Is the New Regulation Successful in Reducing Systemic Risk of Global Systemically Important Insurers? Empirical Evidence from Insurers around the Globe

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Abstract: In response to public awareness of the "too-big-to-fail" problem that arose from the financial crisis in 2008, the G-20 has explicitly expressed the need to tighten up supervision on global systemically important insurers (G-SIIs) since November 2011, and the International Association of Insurance Supervisors (IAIS) has published a series of policy measures to supervise G-SIIs since July 2013. With a panel dataset from 2007 to 2015, we analyze the effect of the new regulation on 173 international insurers from 33 countries. With G-SIIs as the treated group and non-G-SIIs as the control group, we employ the difference-in-difference setting and find that the difference between the systemic risk of G-SIIs and non-G-SIIs, which is measured by static MES and Δ CoVAR, decreased by approximately 37.8% to 60.0% after the G-20 declaration and the IAIS's publication of new policy measures. As the above systemic risk measures are restricted to tail-dependence of stock returns and only reflect stock market participants' perception of insurers' systemic risk, we further analyze the changes of insurers' characteristics and find that downsizing is an important channel for G-SIIs to reduce their systemic importance. [Key words: systemic risk; global systemically important insurers; insurance regulation]

INTRODUCTION

"It is unacceptable that large firms that the government is now compelled to support to preserve financial stability were among the greatest risk-takers during the boom period. The existence of too-big-to-fail firms also violates

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the presumption of a level playing field among financial institutions. In the future, financial firms of any type whose failure would pose a systemic risk must accept especially close regulatory scrutiny of their risk-taking."

Bernanke, Ben, former Chairman of Federal Reserve. "The Crisis and the Policy Response." 13 January 2009, London School of Economics, London, England. Speech.

The financial crisis in 2008 raised the public awareness of the "too-big-to-fail" problem. From an academic perspective, there have been many studies examining the question of how much systemic risk the insurance industry generates. For example, using principal-component analysis and Granger-causality networks to measure connectedness, Billio, Getmansky, Lo, and Pelizzon (2012) find that banks play a more important role in transmitting shocks than insurers, hedge funds, and broker/dealers. Chen, Cummins, Viswanathan, and Weiss (2013) use credit default swap spreads and intraday stock prices to measure systemic risk and find that banks generate significant systemic risk for insurers but not vice versa. With a sample of international insurers, Bierth, Irresberger, and Weiβ (2015) also find that the systemic risk of the insurance sector is small. Despite the almost unanimous finding that the insurance sector has less systemic risk than the banking sector, one should be cautious about making the far-fetched conclusion that the insurance sector generates no systemic risk at all. In fact, the potential reasons for the insurance industry to originate and amplify systemic risk have been well documented in literature. For example, Russell, Fier, Carson, and Dumm (2013) find that life insurance policy surrenders are correlated with macroeconomic variables that cause cash flow problems to life insurers. In the event of economic duress, life insurers are forced to liquidate assets to meet surrender requests. This finding is consistent with Bobtcheff, Chaney, and Gollier (2016)'s argument that surrender options embedded in life insurance policies raise the chance of systemic relevance. Cummins and Weiss (2014) find that non-insurance activities, such as financial guarantees and derivatives trading, cause systemic risk in the insurance industry. Eling and Pankoke (2014) conclude that insurers' non-traditional activities, such as credit default swaps, financial guarantees, and securitization of business, are likely to generate systemic risk. Thimann (2014) argues that the potential channel for insurers to transmit systemic risk is by assuming the role of investor and financial intermediary. Niedrig (2015) argues that life insurers' investment demand for bank bonds drives the contagion between life insurers and banks. ESRB (2015) also identifies four channels through which insurers can generate systemic risk. They are (1) non-traditional and non-insurance activities, (2) procyclicality in asset allocation and procyclicality in pricing of credit and mortgage insurance, (3) collective failure of life insurers under the prolonged low interest rate environment with a sudden drop in asset prices, and (4) failure of insurers with insurance classes that lack substitutes and are vital to economic activities, such as marine, aviation, transport, liability, and property insurance.

