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Multi-objective reference point techniques to optimize profitability, growth, and risk in the non-life insurance industry: international analysis

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Abstract

This paper combines reference point techniques and econometric analyses to provide the profile of non-life insurers that simultaneously optimize the strategic growth, profitability, and risk goals. The econometric analyses provide the relevant relations among the variables. Non-life insurers from 33 Organisation for Economic Co-operation and Development countries over a six-year period are analyzed. A cluster analysis allows forming groups of countries according to the non-life insurance penetration ratio. Several scenarios, which are characterized by the maturity of the market and the crisis/non-crisis situation, are studied. The results indicate that the highest level of profitability (growth) is linked to scenarios with a medium (low) level of maturity and booming times. They also show that the lowest level of risk that is representative of good performance is associated with scenarios where markets have a high level of maturity and crisis times. We find that a higher recommendable size is associated with more mature markets. The results also indicate that reinsurance utilization is linked to a crisis time. We additionally find that the recommendable level of capitalization differs significantly among scenarios.

Keywords: reference point techniques; operational research (OR) in insurance; non-life insurers; risk; profitability; growth; capitalization

1. Introduction

Profitability, growth, and risk are three main and interdependent goals whose management is of utmost importance for insurers. Profitability as a key measure of performance determines firms' ability to generate returns. Growth helps insurers establish a stronger market position (for instance, through scale economies), but its relationship with profitability is not always positive and

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may increase risk (see, e.g., Fields et al., 2012; Eling and Jia, 2019; González-Fernández et al., 2020). Soundness is a strategic goal that is particularly important in the insurance industry due to regulatory requirements and because consumers are sensitive to the risk of insurers.[1] Although the impact of risk on profitability tends to be positive (see, e.g., Eling et al., 2022), the literature shows that an interdependence among these three goals exists and constrains the optimization of all of them at the same time.

In addition to the interdependence among these three goals, two main issues emerge in this setting, particularly from the insurer management point of view. On the one hand, there are other insurers' decisions/characteristics that not only may affect these goals but also their effect on them could be in different and conflicting ways. On the other hand, the prioritization strategy of these goals may depend on exogenous determinants, such as country institutional features and the state of the market. It is argued that during economic crises, risks rise, and soundness may have a higher priority, while growth and profitability become more dominant in booming times (Eling et al., 2022). Regarding life cycle analysis, it is emphasized that many firms in emerging markets focus on growth (Berry-Stölzle et al., 2010), while profitability is more important in mature markets. Consequently, in order to find the right balance among profitability, growth, and risk, an optimization problem is posed comprising several conflicting aspects that call for a multi-objective programming approach.

To our knowledge, only the paper by Eling et al. (2022) simultaneously analyzes the interdependencies among growth, profitability, and risk in the insurance industry. They conduct an econometric analysis by using a simultaneous equation model (SEM) to study the association of these three goals. However, there are no studies that take into account both the trade-offs and interdependencies among these goals, as well as exogenous determinants—such as the level of maturity of the insurance market or macroeconomic determinants—that provide information about the profile of the insures that simultaneously optimize growth, profitability, and risk. We innovate by being the first to address this issue in the insurance industry, developing an empirical framework that combines econometric analysis with multi-objective reference point techniques.

We conduct an international analysis of non-life insurers from 33 Organisation for Economic Co-operation and Development (OECD) countries over the period 2011–2016. These countries differ in terms of macroeconomic conditions and in the maturity level of the non-life insurance market. Since, as stated above, this fact may condition the prioritization of these goals, we consider different scenarios defined by exogenous non-life insurance penetration ratio and Gross Domestic Product (GDP) per capita growth variables.[2] We first conduct an econometric analysis using both a SEM and a panel data model to provide the basis to characterize the objective functions and constraints of the multi-objective programing model. This combination of methodologies (econometric analysis and multi-objective programing models) has proven to be useful when not only the dependencies among the variables are of interest but also the definition of an optimal profile of the units analyzed, based on these dependencies (see, e.g., Marcenaro-Gutierrez, Luque and

[1]Insurer soundness is especially important not only because it protects policyholders by ensuring that the insurer will be able to meet its financial obligation in the future but also because it contributes to the stability of the financial systems. Failures of insurers affect financial and economic fragility (see, e.g., Das et al., 2003).

[2]Non-life insurance penetration ratio (calculated as non-life insurance premiums written to GDP) is a traditional measure of the maturity of the non-life insurance market in an economy. GDP per capita growth is frequently used to distinguish crisis and non-crisis times (see, e.g., González-Fernández et al., 2020).

Ruiz, 2010;, González-Fernández et al., 2020; González-Gallardo et al., 2021). The reference point approach (Wierzbicki, 1980) is used in this case, given its proven ability to generate efficient solutions. This multi-objective programing technique allows providing good compromise results for the profitability, growth, and risk goals under different scenarios defined by a cluster analysis. It also provides the profile (in terms of firm-decision variables) of the insurers that obtain these good results. This analysis is particularly useful for the insurers' managers' decision-making since the maximization of the firm value requires a balance between these three strategic goals. Besides, the study is also useful for regulators and policymakers because issues such as the recommendable level of capitalization under different scenarios are evaluated. The latter is an ongoing debate since the establishment of minimum capital requirements for individual insurers is probably the most widely implemented and discussed insurance regulatory tool.

A few papers can be found where multi-objective programming techniques are applied within the framework of the insurance industry.[3] However, there are no papers on the insurance industry involving econometric analysis and reference point techniques, together with the use of different scenarios.[4] Consequently, our paper mainly contributes to two strands of literature: to the operational research in insurance literature by being the first that combines, for the insurance industry, econometric and reference point methods to simultaneously optimize these goals; to the business and finance research by being the first that addresses the issue of investigating the profile of non-life insurers that optimize simultaneously growth, profitability, and risk, taking into account different scenarios defined by exogenous non-life penetration ratio and GDP per capita growth variables.

The remainder of the paper is organized as follows: Section 2 presents the background and literature review on the interactions between profitability, risk, and growth in the insurance industry; Section 3 explains the sample and the variables used in the analysis. The methodology and results are discussed in Section 4, and Section 5 concludes.

2. Background and literature review

Let us briefly outline the main findings in previous literature on the interactions between profitability, risk, and growth in the insurance industry. The literature shows that interactions exist among these three goals, but the way they influence each other is not conclusive.

[3]Specifically, goal programming (GP) has been applied to numerous settings and sectors. In the insurance sector, Gleason and Lilly (1977) develop a GP model for insurance agency decision-making, and Lawrence and Reeves (1982) present a zero-one GP model for capital budgeting in a property and liability insurance company. More recent studies, such as Aggarwal et al. (2017), use GP to solve a dynamic multi-objective linear integer programming model to optimally distribute an insurance Indian firm's advertising budget among five products. Gharakhani et al. (2018) use a GP approach to generate common weights in a data envelopment analysis model to measure efficiency scores of 30 non-life insurance companies in Iran. Using data from Turkey, Karagül (2018) constructs two different GP models for the non-life insurance sector to find an optimal solution with different goals for financial (e.g., return on assets) and technical (e.g., premiums growth rate) analysis. González-Fernández et al. (2020) develop a minmax GP model to define the profile of the most profitable Spanish non-life insurers, considering different scenarios. Natesan and Dutta (2021) use a logarithmic GP model and the conjoint analysis method to generate a linear utility with data from India.

[4]Nevertheless, Marcenaro-Gutierrez, Luque, and Ruiz (2010) and González-Gallardo et al. (2021) have used a similar procedure, applying econometric analysis and reference point methods to evaluate workers' satisfaction and students' well-being, respectively.

