INSOLVENCY RISK IN THE ITALIAN NON-LIFE INSURANCE COMPANIES.

AN EMPIRICAL ANALYSIS BASED ON A CASH FLOW SIMULATION MODEL

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Abstract

Policyholders do not accurately know the financial condition of insurers because of asymmetric information that makes prices unable in discriminating risk behaviour of insurance companies and provides rationale for prudential regulation. Regulators often imposed capital requirements to ensure solvency having some drawbacks in preventing the assumption of excessive risks. Hence, other methods should be taken into account in order to estimate their ability in identifying troubled insurers.

This study analyses insolvency risk in the Italian non-life insurance market by adopting a deterministic cash flow simulation model in order to predict insolvencies over the period from 1990 through 1994. The model is based on future projections of principal cash inflows and outflows of insurance companies. Several hypotheses about the evolution both of insurance and economic variables such as premiums, losses for claims, stock prices, interest rates and inflation rates are implemented in the model. The results show a strong ability of the model in identifying insolvent insurers during the period examined here and suggest that cash flow simulation models may provide regulators and managers with useful information on insurance solvency.

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1. Introduction

Insurance companies are contractual intermediaries, which issue their liabilities (technical reserves) by committing to pay the future claims of policyholders (Auerbach, 1989; Campbell, 1982; Kidwell, Peterson and Blackwell, 1997; Kohn, 1994; Mishkin, 1992). Insurance contracts are essentially exchanges of money over different periods of time (Arrow, 1974); policy commitments covering a wide range of risks are sold by insurance companies that receive advance premium payments and pay monetary compensation when negative events occur.

The certainty of contractual obligations to policyholders and the uncertainty of the frequency and severity of future claims are distinguishing characteristics of policy commitments. The law of large numbers is applied to estimate this uncertainty. As the number of insurance risks in the portfolio grows, the average loss approaches the expected loss and the standard deviation becomes smaller and at a limit approaches zero (Borch, 1990; Outreville, 1998; Vaughan, 1989). However, the law of large numbers is not meaningful apart from homogeneous and independent risks. The former imply similar characteristics in loss exposures while the latter reveal no correlation between loss exposures.

It should be noted both homogeneous and independent risks are not sufficient for the application of the law of large numbers because the growth in the number of insurance risks increases the magnitude of the maximum possible loss and therefore the possibility that the pool of risks may fail jointly (Cummins, 1991; Shaffer, 1989; Smith and Kane, 1994). This is the well-known “fallacy” of the law of large numbers (Samuelson, 1963) that raises the risk of failures in the insurance industry when monetary resources do not cover payments for losses.

The insurance mechanism implies risk-bearing capacity through premiums higher than expected loss payments and thus the assumption of additional risks in the portfolio reduces the possibility of failure the pooling may have (Smith and Kane, 1994). In this context, solvency relies on the ability of a company to meet its contractual obligations over a long period of time through assets value higher than liabilities value.

This paper discusses financial approaches to solvency analysis in non-life insurance companies from a regulatory point of view by explaining cash flow simulation models which are based on the planning of their typical cash inflows and outflows. These models take into account patterns of loss reserve run-offs and asset cash flows by implementing several hypotheses that also include expectations about external economic variables such as inflation rates and interest rates. The cash inflows and outflows have been planned over a period of time to evaluate how positive net cash flow leads to the increase in assets over liabilities.

Financial approaches may be realised both by deterministic models (Cummins et al., 1999; Hodes et al., 1999b) and stochastic models (Daykin and Hey, 1990; Daykin et al., 1987; Daykin et al., 1994; Kaufmann et al., 2001; Pentikäinen and Rantala, 1982; Pentikäinen et al., 1989). This paper adopts a deterministic cash flow simulation model to investigate the solvency of a sample of 96 Italian non-life insurance companies through the period 1990-1994. Historically, Italy has experienced a low number of failures in the insurance industry because of tougher structural regulation than the US and the UK but during the period examined in this paper there was a significant number of Italian non-life insurers liquidated or submitted to a rehabilitation regulatory order.

Because insurance regulators are concerned with the adequacy of current resources in paying contractual obligations, this analysis is carried out by means of a run-off approach that prevents an insurance company from doing any further business. Thus, the model examines if the current assets can adequately meet the outstanding liabilities by planning the evolution of cash inflows and outflows over a period of time.

This paper is organised as follows. Section 2 analyses the concept of solvency in insurance and also the capital requirements imposed by regulators, Section 3 explains in detail the main features of cash flow models, Section 4 presents the empirical model and the results of the Italian experience and Section 5 concludes this study.

