,k}$ is the cost of capital due to the allocation of the capital requirement under Solvency II for a contract sold a time $k$ for a policyholder at age $x$.
Cost of capital, $CoC_{x,k}$, is determined according to Solvency II requirements:

$$CoC_{x,k} = \partial \cdot \sum_{l=1}^{m} \frac{C \cdot SCR_{x,k+l-1}}{\left(1 + i_{rf}(k, k+l)\right)^t} \tag{7}$$

where:
$\partial$ is the cost of capital rate increase;
$i_{rf}(k, k+l)$ is the risk-free rate for the time horizon $(k, k+l)$;
$C$ is the cost of capital rate, that is, the unrealised extra-return compared to the risk-free rate;
$SCR_{x,k+l-1}$ is the solvency capital requirement for the time horizon $k+l-1$ and a policyholder of age $x$;
$m$ is the number of years when the risk expires in terms of capital requirements.

To determine $CoC_{x,k}$, we consider the EIOPA (2014) standard formula with particular reference to the market, longevity, expense, and operational risks. To note is that in determining $RORAC$, the overall $SCR$ is considered, while in determining $CoC$ only non-hedgeable risks are considered.

Furthermore, important to note is that $BE_{x,k}$ is equal to the present expected value of the liability if considering a reliable technical basis, depending on the mortality table. We assume that the realistic projected mortality table is obtained using the stochastic mortality model considering the scenario without the effects of the COVID-19 pandemic, and the scenario with an acceleration of mortality due to COVID-19 (Carannante et al. 2021a, 2021b); a reliable administrative expenses assumption, that is, an annual cost per contract; the risk-free rate maturity structure for discounting contract cash outflows; a stochastic model to determine $g_t$, that is, the segregated fund return rate for the period $(t-1, t)$ recognised at time $t$, which allows determining the variation of the annuity instalment $R_t$, using the Vasicek model.

The Vasicek model is largely used to evaluate the short-term evolution of a return rate, using a stochastic differential equation according to which shocks fluctuate around a long-term value as a function of volatility (for further details, see Vasicek (1977)):

$$dr_t = (\alpha + \beta r_t)dt + \sigma dZ_t \tag{8}$$

where:
$r_t$ is the short-term interest rate at time $t$;
$\alpha$ is the mean-reverting force of the shocks;
$\beta$ is the long-term interest rate mean;
$\sigma$ is the market volatility;
$Z_t$ is a Wiener process.

## 3. Numerical Application

The application is developed by analysing several different aspects of the definition of an immediate annuity contract. The first concerns the demographic scenario that evaluates the evolution over time of mortality considering the effects of the pandemic. Second, for the financial aspect, we observe the interest rate trend on which the variation of annuity instalment will be based. Third, the cash-flow analysis allows evaluating the differences in the premium in the function of the use of baseline or accelerated mortality tables. The last is the profitability analysis that allows quantifying the extra profit due to the adjustment of the mortality table.

### *3.1. Demographic Scenario*

The first step in evaluating profitability is to determine the demographic technical basis, that is, the individual death probabilities. In this sense, we use a stochastic model capable of projecting the probabilities of life over time. The model defines the probabilities of death with respect to two scenarios.

The baseline scenario assumes the absence of the COVID-19 pandemic, and the projections of survival probabilities are obtained through the Renshaw and Haberman (2003) estimation using the data on deaths collected in the Human Mortality Database,[1] with reference to the entire Italian population, considering the historical series from 1950 to 2017 for all ages from 0 to 100.

The alternative scenario considers the COVID-19 pandemic as a mortality acceleration factor estimated through a multiplicative model, that is, the projections of the accelerated probability of death obtained from the product between the probabilities of the basic scenario model and the multiplicative factor that depends on age $x$ and time $t$.

Cairns et al. (2020) define the multiplicative factor as a negative exponential function as follows:

$$\pi(x,t) = \frac{\alpha(x)}{\rho(x,t)} exp\left(\frac{-t}{12\rho(x,t)}\right) \tag{9}$$

where:
$\alpha(x)$ is the expected proportion of deaths by COVID-19 at age $x$;
$\rho(x,t)$ is the expected loss of years of life expectancy at age $x$ and time $t$.

The $\alpha$ and $\rho$ parameters in Formula (9) are computed from the COVID-19 deaths data and the all-causes mortality data of the Italian population for the year 2020. The data are collected weekly by the Italian Health Institute[2] (ISS) and the Italian Statistical[3] (ISTAT). $\alpha(x)$ is calculated as the ratio of the number of deaths due to COVID-19 infection and the total of deaths for the age $x$, while $\rho(x,t)$ is calculated as the product of the life expectancy at age $x$ and time $t$ and the proportion of deaths due to COVID-19 at age x on the total mortality due to COVID-19. $\pi(x,t)$ is calculated as a negative exponential function, aggregating the data in a monthly granularity, and it is used as a multiplicative coefficient to recalibrate the mortality projection obtained by the Renshaw–Haberman model. Figure 1 shows the death projections by age for 2021 per 100,000 population, distinguishing between deaths due to COVID-19 and all other causes. To make the data easier to read, we report them in logarithmic scale:

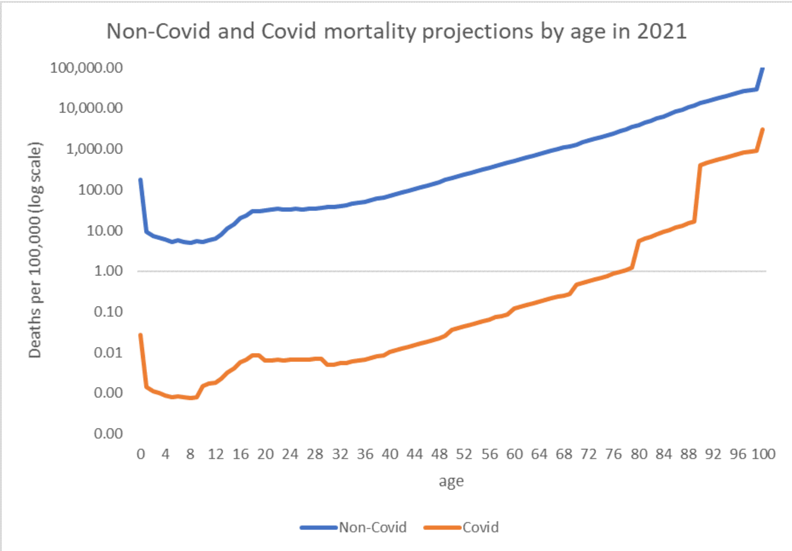


**Figure 1.** Non-COVID-19 and COVID-19 death projections by age for the year 2021.

As Figure 1 shows, the number of deaths from COVID-19 proportionally follows the trend in mortality for all causes of deaths, except for older ages where the proportion of deaths appears higher. This suggests a relationship between age and mortality from COVID-19, with a mortality shock currently present.