2.1. The effect of risk and growth on profitability

The Capital Asset Pricing Model assumes a linear positive relationship between risk and return (Sharpe, 1964). That is, riskier investments should be compensated by higher returns. However, if risk exceeds a certain threshold (when the risk endangers the investment-grade rating), the effect of risk on profitability may become negative (see, e.g., Wakker et al., 1997). Evidence in the insurance industry of the effect of risk on profitability is mixed. Fields et al. (2012) found that risk influenced positively the underwriting margin for an international sample of non-life insurers, but they found no effect of risk on profitability for an international sample of life insurers. González-Fernández et al. (2020) showed a positive effect of risk on investment returns for Spanish non-life insurers. Eling et al. (2022) showed that risk affected positively return on equity (ROE) in their analysis of European insurers. However, Eling and Jia (2019) found that risk affected negatively ROE in an international analysis of non-life insurers.

Growth can help firms to establish a stronger market position (for instance, through scale economies) and thus may increase profitability (Davidsson et al., 2009), but empirical evidence of the impact of growth on insurer profitability is ambiguous. Leverty and Grace (2010), for the U.S. property-liability insurance industry, or González-Fernández et al. (2020), for the Spanish non-life insurance industry, showed that growth does not affect profitability. Eling and Jia (2019) found that growth affected profitability negatively. Eling et al. (2022) found, for European insurers, that moderate firm growth increases profitability, but extremely high growth reduces it.

2.2. The effect of risk and profitability on growth

Since risk is consubstantial to an insurance firm, insurer growth is only possible when more risk is taken, and thus, the effect of risk on growth could be positive. However, high risk may adversely affect insurance demand and, consequently, influence growth negatively. Choi (2010) found that risk affected negatively growth for a sample of U.S. property-liability insurers. Eling et al. (2022) showed that risk negatively affected the growth of European non-life insurers but that risk did not affect the growth of European life insurers.

The effect of profitability on growth could be positive. That is, higher profits may provide both the means (greater availability of finance from retained profits or from capital market) and the incentive (at high rate of return) for new investment (Whittington, 1980). However, empirical evidence in the insurance industry of the effect of profitability on growth is also ambiguous. Hardwick and Adams (2002) found no significant influence on growth from profitability in the U.K. life insurance industry. Choi (2010) showed that profitability did not influence growth for the U.S. property-liability insurance industry. Eling et al. (2022) found that when profitability exceeded a certain threshold, it increased growth for European non-life insurers. However, they did not find that profitability affected the growth of European life insurers.

2.3. The effect of profitability and growth on risk

The predictions of prospect theory establish that the actual profitability of a firm influences its risk-taking decisions. Managers of firms with profits below a threshold (relatively unprofitable firms) seek higher risks in order to increase profitability by implementing corrective processes (Jegers, 1991). In this case, the impact of profitability on risk would be negative. The lower the profitability is, the more managers are willing to take risks. However, managers of firms with profits beyond a critical threshold (relatively profitable firms) tend to be risk-averse. That is, they only undertake risky decisions if they are rewarded with appropriate returns. In this case, the effect of profitability on risk would be positive (Fiegenbaum, 1990). Evidence of the impact of profitability on risk in the insurance industry is not conclusive. Fields et al. (2012) found that profitability has a positive effect on risk in their international analysis of life insurers. This finding is shown when risk is measured by the coefficient of variation of the natural log of the gross premiums written to surplus ratio, as well as when risk is measured by the coefficient of variation of the log of the capital to asset ratio. However, these authors found no effect of profitability on risk in their international analysis of non-life insurers. Nevertheless, Eling et al. (2022) showed that less profitable insurers were more willing to take risks.

The effect of growth on risk could be positive in the insurance industry. A rapid premium growth by, for instance, an aggressive sales strategy is usually seen as a cause of increased risk. This is because, among other reasons, rapid growth may increase the number of new businesses to the company, bringing additional risk sources (see, e.g., Barth and Eckles, 2009). However, for large-scale operations, growth makes risk pooling more effective (Cummins and Rubio-Misas, 2006). This could be due to the law of large numbers, and the potential risk diversification effect may stabilize underwriting results and reduce insurer risk. In this case, the effect of growth on risk would be negative. Some researchers have shown that growth increased insurer risk (e.g., Fields et al., 2012; Rubio-Misas and Fernández-Moreno, 2017), but others did not find any effect of growth on risk (e.g., Eling et al., 2022).

3. Data sources and variables definition

3.1. Data sources

Our sample consists of an unbalanced panel of non-life insurers from 33 OECD countries, spanning a period from 2011 to 2016.[5] We used annual financial statements to construct the relevant variables of interest per firm, which were obtained from the Orbis Insurance Focus dataset provided by Bureau van Dijk. We utilized reports prepared under International Financial Reporting Standards/International Accounting Standards where they existed. Otherwise, we used reports prepared under local generally accepted accounting principles. Unconsolidated data were used for unaffiliated single insurance companies, and consolidated data were used for groups of insurers. Unaffiliated insurers were linked to the country where they were domiciled. Groups of insurers were associated with the country where the group was domiciled, although a group may have subsidiaries domiciled in different countries from the group. Groups' subsidiaries were not included

[5]Countries included in the analysis are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. These countries belong to different regions (East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, and North America).

Table 1
Variable definitions and notations

Notation	Variable	Definition
	Dependent variables	
d_1	Profitability	Return on equity (ROE) defined as profit before taxes to equity capital
d_2	Growth	(Premiums at time t to premiums at time $t-1$) minus 1
d_3	Risk	Standard deviation of an insurer's ROE using a three-year rolling window
	Firm-decision variables	
f_1	Size $t-1$	Log of total assets in $t-1$
f_2	Capitalization	Equity capital to total assets
f_3	Reinsurance use	Ceded premiums to direct premiums plus reinsurance premiums assumed
	Exogenous variables (country variables)	
c_1	Industry profitability	Country-year median value of the firm profitability
c_2	Industry growth	Country-year median value of the firm premiums growth
c_3	Industry risk	Country-year median value of the firm risk
c_4	GDP per capita growth	GDP per capita growth (annual %)
c_5	Inflation	Inflation rate
c_6	Non-life penetration ratio	Non-life premiums written to GDP
c_7	Institutional development	An average of six governance indicators: (a) political stability and absence of violence; (b) government effectiveness; (c) regulatory quality; (d) rule of law; (e) voice and accountability; and (f) control of corruption

to avoid double counting. In addition, the final sample is a result of a series of screening tests. We eliminated non-viable firms, such as firms with non-positive equity capital or net premiums. The final sample includes a total of 18,819 firm-year observations. All monetary variables are expressed in millions of dollars and deflated by the country-specific Consumer Price Index to the base year 2011.

The country-level data were obtained from a variety of sources. Growth in real per capita GDP and inflation rates were sourced from the World Development Indicators. Non-life insurance penetration (the ratio of direct non-life insurance premiums to GDP) was provided by Sigma Swiss Re. The governance dimensions of the country were obtained from the updated World Bank database on governance indicators (Kaufmann et al., 2010).

3.2. Variables

The variables used in our models have been classified into two groups: dependent variables and explanatory variables, which are in turn divided into two sub-groups: firm-level variables and country-level variables (see Table 1). Let us describe them in further detail.

3.2.1. Dependent variables

The dependent variables we use in the econometric analysis are measured in the following way. We use ROE (calculated as profit before taxes to equity capital) as a measure of profitability (see, e.g., Shim, 2011). Growth is measured by premium growth, calculated as ([premiums at time t/premiums at time $t-1]-1$) (see, e.g., Cummins and Nini, 2002). Additionally, we use the standard deviation of an insurer's ROE σ_{ROE} as a measure of risk, where we use a three-year rolling window for σ_{ROE}.[6]

3.2.2. Explanatory variables

The explanatory variables utilized in the econometric analysis are grouped into decision variables and country variables. The decision variables we use are firm-level factors measuring size, capitalization, and reinsurance utilization that the literature has shown to influence profitability, growth, and risk. As a proxy of the size decision variable, we use the log of total assets (see, e.g., Cummins and Xie, 2013). Capitalization is calculated as equity capital to total assets (see, e.g., Cummins et al., 2017). Reinsurance utilization is measured as the ratio of ceded premiums to direct premiums plus reinsurance premiums assumed (see Weiss and Choi, 2008).