From an industrial perspective, the G20 leaders made a declaration in November 2011 expressing the need to address the moral hazard and systemic risk of global systemically important insurers (G-SIIs). Subsequently, the International Association of Insurance Supervisors (IAIS) published the methodologies of assessing G-SIIs (IAIS, 2013a) and the policy measures applicable to them (IAIS, 2013b) in July 2013. Shortly afterwards, the IAIS also published the basic capital requirements (BCR) for G-SIIs (IAIS, 2014) in October 2014 and the higher loss absorbency (HLA) requirements for G-SIIs (IAIS, 2015a) in October 2015. The requirements of the G-SII regulation can be broadly divided into four elements: (i) Enhanced Supervision: The group-wide supervisor should have regulatory power over systemically important insurers as well as their holding companies to facilitate group-wide supervision. Within the regulated insurance groups, all business units that generate systemic importance should be supervised by the group-wide supervisors, regardless of whether the business units are insurance-related or not. In addition, systemically important insurers are required to enhance liquidity management and implement the systemic risk management plan ("SRMP"), which describes how they will manage and reduce their systemic risk. The group-wide supervisor can also implement measures to separate or restrict systemically important insurers' non-traditional and non-insurance activities. (ii) Effective Resolution: G-SIIs should establish crisis management groups, which are responsible for implementing relief measures during financial crises. They should also develop recovery and resolution plans with details of the recovery procedures in the event of financial distress and orderly resolution in the event of bankruptcy. (iii) Basic Capital Requirements (BCR): All G-SIIs are subject to consistent factor-based BCR, which are based on the calculation of applying 15 factors to five main categories, namely, traditional life insurance, traditional non-life insurance, non-traditional insurance, assets, and non-insurance business. According to the field testing data for 2014 and 2015, the average BCR for systemically important insurers match the average capital requirements prescribed by their local regulators (IAIS, 2015b). It is also noted that the IAIS intends to replace the BCR with a risk-based group-wide global Insurance Capital Standard (ICS) once the ICS has been developed and adapted (IAIS, 2014). (iv) HLA Capacity: In addition to the BCR, systemically important insurers are subject to extra capital requirements, namely, the HLA, to compensate for their systemic risk (IAIS, 2015a). To calculate the required capital under the HLA, systemically important insurers are categorized into one of three buckets (low, mid, or high) according to their size, global activity, interconnectedness, asset liquidation, and substitutability. Risk factors are then assigned to each bucket, and the required capital under the HLA is calculated by multiplying the risk factors with the required capital under the BCR. According to the field testing data for 2014 and 2015, systemically important insurers' average required capital under the HLA is approximately 10% of their required capital under the BCR (IAIS, 2015c). The intention of the new regulation is to reduce the systemic risk of G-SIIs so that the moral hazard associated with government interventions during the financial distress of G-SIIs can be minimized. However, the question of whether the new regulation is successful in achieving the intended objective is contentious.

On the one hand, the grounds for enhancing supervision on G-SIIs have been well documented in literature. One of the most discussed problems about G-SIIs is moral hazard (e.g., Kim, 2011; Ötker, Narain, Ilyina, and Surti, 2011). When the failure of a G-SII can threaten the stability of the economy, the market would expect the government to provide financial assistance to the G-SII or to provide guarantees to protect the creditors. With such expectation, creditors and credit rating agencies do not fully price the credit risk of lending to the G-SII, resulting in a lower cost of finance. In fact, Ueda and Di Mauro (2013) estimate that systemically important financial institutions (SIFIs) have 60bps to 80bps of funding cost advantage, which is also consistent with Araten and Turner (2013)'s findings. The funding cost advantage reduces market discipline on G-SIIs and encourages G-SIIs to take greater risks and further expansion. This moral hazard leads to inefficient capital allocation, and taxpayers have to pay for the cost of bailing out G-SIIs when they are in trouble. This is consistent with Dombret and Ebner (2013) in the sense that SIFIs make decisions mainly based on their private benefits and costs, but lack the incentive to factor the macroeconomic costs arising from systemic risk into their decision-making process. Apart from the moral hazard problem, large financial institutions also have a negative impact on social welfare. Boyd and Heitz (2016)'s calculations indicate that the costs of large financial institutions' systemic risk brought to the economy are always much larger than the potential benefits due to economies of scale, suggesting that the social costs of large financial institutions exceed the social benefits. Many scholars also emphasize the systemic risk posed by the insurance industry and the need to identify and manage it. For example, Baluch, Mutenga, and Parsons (2011) find that the systemic risk in the insurance industry is not negligible and has increased in recent years. They urge regulators to, inter alia, limit insurers' use of soft form capital and monitor insurers' risk appetite. Schwarcz and Schwarcz (2014) argue that the traditional state-based regulation fails to account for the correlations and interconnectedness among insurers and, hence, the Federal Insurance Office in the U.S. should enhance supervision to manage systemic risk in the insurance industry. All of the above findings support the need to enhance supervision on G-SIIs and provide incentive for G-SIIs to change their risk-taking behaviors.