### 3.2. Financial Scenario

We estimate the Vasicek model parameters $\alpha$, $\beta$, and $\sigma$ using EURO SWAP maturing at one year (1Y) and ten years (Y10) from 31 January 2005 to 31 December 2020.[4] Figure 2 shows both the Y1 and Y10 EURO SWAP time series.

Figure 2 shows a generalised reduction in interest rates. The decreasing trend affects the values of the simulated interest rate structures using both the annuity instalments variation and the discounted cash flows best estimate. The Vasicek parameters are shown in Table 1.

As Table 1 shows, the parameter $\alpha$ is very close to zero, suggesting a strong persistence in the time series, as also observed in Figure 2, with no strong fluctuations with respect to the decreasing trend. The parameter $\beta$ is estimated at around 1.20%, being affected by a period in which rates even exceeded 3% (up to 2009) and the most recent periods of negative rates (from 2016). The parameter $\sigma$ is 0.48 suggesting quite high volatility. Therefore, according to the estimated model, a divergent trend from the mean is expected, consistent with the most recent time interval in which rates are downward and continue to decrease with non-negligible volatility.

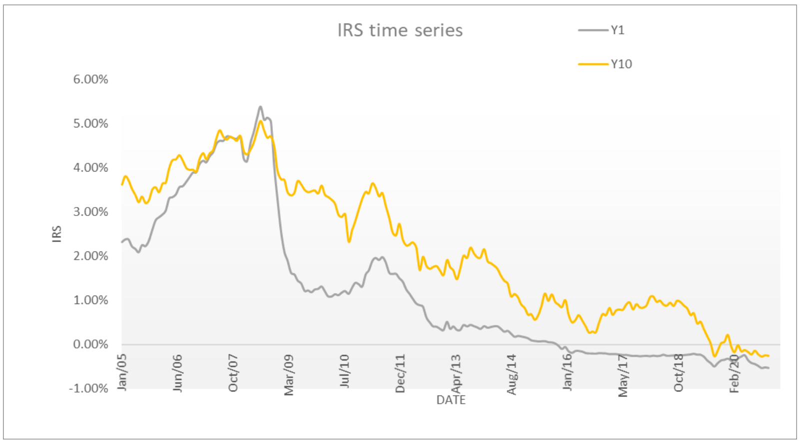


**Figure 2.** Y1 and Y10 EURO SWAP time series from 31 January 2005 to 31 December 2020.

**Table 1.** Vasicek parameters estimation using the Y1 and Y10 EURO SWAP time series.

| Parameter | Estimation |
|---|---|
| $\alpha$ | 0.00069 |
| $\beta$ | 1.20514 |
| $\sigma$ | 0.48054 |

### *3.3. Cash Flow Analysis*

We perform the cash flow analysis considering the conditions shown in Table 2. Important to note is that the A62I unisex table with 50% male and 50% females is the most used by insurance companies for annuity contracts.

**Table 2.** Cash flow analysis variables.

| Variable | Notation | Values |
|---|---|---|
| Contract years | $k$ | 2022, 2024, 2026, 2032 |
| Policyholder ages | $x$ | 20, 40, 60 |
| Mortality table | $l_x$ | A62I unisex with 50% male and 50% female |
| Initial annual instalment | $R_0$ | EUR 1000 |
| Technical rate | $i$ | 0% |
| Guaranteed minimum rate | $m_g$ | 0% |
| Retained rate | $m_t$ | 1% |
| Loading rate for instalment payment | $\alpha$ | 1.50% |
| Loading rate for administrative costs | $\beta$ | 5% |
| Annual management costs at time $t$ | | EUR 0.50 |
| Annual inflation of management costs | | 2% |
| Cost of capital increasing rate | $\partial$ | 1.00 |
| Cost of capital rate | $C$ | 6% |

Using these data, the segregated fund return rate is simulated based on a zero-coupon-bond forward rate at one year for the period 2022 to 2142 for a total 1000 scenarios.

Tables 3 and Tables 5–7 show the effects of COVID-19 acceleration, comparing (for an immediate annuity contract for policyholders of age $x$ = 20, 40, and 60), the pure premium ($PT$), the best estimate of liability ($BE$), the solvency capital requirement ($SCR$), the cost of capital ($CoC$), the expected value of the profit ($E(U)$), and the $RORAC$. Table 3 relates to an annuity contract signed in 2022.

**Table 3.** Effects of COVID-19 for an annuity contract signed in 2022.

| Year<br>Demographic Table<br>Individual Age | 2022<br>Base<br>20 | 2022<br>Base<br>40 | 2022<br>Base<br>60 | 2022<br>Accelerated<br>20 | 2022<br>Accelerated<br>40 | 2022<br>Accelerated<br>60 | 2022<br>Difference<br>20 | 2022<br>Difference<br>40 | 2022<br>Difference<br>60 |
|---|---|---|---|---|---|---|---|---|---|
| $PT$ | 73,064 | 52,302 | 31,917 | 73,064 | 52,302 | 31,971 | 0 | 0 | 0 |
| $BE$ | 65,844 | 44,896 | 25,806 | 66,767 | 44,822 | 25,735 | −77 | −74 | −71 |
| $SCR$ | 5867 | 3433 | 2475 | 5792 | 3416 | 2451 | −75 | −17 | −24 |
| $CoC$ | 11,584 | 4886 | 2465 | 11,516 | 4852 | 2178 | −68 | −34 | −287 |
| $E(U)$ | −4364 | 2521 | 3646 | −4219 | 2628 | 4004 | 145 | 107 | 358 |
| $E(U)/PT$ | −6.0% | 4.8% | 11.4% | −5.8% | −5.0% | −12.5% | 0.2% | 0.2% | 1.1% |
| $RORAC = E(U)/SCR$ | −74.4% | 73.4% | 147.3% | −72.8% | 76.9% | 163.4% | 1.5% | 3.5% | 16.1% |