The country-level explanatory variables include market condition variables, two macroeconomic variables, a factor measuring the relative importance that non-life insurance has in each country and a variable capturing national institutional development. Market conditions are measured by the industry profitability, industry growth, and industry risk variables. They are accounted for by the country-year median values of the firm profitability, growth, and risk measures (Eling et al., 2022). The two variables for the main macroeconomic conditions under which the non-life insurers of each country are operating are the inflation rate and GDP per capita growth (Cummins and Rubio-Misas, 2021; Eling et al., 2022). The relative importance of non-life insurance in each national economy, as we explained before, is traditionally measured by the non-life insurance penetration ratio, calculated as non-life direct premium written to GDP. In addition, we have calculated a general institutional development indicator as an average of six governance indicators: (1) political stability and absence of violence, (2) government effectiveness, (3) regulatory quality, (4) rule of law, (5) voice and accountability, and (6) control of corruption (see Cummins et al., 2017; Rubio-Misas, 2020 for a similar procedure to calculate a general indicator of national institutional development). This governance indicator is measured in units ranging from about −2.5 to 2.5, with higher values corresponding to better governance outcomes.

3.2.3. Summary statistics

Table 2 presents descriptive statistics (mean, median, standard deviation, minimum, maximum) of the variables used in the analysis for the whole sample period.[7] The average ROE, premium growth, and σ_{ROE} were 0.082, 0.081, and 0.073, respectively. Table 3 shows the mean values per country of the national explanatory variables over the sample period. We observe ample heterogeneity among the countries included in the analysis with respect to them. Regarding the macroeconomic variables, the mean value of GDP per capita growth ranged from −3.34% in Greece to 5.80% in Ireland, while the mean value of inflation ranged from −0.378% in Switzerland to 7.86% in Turkey. Countries included in the analysis also differ in terms of the maturity of the non-life insurance market. The

[6] In other words, the standard deviation of the rate of returns on equity of one specific year (e.g., 2011) is calculated as the average of the three-year rolling values (2009–2011). Consequently, to calculate this firm-level variable, we have used data spanning the period 2009–2016.

[7] The firm-level data used in the analysis were winsorized at 5% and 95% level in order to prevent outliers from distorting the results (see, e.g., De Haan and Kakes, 2010; González-Fernández et al., 2020, for a similar procedure).

Table 2
Descriptive statistics. Non-life insurers 2011–2016

	Mean	Median	SD	Min	Max
Dependent variables					
Profitability	0.082	0.072	0.113	−0.239	0.363
Growth	0.081	0.061	0.182	−0.484	0.635
Risk	0.073	0.049	0.073	0.006	0.426
Explanatory variables					
Size t − 1	12.152	12.115	1.892	8.656	16.146
Capitalization	0.413	0.385	0.186	0.131	0.835
Reinsurance use	0.310	0.243	0.259	0.000	0.865
Industry profitability	0.082	0.087	0.032	−0.028	0.301
Industry growth	0.081	0.067	0.060	−0.249	0.323
Industry risk	0.073	0.071	0.021	0.013	0.215
GDP per capita growth	1.302	1.138	1.802	−8.998	23.986
Inflation	1.578	1.505	1.168	−1.736	8.892
Non-life penetration ratio	0.038	0.042	0.011	0.010	0.087
Institutional development	1.300	1.261	0.309	−0.462	1.873

Note: Descriptive statistics corresponding to all the firms in the sample.

mean value of the non-life insurance penetration ratio ranged from 1.1% in Latvia to 8.4% in the Netherlands. Last, we observe that the level of national institutional development differs among the countries of our sample. The mean value of the institutional quality indicator ranged from −0.192 in Mexico to 1.838 in New Zealand.

4. Methodology and results

4.1. Econometric analysis

We first conducted an econometric analysis to find the dependence of the variables profitability, growth, and risk with respect to the explanatory variables previously defined. Given the reciprocal relationship that may exist among the dependent variables, we specify a SEM as follows:

$$d_{1(h,t)} = \beta_{10} + \beta_{12} d_{2(h,t)} + \beta_{13} d_{3(h,t)} + \boldsymbol{\beta}_{14}\, \boldsymbol{Firm}_{(h,t)} + \boldsymbol{\beta}_{15}\, \boldsymbol{Country}_{(c,t)} + \omega_{(h,t)}, \tag{1}$$

$$d_{2(h,t)} = \beta_{20} + \beta_{21} d_{1(h,t)} + \beta_{23} d_{3(h,t)} + \boldsymbol{\beta}_{24}\, \boldsymbol{Firm}_{(h,t)} + \boldsymbol{\beta}_{25}\, \boldsymbol{Country}_{(c,t)} + \sigma_{(h,t)}, \tag{2}$$

$$d_{3(h,t)} = \beta_{30} + \beta_{31} d_{1(h,t)} + \beta_{32} d_{2(h,t)} + \boldsymbol{\beta}_{34}\, \boldsymbol{Firm}_{(h,t)} + \boldsymbol{\beta}_{35}\, \boldsymbol{Country}_{(c,t)} + \varepsilon_{(h,t)}, \tag{3}$$

where h, c, and t refer to firm, country, and year, respectively. $\boldsymbol{Firm}_{(h,t)} = (f_{1(h,t)}, f_{2(h,t)}, f_{3(h,t)})$ is a matrix of firm-level decision variables, $\boldsymbol{\beta}_{14} = (\beta_{141}, \beta_{142}, \beta_{143})$ is the corresponding vector of coefficients for Equation (1), and the same goes for the other two equations. Similarly, $\boldsymbol{Country}_{(c,t)} = (c_{1(c,t)}, c_{2(c,t)}, \ldots, c_{7(c,t)})$ are matrices formed by the seven country-level exogenous variables, with $\boldsymbol{\beta}_{15}$ being the corresponding vector of coefficients for Equation (1) and so on. In practice, only the respective industry variable is contained in each equation. That is, industry profitability, industry

Table 3
Mean values per country of the national explanatory variables

Country	GDP per capita growth	Inflation	Non-life penetration ratio	Institutional development
Australia	1.199	2.132	0.034	1.590
Austria	0.512	1.861	0.031	1.493
Belgium	0.454	1.727	0.027	1.322
Canada	0.968	1.638	0.041	1.638
Chile	2.422	3.499	0.017	1.141
Czech Republic	1.564	1.459	0.019	0.920
Denmark	0.936	1.202	0.028	1.749
Estonia	2.993	1.529	0.013	1.147
Finland	0.099	1.482	0.020	1.818
France	0.574	0.943	0.031	1.145
Germany	1.692	1.250	0.036	1.503
Greece	−3.340	0.172	0.013	0.284
Hungary	2.425	1.498	0.012	0.565
Iceland	1.964	3.347	0.024	1.488
Ireland	5.799	0.777	0.016	1.449
Israel	3.046	3.467	0.023	0.655
Italy	−0.671	1.205	0.023	0.504
Latvia	4.768	1.479	0.011	0.725
Luxembourg	0.407	1.534	0.018	1.720
Mexico	1.618	3.481	0.012	−0.192
The Netherlands	0.579	1.533	0.084	1.690
New Zealand	1.719	1.398	0.047	1.838
Norway	0.496	1.978	0.017	1.774
Poland	2.591	0.933	0.018	0.868
Portugal	−0.445	1.382	0.023	0.973
Slovak Republic	1.484	3.606	0.014	0.756
Slovenia	0.234	1.010	0.037	0.888
Spain	0.462	1.033	0.028	0.844
Sweden	1.268	0.761	0.018	1.777
Switzerland	0.514	−0.378	0.041	1.766
Turkey	4.737	7.860	0.011	−0.178
The United Kingdom	1.290	1.925	0.025	1.428
The United States	1.353	1.616	0.043	1.250

growth and industry risk are included in Equation (1), Equation (2) and Equation (3), respectively. For simplicity, all the variables are formally included in matrix $\boldsymbol{Country}_{(c,t)}$, but the coefficients of the industry variables that do not refer to the corresponding dependent variable (e.g., β_{152} and β_{153} in Equation (1)) are set to 0. Finally, $\omega_{i,t}$, $\sigma_{i,t}$, and $\varepsilon_{i,t}$ are the error terms.