On the other hand, many studies raise concerns about the details of the IAIS's proposed G-SII supervisory framework. First, the G-SII designation reinforces the market perception that G-SIIs will be supported by governments when they are in trouble (Kessler, 2014). In other words, an insurer is viewed by the market as safer after it has been designated as G-SII because of the implicit government guarantees. If the benefits of increased safety exceed the costs of being designated as G-SII (e.g., greater compliance costs and more stringent capital requirements), insurers have incentive to generate more risks so that they can be designated as G-SIIs (Guiné, 2014), which is contrary to the policy intention of the G-20 and the IAIS. Whether the costs of G-SII designation exceed its benefits remains an unanswered empirical question. Second, as insurers, banks, and non-bank financial institutions are subject to three different kinds of designation assessment methodologies, regulatory arbitrage among financial institutions is possible if the risk indicators in these three methodologies are not reconcilable. Jobst (2014) suggests the need to conduct cross-sectoral analysis of assessment approaches for G-SIIs, global systemically important banks (G-SIBs), and non-bank non-insurer global systemically important financial institutions (NBNI G-SIFIs) in areas with common risk drivers (e.g., funding sources, derivative trading, intra-financial assets and liabilities) to prevent regulatory arbitrage. Third, how the five factors (i.e., size, global activity, interconnectedness, non-traditional and non-insurance activities, and substitutability) in the indicator-based G-SII assessment approach proposed by the IAIS relate to systemic risk lacks empirical support. Using data of publicly traded insurers with U.S. headquarters, Weiβ and Mühlnickel (2014) find that global activity and substitutability do not contribute to systemic risk. Instead, insurers' contribution to systemic risk is mainly driven by their size. However, as stated in its policy document (IAIS, 2013a), the IAIS only assigns 5% weighting to the size factor in its G-SII identification methodology. Based on data from 253 international insurers, Bierth et al. (2015) also find that leverage is the primary driver for insurers' contribution to systemic risk. Ironically, the IAIS does not consider leverage as one of the factors in the indicator-based assessment approach. Using factors not related to systemic risk or missing factors that drive systemic risk in the indicator-based assessment approach not only biases the G-SII assessment results, but also biases the HLA required capital by placing G-SIIs in the wrong bucket. Fourth, the short implementation timeframe of G-SII policy measures together with the uncertainties underlying them generate risks for the effectiveness and accuracy of those measures (Guiné, 2014). For example, if an insurer is newly designated as G-SII in November of the current year, it has to implement liquidity management and planning as well as SRMP by the end of next year. It also has to calculate the BCR required capital and HLA required capital on a consolidated basis with appropriate reporting to regulators in the next year. It is a challenge to comply with the above enhanced measures within the short timeframe, even if the G-SII concerned has deployed huge resources on the compliance project. In addition, the insurance capital standard (ICS), which is intended to replace the BCR and has a significant impact on the HLA required capital, has not been finalized at the time of writing. The uncertainties underlying the capital requirements may lead to undesirable behaviors of G-SIIs (e.g., being unable to optimize business operations given the uncertain capital requirements). This is consistent with the findings of Fier and Liebenberg (2013) in the sense that investors reacted negatively to the passage of the Dodd-Frank Act because of the increased regulatory uncertainty underlying the Act.

Although numerous studies have been conducted to support the need to enhance supervision on G-SIIs and criticize the details of supervisory framework proposed by the IAIS, very few studies have investigated whether the new regulation successfully achieves its intended objective of reducing the systemic risk of G-SIIs. The purpose of this paper is to fill the gap in literature and empirically examine whether the new regulation reduces the systemic risk of G-SIIs. We follow existing literature to measure insurers' systemic risk with static Marginal Expected Shortfall (static MES) proposed by Acharya, Pedersen, and Richardson (2017) and ΔCoVAR proposed by Adrian and Brunnermeier (2016). These measures gauge the tail dependence of stock returns and reflect the stock market participants' perception of insurers' systemic risk. Using a panel dataset of 173 international insurers from 2007 to 2015 and the World Datastream Financial Index as the proxy for market index, we employ the difference-in-difference setting and find that the difference between the systemic risk of G-SIIs and non-G-SIIs decreased by approximately 37.8% to 60.0% after the G-20 declared it would tighten up supervision on G-SIIs and the IAIS published the new policy measures. The findings suggest that stock market participants perceived G-SIIs to be less systemically risky after the new regulation.

