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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Abstract

We analyse the effect of failing reinsurance cover on the stability of Dutch insurers. As insurers often reinsure themselves with other (re)insurers, losses could spread contagiously through the sector. Using a unique and confidential data set on reinsurance exposures, we perform a scenario analysis to measure contagion risks. Based on current exposures, we find no evidence of systemic risk in the Netherlands, even if multiple reinsurance companies fail simultaneously. Next, we analyse to what extent the financial position of individual primary insurers is affected following a particular shock, considering solvency, capital and profit levels. The life insurance industry is hardly affected by reinsurance failures. The non-life industry, however, is vulnerable to a crisis in the European reinsurance market. We also find that members of smaller insurance groups are particularly exposed.

Keywords : reinsurance, contagion, simulation

JEL Codes: G20, G22

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1. INTRODUCTION

The proper functioning of a financial system is crucial in facilitating economic activities. If a financial crisis occurs, the cost can be severe and can lead to periods of low growth. As part of the financial sector, the insurance industry contributes to economic growth. The most important reason for this is that the insurance sector allows economic agents to transfer (part of) their risks. Insurance thus facilitates participation in transactions that would otherwise be considered too risky. This is especially relevant in industries with relatively large investments, such as shipping, aviation and manufacturing. Second, the insurance sector is able to transfer funds, by means of their investments, between market participants and over time, and hence functions as a financial intermediary. This enhances the efficient allocation of funds. Especially life insurance companies, which can hold on to their funding over a longer term, increase the potential for long-term investment in the economy. Third, insurance companies have specialised in measuring and managing risks, as well as the promotion of risk mitigation activities. Thus applying this specialised expertise may lower risks for the economy at large.

At first sight, the insurance business seems straightforward: insurance companies accept risks from market participants in exchange for a premium. If an insured event occurs, the insurance company will pay, according to the terms of the contract, out of the (invested) premiums. This implies that insurance companies need to form an expectation about the (future) risks accepted. This, however, is by no means an easy task. If too much risk is accepted or if risks are unexpectedly concentrated in a certain region or client group the premiums received may be insufficient to cover the required pay outs. This may lead to financial distress. Furthermore, as losses are difficult to predict and occur randomly, especially in the non-life segment, uncertainty increases and may lead to volatile income. Therefore, insurance companies often transfer part of their risk to other market participants.

One way to transfer risks is to agree on a reinsurance contract with a reinsurance company. IAIS (2006) defines a reinsurance contract as an “insurance contract between one insurer or pure re-insurer (the re-insurer) and another insurer or pure insurer (the cedant) to indemnify against losses on one or more contracts issued by the cedant in exchange for a consideration (the premium)”. The reinsurance industry thus presents insurance cover for primary insurers. The way in which this reinsurance cover is defined differs per contract. Well-known are the so-called proportional contracts in which the reinsurance premium paid by the insurance company is proportional to the reinsurance cover received. Another contract form is the stop-loss contracts, where the cover is set above a certain floor. Note that the primary insurer remains responsible for fulfilment of the initial contract with the client at all times.

A second way an insurer can transfer risks is through securitization on the capital market.¹ In such a transaction, insurance contracts are bundled into bonds and, sometimes through a Special Purpose Vehicle, sold on the capital market. An example is a catastrophe bond. These bonds have a higher payout triggered by some predefined event. This effectively transfers the insurance risk to the bondholder. Although this market is growing rapidly it is still in its infancy and we will thus not consider it here.

The use of reinsurance increases the number of linkages within the insurance industry. It also exposes an insurance company to the financial fortunes of the re-insurer. The Dutch market can serve as a good example as many primary insurers also offer reinsurance cover. A shock that hits the re-insurer may spread through the network of linkages to other participants in the network. These contagion effects, or domino effects, are hence relevant for the functioning of the insurance market.

Contagion risk has been extensively studied in the banking industry. The literature in this area initially focused on the risk following from bank runs or indirect contagion such as co-movements on stock markets, but since the last decade also moved to the analysis of direct contagion following from interbank exposures (see for instance Elsinger et al (2006), Van Lelyveld and Liedorp (2006), Upper and Worms (2004), and summarised in Upper (2007)). By contrast, the topic of direct contagion risk has hardly been studied in the insurance market. One reason for this may be the relative lack of data on this topic. Insurance companies do not report extensively on their reinsurance exposures, while reinsurance companies themselves have historically not been subject to supervision or to particularly intensive market scrutiny. Furthermore, in the past reinsurance failures have generally not led to widespread losses. As we argue later, this may underestimate the relevance of this topic.

In this paper we will analyse the risk of contagion stemming from direct financial linkages to reinsurance. We investigate the effect of failures of reinsurance cover on primary insurers, and analyse the number and size of insurance failures. From this, we can make an inference on the resilience of the financial system to these types of shocks. In addition, we measure the effect on solvency and the loss-absorbing capacity of primary insurers. Existing research in this field generally finds small contagion effects (see for instance Swiss Re, 2003 and Group of Thirty, 2006). We add to the literature by compiling for the first time a reinsurance matrix which shows all bilateral positions between insurers and re-insurers. This allows us to analyse the impact of a reinsurance failure on a microeconomic level and to detect any market structure effects, which cannot be accomplished using aggregate data. Furthermore, we are able to measure contagion effects and the impact on profit, equity and solvency at the individual firm level. That said, we do not consider the contagion effects following from common exposures, for instance the risk of floods. Nor do we include the impact from indirect contagion such

¹ See Swiss Re (2006) for a full description of securitization.

as reputation risk. These aspects are particularly difficult to assess. However, they will significantly worsen the results for the Dutch insurance sector, especially since all these contagion effects are likely to occur simultaneously.

On the whole our results suggest that the reinsurance sector does not pose a threat to the systemic stability of the insurance sector. Even in the extreme case that the entire reinsurance sector collapses, only a limited number of firms fail. No contagion occurs: only firms with direct financial linkages to failing reinsurers fail. Naturally, severe shocks emanating from the reinsurance sector could of course seriously weaken the primary insurers, raise reputation issues and thus pose a threat in the longer term. Furthermore, reinsurance failures are likely to occur following large shocks, which may already have weakened insurance companies. It is hence feasible that exposures increase, exactly at times that reinsurance counterparties are more likely to default.

The remainder of this paper is structured as follows. The literature review in Section 2 analyses the pros and cons of the use of reinsurance. It also explains how reinsurance can lead to contagion. In this way, it frames our empirical analysis. Section 3 outlines the methodology we use to analyse the scope for contagion. Section 4 and 5 describe the data and the inter-linkages between the reinsurance and insurance markets respectively. The results of our contagion analysis are presented in Section 6. In addition to any systemic effects, we analyse the impact of a reinsurance failure on several balance sheets indicators of insurers. The impact of reinsurance failures on insurance groups is presented in Section 7. Here we analyse whether certain groups or group members are hit harder or more frequently than others. We present our conclusions and some resulting policy implications in Section 8.

2. LITERATURE REVIEW

2.1 Reinsurance, pros and cons

Reinsurance is not just important at the microeconomic level as discussed in the introduction to this paper, but it is also highly relevant from a macroeconomic perspective (Allen and Gale, 2000). First, as insurance companies transfer risks to reinsurance companies, the level of diversification of risks within the economy increases (Group of Thirty, 2006). This reduces the impact of adverse shocks on primary insurers and limits the volatility of earnings. The planned Solvency II framework in Europe also contains incentives for insurance companies to reinsure part of their risks. As reinsurance companies in turn often transfer part of the risks to other re-insurers (retrocession), they can reduce the volatility of their own income as well. Second, the reinsurance market also acts as an intermediary by balancing risk over time. This increases the efficient allocation of risks in the economy at large even further. Third, reinsurance companies increase the overall underwriting capacity by freeing up capital of primary insurers tied up to cover risk. Indeed, as part of the liabilities of a primary insurer is covered by the reinsurance company, the amount of capital effectively available for insurance

activities rises. In addition, since the reinsurance sector collects a lot of information on insurance contracts, it can offer other services, such as consultancy, technical advice on underwriting and the financial analysis of risks and portfolios (Group of Thirty, 2006). Finally, as argued by Plantin (2006), reinsurers might provide effective monitoring of insurers. This enables insurers to raise capital more easily.