A SEM is appropriate for our analysis because it allows us to explicitly consider the reciprocal nature of the three goals and to make statistical inferences about the impact of any of them on the other two, holding the reverse impact constant (see Mankaï and Belgacem, 2016; Eling et al., 2022). To estimate the non-recursive SEM, we use a two-stage least squares procedure (2SLS). We previously test whether profitability, growth, and risk are endogenous by using the Hausman specification test, which rejects the null hypothesis of no endogeneity.[8] Thus, simultaneous equation techniques with instrumental variables should be used. In addition, the Haussman specification test suggests that the size decision variable is endogenous.[9] For this reason, we lag the size variable by one period.

The 2SLS procedure consists of the following two steps. In the first stage, the observed values of profitability, growth, and risk are separately regressed against the exogenous variables and instruments by ordinary least squares.[10] The lagged variables of profitability, growth, and risk are used as instruments in the corresponding equations. We used the F test to confirm the choice of instruments, which rejects the null hypothesis of the existence of weak instruments.[11] In the second stage, we estimate Equations (1) to (3). In this case, the fitted values from the first stage replace the observed values of profitability, growth, and risk on the right-hand side of these equations.[12] The results from the least-squares procedure are presented in Table 4.

Regarding the profitability results (Column 1), we find that risk increases profitability. This result supports the general principles of the capital asset pricing model, which assumes a positive relationship between risk and profitability. This finding is consistent with previous results by Fields et al. (2012) for an international analysis of non-life insurers. It is also in line with the results by González-Fernández et al. (2020) for Spanish non-life insurers and with the findings by Eling et al. (2022), who showed that risk positively impacted the ROE of European insurers. We also observe that size increases profitability since the coefficient of the size variable is positive and statistically significant. This result is in line with previous results in the insurance industry, like Leverty and Grace (2010), Gaganis et al. (2015), and Eling and Jia (2019). In addition, we find a positive relationship between capitalization and profitability, which is consistent with the results by Fields et al. (2012), who found in their international analysis of non-life insurers that capitalization decreases the expense ratio. The results also show that the coefficient of the institutional development variable is negative and statistically significant, indicating that better outcomes in national institutional quality decrease profitability. This result is in line with Cummins and Rubio-Misas (2021), who showed that institutional development decreases performance (measured by the meta-technology

[8]We regress profitability, growth, and risk, one by one, on instrumental variables as well as all explanatory variables to obtain three vectors of residuals. Then, the residuals are added to Equations (1) to (3). In the profitability equation, the residuals from the growth regression are statistically significant at the 1% level (SE = 0.016 with $p < 0.01$) and the residuals from risk regression are statistically significant at the 5% level (SE = 0.005 with $p < 0.05$). In the growth equation, the residuals from the profitability regression are statistically significant at the 1% level (SE = 0.014 with $p < 0.01$) and residuals from the risk equation are significant at the 1% level (SE = 0.025 with $p < 0.01$). In the risk equation, the residuals from the growth equation are statistically significant at the 1% level (SE = 0.003 with $p < 0.01$).

[9]In the profitability equation, the residuals from the size regression are statistically significant at the 1% level (SE = 0.006 with $p < 0.01$) and the residuals from the risk equation are statistically significant at the 1% level (SE = 0.003 with $p < 0.01$).

[10]To save space, the first-stage regression results are not shown. They are available from the authors upon request.

[11]The F-test rejects the null hypothesis of the existence of weak instrument, supporting thus the choice of the utilized instruments (lagged values of profitability, growth, and risk). While in the profitability equation, the F-test is statistically significant at the 5% level (coefficient = 6.18 with $p < 0.05$), in the growth and risk equations the F-test is statistically significant at the 1% level (coefficient = 242.68 with $p < 0.01$ and coefficient = 459.89 with $p < 0.01$).

[12]Since all the equations of the SEM are just identified, the 2SLS should produce consistent results (Wooldridge, 2010).

Table 4
Results on profitability, growth, and risk. Non-life insurers 2011–2016

	Profitability	Growth	Risk
Profitability		0.012	−0.143**
Growth	−0.010		0.023
Risk	0.350***	−0.258*	
Industry profitability	0.859***		
Industry growth		0.942***	
Industry risk			0.733****
Size $t-1$	0.014*	−0.172***	0.009*
Capitalization	0.285***	−0.312***	−0.106***
Reinsurance use	−0.019	−0.556***	0.020
GDP per capita growth	−0.001	−0.002***	0.000
Inflation	0.000	−0.005**	0.001
Penetration ratio	1.690	−0.865	0.974
Institutional development	−0.044**	−0.022	0.011
Constant	−0.369**	2.901***	−0.146*
Observations	18,819	18,819	18,819
Number of insurers	4126	4126	4126
Adjusted R-squared	0.665	0.4624	0.6982
F-statistic	69.470***	238.36***	56.14***

Note: Results from the second-stage least-squares procedure were used to estimate a simultaneous equation model with robust standard errors clustered at the country level. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

revenue efficiency ratio), probably due to its negative effect on life insurance prices. It is also in line with previous findings showing that the cost of financial intermediation for households and firms is lower in countries with better institutions (see, e.g., Demirgüç-Kunt et al., 2004; Laeven and Majnoni, 2005).

The results of the growth equation (Column 2) show that risk negatively influences growth. This finding is consistent with Choi (2010), in his analysis of the U.S. property-liability insurance industry. It is also consistent with Eling et al. (2022), in their analysis of European non-life insurers. Additionally, we observe that the coefficient of the size variable is negative and statistically significant, indicating that size decreases growth. This result is in line with Hardwick and Adams (2002), who found that during the boom years of 1987–1999, smaller U.K. life insurers were growing fasters than the larger ones. It is also consistent with Eling et al. (2022) in their analysis of European insurers. The results also indicate that capitalization and reinsurance utilization decrease growth. In this sense, Choi (2010) shows a negative relationship between the use of reinsurance and growth, indicating that those insurers ceding more business to reinsurers tend to grow slowly.

Regarding the risk regression results (Column 3), we observe that profitability decreases risk. This finding is in line with Eling et al. (2022), who showed that less profitable European insurers were more willing to take risks. Additionally, we observe that the coefficient of the size variable is positive and statistically significant, indicating that size tends to increase risk. However, the coefficient of the capitalization variable is negative and statistically significant, indicating that capitalization decreases risk. This is an expected result since capitalization is associated with financial strength.

Table 5
Preferential weights and scenario variables values used for each scenario

Num	Scenario	ω_1 (δ_1)	ω_2 (δ_2)	ω_3 (δ_3)	c_6	c_4	c_1	c_2	c_3	c_5	c_7
1	High crisis	1	1	2	0.036	−0.424	0.035	−0.059	0.052	−0.693	1.232
2	High non-crisis	2	1	1	0.036	0.216	0.035	0.036	0.052	0.119	1.232
3	Medium crisis	1	2	2	0.026	−0.150	0.095	0.023	0.069	0.508	0.917
4	Medium non-crisis	2	2	1	0.029	1.365	0.145	0.064	0.117	2.573	1.462
5	Low crisis	1	2	2	0.012	−0.329	0.040	−0.021	0.069	−0.047	−0.152
6	Low non-crisis	2	2	1	0.012	0.029	0.072	0.025	0.081	0.309	0.792

Finally, we use panel data models to estimate the relationships among the firm variables capitalization, reinsurance use and size to be used as constraints in the reference point analysis. The Breusch–Pagan Lagrange multiplier test showed that unit effects are present in our data, and therefore, either the fixed or random-effects model should be used (Greene, 2012). The Hausman tests in the three regressions reject the null hypothesis that the unit effects are orthogonal to the regressors. Thus, the fixed effects model is appropriate, and the regressions are based on the fixed-effects model with robust standard errors (SEs). The results from this analysis corresponding to the 95% confidence intervals are presented in Table A1 in the Appendix.