2. Insurance solvency

2.1 Solvency measurement

Risk management is the core activity of insurance companies. They essentially assume underwriting and reserving risk on the liability side, concerning with policy commitments issued, as well as market risk on the asset side, regarding the premiums' investments. Interest rate risk also affects the balance sheet of insurers by exposing them to adverse fluctuations in interest rates. Insurers directly face up not all risks because they may mitigate their exposure through reinsurance operations and derivative instruments (Santomero and Babbel, 1997).

Risks may endanger insurer's ability to fulfil its obligations through stock market crashes, unforeseen rapid increases in interest rates or natural catastrophes and thus consumers and regulators are interested in safety and soundness of insurance companies.

Solvency involves a buffer between assets value and liabilities value and is generally linked to the capital level compared to technical reserves or total assets. Three main approaches to the measurement of solvency in the insurance industry may be pointed out, as follows (Daykin et al., 1987):

1) the winding-up approach;

2) the going-concern approach;

3) the run-off approach.

In the winding-up approach, an insurance company is solvent if the realisation value of assets can sufficiently meet liabilities at a certain time. In the going-concern approach, it is assumed that the insurance company will continue to underwrite policies for the foreseeable future and solvency is measured regularly over this period. Finally, the run-off approach prevents an insurance company from doing any further business by evaluating the adequacy of its assets compared to its liabilities at a certain date. In this approach, it is assumed that the insurance company may or may not continue to underwrite policies for a short period of time (typically one or two years). This represents the period for which regulatory authorities do not take action against the insurance company because of the time gap between two subsequent audit dates. So the failure to maintain an excess of assets over liabilities would not imply that the company is unable to meet future claims, but it would mean that it does not have sufficient resources for carrying on new businesses. Regulatory authorities often adopt the run-off approach when evaluating insurance solvency because their main weapon is the possibility of preventing a company from underwriting any further policies.

2.2 Capital requirements

Information asymmetries between insurance companies and consumers emerge as insurers know more about their financial condition and risk behaviour than do consumers[1] (Munch and Smallwood, 1981). Prices are inefficient in revealing insurance solvency because of adverse selection and moral hazard problems (Harrington, 1991); indeed, lower prices are offered by riskier insurers (adverse selection) having more incentives to risk-taking behaviour during the contract (moral hazard).

Therefore, a trade-off between the behaviour of the insurance company and the policyholders' power of choice emerge because lower prices are offered by riskier companies and higher prices are offered by safer companies, implying an increase in insolvency risk in the first case while a decrease occurs in the second case.

The emphasis of regulation should be to act on the possible values of this trade-off by preventing insurers from an excessive level of risk and monitoring their financial condition in order to promote an adequate protection to policyholders (Eisen, Müller and Zweifel, 1993; Klein, 1995; Skipper and Klein, 2000). As in banking, capital requirements are introduced for

[1] Information asymmetries also occur because of lower information an insurer has on the risk of insured events compared to policyholders. See Dionne and Harrington (1992).

insurance solvency because capital plays an important role in strengthening the ability to pay compensation for monetary losses and protecting the interests of policyholders and third-party claimants. In particular, capital performs many important functions in insurance companies, as follows (Cummins, 1991; Dickinson, 1997; Kopcke, 1996; Staking and Babbel, 1995):

1) it reduces the leverage and thus the value of the put option held by stockholders;[2]

2) it provides signals about the risk behaviour of an insurance company;

3) it allows an increase in premium rates;

4) it reduces interest rate risk exposure.

These functions should be taken into account when the optimal level of capital is estimated. Hence, a company should analyse the nature and composition of its assets and liabilities as well as risks, growth expectations and demand for new capital in the future. A level of capital higher than the optimal level reduces the return to stockholders, at the same time affecting stock prices, while a lower level of capital may not adequately cover the risks and therefore reduces the protection of policyholders (Dickinson, 1997).

Decisions regarding the level of capital should take into account the financial structure of insurance companies and especially the level of debt. It should be noted that capital is more expensive than debt because of the higher return required by stockholders and the effects of taxes. However, more leverage increases insolvency risk and also the cost of capital in insurance companies (Cummins and Lamm-Tennant, 1994).

An insurance company could hold a lower level of capital than the optimal level, raising new capital when needed, but this is not always possible. For example, if a catastrophe occurs, the insurance company commits to raising capital but new capital providers will not willingly pay for past losses. Therefore, the insurance company is forced to raise funds from existing stockholders or through higher prices on new policies (Cagle and Harrington, 1992; Cummins and Danzon, 1994; Harrington et al., 1995).