At the same time, reinsurance also introduces several risks that could threaten financial stability. First and most importantly, reinsurance is not risk free as it introduces credit risk for a primary insurer. Failing reinsurance cover leaves the primary insurer with the obligation to fulfil the contract itself, possibly posing solvency and liquidity constraints. Several market factors reinforce the level of credit risk. Both the insurance and the reinsurance market are highly concentrated and are showing increasing concentration levels over the last couple of years (Cole and McCullough, 2006). The global reinsurance market is dominated by a few large reinsurance companies, the largest five representing about 57% of the market in 2001² (while ten years ago this was merely 40%; Swiss Re (2003)). Next to the rising concentration at market level, the risks insured are also becoming increasingly related. Rising population density for instance leads to more and more simultaneously occurring health and property risks. This will increase the volatility of insurance shocks (Krenn and Oschischnig (2003)). Furthermore, the demand for reinsurance is declining following international consolidation. Insurance companies with activities in various regions in the world can diversify risks internally and thus do not have to turn to the market. This leaves reinsurance companies with only those (large) risks the primary insurers are wary to accept. This increases the volatility of the shocks that reinsurance companies face and thus exposes primary insurers to higher risks. In addition, reinsurance companies invest their assets in complex financial products, which exposes them to the highly volatile stock market developments.

A second risk following from reinsurance stems from retrocession: the notion that reinsurance companies transfer risks to other reinsurance companies. When a particular (re)insurance company fails, this could spread to other (re)insurance companies, possibly affecting the complete insurance industry and ultimately affecting the economy as whole.

A third risk factor is the underwriting cycle. In times of limited losses, profits of incumbent reinsurance companies rise, attracting new firms. The market entry and associated increase in competition will lead to a decrease in the general reinsurance premium level. Reinsurance companies will find it harder to survive, making failures more likely. In case of large losses the opposite holds, and the general premium level will increase. These fluctuations in premium levels are called the “underwriting cycle”. In times of a high premium level, market participants find it hard to find

coverage for a cost-effective price. They may then decide to retain a larger part of the risks on their balance sheet which will increase the firm's risk. Such hog cycles are also visible in many other sectors outside the financial sector; the high volatility of the general (re)insurance premium level creates an unstable economic environment, and could lead to lower growth (see Lamoen (2007)).

Fourth, the reinsurance sector is generally not yet subject to supervision. In Europe this has changed recently as the EU Directive on Reinsurance (2005/68/EG) has come into force (as of January 2008). This Directive requires all reinsurance companies to be licensed, increase transparency and it introduces principles for solvency requirements, risk management and firm governance.

All in all, risk transfer through reinsurance contributes to the smooth functioning of the economy. It facilitates diversification and an efficient allocation of risk over market participants and time. It also increases the underwriting capacity of primary insurers. However, the use of reinsurance introduces several risks that could threaten financial stability, the most relevant being credit risk. A single failure of a reinsurance company, especially in such a concentrated market, may present large losses, both for the reinsurance and primary insurance market. Given the rising interaction between financial sectors, the banking sector and financial markets may also be affected. This may have implications for the economy as a whole.

However, the probability of a reinsurance failure is generally assessed to be small. As mentioned by Swiss Re (2003), a reinsurance bankruptcy may result from risk underwriting, retrocession and the investment policy of the reinsurance company. Swiss Re (2003) counted only 23 bankruptcies worldwide since 2002. They argue that a collapse of the entire reinsurance system is only conceivable in the case of very large exogenous shocks, of which the reinsurance industry has not taken account.³ Furthermore, they state that credit ratings for reinsurance companies are generally high. This however, might give a distorted image about the number of re-insurers who run into financial trouble. In many cases when reinsurance companies are about to fail, the existing claims are taken over by another firm. Reinsurance failures are also more likely to occur following severe shocks. In such a case, just when primary insurers will face large losses following such a shock and call upon the contracted reinsurance, the reinsurance company will default on its obligations, exacerbating losses for the primary insurer. This will consequently impact the real economy. This may also work vice versa. As some of the Dutch insurers are quite large and have significant positions, their failure may impact reinsurance companies as well. For one, both insurance and reinsurance companies are vulnerable to the same large disasters. But second, the failure of a large insurance company may affect financial markets, which in turn will affect the investment portfolio of a reinsurance undertaking.

² Measured in terms of gross premium income.

³ The recent troubles of the American insurer AIG would point in this direction, however.

2.2 Contagion channels

Following the terminology introduced by De Bandt and Hartmann (2000) we focus on *narrow* systemic events, that is, an event which initially impacts only one single institution⁴, and may consequently spread to other parts of the industry and even the real economy. In the literature, two main channels have been identified through which a reinsurance failure can influence the primary insurer: through direct and indirect financial exposures (see for instance Allen and Gale (2000)).

Direct exposures

The use of reinsurance creates a direct financial link between an insurance company and a re-insurer. It exposes the insurance company to credit risk, namely the risk that a re-insurer is not willing or not able to pay the claim to the primary insurer. In general, three effects of a reinsurance failure can be distinguished. First, the claim of the primary insurer on the re-insurer cannot be collected. Regardless of the occurrence of an actual loss event, this decreases the financial strength of the primary insurer. As the reinsurance cover is lost, the primary insurer has to hold capital again for these contracts. This weakens its solvency level. The loss of financial strength can decrease the credit rating of the primary insurer, which further deteriorates its financial position. If the exposures to the failing reinsurance company are large enough and exceed the company's capital base, a primary insurer could even fail. This again, could affect other primary insurers since primary insurers may also offer reinsurance. In the case that an actual loss has occurred, the liquidity position of the primary insurer is also affected, aggravating the position of the firm. Second, if the insurance company holds equity shares of (re)insurance companies (cross-participations), it will lose these in case of failure. Third, if a guarantee fund is in place, a failure could force the other insurance companies to pay for the claims of the failed re-insurer and any insurer that fails as a consequence of the re-insurers failure.

Swiss Re (2003) analyses the direct contagion risk of the reinsurance sector for primary insurers using aggregated global data, focussing on the first effect. They conclude that the risk potential resulting from reinsurance is low for three reasons. First, based on total global premiums written, only a small percentage (6%) of total risk is reinsured. Second, based on the credit ratings of reinsurance companies, the probability of reinsurance bankruptcies is low, implying that the risk from retrocession is also small. Third, the study notes that only a small number of reinsurance companies have failed in the past, and none of the failures showed any evidence of being a threat to systemic stability⁵. Indeed, to date reinsurance failures are a relatively rare phenomenon. This, however, might give a distorted

⁴ In contrast to broad systemic events, which additionally include simultaneous adverse effects on a large number of markets and/or institutions.

⁵ The recent problems for many monoline insurers, which provide credit protection, would contradict this statement.

image about the number of re-insurers who run into financial trouble. In many cases when reinsurance companies are about to fail, the existing claims are taken over by another firm.

The Group of Thirty (2006) follows a similar approach in its assessment of contagion risk in the insurance sector. To analyse possible sources of systemic risk, a sector wide stress test is performed. It assumes that because of a large catastrophe, 20% of total reinsurance capacity is lost. Loss estimations are based on total global premiums written and premiums paid to re-insurers. Three channels through which a reinsurance shock can influence the primary sector are considered. First, the exposure to the reinsurance company would be lost. Second, significant losses can result in the case the primary insurer has bonds and equities of the failed re-insurer (cross-participations). Third, the primary insurer could face higher costs in replacing the reinsurance cover. In conclusion, the Group of Thirty expects a relatively small effect on the primary insurance sector as only a small proportion of the total risk is reinsured and the probability of bankruptcy is low. Furthermore, new reinsurance cover should be easy to obtain because of low entry barriers.

This view need not be true however. As a reinsurance failure is generally more likely to occur as a result of a large shock to the economy, and may thus affect other re-insurers as well, it may become more difficult to obtain new reinsurance cover. Moreover, acquiring new coverage will probably lead to additional costs, as prices are highest at that time. As a remark to their findings, the Group of Thirty notes that the stress tests are executed on an aggregate level and that the effect on sub-segments could be larger due to the concentration of risks and/or higher cession rates. Also, many assumptions had to be made as the reinsurance market is relatively in-transparent. And last, only pure reinsurance companies are considered in the dataset while other risk transfer instruments can also be used and many primary insurers offer both reinsurance and primary insurance products.

Indirect exposures

A second contagion channel arises from indirect exposures between companies following from asymmetric information. This has been termed information-based contagion. In this case, contagion occurs when market participants are imperfectly informed about the type of shocks hitting insurance companies. The arrival of new information about a particular reinsurance company can be interpreted as a signal of new information about rival (re)insurance firms as well, whether it is true or not. Investors in (re)insurance companies may react by selling their shares in the companies, causing the financial position to deteriorate. DNB (2006) mentions that the failure of a single reinsurance company could cause reputation damage for the industry as a whole. Note however that a classical bank run (as in Diamond and Dybvig (1983)), where depositors withdraw their deposits causing a liquidity problem, is not possible in the insurance industry. In the non-life industry, a premium is paid in advance to cover a particular risk and this premium cannot be withdrawn within the remaining

contract period. The life industry has a saving component, but the amount saved is difficult to withdraw on a short notice and savings can generally only be withdrawn subject to a fine. Notwithstanding the saving component, lapse risk can be significant, as some US insurance companies ran into liquidity problems following large lapse requests.