4.2. Cluster analysis: scenarios

Since, as stated above, the prioritization of the different goals (profitability, growth and risk) is linked to the maturity of the market, we conducted a cluster analysis to form three groups of homogeneous countries based on the non-life insurance penetration variable. Namely, we form a group of countries with the highest non-life insurance penetration level, another group with a medium level and another one with the lowest level. We have used the k-means iterative process, proposed by McQueen (1967), because it allows specifying a priori the number of groups to be formed and working directly with the original data, which makes it suitable for analyzing many observations. Next, we calculated different scenarios in each group of countries, which are given by the values of the exogenous variables corresponding to the mean, median, percentiles 1, 5, 10, 25, 75, 90, 95, and 99, minimum and maximum. Finally, we have chosen two scenarios in each cluster: one representing crisis times (with a negative value of GDP per capita growth) and another one representing booming times (with a non-negative value of GDP per capita growth). Table 5 presents the scenarios, which are defined considering both the maturity level of the market, represented by the penetration variable (high, medium, low) and the crisis/non-crisis situation (given by the negative/positive value of the GDP per capita growth variable). The statistical values of the different firm-level decision variables per scenario, used in the multi-objective reference point analysis, are presented in Table A2 in the Appendix.

4.3. Multi-objective reference point analysis

In this subsection, a multi-objective model is built in order to examine the profiles of the insurers that would obtain better results for the three dependent variables considered, under the different scenarios defined by the cluster analysis, and according to the econometric analysis carried out previously. First, although the reference point approach is a well-known multi-objective technique, let us present its main features here. Generally, a multi-objective model takes the following form:

$$\begin{cases} \text{Max} f(\mathbf{x}) = \left(f_1(\mathbf{x}), f_2(\mathbf{x}), \ldots, f_p(\mathbf{x})\right), \\ \qquad\qquad \text{subject to } \mathbf{x} \in \Omega \end{cases} \tag{4}$$

where $\mathbf{x} = (x_1, x_2, \ldots, x_n)$ is a vector formed by the n decision variables, $f_1, f_2, \ldots, f_p$ are the p objective functions, which we intend to maximize, and Ω is the admissible set, that is, the subset of decision variables that satisfy a series of constraints and bounds. In a real multi-objective problem, no feasible solution exists where all the objectives are simultaneously optimized. Instead, the concept of Pareto efficient solutions is used. A feasible solution is said to be Pareto efficient for Problem (4) if no objective can be improved without impairing another objective. More precisely, a feasible solution $\mathbf{x}^* \in \Omega$ is said to be Pareto efficient for (4) if there is not another feasible solution $\mathbf{y} \in \Omega$, such that $f_i(\mathbf{y}) \geq f_i(\mathbf{x}^*)$, for all $i = 1,\ldots,p$, and $f_j(\mathbf{y}) > f_j(\mathbf{x}^*)$ for some $j \in \{1, \ldots, p\}$. The set of all Pareto efficient solutions to a multi-objective problem is called the Pareto efficient set (see Miettinen, 1999, for further details).

The reference point method is part of the family of distance-based multi-objective methods, which have been widely applied in the field of finance and insurance (see, e.g., Bouslah et al., 2022, for a recent application). The original reference point method was defined by Wierzbicki (1980). Although different variants of the method exist (see Wierzbicki et al., 2000), in its basic form, the reference point method requires the establishment of a reference (desired) level q_i for each objective function. The vector formed by all these levels, $\mathbf{q} = (q_1, q_2, \ldots, q_p)$, is called a reference point. If, as in Problem (4), all the objective functions are to be maximized, this means that the decision-maker wishes to find feasible solutions $\mathbf{x} \in \Omega$ such that $f_i(\mathbf{x}) \geq q_i$, for all $i = 1, 2,\ldots, p$, if they exist. Once the reference point is given, the following problem is solved:

$$\begin{cases} \text{Min} s(\mathbf{x}, \mathbf{f}, \mathbf{q}) = \max\limits_{i=1,\ldots,p} \left\{ \dfrac{\omega_i}{n_i} \left(q^i - f_i(\mathbf{x})\right) \right\} + \rho \sum_{i=1}^{p} \left(q^i - f_i(\mathbf{x})\right), \\ \qquad\qquad\qquad \text{subject to } \mathbf{x} \in \Omega \end{cases} \tag{5}$$

where s is the so-called achievement scalarizing function, n_i are normalizing factors (to avoid bias effects) and ρ is a small enough parameter. Besides, preferential weights ω_i can be used, which measures the importance of achieving each reference level (Luque et al., 2009). Wierzbicki (1980) shows that the optimal solution of Problem (5) is a Pareto efficient solution of Problem (4). Problem (5) is non-differentiable, but there is a differentiable equivalent formulation, which also maintains linearity if the original Problem (4) is linear:

$$\begin{cases} \text{Min} s(\mathbf{x}, \mathbf{f}, \mathbf{q}) = \gamma + \rho \sum\limits_{i=1}^{p} \left(q^i - f_i(\mathbf{x})\right) \\ \qquad\qquad \text{subject to } \mathbf{x} \in \Omega \\ \frac{\omega_i}{n_i} \left(q^i - f_i(\mathbf{x})\right) \leq \gamma \qquad (i = 1, \ldots, p) \end{cases} . \tag{6}$$

Let us show how this reference point scheme has been applied to our problem. A multi-objective programming model was defined for each scenario found (Section 4.2). Let us denote by s the current scenario, and let us describe the elements of the corresponding model:

(a) Scenario parameters. Each scenario is defined by specific values of the country variables c_l (l = 1,…,7). Let us denote by c_l^s (l = 1,…,7) the values corresponding to scenario s as described in Table 5.
(b) Objective functions. In our problem, the dependent variables (d_1, d_2, and d_3) are regarded as objective functions. The first two ones, d_1 (profitability) and d_2 (growth), are to be maximized, while the third one, d_3 (risk), is to be minimized.
(c) Variables. The firm-level variables (f_1, f_2, and f_3) are regarded as decision variables for our model, given that we are seeking to find the values of these variables that provide better results. In addition, given that each dependent variable appears (Section 4.1) as an explanatory variable for the other two ones, all three of them (d_1, d_2, and d_3) are also regarded as decision variables in our model.
(d) Constraints. Two blocks of constraints have been considered in our model to take into account the dependence relations found among the variables in Section 4.1.
(e) Relations among firm-level variables.