As Table 3 shows, for policyholders aged 20, the contract is at a loss even without COVID-19 acceleration. This is due to the technical basis used to determine the expenses loaded premium, already inadequate to determine future longevity of the age considered. Furthermore, the $RORAC$ is negative, and the mortality increase due to COVID-19 determines an increment of only 1.5%. For the year 2022, the pandemic acceleration causes an increase in profitability at most equal to 16.1% of $RORAC$. Furthermore, for ages 40 and 60, there is a huge profit for the insurance company even without considering the effects of the pandemic on mortality.

We further explore the profitability of annuity contracts in Table 4 showing the annual cash flows for the three ages considered for one hundred years forward, comparing the baseline mortality table, ignoring the pandemic effects, and the accelerated mortality table.

**Table 4.** Cash flow analysis for one hundred years forward.

| t | Base 20 | Accelerated 20 | Base 40 | Accelerated 40 | Base 60 | Accelerated 60 |
|---|---|---|---|---|---|---|
| 1 | 1051 | 1051 | 1050 | 1050 | 1046 | 1046 |
| 2 | 1051 | 1051 | 1050 | 1050 | 1041 | 1041 |
| 3 | 1052 | 1052 | 1051 | 1051 | 1036 | 1036 |
| 4 | 1053 | 1053 | 1051 | 1051 | 1030 | 1030 |
| 5 | 1054 | 1054 | 1051 | 1051 | 1023 | 1023 |
| 6 | 1054 | 1054 | 1051 | 1051 | 1016 | 1016 |
| 7 | 1055 | 1055 | 1051 | 1051 | 1008 | 1008 |
| 8 | 1056 | 1056 | 1050 | 1050 | 1000 | 1000 |
| 9 | 1057 | 1057 | 1050 | 1050 | 990 | 990 |
| 10 | 1057 | 1058 | 1049 | 1049 | 980 | 979 |
| 11 | 1058 | 1059 | 1049 | 1049 | 969 | 968 |
| 12 | 1059 | 1060 | 1048 | 1048 | 956 | 956 |
| 13 | 1060 | 1061 | 1047 | 1047 | 943 | 942 |
| 14 | 1061 | 1062 | 1046 | 1046 | 928 | 927 |
| 15 | 1062 | 1063 | 1045 | 1045 | 911 | 910 |
| 16 | 1063 | 1064 | 1043 | 1043 | 893 | 892 |
| 17 | 1063 | 1066 | 1041 | 1041 | 873 | 871 |
| 18 | 1064 | 1067 | 1039 | 1039 | 851 | 849 |
| 19 | 1065 | 1068 | 1036 | 1036 | 827 | 825 |
| 20 | 1066 | 1069 | 1033 | 1033 | 800 | 797 |
| 30 | 1070 | 1080 | 975 | 975 | 387 | 372 |
| 40 | 1056 | 1077 | 806 | 805 | 36 | 34 |
| 50 | 997 | 1029 | 395 | 383 | 19 | 17 |
| 70 | 401 | 416 | 19 | 19 | 0 | 0 |
| 90 | 20 | 21 | 0 | 0 | 0 | 0 |
| 100 | 0 | 0 | 0 | 0 | 0 | 0 |

As Table 4 for all ages, the expected cash flows for the baseline scenario and the accelerated scenario are similar, showing some differences only for very large values of $t$ that do not affect the value of $BE$. Furthermore, no particular differences emerge when comparing the $BE$ distributions by age and mortality basis. The results are shown in Figures 3–5. Therefore, both in terms of expected values and variability, cash flows and $BE$s are little affected by the mortality shock due to COVID-19.