Indirect contagion in the primary insurance market has been investigated several times. Polonchek and Miller (1999) considered the U.S. insurance market over the period 1977-1993. They argue that because of high monitoring costs, investors holding securities of a reinsurance company are relatively uninformed about the quality of the portfolio of the insurance company. The arrival of new information about a particular insurance company is hence interpreted as information about rival firms as well. By looking at stock price reactions, they tested indirect contagion empirically. They find that when negative news about the asset quality of a particular firm arrives, negative abnormal returns are observed at rival firms as well. This indicates some evidence of indirect contagion. Avila and Eastman (1995) follow a similar approach. The effect of information releases about the failure of four major U.S. life insurance companies is investigated in the period 1990-1991. The response of the capital market is measured for three different groups of rival firms, each group listed at a different stock exchange. Contagion is modelled by the abnormal return on announcement dates. For only one stock market group, some weak evidence for information contagion is found, while the other two groups did not show any evidence of information contagion.

In our analysis, we focus on direct contagion, namely the risks that emanate from the direct financial links between an insurance company and the re-insurer that follow from the use of reinsurance. As we consider data from individual insurance companies, we are able to analyse in far greater detail the effects of a reinsurance failure on an individual company and on the insurance sector as a whole.

3. METHODOLOGY

For our empirical exercise we first need information on the (re)insurance exposures of all Dutch (re) insurers. Given the linkages between firms we then compute a number of scenarios. For example, we simulate the failure of each firm in turn and assess the (average) impact this has. We look at the impact on equity, solvency, and profit.

3.1 Insurance Matrix

To represent the system of reinsurance claims of primary insurers on re-insurers, we use a matrix \mathbf{X} (see Figure 1), comparable to the inter-bank lending matrix in for instance Upper and Worms (2004), Van Lelyveld and Liedorp (2006), and Elsinger et al. (2006), etc.⁶ The matrix comprises all

⁶ See Upper (2007) for an excellent overview of this literature.

reinsurance claims outstanding on both primary and pure re-insurers, where “P” represents a primary insurer and “R” stands for a pure re-insurer.

Figure 1: Reinsurance matrix

$\mathbf{X} =$	$\begin{pmatrix} P_i & P_j & P_n \\ P_i & P_{ii} & P_{ij} & P_{in} \\ P_j & P_{ji} & P_{jj} & P_{jn} \\ P_n & P_{ni} & P_{nj} & P_{nn} \\ \dots & \dots & \dots & \dots \\ R_i & R_{ii} & R_{ij} & R_{in} \\ R_j & R_{ji} & R_{jj} & R_{jn} \\ R_n & R_{ni} & R_{nj} & R_{nn} \\ \hline \sum_I \text{assets} & I_i & I_j & I_n \end{pmatrix}$	$\begin{pmatrix} R \\ \text{empty} \\ \dots \\ \text{not known} \end{pmatrix}$	$\begin{pmatrix} \sum_j \text{liabilities} \\ A_i \\ A_j \\ A_n \\ \dots \\ B_i \\ B_j \\ B_n \end{pmatrix}$
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For instance, “ R_{ij} ” represents the amount that primary insurer “ P_j ” has reinsured with re-insurer “ R_i ”. Hence, the total amount of reinsurance claims that insurer “ P_j ” has outstanding on other companies is represented by column total “ I_j ”. Re-insurers generally do not reinsure with primary insurers, hence part of the matrix remains empty (i.e. “empty”). The rows represent the claims that a (re)insurance company “ R_j ” should fulfil. The reinsurance claims of reinsurance companies outstanding on other re-insurers (retrocession) are not known (i.e. “unknown”).⁷ Note that “ P_{ij} ” represents a reinsurance claim outstanding from one primary insurance company to another.⁸ This implies that some primary insurers are “hybrid insurers”: primary insurers that also act as a re-insurer. The primary reason for structuring the matrix this way is that for firms we defined as insurer we have more information than for the re-insurers. The total amount of reinsurance claims on a primary insurer, which offers reinsurance as well, is represented by “A”. The total amount that a pure re-insurer has insured for Dutch insurance firms is represented by “B”. The cells on the diagonal are all zeros, as individual insurance entities do not directly reinsure with themselves.⁹

3.2 Scenario analysis

Based on the insurance matrix \mathbf{X} , we apply several shocks to the system. These include (1) the failure of a single reinsurance company, where all companies that provide reinsurance (including hybrid Dutch life and non-life insurers) fail in turn. Such a shock measures concentration risk, namely the impact of a single reinsurance failure on primary insurers. On a technical level, this means that the specific row in the matrix which represents this failed re-insurer is replaced with zeros. This implies that all firms which reinsured with this party lose their claims. As a worst case event, we also analyse

⁷ However, Swiss Re (2003) finds that reinsurance companies reinsure about 21% at other reinsurance companies, possibly posing a threat to financial stability.
⁸ Note that the term “re-insurer” in this paper is used both for pure re-insurers (which only offer reinsurance) as well as for primary insurers that offer both primary insurance and reinsurance.
⁹ Our analysis is on the level of legal entities; these entities can belong to groups and reinsure within the group. We provide more detail on the effect of groups in Section 7.

the impact on the Dutch insurance industry if the complete reinsurance sector fails. (2) We also test the resiliency of the Dutch insurance sector to a simultaneous failure of a large part of the reinsurance industry, for instance to a particular region in the world. Although this scenario might seem exceptional, it cannot be excluded; through retrocession a crisis can originate in particular parts of the reinsurance market. (3) Then we test the sensitivity of the insurance sector to a failure of the two largest reinsurance players in the market. (4) Finally, we also assess the impact of a reinsurance failure on insurance groups (instead of individual players).

3.3 Impact measurement

Following the initial (exogenous) failure of a reinsurance company, a primary insurance company fails when the loss following this failure is larger than its equity. The loss does not necessarily have to be equal to the outstanding claim, as part of the claim might be recovered following the sale of the assets of the failed institution. The collection of bankruptcy recoveries may take a long time though, and empirical evidence is not conclusive on what a typical loss rate would be. In banking, the few studies on the empirical loss rate find a mean loss rate of 30% of the assets of the failed bank and another 10% as direct bankruptcy costs (James, 2001). For the insurance industry, such a loss rate seems rather low. Hall (1998) finds that insurance failures are on average far more expensive than banking insolvencies. The net costs of resolving bankruptcy failures may be as large as \$1.22 per \$1.00 of pre-insolvency assets (compared to a ratio of 0.3 of resolution cost to asset in the banking industry). Hall speculates that this can be attributed to both the liability as well as the asset side of the balance sheet of the failed insurance companies. That is, the high cost can on the one hand be attributed to large increases in liabilities, perhaps driven by moral hazard considerations. On the other hand, Hall finds that state regulators recover relatively little from the asset sales of failed companies. He estimates that state insurance regulatory bodies return only 33% of the insurance assets after insolvency, implying an average loss rate of 70%. Part of this loss is likely the result from regulatory failure to recover the losses however.

To account for the incomplete information on losses from insurance failures we use several loss rates. The loss rate is however supposed to remain constant over time, as the reinsurance contract is usually fixed and cannot be altered within the term of the contract. Insurance companies hence cannot react to problems at other companies. Then, the failure of one re-insurer could lead to the failure of primary insurer(s). This could result in the failure of other primary insurers. Thus, a primary insurance company fails when the sum of the losses following the failure of one or multiple re-insurer(s), is larger than its equity:

$$\theta * (\sum_{j=1}^N P_{ij}, R_{ij}) > E_j$$

where θ denotes the loss rate ranging from [0, 1]. P_{ij} represents the claim of the primary insurer “ P_j ” outstanding on another primary insurance company P_i (i.e. a hybrid company). R_{ij} represents the claim of the primary insurer P_j on the reinsurance company R_i . The amount of equity of primary insurer “ P_j ” is represented by “ E_j ”.

The impact of shocks can now be analysed at two levels: on a system level and on an individual level. On a system level, we are interested in the impact of reinsurance failures on the stability of the system. We measure the number of scenarios where contagion occurs, the number of institutions that have failed, the number of rounds and the percentage of assets that is lost. In this way, we measure the severity of contagion effects. On an individual level, the impact of one or multiple reinsurance failure(s) on several balance sheet indicators of individual insurers is measured. We use three indicators: equity, solvency and profit.

Equity

Equity acts as a buffer for a company, and the percentage of equity that is lost, reflects the reduction in the loss-absorbing capacity of the primary insurer. Note that if there is an equity loss over 100 percent, the primary insurer becomes insolvent and fails.

Solvency

The solvency, or financial strength, of an insurance company represents its ability to pay for its obligations. To calculate the impact of a failure on the solvency of an individual insurer, we use an indicator for solvency defined as¹⁰:

$$Solvency = \frac{Equity}{Technical \cdot Provisions - \sum_{j=1}^N Reinsurance}$$

This ratio can be seen as representing the (inverted) leverage of the institution. When a reinsurance company fails, the primary insurer still has an obligation to pay its policy holder(s). The failure reduces its reinsurance cover and thus increases liabilities, and as a result the solvency ratio decreases.