We further conduct additional analysis to the above findings. First, we investigate whether the systemic risk of G-SIIs and non-G-SIIs moved in parallel in the pre-treatment period, which is a key assumption of the difference-in-difference setting. Second, we examine whether the empirical results are sensitive to the choice of proxy for market index. Using World Datastream Market Index, World Datastream Bank Index, and World Datastream Insurance Index as alternative proxies for market index, we recalculate static MES and ΔCoVAR for each insurer and re-perform the regression analysis. The results are similar no matter which index is used as market proxy. Third, we investigate whether the results are driven by the extreme values of data from the financial crisis. We follow the National Bureau of Economic Research (NBER)'s definition of business cycle contraction and repeat the regression analysis after dropping the data from 2007 Q4 to 2009 Q2. The regression results still suggest that the systemic risk of G-SIIs decreased significantly after the new regulation. Fourth, we examine whether the results are biased by data of insurers from countries without G-SIIs, as the reduction of systemic risk may be country-specific. We repeat the regression analysis with the subsample after excluding the data of insurers from countries without G-SIIs, and obtain similar empirical results with the baseline regression. Fifth, we check the robustness of the time period of our treatment effect. We revise the treatment time period to ensure that all G-SIIs were certain of their G-SII status in the revised period. The empirical findings do not materially change with the revised treatment effect. Sixth, as life insurers and non-life insurers have different characteristics, we repeat the regression analysis on these two types of insurers separately. We find that the systemic risk of G-SIIs decreased after the new regulation for both the subsample of life insurers and the subsample of non-life insurers. Seventh, we study whether the new regulation's impact on G-SIIs remained strong outside the U.S., as the public awareness of the "too-big-to-fail" problem in the insurance sector arose from the financial distress of the American International Group and the subsequent bailout from the U.S. government in 2008. Some industry practitioners even consider that the regulators around the world follow the U.S. lead in the regulation of G-SIIs (PricewaterhouseCoopers, 2013). After splitting our sample into U.S. insurers and non-U.S. insurers, we repeat the regression analysis and find that although the systemic risk of G-SIIs decreased after the new regulation on a worldwide basis, the magnitude of systemic risk reduction for G-SIIs in the U.S. was greater than that for G-SIIs outside the U.S. Eighth, we examine whether the new policy reduced systemic risk of large insurers, regardless of whether they had been designated as G-SIIs. By defining large insurers as the upper quartile of insurers in terms of total assets and total insurance reserves, we find that the systemic risk of large insurers decreased after the new regulation, which is supportive of the argument that the threat of being designated as G-SIIs motivates large insurers to change their risk-taking behaviors. Ninth, we address the missing data problem of the quarterly accounting data by using the multiple imputation method to impute the missing values. The regression results are similar before and after the multiple imputation, implying that although the data are not missing completely at random, the missing data problem does not bias our empirical findings. Tenth, we follow Brownlees and Engle (2017) to construct an alternative measure of systemic risk, namely, dynamic MES, and repeat the regression analysis to examine if the empirical results are sensitive to the choice of alternative systemic risk measure. We obtain the same conclusion no matter if systemic risk is measured by static MES, ΔCoVAR, or dynamic MES. Finally, we construct the systemic importance score based on insurers' accounting data and find that downsizing is an important channel for G-SIIs to reduce their systemic importance.

We complement the literature on systemic risk and insurance regulation by performing difference-in-difference analysis on a panel dataset of international insurers. To the best of our knowledge, we are the first to provide empirical evidence supporting the effectiveness of the G-20's and the IAIS's new supervisory measures on G-SIIs. To be specific, we show that the systemic risk of G-SIIs decreased significantly after the regulators focused on the supervision of G-SIIs. This finding is important to both the regulators and industry practitioners around the globe in the sense that the new regulation deserves some credit for reducing the systemic risk of the insurance industry.

We organize the remainder of this paper as follows. The next section presents the data and discusses the measures of systemic risk. We present the empirical model and discuss the empirical results in the section "Empirical Model and Results". Additional analysis to the baseline regression model is conducted in the section "Additional Analysis". The last section states the concluding remarks.