Let us denote by α_{ij}^- and α_{ij}^+, respectively, the lower and upper bounds of the 95% confidence interval of firm variable j in the estimation of variable i (see Table A3 in the Appendix). Then, we consider the following set constraints:

$$\left\{\begin{array}{l} f_i \geq \sum_{\substack{j=1 \\ j\neq i}}^{3} \alpha_{ij}^- f_j + \alpha_{i0}^{s-} \\ f_i \leq \sum_{\substack{j=1 \\ j\neq i}}^{3} \alpha_{ij}^+ f_j + \alpha_{i0}^{s+} \end{array}\right. \quad (i = 1, 2, 3)\,. \tag{7}$$

Here, α_{i0}^{s-} is a perturbation of the original constant α_{i0}^- to ensure that the percentile 25 values of the firm variables for the scenario considered are simultaneously feasible for the $\geq$ constraint. Similarly, α_{i0}^{s+} is a perturbation of the original constant α_{i0}^+ to ensure that the 75 percentile values of the firm variables are simultaneously feasible for the $\leq$ constraint. In this way, Equations (7) consider the functional relations among variables found in Section 4.1, and at the same time, they assure a wide enough range of possible values of the firm variables according to the current scenario.

d.1.Relations obtained from the SEM. Following an analogous philosophy to d.1, let us build these other constraints.

$$\left\{\begin{array}{l} d_i \geq \sum_{\substack{j=1 \\ j\neq i}}^{3} \beta_{ij}^- d_j + \sum_{j=1}^{3} \beta_{i4j}^- f_j + \beta_{i0}^{s-} \\ d_i \leq \sum_{\substack{j=1 \\ j\neq i}}^{3} \beta_{ij}^+ d_j + \sum_{j=1}^{3} \beta_{i4j}^+ f_j + \beta_{i0}^{s+} \end{array}\right. \quad (i = 1, 2, 3)\,, \tag{8}$$

where, again, β_{ij}^{-} and β_{i4j}^{-} are the lower upper bounds of the 95% confidence interval of the decision variable j and the firm variable j, respectively, in the estimation of decision variable i. On the other hand, β_{i0}^{s-} and β_{i0}^{s+} are scenario-dependent constants that contain the country variables, that is:

$$\begin{cases} \beta_{i0}^{s-} = \sum_{j=1}^{7} \beta_{i5j}^{-} c_j^s + \beta_{i0}^{-} + p_i^{-} \\ \\ \beta_{i0}^{s+} = \sum_{j=1}^{7} \beta_{i5j}^{+} c_j^s + \beta_{i0}^{+} + p_i^{+} \end{cases} \quad (i = 1, 2, 3), \tag{9}$$

where p_i^{-} is a perturbation term that assures that the percentile 25 values of the decision and firm variables for the scenario considered are simultaneously feasible for the $\geq$ constraint and p_i^{+} assures that the percentile 75 values of the decision and firm variables are simultaneously feasible for the $\geq$ constraint.

d.1.Simple bounds. Finally, the values of the decision and firm variables are constrained between percentiles 5 (d_i^{5s} and f_i^{5s}) and 95 (d_i^{95s} and f_i^{95s}) of the corresponding scenario:

$$\begin{cases} d_i^{5s} \leq d_i \leq d_i^{95s} & (i = 1, 2, 3) \\ f_i^{5s} \leq f_i \leq f_i^{95s} & (i = 1, 2, 3) \end{cases}. \tag{10}$$

Taking all these elements into account, the multi-objective model is the following:

$$\begin{cases} \text{Max} d_1 \\ \text{Max} d_2 \\ \min d_3 \\ \text{subject to } \textit{constraints } (7), (8), \text{and } (10) \end{cases}, \tag{11}$$

Once the multi-objective problem has been formulated, the following procedure is followed for each scenario considered:

Step 1. The individual optimum of each one of the three objective functions is calculated by solving the corresponding single objective version of Problem (11). Let us denote by d_i^{*} the optimal (ideal) value of objective function i. Moreover, let d_{i*} be the anti-ideal value of objective i, that is, the worst value of objective function i in the three optima obtained. Although this anti-ideal value is, in general, just an approximation of the worst value (nadir value, see, e.g., Deb et al., 2010) of objective function i in the efficient set of Problem (11), it serves our purposes (it will be used, as seen later, to obtain the corresponding normalizing factors).

Step 2. In order to determine the profile of the firms with a better performance for the three objective functions considered (under the current scenario), the optimal values are taken as reference levels. Therefore, the following reference point problem is formulated:

$$\begin{cases} \min \gamma + \rho \sum_{i=1}^{3} \left| d_i^* - d_i \right| \\ \text{subject to } \textit{constraints } (7), (8), \text{and } (10) \\ \frac{\omega_1}{n_1}\left(d_1^* - d_1\right) \leq \gamma \\ \frac{\omega_2}{n_2}\left(d_2^* - d_2\right) \leq \gamma \\ \frac{\omega_3}{n_3}\left(d_3 - d_3^*\right) \leq \gamma \end{cases}, \tag{12}$$

where $n_i = |d_i^* - d_{i*}|$ $(i = 1,2,3)$ are the normalizing factors and ρ has been set to 0.0001. With respect to the preferential weights ω_i, two sets of weights have been used in each scenario:

- Under each scenario, it is assumed that the firm management reacts giving more importance to one (or several) objective function. Under this assumption, the weights used for each scenario are shown in Table 5. These weights are justified because, as we stated above, soundness may have a higher priority in economic crises, while growth and profitability become more dominant in booming times (Eling et al., 2022). On the other hand, it is emphasized that in emerging markets, many firms focus on growth (Berry-Stölzle et al., 2010), while profitability is more important in mature markets. Consequently, in crisis times, we prioritized risk and assigned Weight 2 to it, while in booming times, we prioritized profitability and assigned Weight 2 to it. In addition, we have prioritized growth in markets with low and medium levels of maturity and assigned Weight 2 to the growth goal. Otherwise, we have assigned the Weight 1.
- Equal weights give the same importance to the three objective functions.

Step 3. To obtain more solid results with respect to the preferential weights used in Step 2, a set of problems was solved, where the Weight(s) 2 of each scenario varied between 1.5 and 2.5.

The results when a greater importance is given to one (or several) objective function are presented in Fig. 1 (results for the objective functions) and Fig. 2 (results for the decision variables).[13] We start the discussion on Scenario 1, which is characterized by markets with a high level of maturity (measured by the non-life insurance penetration level) and crisis, where minimizing risk is prioritized (by assigning weight 2 to this objective). We observe that, for this case, the level of profitability that is representative of good performance is the lowest of all. This is probably due to the fact that the level of risk representative of good performance is also the lowest of all, as well as to a relatively low growth rate. Regarding the decision variables that allow simultaneously obtaining good performance for the three objective functions, we note that the recommended firm size

[13] Figure 1 (and Fig. 3) presents the values of the objective functions within the range between the best possible value (ideal, 100%) and the worst value (anti-ideal, 0%). These are the best and worst values obtained by each objective value in the pay-off matrices of all the scenarios. Therefore, in these figures, the higher the value, the better for the three functions (including risk, where 100% means minimum risk).

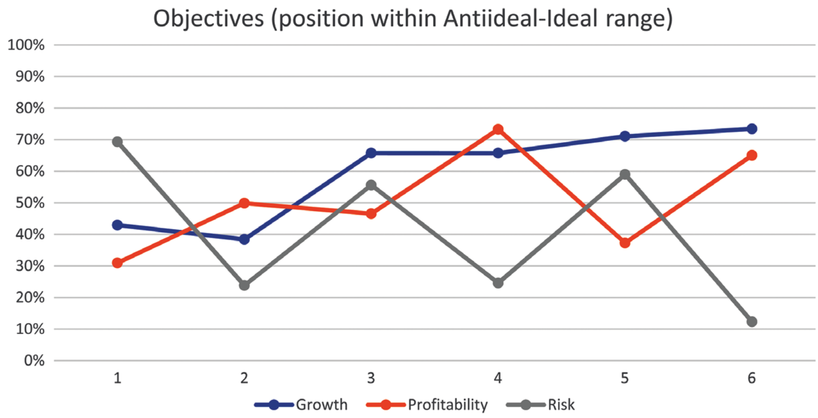

Fig. 1. Multi-objective reference point analysis. Values of the objective functions for each scenario. Case with different weights.