¹⁰ The ideal situation would be to measure the impact on actual and required solvency following the supervisory requirements. However, due to data limitations such a detailed measure is not possible.

In our analysis, we use the change in the solvency ratio following a shock as an indicator of the severity of the loss.

Profit

We also measure the impact in terms of year's profit. Although this indicator is likely to generate outliers as profits can fluctuate heavily from year to year, it gives an indication of the size of losses.

4. DATA

We have extracted our data set from regulatory reports to the Dutch supervisory authority (DNB) for the years 2003 through 2005. Primary insurers annually have to report their outstanding reinsurance claims to DNB, indicating the specific re-insurer and the amount reinsured. These data specify the region in which the re-insurer is located. Regions are defined as Dutch, European or Rest of the World. We can also infer whether the counterparty concerns a pure or hybrid re-insurer. The dataset does not include information on (re-)insurers not located in the Netherlands.¹¹ As only small differences are observed over time in the specific reinsurance counterparties and the claims outstanding are fairly stable, we will only present the results for the year 2005 in the remainder of this paper. More importantly, no trend is observed in such a small period of time. Throughout the paper, the life and non-life insurance sector are discussed separately because of their different nature; contracts for life insurance companies have a longer term. Furthermore, where the premium of non-life insurance is based only on the risk that is accepted, the premium of life insurance often consists of a saving component. These differences lead to a different demand for reinsurance.

Market characteristics

In 2005, the Dutch insurance sector consisted of 315 firms, divided into 77 life insurance firms (excluding pension funds) and 238 non-life firms.¹² The four largest life insurers serve 44% of the life insurance market, whereas the four largest non-life insurance companies comprise 26% of the non-life market. In comparison to other financial service industries, such as the Dutch banking sector, the degree of concentration in the non-life insurance market is relatively low.¹³ This relatively strong market fragmentation leaves room for many smaller market participants. Firms are grouped according to gross premium written into the classes large, medium and small (see Appendix A). In 2005, the size composition was 11 (4 life and 7 non-life) large, 49 (10 life and 39 non-life) medium and 255 (63 life and 192 non-life) small-sized firms (see Table 1 and 2).

¹¹ Cole and McCullough (2006) show that the choice of re-insurer is not driven by (foreign) market characteristics but by firm specific attributes.

¹² In 2003, there are 83 life insurers and 278 non-life insurers. For 2004, there are 81 life insurers and 247 non-life insurers active on the Dutch market.

¹³ For this period the average market share of the four largest banking firms amounts to 82%.

Table 1: Descriptives life insurance sector (2005)¹⁴

<i>Life Insurance Sector (EUR million)</i>		Total Assets	Equity	Gross premium	Net profit
	Range of obs	Mean (st.dev)	Mean (st.dev)	Mean (st.dev)	Mean (st.dev)
Small	59-61	922 (1198)	102 (188)	88 (104)	9 (16)
Medium	10	9,981 (7,710)	982 (983)	860 (397)	93 (87)
Large	4	36,800 (23,400)	3,870 (3,560)	2,755 (1387)	465 (376)
Total	73-75	303,000	31,500	24,800	3,322

Table 2: Descriptives non-life insurance sector (2005)¹⁴

<i>Non-Life Insurance Sector (EUR million)</i>		Total Assets	Equity	Gross premium	Net profit
	Range of obs	Mean (st.dev)	Mean (st.dev)	Mean (st.dev)	Mean (st.dev)
Small	165-180	40 (94)	18 (41)	16 (25)	2 (6)
Medium	38-39	529 (428)	165 (128)	307 (180)	30 (26)
Large	7	2,589 (1,221)	635 (179)	1,296 (378)	122 (75)
Total	211-226	46,000	13,800	23,700	2,475

There are in total 380 players that offer reinsurance cover. The largest four reinsurance parties active in the life market reinsure 62% of total claims in this segment, and 37% in the non-life market. However, a few large re-insurers serve a big part of the Dutch market. Important players are among others international reinsurance groups, but also Dutch insurers offer reinsurance services.

Groups

Many Dutch insurers and re-insurers are part of a larger conglomerate. In 2005, we have identified 61 different groups consisting of two or more primary insurers. These groups usually consist of both life and non-life insurance companies. In total 185 companies are part of such a group. The average group consists of 5 parties, while the largest group is formed by 38 parties. In the reinsurance sector, there are in total 47 reinsurance groups of two or more reinsurance companies. The average size of such a group is four parties, while the maximum size is 15. In total 183 companies are part of a reinsurance group.

5. DESCRIPTION OF THE MATRIX

For our contagion analysis we only consider insurance companies that use reinsurance and have provided information about their equity. In 2005, this leaves us with 213 firms that used reinsurance (68%), out of a total of 315 firms. The split over sectors is 64 (50 small, 10 medium and 4 large) life insurers and 149 (121 small, 23 medium and 5 large) non-life insurers. These insurance companies have claims outstanding on a total of 350 counterparties. There is some overlap between the insurers and the reinsurance counterparties because some insurers also act as re-insurers. This is the case for 110 parties, which are hence hybrid insurers. The matrix we construct is thus a square matrix of 453 x 453. Remember that part of this squared matrix remains empty, as we do not have information of the retrocession activities of reinsurers (i.e. we do not know how much and where these reinsurance parties may reinsure elsewhere), and since reinsurance parties generally do not reinsure with primary insurance companies.

In aggregate, reinsurance claims make up 1.6% of the assets in the total life industry (including companies that do not reinsure), and 7.6% in the complete non-life industry. In terms of equity, reinsurance claims represent 15% of total equity in the life industry and 25% in the non-life sector. Overall, standard deviations are high, indicating that large differences exist within sectors and size groups.

Based on the reported claims, we find that both in the life and non-life sector, small insurers on average use a lower number of re-insurers with a smaller reinsurance claim (see Table 3). Small firms on average have four reinsurance claims, whereas for larger firms this number may increase to even thirteen claims. For small life insurance companies, the average claim amounts to € 9 million, whereas large life insurance firms have an average claim of € 49 million. For non-life insurers, these amounts are € 1.9 million and € 30 million for small and large firms respectively. In relative terms though, the claims of smaller firms represent a larger part of equity and assets than for large firms (the latter not shown). Furthermore, in the life industry, the number of reinsurance claims increases with firm size and claims are generally larger. We also find that primary insurers do not spread their claims equally over multiple re-insurers, as on average there are one or two large claims outstanding and various small claims.

¹⁴ There are 14 small insurance companies that do not report balance sheet information.

Table 3: Descriptives reinsurance matrix

<i>Life Insurance Sector</i>	% of firms using reinsurance (% premium income)	# of claims	Average claim size (EUR million)	Average claim in terms of equity (%)
		Mean (stdv)	Mean (stdv)	Mean
Small	98%	3.8 (4.9)	9 (61)	22.0%
Medium	100%	7.6 (4.6)	17 (16)	1.1%
Large	100%	13.0 (8.6)	49 (42)	0.7%
All firms	99%	5.3 (5.8)	19.8 (52)	12.0%
Total value		239	4,721	

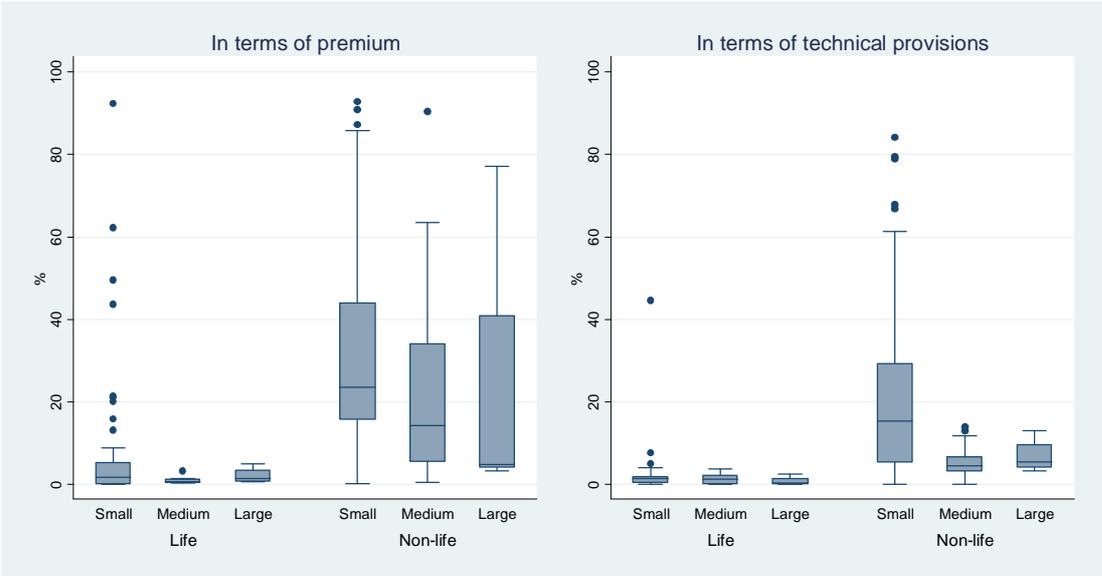
<i>Non-life Insurance Sector</i>	% of firms using reinsurance (% premium income)	# of claims	Average claim size (EUR million)	Average claim in terms of equity (%)
		Mean (stdv)	Mean (stdv)	Mean
Small	67%	4.0 (5.8)	1.9 (7.0)	17.6%
Medium	63%	12.1 (11.0)	6.9 (9.0)	7.7%
Large	66%	7.4 (10.6)	30.0 (71.8)	4.7%
All firms	67%	5.7 (7.9)	5.1 (19.1)	12.9%
Total value		683	3,448	