The optimal level of capital for insurance companies is not equal to the adequate level for regulatory authorities. Insurance companies choose the optimal level of capital by taking into account the characteristics of their business while regulatory authorities take into account the interests of policyholders and thus the stability of insurance markets (Dickinson, 1997). Thus, regulation must pursue the maximisation of the trade-off between the higher protection given to policyholders by increasing capital requirements and the higher costs imposed on insurance companies by forcing an increase in capital (Pentikäinen, 1988).

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[2]According to the option pricing theory (Black and Scholes, 1973; Merton, 1974), stockholders hold a put option against the asset value of the firm. Because the value of the put option increases in volatility, stockholders may have an incentive to invest in risky projects by exploiting their limited liability. Thus, an increase in the level of capital reduces the incentive towards risky projects and, at the same time, the value of the put option held by stockholders.

2.3 Solvency and liquidity

Solvency and liquidity are strictly linked because a liquid insurer is also solvent. Liquidity implies the ability to refund assets and meet obligations under a variety of foreseeable circumstances, whereas solvency is concerned with the ability to ensure the protection of policyholders and implies having enough assets to meet liabilities.

Premiums are typically received before payments for losses are made because the production cycle of insurance companies is reversed and therefore achieving liquidity is not a particular problem. However, the estimate on the occurrence of negative events should be made carefully in order to accurately price insurance contracts and preserve an adequate level of liquid resources.

An insurance company gets liquidity from underwriting, investment income and asset liquidation (Holden and Ellis, 1993). Underwriting includes premium revenues less claim payments and operating expenses; investment income consists of dividends and realised capital gains on stocks and coupon payments and principal payments on bonds; asset liquidation is concerned with the sale of stocks and bonds on the financial markets.

Cash holdings vary considerably among insurance companies. In non-life insurers, cash flow is less volatile than for non-life insurers because of the longer duration of liabilities and the easier predictability of the date and the size of negative events (Kaufmann et al., 2001). Therefore, portfolio allocation in non-life insurers is clearly more conservative and cash holdings are greater than for life insurers (Holden and Ellis, 1993). However, the pooling of many risks in the insurance portfolio reduces the volatility of cash flow both in life and non-life insurers and so leads to a lower level of liquid resources (Colquitt et al., 1999). Moreover, in life insurance companies, liquidity problems are linked to unanticipated monetary outflows for policy surrenders and loans (Kohn, 1994). Thus, a company must issue new liabilities or sell assets held in the balance sheet in order to increase liquid resources. In particular, the growth of policy loans is linked not only to the choice of the insured but also to the rapid increases in interest rates on bank loans.

Liquidity in insurance companies is measured over a short period of time through typical cash inflows such as premiums and investment income which are higher than typical cash outflows such as operating expenses and losses. Clearly, a positive net cash flow increases the surplus of assets over liabilities and so leads to the solvency of the insurance company. Therefore, many interdependencies between liquidity and solvency emerge because the achieving of the former in the short run is essential for preserving the latter over a long period of time.

It is clear that a more positive net cash flow increases liquidity and more capital increases solvency. Profits affect both liquidity and solvency because the increase in profits leads to a greater net positive cash flow (liquidity) and, at the same time, a greater level of capital (solvency). Moreover, achieving liquidity in the short-term permits solvency in the long-term because net positive cash flow increases capital. Therefore, an analysis of the liquidity position, by implementing a short-term financial plan of cash inflows and outflows, provides both regulatory authorities and managers with useful information on insurance solvency.

3. Cash flow simulation models

3.1 Basic characteristics

Capital requirements are not drawn up in such a way as to dynamically measure the solvency of insurance companies because they show the level of capital at a certain date only (Cummins et al., 1995; Dickinson, 1997; Grace et al., 1998; Kopcke, 1996). These requirements are essentially static measures that fail to capture the real solvency condition of a company. Moreover, the selection of on -and off - balance sheet classes and their risk factors in the American risk-based capital model and the level of required capital in relation to premiums or losses in the European solvency margin model is somewhat arbitrary and does not recognise the overall risk position of an insurance company (Farny, 1997; Müller and Reischel, 1996).

Therefore, capital requirements do not provide any detailed information on the evolution of insurance solvency in the future. Thus, it is useful to infer the position of a given insurance company by developing a financial plan of cash inflows and outflows in which assumptions are made about future premiums, losses and returns on investments.

It should be noted that the difference between cash inflows and outflows shows the liquidity position of an insurance company at a certain date. The analysis of this liquidity position in the short run provides some useful information for solvency measurement in the long run. In this context, cash flow simulation models extend the existing methods for evaluating insurance solvency by implementing several scenarios which are based both on internal information on the dynamic evolution of the insurance business, such as premiums, operating expenses and losses, and on external information on economic variables, such as inflation rates and interest rates. These scenarios will be combined to consider the possible changes in the value of factors that influence the cash inflows and outflows of a company.