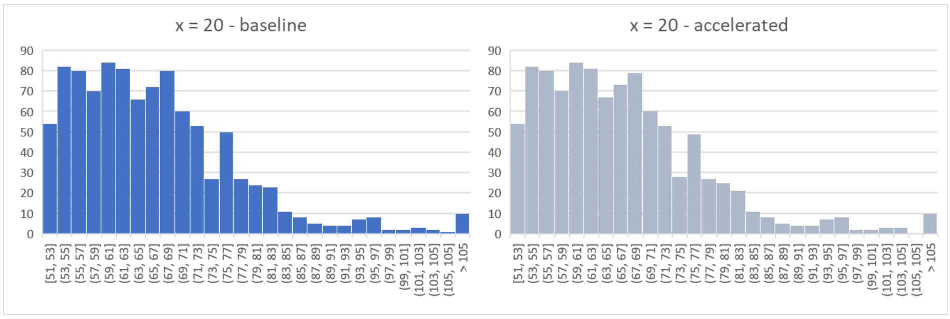


**Figure 3.** $BE$ distribution for the baseline and accelerated mortality tables for age 20 (EUR/thousands).

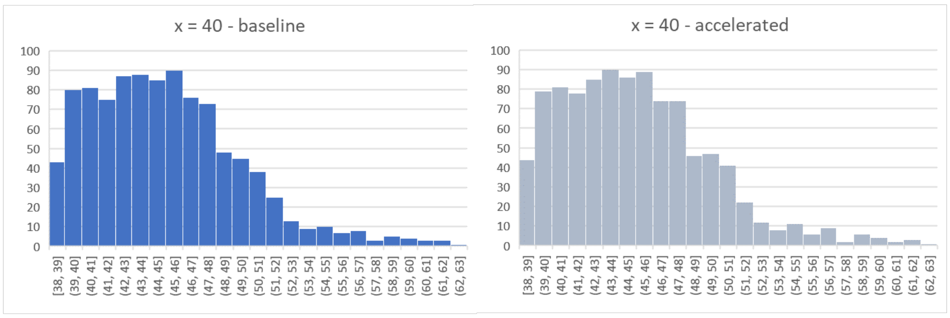


**Figure 4.** $BE$ distribution for baseline and accelerated mortality tables for age 40 (EUR/thousands).

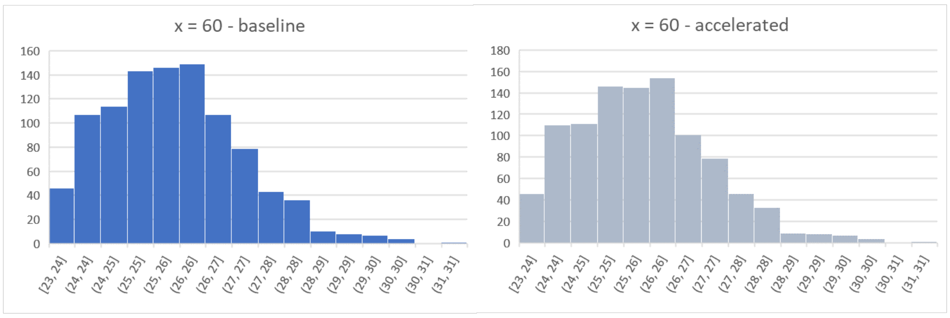


**Figure 5.** $BE$ distribution for baseline and accelerated mortality tables for age 60 (EUR/thousands).

Table 5 shows the results of an annuity contract signed on 1 January 2024.

**Table 5.** Effects of COVID-19 for an annuity contract signed in 2024.

| **Year<br>Demographic Table<br>Individual Age** | **2024<br>Base<br>20** | **2024<br>Base<br>40** | **2024<br>Base<br>60** | **2024<br>Accelerated<br>20** | **2024<br>Accelerated<br>40** | **2024<br>Accelerated<br>60** | **2024<br>Difference<br>20** | **2024<br>Difference<br>40** | **2024<br>Difference<br>60** |
|---|---|---|---|---|---|---|---|---|---|
| $PT$ | 73,063.66 | 52,302.43 | 31,916.68 | 73,063.66 | 52,302.43 | 31,916.68 | 0.00 | 0.00 | 0.00 |
| $BE$ | 66,473.08 | 45,310.30 | 26,085.22 | 66,391.41 | 45,233.16 | 26,011.08 | −81.67 | −77.15 | −74.15 |
| $SCR$ | 5967.65 | 3473.89 | 2496.08 | 5892.18 | 3456.21 | 2471.78 | −75.47 | −17.68 | −24.30 |
| $CoC$ | 11,828.06 | 4971.35 | 2233.67 | 11,757.23 | 4936.24 | 2213.17 | −70.84 | −35.11 | −20.49 |
| $E(U)$ | −5237.49 | 2020.77 | 3597.79 | −5084.98 | 2133.03 | 3692.43 | 152.51 | 112.26 | 94.64 |
| $E(U)/PT$ | −7.2% | 3.9% | 11.3% | −7.0% | 4.1% | 11.6% | 0.2% | 0.2% | 0.3% |
| $RORAC = E(U)/SCR$ | −87.8% | 58.2% | 144.1% | −86.3% | 61.7% | −149.4% | 1.5% | 3.5% | 5.2% |

As Table 5 shows, not all the contracts are in profit. For policyholders aged 20, the insurance company is at loss, with $RORAC$ −87.8%, and the adjustment of the tables to the effects of COVID-19 allows partial recovery only at 1.5%. For policyholders aged 40 and 60, the contract always has positive expected profitability both with and without the COVID-19 acceleration adjustment. In summary, for an annuity contract signed in 2024, the COVID-19 acceleration allows increasing profitability by only 5.2% of $RORAC$ for a policyholder age 60. Conversely, with very young policyholders, it does not allow full recovery of the loss due to the increase in longevity from 2022 to 2024.

Table 6 shows the effects of COVID-19 for an annuity contract signed on 1 January 2026.

**Table 6.** Effects of COVID-19 for an annuity contract signed in 2026.

| Year<br>Demographic Table<br>Individual Age | 2026<br>Base<br>20 | 2026<br>Base<br>40 | 2026<br>Base<br>60 | 2026<br>Accelerated<br>20 | 2026<br>Accelerated<br>40 | 2026<br>Accelerated<br>60 | 2026<br>Difference<br>20 | 2026<br>Difference<br>40 | 2026<br>Difference<br>60 |
|---|---|---|---|---|---|---|---|---|---|
| $PT$ | 73,063.66 | 52,302.43 | 31,916.68 | 73,063.66 | 52,302.43 | 31,916.68 | 0.00 | 0.00 | 0.00 |
| $BE$ | 67,114.49 | 45,732.18 | 26,368.39 | 67,028.23 | 45,651.28 | 26,290.94 | −86.25 | −80.90 | −77.45 |
| $SCR$ | 6070.58 | 3515.85 | 2517.68 | 5994.27 | 3497.69 | 2493.14 | −76.31 | −18.17 | −24.54 |
| $CoC$ | 12077.99 | 5058.48 | 2270.46 | 12003.72 | 5022.09 | 2249.39 | −74.27 | −36.40 | −21.07 |
| $E(U)$ | −6128.82 | 1511.77 | 3277.82 | −5968.30 | 1629.07 | 3376.35 | 160.52 | 117.30 | 98.52 |
| $E(U)/PT$ | −8.4% | 2.9% | 10.3% | −8.2% | 3.1% | 10.6% | 0.2% | 0.2% | 0.3% |
| $RORAC = E(U)/SCR$ | −101.0% | 43.0% | 130.2% | −99.6% | 46.6% | 135.4% | 1.4% | 3.6% | 5.2% |

As Table 6 shows, for a policyholder aged 20, the insurance company is at loss with huge negative $RORAC$ −101.0%, which reduces only to −99.6% considering the COVID-19 effects. Contracts with policyholders aged at least 40 maintain reduced profitability compared to the previous two years but are still satisfactory, even more so considering an increase in $RORAC$ with acceleration due to COVID-19 of at least 3.6%. In summary, considering the data relating to the year 2026, the acceleration of mortality due to COVID-19 entails a negligible increase in profitability compared to the increase in longevity from the year 2022 to the year 2026.