If we look at the relative importance of the reinsurance claims, we find that non-life insurers reinsure a relatively large part of the total risk they have accepted, measured in terms of the premium paid to reinsurers as part of total premium income (see Figure 2). This may run up to over 30% of total premium income. The smaller firms reinsure a relatively larger part of their risks (33%) than larger firms (22%). Life insurers reinsure relatively little, close to 9% (see Figure 2), although some small life insurers do reinsure a significant part of total risk. We find similar results if we analyse the relative importance of reinsurance in terms of technical provisions (which are made for future payments). The large differences in the relative size of the risks that are reinsured across the life and non-life sectors can be explained by the characteristics of the life insurance sector: life insurers face less uncertainty because of their relatively long-term contracts. Also the risks insured are more predictable. Therefore the need for reinsurance is relatively lower.

From a comparison of both ratios, it becomes clear that the level of reinsurance in terms of premium income is generally higher than in terms of technical provisions. An explanation for this outcome lies in the nature of reinsurance. Reinsurance is often used for extreme risks; so only a small part of technical provisions is reinsured while a relatively high premium is paid for this part. Indeed, extreme risks will cost more.¹⁵ The comparison also shows that in the life insurance sector, mainly the large and small parties insure such extreme risks. In the non-life insurance sector, mainly medium and large insurers seek coverage.

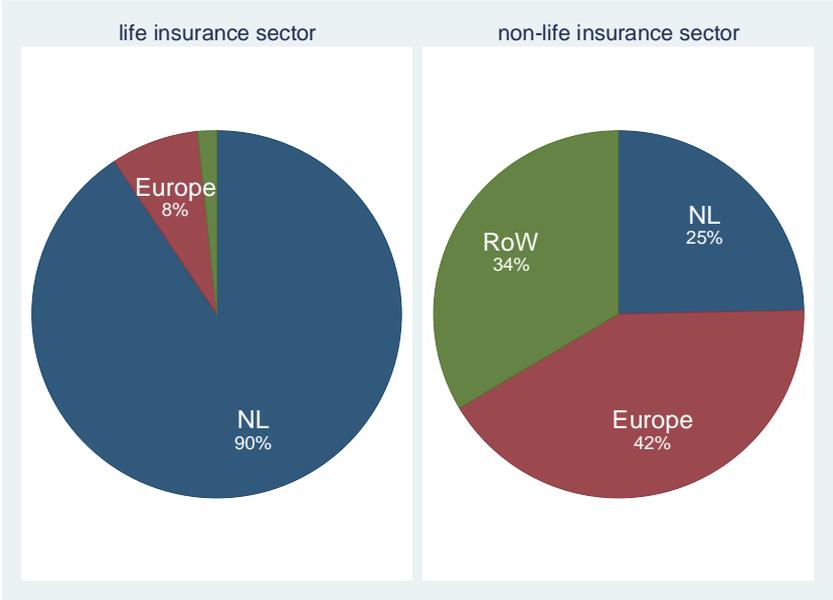
¹⁵ Another explanation may be that no loss event has occurred to validate a claim on the re-insurer. In that case, the size of reinsurance in terms of the premium is also higher than in terms of technical provisions.

Figure 2: Level of reinsurance in terms of premiums and technical provisions



From a geographical perspective, the matrix shows us that the majority of the reinsurance claims of life insurance companies (91%) is with other Dutch counterparts (see Figure 3). For the largest part, the claims on Dutch counterparts are with hybrid insurers (almost three quarters of the claims on Dutch counterparts is with a hybrid) and not with pure re-insurers. For life insurance companies, the reinsurance claims on Dutch companies also includes Dutch-based entities of large foreign reinsurance parties, accounting for one third of these Dutch claims and 30% of total life claims. By contrast, non-life insurers spread their reinsurance claims more equally over Dutch (25%), European (42%) or international re-insurers (34%). For the European and other international re-insurers, most non-life claims are with pure reinsurance companies (91% of the claims with European counterparts and all of the claims with other international counterparts), while only half of the claims on Dutch counterparts is with a hybrid company.

Figure 3: Geographical distribution of reinsurance claims (2005)



Furthermore, we find that 36% of all reinsurance claims is reinsured within a group. In the life industry small firms reinsure on average 74% of their reinsurance claims with a group member, while for large firms this percentage amounts to only 31%. Small non-life firms reinsure 15% of their reinsurance claims with a group member, the medium and large firms reinsure respectively 42% and 48% within the group (see Table 4).

Table 4: Percentage of reinsurance claims on other group entities

	Life	Non-life
Small	74%	15%
Medium	3%	42%
Large	31%	48%
Total	55%	29%

To sum up, we see that Dutch life insurers reinsure only a small part of their total risks and generally do this with other Dutch-based insurers. Contagion risk in the life insurance sector hence follows mainly from Dutch hybrid insurance companies. Contagion risk in the non-life sector is expected to be larger as the level of reinsurance (relative terms) is generally higher. This holds especially for small firms which, on average, reinsure the most. Any contagion effects are likely to originate from European and international reinsurance companies. Furthermore, also linkages within a group are relevant for our analysis, given the considerable level of reinsurance within a group.

6. RESULTS SCENARIO ANALYSIS

Based on the matrix, a scenario analysis is run to detect whether there are any contagion effects. As mentioned before, we apply several shocks to the system. First, we simulate the failure of a single

reinsurance company, where the companies that provide reinsurance (including hybrid Dutch life and non-life insurers) fail one-by-one. As a worst case event, we also analyse the impact on the Dutch insurance industry if the complete reinsurance sector fails. Second, we simulate the simultaneous failure of a part of the reinsurance industry, in this case in a particular region in the world. Third, we assess the impact of a failure of the two largest reinsurance players in respectively the life and non-life market. To assess the impact of these shocks on the Dutch insurance industry, we measure the impact on the Dutch insurance industry at a system level (contagion) and at an individual level. We only show the impact using a 100% loss rate, as this presents the largest risk to the sector.

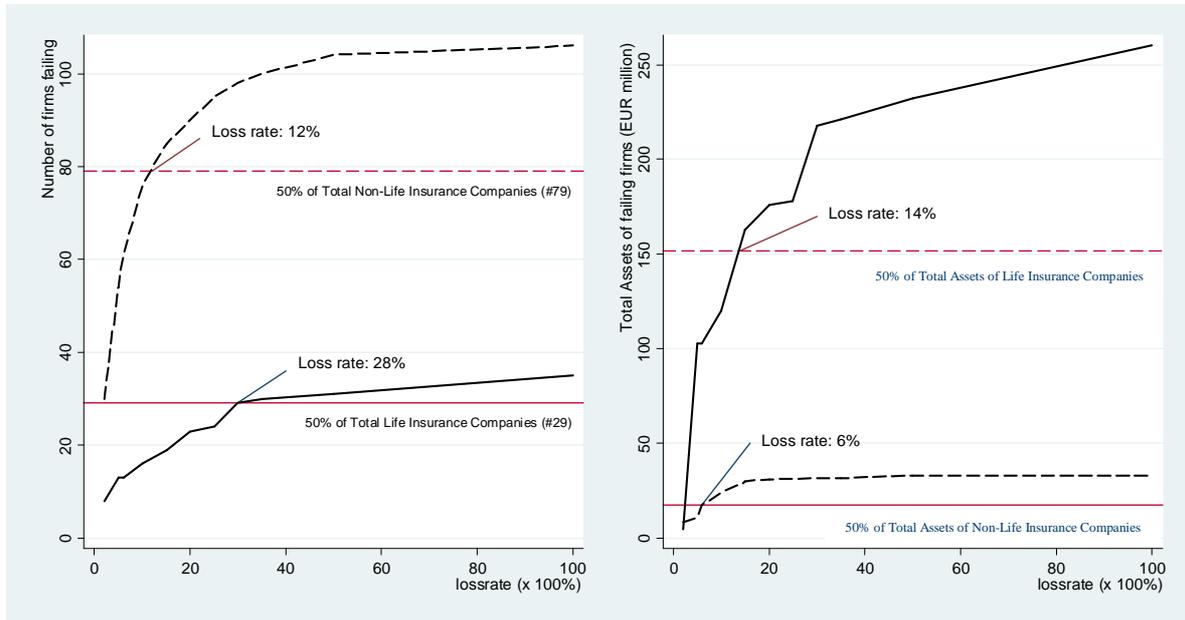
6.1 Failure of a single reinsurance company and of the complete reinsurance sector