Cash flow simulation models take into account the main cash inflows such as premiums, investment income and asset liquidation, and the main cash outflows such as losses, operating expenses and taxes. These models are based on the analysis of the balance sheet and income statement of an individual insurance company in a specified year (starting date) and the planning of cash inflows and outflows over at least a time line of twenty years. Simulated year-by-year net cash flows are generated and at the end of the time line the resulting present values of the net cash flows will be added to the capital of the insurance company to see if this company is considered to have survived (positive value of the capital) or failed (negative value of the capital).

In the beginning, cash flow simulation models were introduced in the context of life insurance companies to evaluate the impact of unanticipated changes in interest rates on companies' investment strategies and thus on their future performance. The extension of these models to non-life insurance companies is more recent both for management and regulatory purposes (Hodes et al., 1999b). As management tools, they provide some information making possible an analysis of the insurer's business decisions, such as the pricing of insurance products and the allocation of capital to business units, while as regulatory tools they show the size of the initial margin of assets over liabilities which is needed to ensure the solvency. The model can be carried out either on a going-concern or on a run-off basis. The latter is typically employed for regulatory purposes, whether or not the existence of new business for the initial period of the simulation is assumed and thus prevents an insurance company from underwriting new policies, while the former is typically adopted for management purposes. Because of their interest in ensuring the solvency of a company, regulatory authorities may be concerned with the taking of a more conservative approach in the building of a cash flow simulation model.

The cash flow simulation models are investigated by using two types of approaches: stochastic and deterministic (Feldblum, 1995). Each method may be implemented in building this model but it is worth pointing out the main features of the two approaches and also the major advantages and drawbacks in their application to real context.

3.2 *The stochastic approach*

The stochastic approach is essentially based on the variables that are selected randomly from a specified probability distribution function; these variables represent the most important factors affecting insurance business. This approach is grounded in the actuarial studies on the risk theory and ruin probability theory by using probability distributions of premiums, losses and investment income in order to assign the values to the main cash inflows and outflows and thus to perform a simulation analysis. The output of stochastic approaches is represented by a measure of the probability that assets will adequately meet liabilities, keeping the net worth from falling below a specified ruin probability level (Daykin and Hey, 1990; Daykin et al., 1987; Daykin et al., 1994; Kaufmann et al., 2001; Pentikäinen and Rantala, 1982; Pentikäinen et al., 1989).

It should be noted that some drawbacks emerge when uncertain interest rates and stock price changes, mixed lines of business and adverse loss development and economic conditions have to be implemented within a stochastic approach (Feldblum, 1995). Therefore, a simulation by means of Monte Carlo methods may be carried out and multiple scenarios are built firstly by defining a parameter scenario in which the probability distribution function is introduced, and secondly by randomly generating a set of runs, each of which may be considered as a single scenario. The use of Monte Carlo methods with a large number of simulations permits some measures of variability to be introduced in the model when future losses and new business are evaluated.

Stochastic approaches are quite complex but provide robust mathematical results. However, some drawbacks may be associated with these approaches. The most common ones concern with the following (Feldblum, 1995):

a) the reasons for a surviving or failing company;

a) the parameterisation of the model;

b) the rerun of the model.

The first drawback considers the skill of the model in justifying the survival or failure of the company at the end of the simulation period. Indeed, the model shows the insolvency ratios in each scenario but does not recognise why a particular company is survived or failed.

The second drawback relates to the selection of a specified probability distribution function for the main cash inflows and outflows of a given insurance company. This implies validating the form and the parameters of the distribution function, which is used in order to ensure the most accurate representation of the process underlying the evolution of the variables, involved.

The third drawback relates to the rerun of the model when some initial assumptions are changed because of a reparameterisation. This involves a change in the resulting probability of ruin that does not convey any information on their nature and thus one does not recognise if this change is due to the revised assumptions or randomness.

3.3 *The deterministic approach*

The deterministic approach is based on a "what if" analysis, which is concerned with the selection of a set of some economic and insurance variables that are used in the building of several scenarios. This approach measures the impact of these variables on the main cash inflows and outflows of an insurance company according to the various scenarios that are implemented. In contrast to the stochastic approach, which considers all the resulting scenarios as realistic, scenarios in the deterministic approach are selected by taking into account only the most realistic simulated outcomes for the economic and insurance variables (Cummins et al., 1999; Hodes et al., 1999b).

Based on simple mathematical calculations, this approach presents the main advantage of being meaningful both to regulators and insurers. The impact of several scenarios on the cash flows of an insurance company is analysed to get some information on the resilience of this company to the severity of economic and insurance conditions. On the one hand, it allows the company to redefine the business or investment strategy that may be carried out, and on the other hand, it allows regulatory authorities to apply the most suitable methods for ensuring solvency.