Table 7 shows the results for an annuity contract signed on 1 January 2032.

**Table 7.** Effects of COVID-19 for an annuity contract signed in 2032.

| Year<br>Demographic Table<br>Individual Age | 2032<br>Base<br>20 | 2032<br>Base<br>40 | 2032<br>Base<br>60 | 2032<br>Accelerated<br>20 | 2032<br>Accelerated<br>40 | 2032<br>Accelerated<br>60 | 2032<br>Difference<br>20 | 2032<br>Difference<br>40 | 2032<br>Difference<br>60 |
|---|---|---|---|---|---|---|---|---|---|
| $PT$ | 73,063.66 | 52,302.43 | 31,916.68 | 73,063.66 | 52,302.43 | 31,916.68 | 0.00 | 0.00 | 0.00 |
| $BE$ | 69,134.24 | 47,057.37 | 27,254.28 | 69,033.10 | 46,964.43 | 27,166.33 | −101.14 | −92.94 | −87.95 |
| $SCR$ | 6395.46 | 3648.20 | 2585.94 | 6316.43 | 3628.56 | 2560.78 | −79.03 | −19.64 | −25.16 |
| $CoC$ | 12867.52 | 5332.32 | 2385.92 | 12782.22 | 5291.93 | 2363.12 | −85.29 | −40.39 | −22.80 |
| $E(U)$ | −8938.10 | −87.26 | 2276.48 | −8751.67 | 46.07 | 2387.24 | 186.43 | 133.32 | 110.76 |
| $E(U)/PT$ | −12.2% | −0.2% | 7.1% | −12.0% | 0.1% | 7.5% | 0.3% | 0.3% | 0.3% |
| $RORAC = E(U)/SCR$ | −139.8% | −2.4% | 88.0% | −138.6% | 1.3% | 93.2% | 1.2% | 3.7% | 5.2% |

As Table 7 shows, for policyholders aged 20, the insurance company is heavily at loss with a reduction in $RORAC$ compared to the previous decade (2022) equal to 65%. For all the ages considered in the year 2032, the acceleration of mortality due to Covd-19 entails a negligible increase in profitability compared to the increase in longevity from the year 2022 to the year 2032. Considering a balanced portfolio in terms of the age of policyholders, the empirical evidence suggests that in 2032, insurance companies need to update the currently used A62I mortality table.

*3.4. Focus on Profitability*

Figures 6–8 show the *RORAC* indicator trend by year for the three ages considered. To note is that for all ages analysed, the impact of COVID-19 is very modest and decreases over the years, except for policyholders aged 60, for which in 2022 the impact of COVID-19 determines a consistent reduction in *RORAC*. In addition, as noted in Tables 3 and 5–7, for all three ages considered, the *RORAC* trend decreases with significant variations over the years. This trend confirms the significant weight of the longevity risk in the management of annuities.

Furthermore, looking more deeply at the longevity risk and how much it can affect profitability, the distributions of expected profit and *RORAC* for the year 2022 shown in Figures 9–11 indicate high variability of profit and consequently *RORAC* in all scenarios considered and for all ages:

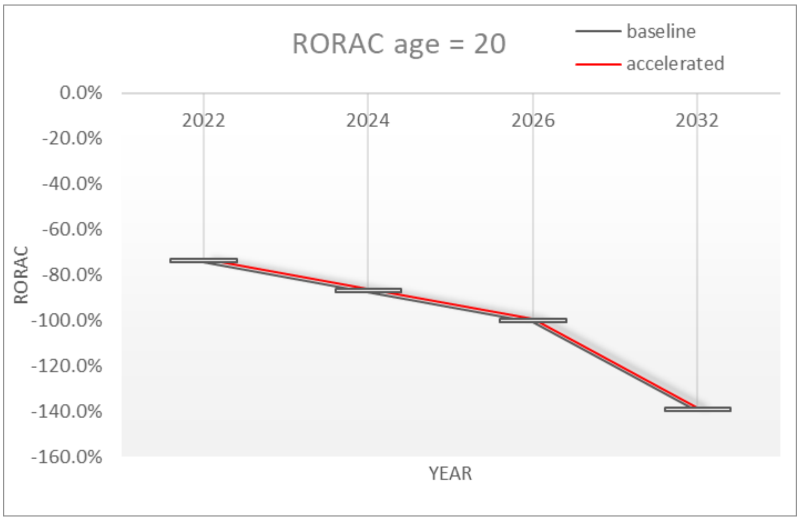


**Figure 6.** *RORAC* by year for a policyholder aged 20.

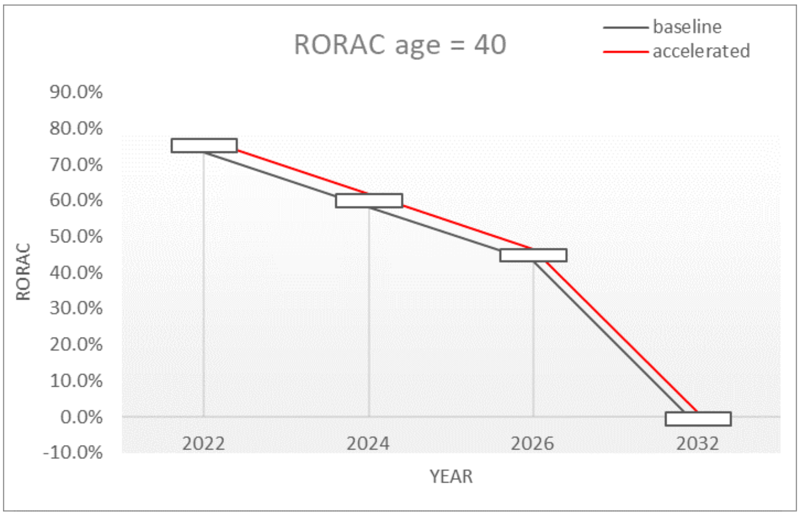


**Figure 7.** *RORAC* by year for a policyholder aged 40.

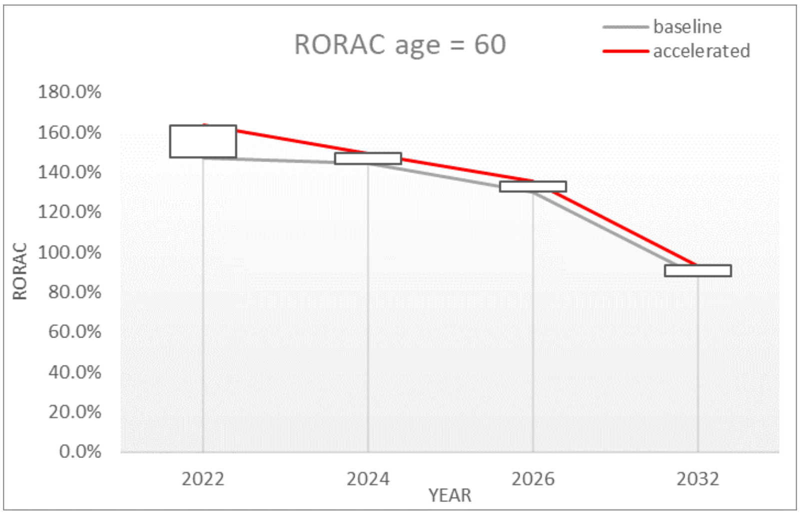


**Figure 8.** *RORAC* by year for a policyholder aged 60.

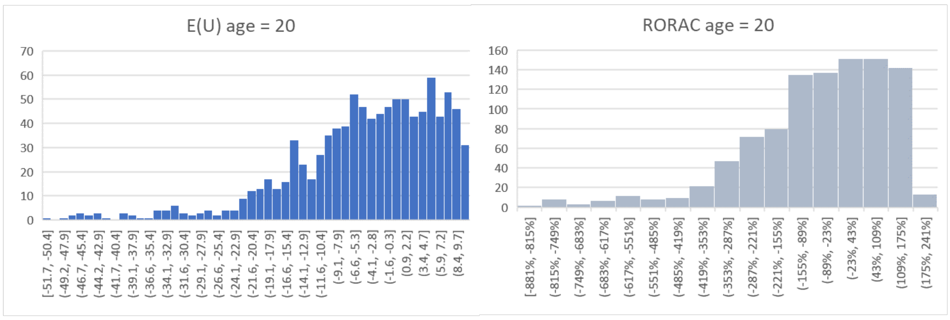


**Figure 9.** Expected profit and *RORAC* distributions for a policyholder aged 20.

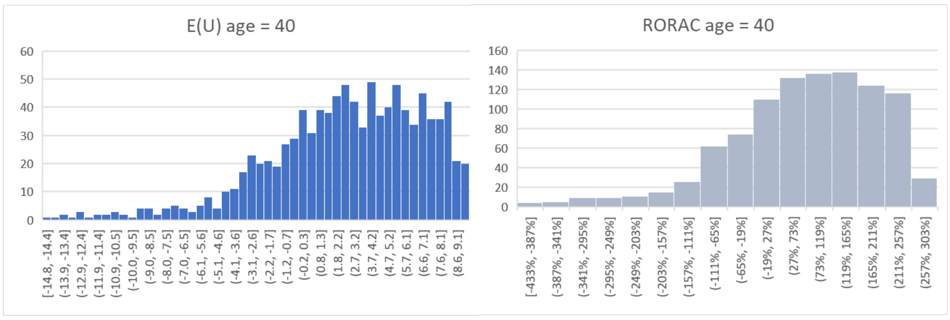


**Figure 10.** Expected profit and *RORAC* distributions for a policyholder aged 40.

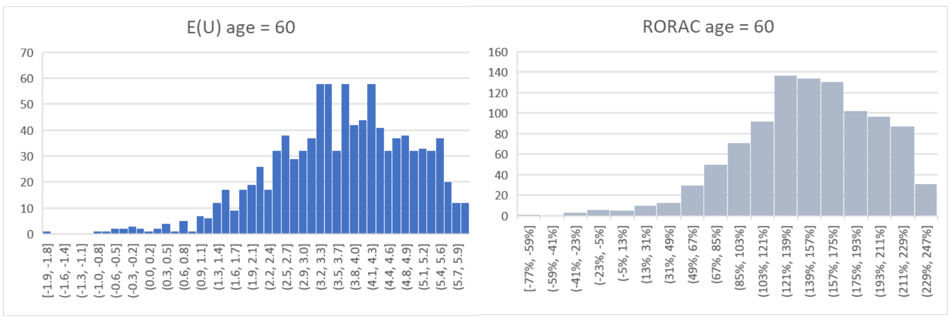


**Figure 11.** Expected profit and *RORAC* distributions for a policyholder aged 60.

Estimating the expected profit and relative distribution, we obtain the probability of a negative profit, which could prove very useful to understand that even in the presence of a positive profit value, the risk of obtaining a negative result could be high. For example, taking into account the 2022 contracts, the probability of a negative profit is equal to 0.596 for policyholders at age 20, 0.253 at age 40, and 0.012 at age 60. Therefore, while for policyholders aged 60 the probability of obtaining a negative result is negligible, for policyholders aged 40, despite a very positive value of profit and $RORAC$, this probability is to be taken into account and confirms the importance of a good pricing and longevity risk monitoring system.

### *3.5. Discussion*

The analysis of profitability is of great practical and policy value to study how the pandemic affects the insurance market. In particular, the study provides useful indications we can re-formulate as valuable recommendations. In order to increase the resilience of the life insurance business to the COVID-19 pandemic, proactive risk management is required. We suggest taking into account the profitability in the long run by implementing prompt premium adjustments. Due to the long-run dynamics of the mortality characterised by a decreasing effect of the COVID-19 acceleration, accurate safety loadings are necessary to guarantee stability for the insurance industry. In order to evaluate the effects of the acceleration of mortality in the life insurance business, we initially define a framework to operate. In this sense, we analyse the demographic scenario, which shows a greater acceleration of mortality due to COVID-19 for older ages, and the financial scenario, which shows that interest rates tend to decrease in the long term with a certain volatility. The two scenarios make it possible to define the contractual conditions of the immediate annuities for which the cash flow and profitability from 2022 to 2032 are analysed. With regard to cash flow, it is observed that the acceleration in mortality does not generate large differences, with the exception of the older ages and considering a rather long period of time. Regarding profitability, it is noted that age and time are the determining factors to be taken into consideration. In particular, if we consider a short time horizon, adapting the mortality tables to the acceleration from COVID-19 allows obtaining greater profitability for the older ages, while it does not allow to remedy the inadequacy of the tables themselves for the older ages, recording a loss. Similarly, the broader the time horizon, the lower the margin obtained from the use of tables that take acceleration into account while the improvement in longevity tapers the margin more and more, increasing the losses for the younger age and also recording losses for the middle ages. In accordance with our results, Harris et al. (2021) observe an adjustment in life insurance market profitability in presence of some particular health condition or old age, although to a limited extent.