Contagion effects

In all scenario analyses, the bankruptcy of an individual reinsurance company leads at maximum, given a loss rate of 100%, to the insolvency of a limited number (namely 2) of primary insurers, which each have a direct financial link to this failed party. This limited impact also holds if all reinsurance companies to which Dutch insurers are exposed (i.e. the complete reinsurance industry) fail and parties lose all of their claims (100% loss rate). Maximum 21 firms experience insolvency, but in none of the scenarios do large firms become insolvent. Furthermore, in both cases the insolvent parties only represent a limited part of the Dutch insurance sector in terms of assets (Table 5). Hence, no second round effects occur and there is only limited risk of contagion following from this channel. Note however that there are certain firms that are more vulnerable for a failure of reinsurance companies, as they become insolvent in several scenarios (not shown).

As the impact on the insurance sector remains relatively limited, even using a 100% loss rate (i.e. a complete loss of the exposure), we wondered in what circumstances contagion effects do occur such that a significant part of the insurance sector is affected? Therefore, we relax the assumption of a 100% loss rate and increase the loss rate until either half the number of insurance companies that make use of reinsurance fails, or half the total assets in the sector is affected. In the life insurance sector, the loss rate needs to be at least 28 times as high (i.e. 2800%) to trigger the failure of half of the insurance companies. However, this factor reduces to about 14 if we look at the assets of the failed institutions and use half of total assets as a threshold for a significant impact. This implies that when the loss rate is increased, certain large firms become insolvent as well. In the non-life insurance sector, a comparable, though smaller, effect can be distinguished (respectively 12% in terms of the number of failing firms and 6% in terms of assets of failing firms, see Figure 4).

Figure 4: Contagion effects and loss rates



Balance sheet impact

Although these results seem comforting, the loss-absorbing capacity of individual companies and therefore of the system as a whole following a shock can be seriously reduced. This is relevant since reinsurance failures are generally not isolated events and are more likely to occur in distressed economic situations or in the case of large loss events. Insurers have to deal with the combined effects of these shocks. On average, a scenario of a failure of the complete reinsurance sector and in which parties lose all of their claims (100% loss rate) will lead to a loss of about one fifth of equity of an insurance firm, and an affected firm will need a considerable time to recover this loss in terms of profit. Also solvency levels may decrease substantially, especially in the non-life sector (Table 5). The failure of an individual reinsurance company leads *on average* to a small loss in terms of equity, profit and solvency ratios, which a company should be able to withstand. However, the *maximum* impact of an individual failure can, for certain companies, be substantially higher, and lead to the loss of almost all equity, 40 times annual profits and almost half the solvency ratio.

Table 5: Results contagion analysis and individual analysis

	Life		Non-Life		Total ¹	
	<i>Single failure</i>	<i>Complete reinsurance sector fails</i>	<i>Single failure</i>	<i>Complete reinsurance sector fails</i>	<i>Single failure</i>	<i>Complete reinsurance sector fails</i>
<i>Maximum number of insolvencies</i>	2	5	2	16	2	21
<i>Total assets involved in insolvencies (EUR million)</i>	2,086	2,487	382	2,637	2,086	5,124
<i>Average equity loss²</i>	2.3%	13.6%	6.2%	23.7%	5.1%	20.9%
<i>Average profit loss²</i>	22.7%	136%	82.0%	450%	66.4%	361%
<i>Average change in solvency ratio (percent points)²</i>	-0.4%	-2.0%	-7.0%	-28.6%	-5.2%	-21.2%

¹ Note that in the case of a single failure, the impact on the life and non-life insurance sector do not have to add up as the failures may occur following the same shock.

² Excluding insolvent insurance companies

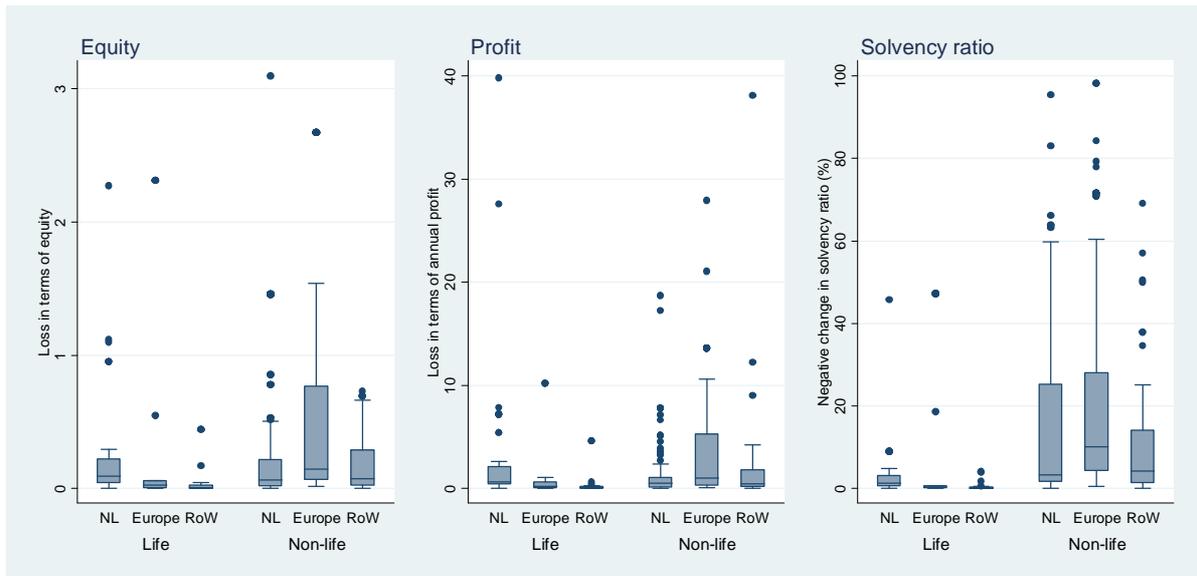
6.2 Further analysis

A more in-depth analysis of the impact of a reinsurance failure on the financial strength of individual insurers may provide some insight as to the level and distribution of their resilience. In this way, we can identify which particular scenario outcomes significantly weaken specific firms. First, we investigate the impact on balance sheet data of primary insurers following the failure of all re-insurers in a particular region. Then we simulate the simultaneous failure of the two largest re-insurers (in terms of total reinsured claims) in respectively the life and non-life industry. This scenario impact is of similar size compared to the scenario used by the Group of Thirty (2006) where 20 percent of world wide capacity is lost due to a large catastrophe.

Failure of reinsurance companies in a particular region

The impact of a simultaneous failure of all reinsurance companies in a particular region on life and non-life insurance companies is presented in Figure 5. The horizontal axis displays three scenarios: the simultaneous failure of all Dutch re-insurers (NL), the simultaneous failure of all European reinsurance companies (Europe) and the simultaneous failure of international reinsurance companies (RoW). The vertical axes measure respectively the loss in terms of equity, the loss in terms of profit and the change in solvency ratios following from the shock.

Figure 5: Impact of a regional reinsurance failure (with a 100% loss rate)



In terms of equity, the impact of a failure of all re-insurers in a particular region in all cases is considerable (see the left pane of Figure 5). In several instances, such a shock leads to the failure of an insurance company, as the loss exceeds equity (>1). But only a breakdown of the Dutch or European reinsurance market leads to contagion effects, while the losses in case of an international market failure remain limited. The insurance companies that do not go bankrupt following a regional shock experience a reduction in equity averaging 11% in the life sector and 18% in the non-life sector, though deviations are generally large. Furthermore, we find that mainly non-life insurance companies are vulnerable to this type of shock, especially in the case of a European failure.

The impact of a regional breakdown in terms of profit is the most substantial compared to the impact on equity or solvency, both for life and non-life insurers (see the middle pane of Figure 5). This loss can be as large as 40 times the annual profit. The average loss in terms of profit is considerably smaller, but still presents more than two years proceeds. The impact on non-life insurance companies is again larger than for life insurers. For the former, the European reinsurance industry forms the largest risk, as losses are highest in this case. For the latter, the Dutch market represents the main risk.