The assumptions underlying the scenarios of the deterministic models can be easily modified if there are unanticipated changes in the variables that are adopted and thus the model may be updated according to the development of economic and insurance conditions.

Therefore, deterministic approaches have some advantages, such as the meaningful of the results and the modifiability of the scenarios, but there are also some pitfalls, as follows:

a) the judgment in scenario building;

b) the misspecification of the relationships between exogenous variables.

The first drawback is linked to the fact that scenario building reflects the judgment of individuals and thus one may overestimate/underestimate a more optimistic/pessimistic scenario. Therefore, the modeler must build realistic scenarios in order to get unbiased results from the simulation.

The second drawback depends on the unawareness of the relationships between some variables that are implemented in the scenarios. The modeler must be aware that when a hypothesis is assumed in a given scenario, many correlations with other variables may emerge. These ones must be recognised and adequately estimated.

Notwithstanding the differences that have been explained, including both deterministic elements in a stochastic approach and stochastic elements in a deterministic approach permits to combine the stochastic and the deterministic approaches in order to build a more accurate model in representing the real world.

3.4 *Scenario building*

Because scenario building is crucial in both the stochastic and the deterministic approaches, it is worth emphasising how a scenario is built and what kinds of variables should be considered.

More specifically, a scenario is a set of assumptions about external variables that may be expected to affect the business and the strategy of an insurance company. This set of assumptions represents the environment in which this company will presumably operate in the future.

There are three main steps in the building of a scenario, as follows (Feldblum, 1995; Hodes et al., 1999b):

1) selection;

2) effects;

3) calibration.

Scenario selection requires formulating some hypotheses on the trends that both the economic and insurance environment will follow. The economic environment may affect an insurance company through recession or overheating, stock market declines, wide fluctuations in inflation rates and interest rates. The insurance environment may influence an insurance company through a prolonged negative underwriting cycle, higher competitive pressure, restrictive regulation and natural catastrophes.

Scenario effects are concerned with the translation of the various hypotheses on the economic and insurance environment into a general model that must be applied to the company. This translation requires taking into careful account the main relationships between the economic and insurance environment because they are not independent. For instance, unanticipated changes in interest rates affect the return on investments and at the same time the underwriting cycle of a company which includes premiums, operating expenses and losses. In addition, inflation rates and interest rates are correlated and thus changes in inflation rates are presumably associated with changes in interest rates. Consequently, there are some influences not only on the return on investments and underwriting cycle, but also on the reserving method which is adopted by the company (Butsic, 1981).

Scenario calibration involves the choice of the most accurate method for determining the severity of each scenario. Concerning this, there are many methods that can be implemented, such as the use of past experience or management's expectations for the coming years. Typically, the severity of each scenario is incorporated within the model by defining a standard scenario that consists of the most reasonable expectations about the foreseeable future and one or more alternative scenarios that reflect more optimistic or pessimistic expectations about the future.

4. **Empirical analysis**

4.1 *The model*

This section presents an empirical analysis for solvency monitoring of the Italian non-life insurance companies by implementing a deterministic cash flow simulation model to predict the solvency of insurers. The sample of the companies consists of all non-life insurers that became insolvent from 1990 through 1994 as well as a sample of solvent non-life insurers during the same period. This analysis was carried out with a five-year prediction horizon based on balance sheet and income statement data from 1989.

Because of its emphasis on solvency monitoring purposes, this analysis adopts a cash flow simulation model on a run-off basis and only a simplified standard scenario, which takes into account past experience in formulating assumptions on the future trends of both economic and insurance variables, is implemented.

The empirical model used is a deterministic cash flow simulation model. This model involves planning the future cash inflows and outflows of a given company that result from premiums, losses and investments for a twenty-years time line by building a standard scenario in order to predict solvency. Table 1 shows principal cash flows data gross of reinsurance operations for the Italian non-life insurers in the 1989.

The remainder of this section provides the description of the empirical model and then data and results of the analysis are presented.

Table 1

Principal cash inflows and outflows for the Italian non-life insurers in the 1989.
(*in € millions*)

Cash inflows	
Premiums	11.154
Investment income	1.878
Cash outflows	
Loss payments	8.033
Underwriting expenses	2.431
Taxes	85
Net cash flow	2.883

Source: *ANIA, Annual Report, 1991*.

4.1.1 Premiums

On a run-off basis, an insurance company does not continue to engage in any further business over the simulation period. However, regulatory authorities audit the financial statement of the company after a few months and during this period the company may underwrite new policies. More precisely, in the cash flow simulation model it is assumed that the insurer is solvent at the starting date of the simulation and regulatory authorities will audit the company eighteen months after the starting date.