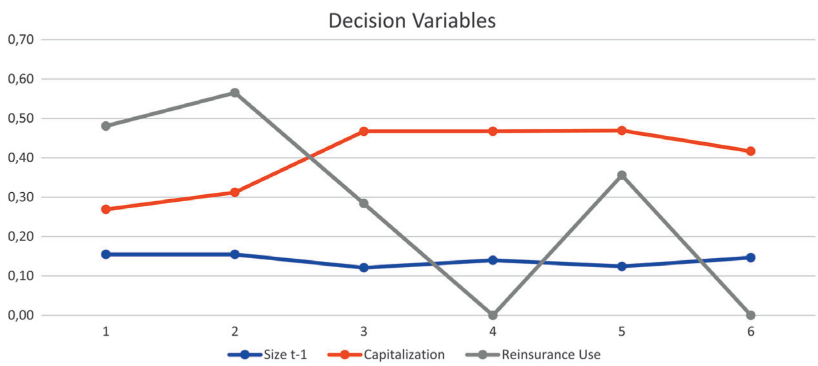

Fig. 2. Multi-objective reference point analysis. Values of the decision variables for each scenario. Case with different weights.

is the highest, not being the case of the level of capitalization, whose advisable level is the lowest of all the scenarios. We also observe that the advisable level of reinsurance use is relatively high. The following scenario (Scenario 2) refers to markets with a high level of maturity and booming times where profitability is prioritized (by assigning Weight 2 to it). We observe that the level of profitability that is representative of good performance increases around 20% with respect to the level of this variable in Scenario 1. This could be due, among other reasons, to the fact that the level of risk representative of good performance increases around 50% with respect to the level of risk for Scenario 1. This last increase implies that both the advisable levels of capitalization and reinsurance use increase considerably in relation to Scenario 1. In this respect, it is known that both capitalization and reinsurance utilization are tools for hedging insurer risk (see, e.g., Cummins and Nini, 2002; Shiu, 2011).

The numerical values of the objective functions in the different scenarios are shown in Table 6.

Next, the results of Scenario 3 are discussed. This scenario is characterized by markets with a medium level of maturity and crisis where both minimizing risk and maximizing growth are

Table 6
Objective values for each scenario. Case with different weights

	1	2	3	4	5	6
Profitability	0.071	0.125	0.116	0.192	0.089	0.168
Growth	0.072	0.037	0.249	0.248	0.289	0.308
Risk	0.054	0.122	0.074	0.120	0.069	0.139

prioritized (by assigning Weight 2 to them). In this case, the levels of profitability, growth, and risk representative of good performance are significantly higher than the corresponding levels of these variables for Scenario 1, which is also characterized by crisis but refers to markets with a high level of maturity. We observe that to simultaneously obtain these levels for the three objective functions, the advisable capitalization is significantly higher than that of Scenario 1, not being the case of the advisable size and reinsurance use, which are lower than those corresponding to Scenario 1. Next, we show the results corresponding to Scenario 4, which is representative of markets with medium maturity levels and booming times where both profitability and growth are prioritized (by assigning Weight 2). We have to highlight that, of all the scenarios, this is associated with the highest level of profitability. Regarding the decision variables, we observe that the advisable levels for insurer size and capitalization are similar to those of Scenario 3, but in contrast to Scenario 3, in this scenario, it is advised not to use reinsurance.

Next, the results of Scenario 5 are discussed. This scenario is characterized by markets with lower levels of maturity and crisis whereas for Scenario 3, growth and risk are prioritized. In this case, both the level of profitability and risk that are representative of good performance is lower than the corresponding levels of these variables for Scenario 3, while the level of growth is higher. We also observe that the advisable levels of both firm size and capitalization are similar to the corresponding levels of these variables for Scenario 3 except that a higher use of reinsurance is advisable now. Finally, we present the results corresponding to Scenario 6, which refers to markets with a lower level of maturity and booming times for which growth and profitability are prioritized (as was done for Scenario 4). We have to highlight that both the level of growth and risk representative of good performance is the highest of all. This translates into a high level of profitability (specifically the second highest of all scenarios). Regarding the decision variables, we observe that the advisable level of capitalization (size) is lower (higher) than the corresponding to Scenario 4 and that, similar to Scenario 4, it is advised not to use reinsurance.

The results corresponding to the multi-objective reference point analysis when the same importance is given to the three objective functions are presented in Fig. 3 (results for the objective functions) and Fig. 4 (results for the decision variables). As stated above, the usual way management faces those different scenarios is not to give the same importance to the three objective functions. However, we conduct this analysis to provide additional information on the variables. Particularly, we want to know the variables for which the observed pattern with respect to the different scenarios that we show in the previous analysis is maintained even when the same weight is given to the three objective functions. First, we observe that in this case, there are no differences among the results corresponding to the crisis and non-crisis scenarios within a type of market (classified according to the level of maturity). This finding reinforces the need to prioritize objectives depending on crisis/non-crisis times. Furthermore, we highlight the following results from this analysis. The

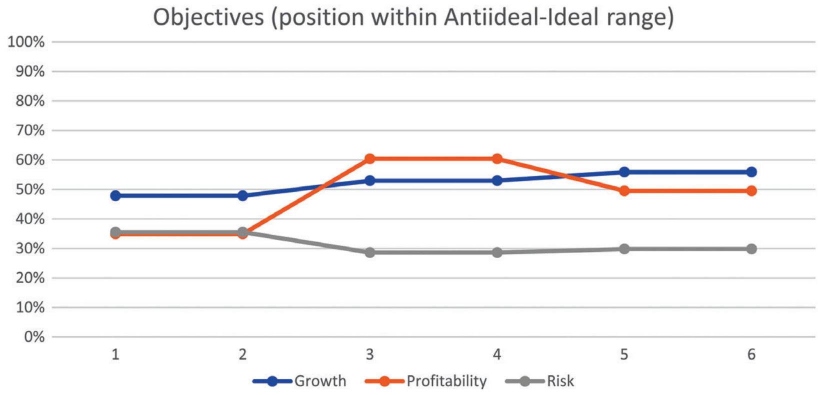

Fig. 3. Multi-objective reference point analysis. Values of the objective functions for each scenario. Equal weights case.

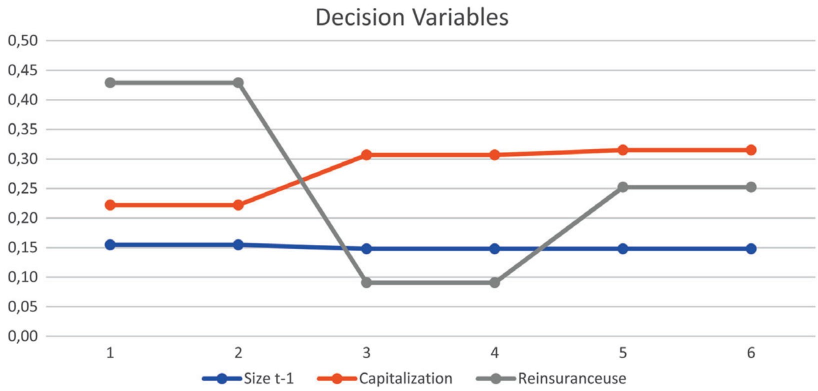

Fig. 4. Multi-objective reference point analysis. Values of the decision variables for each scenario. Equal weights case.

highest level of profitability is associated with scenarios where the markets are characterized by a medium level of maturity, the next highest level of profitability is linked to scenarios with markets with a lower level of maturity and, finally, the lowest level of profitability is associated with scenarios with markets with the highest level of maturity.

This pattern was also observed in the analysis where different importance was given to the three objective functions both in crisis scenarios (the ranking according to the level of profitability was Scenario 3—markets with a medium level of maturity, Scenario 5—markets with a low level of maturity, and Scenario 1—markets with a high level of maturity), as well as in non-crisis scenarios (the ranking according to the level of profitability was Scenario 4—markets with a medium level of maturity, Scenario 6—markets with a low level of maturity, and Scenario 2—markets with a high level of maturity). We also observe that the ranking of the scenarios by the level of market maturity with respect to the linked level of growth coincides in both analyses. That is, the highest level of growth is associated with scenarios where the markets have a low level of maturity, the next highest level of growth is associated with scenarios where the markets have a medium level of maturity and the lowest level of growth is associated with scenarios with markets with a high level of maturity. However, we do not observe that a similar pattern happens between the results of the two analyses with respect to the risk variable. This finding may indicate that this variable is particularly affected by the fact that different importance used to be given to the different functions depending on the scenarios. Regarding the decision variables, we observe that associated scenarios where the markets have a high level of maturity get the highest advisable size, the lowest advisable level of capitalization and the highest advisable level of reinsurance use. This association is also observed when different weights are given to the objective functions (see the results corresponding to Scenarios 1 and 2).