## 4. Concluding Remarks

The pandemic phenomenon has a non-material impact on the profitability of annuity contracts as it has an instant impact since in a pandemic event there is an increase in mortality only in the first years of the contract and therefore for medium and long-term contracts such as annuities, post-shock mortality quickly tends to mortality without considering the COVID-19 effect.

Therefore, for these contracts, with medium and long durations, this effect with an accidental and unsystematic nature leads to non-material increases in profitability with respect to the same contracts without COVID-19 effects with the same contractual conditions.

On the other hand, as regards the opposite phenomenon, that is the longevity risk, it is a systematic risk that has a material impact over the entire duration of the contract and for such contracts, with medium or long durations, this risk is significant. In fact, if we consider a contract with a very young insured, for example with age $x = 20$, we always have negative returns that increase in material measure passing from the marketing year 2022 to the year 2032 or to the year 2042. For example if we consider the RORAC for $x = 20$

passing from the year 2022 to 2024 we have a contract always with negative profitability and a loss of RORAC without the COVID-19 effect equal to 13.4% while with the COVID-19 effect this loss of RORAC is equal to 13.5%. If we consider the year 2026 the differences become even more significant, in fact without the COVID-19 effect there is a loss of RORAC equal to 26.6% while with the COVID-19 effect this loss is equal to 26.8%.

Therefore, we can conclude that in just two calendar years, the longevity risk and therefore the increase in the life expectancy of the insured lead to an increase in losses for the insurer of approximately 13% while considering four years this increase in loss exceeds 26%.

These conclusions are also fully consistent with the same ones in the paper by Carannante et al. (2021c) in which the authors analyse a pure mortality risk insurance product such as term insurance which cover the opposite risk compared to those of annuities.

Even for these contracts, the acceleration of mortality from COVID-19 would lead to price increases with the same profitability always lower than 0.5%.

Besides in the paper we show that COVID-19 would bring material increases in profitability for insurance companies only in the case of old insureds, in fact for instance if we consider in the commercial year 2022 an insured 60 years old we have, after COVID-19 mortality shock, a RORAC increase equal to 16%, but in our opinion, this case is not real because if we analyse a real new business Italian insurance portfolio the majority of the insured are younger than 50 years old. We conclude that from a theoretical point of view the COVID-19 phenomenon has brought benefits to insurers for non-young policyholders but from a real point of view given the real age of the policyholders of annuity insurance portfolios, the profit margins are not material.

Therefore, the study confirms that it is much more important how the estimated trend of post-COVID-19 mortality realigns to what was predicted in the ante-COVID-19 situation, rather than the shock level recorded in a very short period (1–2 years), i.e., during the pandemic.

The effects of COVID-19 are expected to continue hitting some property-casualty lines harder than others. Nevertheless, pension schemes and annuity portfolios are also exposed to the aftermath of the pandemic. According to Deloitte (2021), the growth and profitability in annuities and many non-term life insurance products will likely be impacted throughout 2021 and beyond with persistently low interest rates. The profitability of life offices also seems to be threatened by the temporary shock of mortality.

In light of these considerations, our paper explores how the COVID-19 pandemic mortality shock might affect the profitability of insurance companies considering immediate annuity contracts, as well as the financial and actuarial aspects. Unlike the commonly assumed post-pandemic effects, COVID-19 mortality acceleration did not and will not bring insurance companies a huge increase in annuity contract profitability, considering a risk portfolio with different ages.

On the other hand, the increasing longevity issue will remain the main problem over the years and will lead insurance companies to adjust their mortality tables with a frequency that never exceeds five years, particularly if the portfolio is composed of a rather low mean policyholder age (see Supplementary Materials).

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/10.3390/risks10020040/s1.

**Author Contributions:** Conceptualization, V.D. and S.F.; methodology, S.F. and P.F.; software, G.M. and M.C.; validation, V.D. and M.C.; formal analysis, S.F., G.M.; data curation, M.C. and G.M.; writing—original draft preparation, S.F. and V.D.; writing—review and editing, M.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding

**Data Availability Statement:** Publicly available datasets were analysed in this study. Human Mortality Database data can be found here: https://www.mortality.org/, accessed on 28 September 2021. Euroswap data can be found here: https://www.eurex.com/ex-en/markets/int/eur-swap/eur-swap-fut/, accessed on 25 September 2021.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Notes

[1] https://www.mortality.org/, accessed on 28 September 2021.

[2] https://www.epicentro.iss.it/coronavirus/sars-cov-2-decessi-italia, accessed on 5 October 2021.

[3] https://www.istat.it/it/archivio/240401, accessed on 5 October 2021.

[4] https://www.eurex.com/ex-en/, accessed on 25 September 2021.

## References


Andersson, Patrik, and Mathias Lindholm. 2021. A Note on Pandemic Mortality Rates. Available online: https://ssrn.com/abstract=38058811 (accessed on 11 October 2021).

Bacinello, Anna Rita. 2001. Fair pricing of life insurance participating policies with a minimum interest rate guaranteed. *ASTIN Bulletin* 31: 275–97. [CrossRef]

Bacinello, Anna Rita. 2003a. Fair valuation of a guaranteed life insurance participating contract embedding a surrender option. *The Journal of Risk and Insurance* 70: 461–87. [CrossRef]

Bacinello, Anna Rita. 2003b. Pricing guaranteed life insurance participating policies with annual premiums and surrender option. *North American Actuarial Journal* 7: 1–17. [CrossRef]

Bryan, Ana Ferguson, and Thomas C. Tsai. 2021. Health Insurance Profitability during the COVID-19 Pandemic. *Annals of Surgery* 273: 88–90. [CrossRef] [PubMed]

Cairns, Andrew J. G., David Blake, Amy R. Kessler, and Marsha Kessler. 2020. *The Impact of COVID-19 on Future Higher-Age Mortality*. London: Pensions Institute. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract$_$id=3606988 (accessed on 11 October 2021).