Following a breakdown of a regional reinsurance market, the average solvency ratio declines with 2% for life insurance companies and 17% for non-life insurance companies. Note that these averages hide large differences between companies, as the maximum effect can be more than 13 (6) times as large for life (non-life) insurance companies. For life insurance companies, failed insurance companies represent the largest decreases in solvency. For non-life insurance companies, this is surprisingly not the case. If failed non-life companies are excluded from this analysis, the impact on solvency levels remains as large. This points to the fact that some insurance companies have considerable excess funds

and can withstand a large shock. At the same time, it may also indicate that the companies that failed did not have large buffers to begin with.

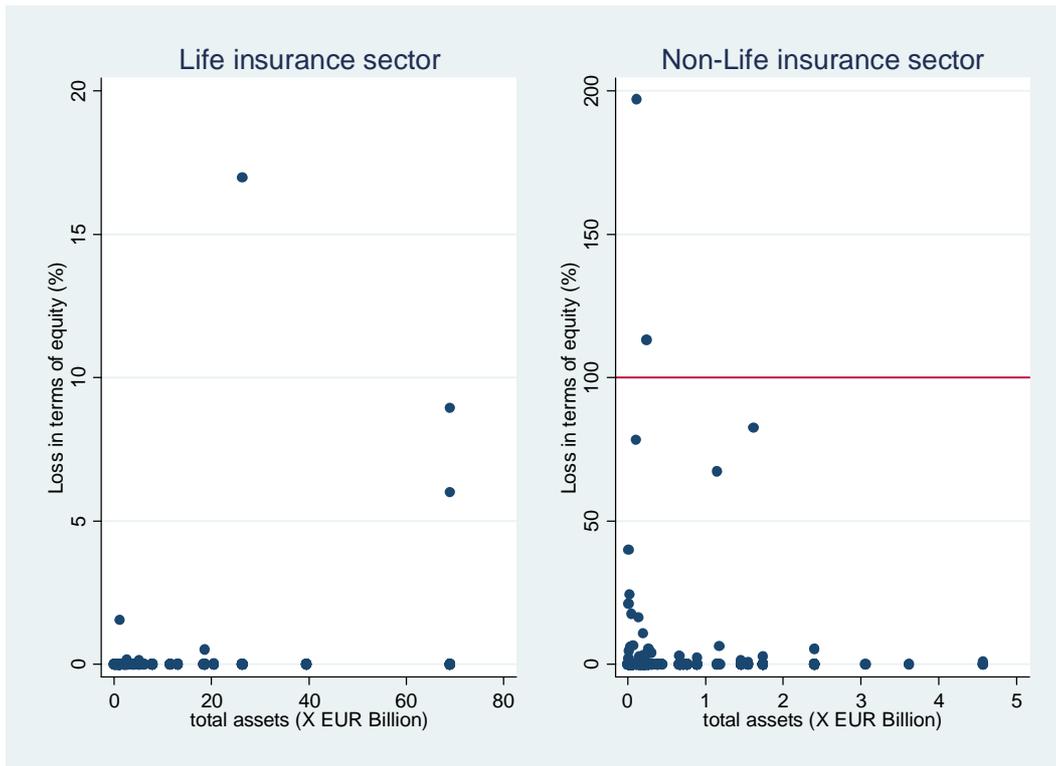
All in all, in the life industry, the overall effect of a loss of reinsurance in a particular region is low. There are only a few large impacts. In case of the failure of all Dutch reinsurance companies two life insurance companies face serious equity problems, as is the case for one company in case of a European reinsurance failure. Profit levels and solvency ratios are affected only to a limited degree. The minor impact on life insurance firms is not surprising, given their limited use of reinsurance cover.

In the non-life insurance sector, the impact of regional reinsurance failures remains modest as well, though a larger number of firms show substantial changes in their equity levels and solvency ratios. Also profits will be affected substantially. A failure of all European reinsurance companies has by far the largest impact. Although most companies only face a relatively limited impact in this scenario, several companies (1 large, 2 medium, 11 small), including even a large firm, face a severe decline in their solvency ratio. A simultaneous failure of all Dutch or international (RoW) reinsurance companies would lead to a large impact on at most a dozen (respectively 11 and 8) of small non-life firms.

Failure of the two largest reinsurance companies in the life and non-life sector

If we follow the analysis performed by the Gourp of Thirty (2006) which simulates a reinsurance capacity drop of around 20%, we simulate the failure of the two largest reinsurance companies for respectively the life and non-life insurance sector. In the life insurance industry, such a failure accounts for 38% of total claims outstanding, whereas in the non-life industry this accounts for approximately 22% of total claims outstanding. The impact of the failure of the two largest reinsurance companies on both the life (left-hand panel) and the non-life (right-hand panel) is shown in Figure 6. The horizontal axis represents the size (in terms of total assets) of the institution that is hit following the shock. The vertical axis represents the loss in terms of equity.

Figure 6: Impact of a failure of the largest two reinsurance parties on life and non-life insurers (100% loss rate)



In the life insurance sector, a considerable part of the reinsurance claims is lost following this shock, but the impact remains limited as losses do not exceed 20% of equity. Still, this represents about one-fifth of the capital. No firms go bankrupt. This can be explained since only a few firms have considerable linkages to the largest two reinsurance parties. By contrast, in the non-life insurance sector, quite a number of firms is affected following the failure of the two largest reinsurance firms. Moreover, two firms show a loss that exceeds their equity, factually going bankrupt. These are relatively small firms, with only a small buffer to cushion losses. The maximum change in the solvency ratio for the non-life insurance sector is below 50%. Our outcomes are generally larger than the results of the Group of Thirty. This would, however, still not pose a serious threat for the stability of the Dutch insurance sector.

7. GROUPS

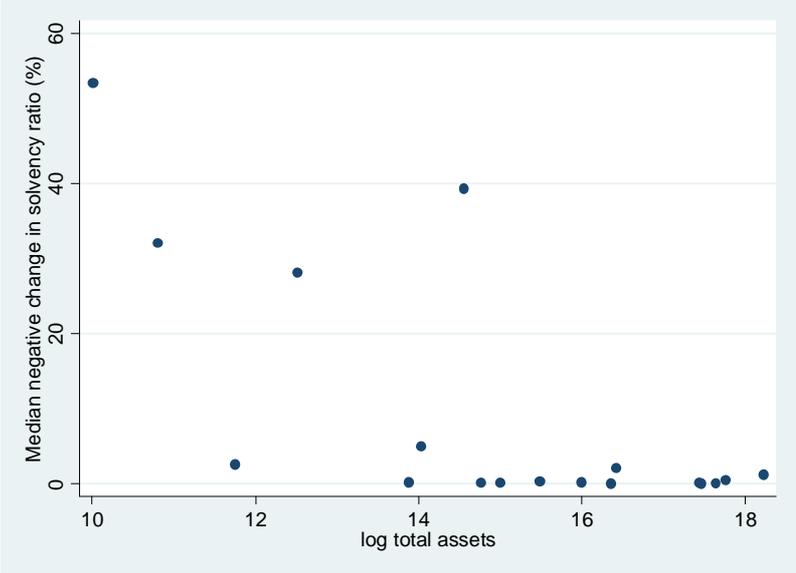
As many insurance firms are part of a group, it is interesting to analyse the effects of a reinsurance failure from a group perspective. Are certain groups hit harder or more frequent than others? Do particular reinsurance failures affect all parts of a group and may thus weaken the group as a whole? Does the structure of the group influence its vulnerability for a reinsurance failure? We use consolidated data to investigate whether some groups are hit harder than other groups. In all these

events, we consider a worst case scenario and use a 100% loss rate. As groups do not report their data, we will make a best estimate of the risks involved based on the data reported at solo-level.

Not all groups make use of reinsurance. Out of the total number of groups, there are only 42 groups of which at least one member uses reinsurance. Note that group members only include re-insurers and primary insurers that are active in the Dutch market and that our analysis thus excludes any foreign branches.

We use the median impact per group¹⁶ as a proxy of the impact of a reinsurance failure, as we have no reported data from groups. In this way, we can assess which type of groups are most vulnerable. Figure 7 presents the median change in solvency ratios of group members relative to the total assets of the group (for presentation purposes, the x-axis is shown in log values). It shows that members of small groups, measured in terms of assets, are hit harder than those of larger groups. A similar picture results if the loss is measured in terms of equity. In this case members of smaller groups are more vulnerable for a reinsurance failure as well. This could indicate that smaller groups rely more on reinsurance. An explanation for this outcome could be that smaller groups cannot or do not want to take on large risks and therefore have to use reinsurance. Also, they may not benefit from the diversification effects that large groups may have (or, alternatively, face more idiosyncratic risks).