Thus, the standard scenario implemented in the model assumes that the premiums collected in the two simulation years, t_1 and t_2, are equal to (Cummins et al., 1999):

$$P_1 = P_0 \cdot m_p \tag{1}$$

$$P_2 = \frac{P_0 \cdot m_p^{3/2}}{2} \tag{2}$$

where P_0 represents premiums collected during year t_0 prior to the beginning of the simulation and m_p is the premiums' average growth rate in the five years prior to the beginning of the simulation.

It should be noted that the new business implies operating expenses E_1 and E_2 as follows (Cummins et al., 1999):

$$E_1 = ER_0 \cdot P_1 \tag{3}$$

$$E_2 = ER_0 \cdot P_2 \tag{4}$$

where ER_0 represents the expense ratio, i.e., the ratio of operating expenses to premiums at time t_0. Hence, the model assumes that the expense ratio is the same over the two years following the beginning of the simulation.

4.1.2 Losses

Estimating expected claims has been carried out by planning loss cash flows over the simulation period. This planning is based on the chain ladder incurred losses development to estimate future claims.[3] This involves building of a loss development triangle to extract a pattern for the run-off.

[3]There are many methods for estimating future claims and thus the relative estimated level of loss reserves, such as basic chain ladder, separation technique, average cost per claim, Bornheutter-Ferguson, operational time, bootstrap,

Loss development is a distinguishing characteristic of the underlying claims process of non-life insurance companies. Loss reserves represent the estimate of the total amount a non-life insurer will pay to settle underlying claims. However, this estimate is subjected to several revisions as information improves and thus it converges to the ultimate value which presumably will not be equal to the initial value. This convergence process is loss development. We can quantify the changing estimate of the ultimate value of claims by measuring loss development factors that show the direction from the initial value to the ultimate value.

In this study, the measurement of loss development factors is based on an accident-year basis that attributes losses to the period in which the accident occurred. In addition, building the loss development triangle in respect of incurred losses,[4] that is the sum of paid losses and case reserves, gives more information on the delay period through the initial value of claims converges to the ultimate value.

The basic chain ladder method may be expressed as follows (Booth et al., 1999):

$$C_{i,j} = S_i R_j + E_{i,j} \tag{5}$$

where $C_{i,j}$ represents the incurred losses for accident year i reported at the end of development year j, S_i is the ultimate level of losses for accident year i, R_j is the proportion of the ultimate that emerges at the end of development year j and $E_{i,j}$ reflects an error term.

The measurement of loss development factors assumes that the cumulative incurred losses at development year $j + 1$ is derived from the cumulative incurred losses at development year j by estimating the volume weighted development factors as follows (Booth et al., 1999):

$$LDF(j \to j+1) = \frac{\sum_{i=1}^{n-j} C_{i,j+1}}{\sum_{i=1}^{n-j} C_{i,j}} \tag{6}$$

When the estimated loss development factors are stable over the different periods of time, they can be used to provide estimated future payments by calendar year.

The various lines of business pay out losses in non-life insurers differently. Short-tail lines are characterised by a short time gap between the occurrence and the entire payment of claims while long-tail lines are characterised by a more long time gap.

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distribution-free and linear model. The most widely used of these methods is the chain ladder. For a general comparison, see Booth et al. (1999).

[4]In contrast, Hodes et al. (1999b) use paid losses to avoid the issue of different reserving philosophies of insurance companies.

In this model it is assumed that short-tail lines have a loss development period of three years and pay the remaining loss cash outflows in the fourth year after the accident year while long-tail lines generate loss cash outflows over the entire simulation period. Tail development assumptions are based on estimates of loss development process of the Italian non-life insurance market because of the lack of publicly available individual data. The Italian supervisory authority -ISVAP- reported data for the development history of the auto liability line that represents the major line of business in the Italian non-life insurance companies. For this reason, reported industry data on the development history of the auto liability line are used to estimate the development history of long-tail lines in each company. Because reported industry data take into account only a six-year development period, the model estimates the future loss cash flows from development year 7 through development year 20 by fitting an inverse power curve[5] to the first six years of loss payments (Cummins et al., 1999; Hodes et al., 1999a).

On the other hand, short-tail line proportions of ultimate losses for the first three years are set equal to 0.55, 0.3 and 0.1 respectively while the remaining 0.05 is paid in the fourth year. These proportions may be considered plausible estimates of the process underlying the loss development history of short-tail lines.