Carannante, Maria, Valeria D'Amato, and Guido Iaccarino. 2021a. Stochastic Charlson Comorbidity Index: A projection of the mortality acceleration due to the COVID-19. *Statistics in Medicine. under review*.

Carannante, Maria, Valeria D'Amato, and Steven Haberman. 2021b. COVID-19 accelerated mortality shocks and the impact on life insurance: The Italian situation. *Annals of Actuarial Science. under review*.

Carannante, Maria, Valeria D'Amato, Paola Fersini, and Salvatore Forte. 2021c. Gli effetti della pandemia COVID-19 sulla popolazione italiana e sul pricing dei prodotti assicurativi di puro rischio. In *Diritto Economia e Società dopo la pandemia*. Edited by D'Ambrosio I. and Palumbo P. Naplesm. Napoli: Edizione Scientifica, pp. 19–29.

Deloitte. 2021. Insurance Industry Outlook. Deloitte Insights. Available online: https://www2.deloitte.com/us/en/insights/industry/financial-services/financial-services-industry-outlooks/insurance-industry-outlook.html (accessed on 11 October 2021).

ECB. 2021. The role of financial stability considerations in monetary policy and the interaction with macroprudential policy in the euro area. *Occasional Paper Series 272*. Available online: https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op272~dd8168a8cc.en.pdf (accessed on 14 December 2021).

EIOPA. 2014. Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 Supplementing Directive 2009/138/EC of the European Parliament and of the Council on the Taking-up and Pursuit of the Business of Insurance and Reinsurance (Solvency II). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R0035$&$from=EN (accessed on 11 October 2021).

EIOPA. 2020a. EIOPA's Response to the Coronavirus Crisis. Available online: https://www.eiopa.europa.eu/content/eiopas-responsecoronavirus-crisis$_$en (accessed on 20 December 2021).

EIOPA. 2020b. European Insurers Face Increased Risk Exposures Due to COVID-19, but Market Perceptions and Imbalances Remained at Medium Level. Available online: https://www.eiopa.europa.eu/content/european-insurers-face-increased-risk-exposuresdue-covid-19-market-perceptions-and$_$en (accessed on 20 December 2021).

Farooq, Umar, Nasir Adeel, Bilal, and Muhammad Umer Quddoos. 2021. The impact of COVID-19 pandemic on abnormal returns of insurance firms: A cross-country evidence. *Applied Economics* 53: 3658–78. [CrossRef]

Gründl, Helmut, Danjela Guxha, Anastasia Kartasheva, and Hato Schmeiser. 2020. Insurability of pandemic risks. *Journal of Risk and Insurance* 88: 863–902. [CrossRef]

Harris, Timothy F., Aaron Yelowitz, and Charles Courtemanche. 2021. Did COVID-19 change life insurance offerings? *Journal of Risk and Insurance* 88: 831–61 [CrossRef] [PubMed]

Karlsson, Fredrik. 2020. Time for a Rethink? The Insurance Industry Faces up to COVID-19. Available online: https://latinlawyer.com/article/1225838/time-for-a-rethink-the-insurance-industry-faces-up-to-covid-19 (accessed on 20 December 2021).

Marsh. 2021. COVID-19: Considerations for the Insurance Industry. Available online: https://www.marsh.com/uk/risks/pandemic/insights/covid-19-considerations-for-insurance-industry.html (accessed on 11 October 2021).

Milesky, Moshe A. 2021. Is COVID-19 a Parallel Shock to the Term Structure of Mortality? Is COVID-19 a Parallel Shock to the Term Structure of Mortality? With Applications to Annuity Valuation. Available online: moshemilevsky.com (accessed on 11 October 2021).

Moody's Analytics. 2020. EIOPA Risk Assessment Shows Increase in Credit and Market Risks. Available online: https://www.moodysanalytics.com/regulatory-news/May-18-20-EIOPA-Risk-Assessment-Shows-Increase-in-Credit-and-Market-Risks (accessed on 20 December 2021)

Nguyen, Duc Khuong, and Dinn-Tri Vo. 2020. Enterprise Risk Management and Solvency: The Case of the Listed EU Insurers. *Journal of Business Research* 113: 360–69. [CrossRef]

Olivieri, Annamaria, and Ermanno Pitacco. 2015. *Introduction to Insurance Mathematics. Technical and Financial Features of Risk Transfers*, 2nd ed. EAA Series. Cham: Springer Nature.

Pułanska, Karolina. 2021. Financial Stability of European Insurance Companies during the COVID-19 Pandemic. *Journal of Risk and Financial Management* 14: 266. [CrossRef]

Renshaw, Arthur, and Steven Haberman. 2003. Lee–Carter mortality forecasting: A parallel generalized linear modelling approach for England and Wales mortality projections. *Applied Statistics* 52: 119–37. [CrossRef]

Scism, Leslie. 2020. Less driving, fewer accidents: Car insurers give millions in coronavirus refunds. *The Wall Street Journal*. Available online: https://www.wsj.com/articles/car-insurer-american-family-gives-200-million-in-coronavirus-refundsas-accidents-decline-11586175602 (accessed on 20 December 2021).

Spiegelhalter, David. 2020. Use of "normal" risk to improve understanding of dangers of COVID-19. *BMJ* 370: 3259. [CrossRef]

Vasicek, Oldrich. 1977. An equilibrium characterization of the term structure. *Journal of Financial Economics* 5: 177–88. [CrossRef]

Wang, Yating, Donghao Zhang, Xiaoquan Wang, and Qiuyao Fu. 2020. How Does COVID-19 Affect China's Insurance Market? *Emerging Markets Finance and Trade* 56: 2350–62. [CrossRef]