Figure 7: Median impact of individual reinsurance failures on groups’ solvency ratio



Note: the x-axis shows the log of total assets of the group. The y-axis shows per group the median negative change in the solvency ratio

¹⁶ To be accurate, per group member we calculate the median impact on the solvency ratio, equity and profit, from all possible reinsurance cover losses. This is the loss the group member would typically lose. For the group as a whole, we then calculate the median of these impacts. This would thus be the typical impact on group members. We prefer to use the median impact as the mean impact would be driven by the very small or very large outcomes (outliers).

To examine the role of groups in more detail we assess how reinsurance risks are managed within a group. We are interested in the question whether group members use the same counterparties for the business they want to reinsure. In that case, the failure of this particular re-insurer will affect several members of the group, which may weaken it substantially. In total, there are 15 groups in which group members are exposed to the same counterparty. The number of group members exposed to such a common counterparty range from minimally 2 to a maximum of 17. Generally the members of large well-known groups have such common exposures. Later we will show that this is in many cases the result from their centralised risk management. For a number of groups, there are even several common reinsurance counterparties. The maximum loss that a single group member faces if a common counterparty defaults can be as high as 60% of equity. Thus, groups generally concentrate their reinsurance exposures more than solo entities.

To calculate the impact of a failure of a common counterparty on the group as a whole, we sum the exposures to the specific re-insurer that (some of) the group members have in common. This is the group exposure to this party. We also sum the equity capital of all group members to get the capital buffer of the group. Obviously, this results in an overestimation of the group capital, as it still includes intra-group transactions and will thus lead to an overestimation of groups' resilience. On the other hand, we may underestimate the capital position of the group because we only consider Dutch entities. Depending on whether capital can be transferred to the Dutch subsidiaries by their foreign group members if they need it, the Dutch entities might have a larger buffer. Using these aggregate data, we can calculate the impact of a specific reinsurance failure on the group. We find that on average, groups lose at most 21% of equity if a common counterparty defaults. One group though will fail following such a shock, as the total group's exposure exceeds their equity. This impact is considerably larger than for solo entities.

At the same time, we find that for seven groups, the largest loss results from the failure of a reinsurance party that is part of the group. In almost all of these cases, the counterparty concerned is a special reinsurance entity set up by the group. Indeed, a commonly mentioned business model in insurance groups is that firms reinsure their claims with a designated in-house re-insurer (the "hub", or "captive" reinsurer) who then goes into the market to reinsure those risks the group does not want to bear. Based on the insurance matrix, we try to find additional evidence for such a structure and look at the role of hubs in groups. In order to do this we first need a definition of what constitutes a hub and we will examine two alternative specifications. In the first we focus on the internal role the hub plays while in the second we look at the external role of the central re-insurer. In the internal specification, we define the hub as the group member that receives the most and the most significant reinsurance claims from other group members. To find the hubs using this definition, we first rank the in-house re-insurers by the number of incoming contracts from other group members they have. We then weigh

the rankings with the total exposures. The hub is the re-insurer with both many, as well as sizable connections. In the second definition the hub is the insurer with the largest combined exposure outside the group. Taking these two definitions we get the following summary statistics for the size of the net claims (see Table 6).

Table 6: The importance of hubs

		<i>Hub defined by its internal role in the group</i>		<i>Hub defined by its external role for the group</i>	
		# obs	Average claim size (EUR million)	# obs	Average claim size (EUR million)
External linkages	Not hub	505	7,1	301	2,6
	Hub	29	21,3	233	14,6
Intra-group linkages		74	37,3	74	37,3

Note: These statistics are only measured for groups consisting of two or more members.

For both definitions of a hub, we find that group members that function as a hub have considerably larger external claims than group members that do not function as a hub. Our definitions seem to capture hubs pretty well. We also find that reinsurance claims within a group are substantial. Furthermore, drilling into the data we find that there is considerable overlap between the group members defined as “hub” using these two definitions. From this we may conclude that group members transfer a considerable part of their risks to a central group counterpart, which collects all claims and then reinsures the aggregate risks externally. This corroborates our assumption that many groups have centralized risk management via a designated in-house re-insurer model. Although not shown here, we find that especially large insurance groups are structured in such a way. This business model may on the one hand prove more efficient and less risky, as only one group member is vulnerable for shocks following from lacking reinsurance cover. On the other hand, it may also expose the group to larger risks if this hub fails. For in that case, all group members will be affected. As in several cases the central counterpart in the groups with such a business model is a reinsurance firm, no further information is available on the financial position or strength of this group member, nor on how it manages these risks. In these situations, we cannot determine the likelihood of contagion risks in such a structure. For the groups in which the hub is not a special in-house reinsurance company (or at least is not registered as a reinsurance company), we find that there is indeed contagion risk, as the solvency ratio of these central counterparts or hubs generally is not higher than that of other group members, and hence cannot function as a bulwark for other members of the group.

8. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, we assessed the impact of direct contagion, that is, how the loss of (part of) reinsurance claims affects the stability of the insurance market. We have employed a novel approach using confidential data on re-insurance linkages. This approach could be implemented in other countries. Our results seem comforting: No evidence for systemic risk is found based on this direct contagion

channel. Even when the complete reinsurance sector collapses, just a limited number of insurance companies fail, representing a negligible part of the insurance sector. As the average change in the solvency ratio is below 100% in these instances, it is likely that these failed insurers did not have a large buffer to begin with. In addition, no contagion effects occur as only primary insurers with direct linkages to the failed reinsurance company fail. The insurance sector as a whole seems resilient to reinsurance failures.

The impact on individual insurers' balance sheet remains limited as well. In the life insurance industry, only a few small firms face a severe deterioration of the balance sheet indicators (equity, solvency ratio and profit) in the case of the failure of all Dutch reinsurance companies. Non-life insurance companies are more vulnerable to reinsurance risk. Following the failure of all European reinsurance firms, a number of firms would run into financial distress. At the same time, however, this does not disrupt the financial sector as a whole.

As our analysis only captures part of the risks some caveats are in order. We only consider reinsurance companies' credit risk. This excludes other risks which may influence the financial position of primary insurers. These include first of all the direct exposures of insurance companies to each other, for instance via cross-participations, direct loans, etc. Second, indirect contagion effects are also not included in the analysis. Reputation risk, especially in the case of insurance groups, may be substantial. Third, the financial position of firms may already have been harmed by macroeconomic developments, i.e. lower interest rates, recession, etc. Because of this, our analysis may underestimate the risks. Furthermore, no information is available on the size of retrocession, nor where the risks ultimately reside. Because of this, it may not be clear where risks materialise, as a hybrid insurance company may even reinsure risks for a third party that it had initially transferred its risks to itself. This happened for instance after the September 11th attacks. This leads to an underestimation of the risks as well. Moreover, we analyse the current exposure. It is feasible that exposures increase exactly in those times that counterparties are more likely to default. This holds especially as we have no information on the type of the reinsurance contract. It is likely that the combined effects of direct and indirect contagion, as well as those following from common exposures, will exacerbate the impact on insurance companies.

From the reinsurance matrix, it becomes clear that, especially the non-life insurance sector has a considerable exposure to foreign reinsurance counterparties. Although the reinsurance sector is essentially a global business, reinsurance companies are not regulated at all or are regulated by local requirements that may differ from country to country. Mainly due to this lack of overarching regulation, there is little information on retrocession and hence on the ultimate location of risks. It may not be clear who bears the final risk. This may pose a threat in turbulent times. More transparency

from reinsurance companies about their reinsurance and investment policies would help to alleviate these concerns. Increased cooperation between different supervisory authorities is needed to achieve this. The Reinsurance Directive in the European Union is an important first step in this respect.

In addition, in the Netherlands, hybrid insurers are important. Furthermore, about one third of the reinsurance claims is reinsured between group members. Our analysis shows that especially small groups are vulnerable to reinsurance failures. Furthermore, we find suggestive evidence that designated in-house re-insurer structures exists, especially for large groups. Supervision so far has primarily focussed on single institutions, while in many cases, in supervised entities, risks are assessed and managed at group level. Supervision and the assessment of (reinsurance) risk management should therefore also take a group perspective.

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Appendix A: Determination of size groups

Differences in size may lead to different firm behaviour, for instance larger firms may take on different or larger risks, compared to small companies. This could lead to diverging reinsurance behaviour. Gross premium income is a common used measure of firm size, so based on the amount of gross premiums received, all companies are grouped according to size. Size groups are distinguished following the classification below. Boundaries were selected such to provide for a clear demarcation of size groups.

Table 1: Classification into size groups

<i>In EUR million</i>	<i>Life</i>	<i>Non-Life</i>
Small (S)	$0 \leq \text{Gross premium income} < 400$	$0 \leq \text{Gross premium income} < 100$
Medium (M)	$400 \leq \text{Gross premium income} < 1,500$	$100 \leq \text{Gross premium income} < 750$
Large (L)	$\text{Gross premium income} \geq 1,500$	$\text{Gross premium income} \geq 750$

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