The standard scenario assumes that future loss payments have been adjusted to take into account the estimated inflation rate. Therefore an inflation rate equal to the Italy's average inflation rate for the period from 1950 through 1989 as reported by the *International Financial Statistics Yearbook* of the International Monetary Fund (IMF) was introduced in the model. Moreover, the new business deriving from the premiums collected in the eighteen months after the beginning of the simulation is assumed to generate new losses according to a percentage to 0.5 times the company's average loss ratio for the three years before the beginning of the simulation plus 0.5 times the industry's average loss ratio during the same period.

4.1.3 Investments

The model takes into account the investments of an insurance company by estimating the cash flow that will be generated over the simulation period. More specifically, these investments consist of stocks and bonds as reported in the company's annual statement.

Stocks typically produce cash flows in the form of capital gains or losses and dividends. Capital gains on stocks for simulation year *i*, CAP_i, are estimated by multiplying the reported value for the previous simulation year S_{i-1} and the capital gain accumulation factor for

[5] For a detailed analysis of the properties of inverse power curves see Sherman (1984).

simulation year *i*, CG_i. Thus, the amount of capital gains for simulation year *i* is equal to (Cummins et al., 1999):

$$CAP_i = S_{i-1} \cdot CG_i \quad (7)$$

In the standard scenario, capital gains factors are equal to the historical average for the Italian listed stocks from 1950 through 1989 as reported by *International Financial Statistics Yearbook* of the IMF. It should be noted that capital gains do not represent cash flows until an insurance company needs to sell stocks.

The dividends for simulation year *i* are estimated like capital gains. In the standard scenario, dividends factors are equal to the historical average dividend yield on the Italian listed stocks from 1950 through 1989 as reported by *Indexes and Data* of Mediobanca.

Bonds typically produce cash flows in the form of coupon payments and principal payments, but in this model only the former are implemented. Since short-tail lines and long-tail lines represent liabilities, it is assumed that bonds are made up of medium-term bonds. Bonds typically produce interest and in the standard scenario coupon payments are based on the historical average yield on Italy's medium-term Government bonds from 1950 through 1989 as reflected in the *International Financial Statistics Yearbook* of the IMF. This scenario also considers a flat yield curve and thus the simplified assumption of a no interest rate risk is adopted. Therefore, the principal payment that the company receives when a bond is sold is equal to the book value with no capital gains or losses.

The model assumes that the selling rule for assets in order to face the negative cash flows is concerned with the sale of stocks first and then bonds. Therefore, bonds are sold to meet uncovered future negative cash flows until the stock portfolio has been exhausted. It should be noted that when stocks are sold in a specified simulation year, the capital gains are realised and thus it must be added to the cash flow of this year.

4.1.4 Net cash flow

The final equation for the cash flow simulation model derives from the main cash inflows and outflows of an insurance company. The main cash inflows are premiums, investment income and asset liquidation and the main cash outflows are loss payments and operating expenses.

It should be noted that the model used here does not consider the cash flow from other assets and liabilities and also reinsurance operations; thus, in this model only the underwriting and investment incomes are taken into account. More specifically, reinsurance operations are often particularly volatile and unpredictable and consequently their estimation is much more complicated because the company must be able to evaluate the probability of recovering from reinsurers (Daykin et al., 1987).

Thus, the equation for an insurance company i in simulation year y is equal to:

$$NCF_i = P_i + DIV_i + CP_i + AL_i - L_i - EX_i \tag{8}$$

where:

NCF_i = net cash flow for simulation year y;

P_i = total premiums collected during simulation year y;

DIV_i = total dividends received on stocks during simulation year y;

CP_i = total interest received on bonds during simulation year y;

AL_i = total proceeds from asset liquidation during simulation year y;

L_i = total losses incurred during simulation year y;

EX_i = total operating expenses paid during simulation year y.

The sum of the simulated net cash flows is added to the capital of each company in order to verify the survivorship or the failure of this company over the sample period. Accordingly, present values of the net cash flow in each year of the simulation are generated by setting an after-tax discount rate equal to Italy's average yield on medium-term Government bonds minus a tax rate of 50%.[6]

4.2 *Data and results*

This study used data from one base year -1989- to predict failure rates for the period from 1990 through 1994. Accordingly, data reported in the *Annual Report* of ANIA, the Italian association of insurers, are used to carry out this analysis which separates all companies into two samples of solvent and insolvent non-life insurers respectively.

The sample of insolvent companies consists of all non-life insurance companies that were reported by the Italian supervisory authority -ISVAP- as becoming insolvent. Concerning this, a company is assumed to be considered insolvent when is liquidated or submitted to a rehabilitation regulatory order.