As explained in Step 3, we additionally conducted a sensitivity analysis to check the reliability of our results.[14] To this end, different reference point problems have been solved where the weights of the objectives that were originally given Weight 2 in each scenario have been varied between 1,5 and 2,5. The results obtained are consistent. This means that the variables whose values increase (decrease) from the equal weight problem to the problem with different weights increase (decrease) in a constant and uniform way as the corresponding weight increases. Other variables remain constant all the time.

5. Summary and conclusions

This paper innovates by being the first to apply reference point techniques as a complement to econometric analyses in order to seek the profile of non-life insurers that simultaneously optimize the strategic growth, profitability, and risk goals. The econometric analyses provide the relevant relations among the variables. They include a SEM to characterize the objective functions and constraints of the multi-objective programming model, as well as panel data models on the relationship among firm-decision variables. We analyze non-life insurers from 33 OECD countries over the period 2011–2016. Countries included in the analysis differ in terms of maturity of the non-life insurance market. For this reason, we conducted a cluster analysis to form three groups of countries based on the non-life insurance penetration ratio and analyze different scenarios, which are characterized by the level of maturity of the market as well as the crisis/non-crisis situation. Our main analysis gives different weights to the objective functions, taking into account that the literature shows that in emerging countries, many firms focus on growth, while profitability is more important in mature markets. We also considered that in economic crises, soundness may have a higher priority, while growth and profitability become more dominant in booming times. We also carried out an analysis where we give the same importance (weights) to the three objective functions. We additionally conduct a sensitivity analysis to check the reliability of our results where the Weight(s) 2 of each scenario are varied between 1.5 and 2.5.

Our econometric analysis shows that insurer risk, size, and capitalization increase profitability. However, national institutional quality decreases insurer profitability. It also shows that risk, size, capitalization, and reinsurance utilization decrease insurer growth. In addition, this analysis notices that profitability and capitalization decrease risk, but size increases risk. These findings are consistent with previous studies on the insurance industry that use econometric analysis to provide evidence on factors explaining profitability, growth, and risk. This consistency, and the fact that we use a SEM in the econometric analysis to explicitly consider the reciprocal nature of the three goals, provide reliability to our econometric results that conform to the first part of our analysis.

[14]Numerical results of these analyses are available upon request from the authors.

The multi-objective study conducted in the second part of our analysis innovates since, taking into account the dependencies among the used variables given by the econometric study, it provides information about the profile of non-life insurers that simultaneously optimize the three goals under different scenarios. In this respect, the use of the multi-objective reference point technique allows us to note the following findings, which would remain unnoticed in the econometric analysis:

1. Regarding the objective functions (in terms of the levels of these functions representative of good performance), the highest (lowest) level of profitability is associated with scenarios where the markets have a medium (high) level of maturity and booming (crisis) times. The results also indicate that the highest level of growth is linked to scenarios characterized by markets with a low level of maturity and booming times. In addition, the results with respect to the risk objective function show that a significant change appears in the level of risk representative of good performance between the crisis and non-crisis situation within a type of market (characterized by the level of maturity). This finding highlights the importance of prioritizing risk in crisis times. In this respect, the results indicate that the lowest level of risk is linked to scenarios where the markets have a high level of maturity and crisis times.
2. Regarding the decision variables to simultaneously obtain good performances for the three objective functions in each scenario, a higher recommendable size is associated with more mature markets, being even higher for booming times, compared to crisis times. The results with respect to the capitalization variable present ample differences among scenarios, emphasizing the idea that one capitalization level does not fit all. These results are consistent with those of Altuntas et al. (2015), who emphasize that the optimal capital structure is not homogeneous across countries. We find that a lower capitalization level is associated with mature markets being the lower one for crisis times. These findings are in line with Berger and Bouwman (2013), who show for the banking industry how capital varies depending on the time period (crisis vs. non-crisis time). The results also show that reinsurance utilization is associated with crisis times as well as with booming times in markets with a high level of non-life insurance penetration.

Consequently, it must be pointed out that the combination of multi-objective reference point techniques with econometric analysis has proven to be of great interest for the analysis conducted in this paper. The reference point scheme allows us to go further than just identifying relationships among variables and to provide managers with a tool that can effectively aid them in decision-making processes under different scenarios. Therefore, our findings are particularly useful in the management of insurance firms since the maximization of the firm value requires a balance between the growth, profitability, and risk goals. In addition, they also contribute to the policy discussion of global regulatory capital requirements since the recommendable level of capitalization under different scenarios is evaluated.

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Appendix A

Some tables containing data used in the reference point model are shown here:

Table A1
Lower and upper bounds of the 95% confidence intervals. Relations among size, capitalization, and reinsurance

	Size $t-1$		Capitalization		Reinsurance use	
Size $t-1$			−0.027	−0.011	−0.010	0.011
Capitalization	−0.566	−0.213			−0.111	−0.006
Reinsurance use	−0.092	0.104	−0.052	−0.003		

Table A2
Values per scenario of the firm variables used in the reference point analysis

	Percentile 5	Percentile 25	Percentile 75	Percentile 95
		High crisis and non-crisis scenarios		
Profitability	−0.106	0.021	0.127	0.263
Growth	−0.201	−0.003	0.171	0.474
Risk	0.008	0.023	0.081	0.221
Size $t-1$	9.149	10.759	13.649	15.469
Capitalization	0.173	0.296	0.525	0.783
Reinsurance use	0.000	0.100	0.539	0.806
		Medium crisis and non-crisis scenarios		
Profitability	−0.118	0.024	0.205	0.346
Growth	−0.246	−0.047	0.097	0.453
Risk	0.009	0.031	0.119	0.277
Size $t-1$	8.817	10.639	13.679	15.469
Capitalization	0.133	0.179	0.523	0.832
Reinsurance use	0.000	0.030	0.339	0.684
		Low crisis and non-crisis scenarios		
Profitability	−0.139	0.011	0.167	0.317
Growth	−0.259	−0.068	0.159	0.513
Risk	0.014	0.037	0.123	0.263
Size $t-1$	9.149	10.331	12.773	14.798
Capitalization	0.135	0.225	0.571	0.828
Reinsurance use	0.000	0.061	0.560	0.845

Table A3
Lower and upper bounds of the 95% confidence intervals obtained in the simultaneous equation model

	Profitability		Growth		Risk	
Profitability			−0.230	0.255	−0.273	−0.012
Growth	−0.043	0.022			−0.019	0.066
Risk	0.144	0.556	−0.538	0.021		
Industry Profitability	0.776	0.943				
Industry Growth			0.871	1.013		
Industry Risk					0.570	0.897
Size $t-1$	−0.001	0.029	−0.259	−0.086	0.000	0.019
Capitalization	0.216	0.354	−0.457	−0.168	−0.148	−0.064
Reinsurance use	−0.057	0.020	−0.605	−0.508	−0.013	0.054
GDP per capita growth	−0.001	0.000	−0.004	−0.001	0.000	0.001
Inflation	−0.003	0.004	−0.009	0.000	−0.002	0.003
Penetration ratio	−1.657	5.037	−7.884	6.155	−1.736	3.685
Institutional Development	−0.083	−0.006	−0.108	0.063	−0.027	0.048
Constant	−0.669	−0.068	1.549	4.252	−0.305	0.013