The sample of insolvent non-life insurers consists of 10 companies that became insolvent during the period 1990-1994. In addition to these companies, the sample also includes 86

[6]This tax rate reflects the high tax burden on the Italian firms' gross income.

solvent non-life insurers in order to make a comparison between the rates of predicted insolvent companies and solvent companies that have been correctly classified by the model.

The results of the deterministic cash flow simulation model for the two samples of insolvent and solvent Italian non-life insurance companies from 1990 through 1994 are pointed out in Table 2. The model, which assumes a standard scenario according to the hypotheses explained above, performs a Type I error rate of 10.00 percent and a Type II error rate of 15.12 percent. These error rates show a more accurate prediction ability of the model to correctly classify the insolvent companies as opposed to solvent companies. More specifically, a Type I error rate of 10 percent reveals a strong ability of the model to predict non-life insurers which have became insolvent.

It should be noted that the prediction ability of the model used for this analysis should be evaluated in comparison with other solvency regulatory methods such as capital requirements and financial ratios. In this context, the cash flow simulation models, capital requirements and financial ratios can be compared both in isolation and in combination in order to determine the suitable regulatory framework for preserving the solvency of insurance companies.

The standard scenario has been chosen not as a fixed basis for discriminating between insolvent and solvent companies, but rather as a basis for selecting several alternative scenarios taking into account more adverse economic and insurance conditions such as wide fluctuations in inflation rates and interest rates, stock market declines, high competitive pressure in insurance markets and an adverse loss development process.

Thus, this model provides a powerful tool for dynamically analysing the financial condition of an insurance company. The selection of alternative scenarios that incorporate risk factors and the comparison with other regulatory methods should assign more explanatory power to this analysis.

Table 2

Cash flow simulation prediction results.

1990-1994 Error rates	
Standard scenario (%)	
Type I error	Type II error
10.00	15.12

The Type I error rate is the percentage of companies which became insolvent during the period 1990-1994 and which have been incorrectly predicted to remain solvent.
The Type II error rate is the percentage of companies which remained solvent during the period 1990-1994 and which have been incorrectly predicted to become insolvent.

5. Concluding remarks

The traditional approach to insurance solvency involves the use of capital requirements by establishing a direct relationship between capital and risk. A major drawback of capital requirements is that they are based on a static analysis and therefore do not provide updated information on the financial condition of a given insurance company.

A more effective approach to insurance solvency consists of implementing the cash flow simulation model, which is based on the links existing between liquidity and solvency. Indeed, liquidity is made up of cash inflows and outflows of the insurance company and concerns with the ability of the company to meet its contractual obligations, whereas solvency is the result of an excess of assets over liabilities, which means a positive value of capital.

It should be noted that achieving liquidity over a short-term period conducts to solvency over a long-term period because a positive net cash flow increases capital. An adequate planning of the cash inflows and outflows that will be presumably generated in the foreseeable future is extremely important in preserving the solvency condition of an individual non-life insurance company.

Regulatory authorities are interested in monitoring the development of cash flow by simulating monetary inflows and outflows over a certain period of time. Thus, the cash flow simulation approach allows a dynamic analysis of insurance solvency compared to the static analysis provided by capital requirements.

Cash flow simulation models are realised by a stochastic approach or a deterministic approach. Although the former is more accurate from an actuarial point of view if properly designed, the latter is less complex and its implementation is quite easy. Specifically, the deterministic approach consists of several scenarios for premiums, losses and investment income, and also incorporates some expectations about inflation rates and interest rates. These scenarios are typically assumed on a run-off basis, which prevents an insurance company from underwriting any further policies. Regulatory authorities use the run-off basis because it dynamically shows the solvency of an insurance company.

The deterministic cash flow simulation model that has been discussed in this paper is based on planning of premiums, losses and investment income. More precisely, it is assumed that premiums will be written for eighteen months after the starting date of the simulation because of the time gap between two subsequent audits by regulatory authorities. Losses are calculated by using the basic chain ladder method to estimate the claims to be paid when a loss occurs. Investment income consists of cash flows received on the securities portfolio held by an insurance company.

The empirical analysis has been carried out by means of the deterministic cash flow simulation model that established a standard scenario and took into account two samples of insolvent and solvent Italian non-life insurance companies from 1990 through 1994 in order to show the prediction ability of the model in correctly classifying the companies. Simulated results show that the model had a strong ability to predict the companies that became insolvent during the period 1990-1994.

Thus, it is clear that the cash flow simulation model is useful for regulatory authorities in verifying insurance solvency. This model is based on the relationship between liquidity and solvency and allows a dynamic analysis of the financial condition of an insurance company. Moreover, this model must be evaluated both on its own and in combination with other regulatory methods for insurance solvency such as capital requirements and financial ratios.

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