DATA

In this section, we discuss the construction of our sample and the methodologies for measuring systemic risk. We also explain our choice of independent variables and present the descriptive statistics as well as the results of univariate analysis.

Sample Construction

We construct the panel dataset from the *Thomson Reuters Financial Datastream* ("*Datastream*") for the period 2007 to 2015. We first select all the insurers that are constituents of the World Datastream Insurance Index as of the end of 2015. Some insurers might be in the World Datastream

Insurance Index during the sample period but dropped out of the index before 2015. Unfortunately, the names of such insurers are not available from *Datastream* and those insurers are excluded from our sample. Hence, there could be survivorship bias, and readers should exercise caution when interpreting the empirical results. Next, all insurers with quarterly accounting data or daily stock prices unavailable in *Datastream* are omitted. We are then left with 173 insurers from 33 countries. Nine of these insurers[3] were designated as G-SIIs by the Financial Stability Board (FSB) in July 2013 (FSB, 2013). The full list of insurers in our sample can be found in Table 1.

Quarterly accounting data and daily stock prices of these 173 insurers are downloaded from *Datastream* and are expressed in U.S. dollars. Country-specific macroeconomic variables, such as the annual GDP growth rate and inflation, are retrieved from the *World Development Indicators* of World DataBank. In addition, index prices of World Datastream Financial Index, World Datastream Market Index, World Datastream Bank Index, and World Datastream Insurance Index are retrieved from *Datastream*.

Measuring Systemic Risk

Different kinds of systemic risk definitions have been documented in the literature and there is no consensus about which definition is the best. After reviewing the recent systemic risk literature, Thimann (2014) summarizes that systemic risk is the risk of system-wide distress and economic damage. To be specific, system-wide distress could be the failure of financial institutions, correlated defaults of financial institutions, impairment of the financial system, malfunctioning of the financial system, loss of economic value of the financial system, or loss of confidence in the financial system. In this study, we use two different measures for systemic risk that address the systemic-wide distress in terms of failure of financial institutions and impairment of the financial system. They are static MES proposed by Acharya et al. (2017) and ΔCoVAR proposed by Adrian and Brunnermeier (2016). These measures are constructed from the stock returns of insurers and a market index which serves as a proxy for the aggregate sector. By the nature of their construction, they represent the investors' perception of economic shock spillovers in the insurance industry. All of these measures have been widely discussed in literature and applied in various studies of systemic risk (e.g., Anginer, Demirguc-Kunt, and Zhu,

[3]These nine insurers are Allianz SE, American International Group, Inc., Assicurazioni Generali S.p.A., Aviva plc, Axa S.A., MetLife, Inc., Ping An Insurance (Group) Company of China, Ltd., Prudential Financial, Inc., and Prudential plc.

Table 1. List of Insurers in the Panel Dataset

Name	Country	Name	Country	Name	Country
ADMIRAL GROUP PLC	UNITED KINGDOM	ERIE INDEMNITY COMPANY	UNITED STATES	PORTO SEGURO SA	BRAZIL
AEGON N.V.	NETHERLANDS	ESURE GROUP PLC	UNITED KINGDOM	POSTE ITALIANE SPA	ITALY
AFLAC INCORPORATED	UNITED STATES	EULER HERMES GROUP SA	FRANCE	POWER CORPORATION OF CANADA	CANADA
AFMA SA	MOROCCO	EVEREST RE GROUP, LTD.	UNITED STATES	POWER FINANCIAL CORP	CANADA
AGEAS SA	BELGIUM	FAIRFAX FINANCIAL HOLDINGS LIMITED	CANADA	POZAVAROVALNICA SAVA DD	SLOVENIA
AGMA LAHLOU TAZI INTERMEDIAIRE D ASSURANCES SA	MOROCCO	FBD HOLDINGS PLC	IRELAND	PRINCIPAL FINANCIAL GROUP, INCORPORATED	UNITED STATES
AIA GROUP LIMITED	HONG KONG	FIRST AMERICAN FINANCIAL CORPORATION	UNITED STATES	PROGRESSIVE CORP	UNITED STATES
ALLEGHANY CORPORATION	UNITED STATES	GJENSIDIGE FORSIKRING ASA	NORWAY	PROTECTOR FORSIKRING ASA	NORWAY
ALLIANZ SE	GERMANY	GREAT EASTERN HOLDINGS LTD	SINGAPORE	PRUDENTIAL PLC	UNITED KINGDOM
ALLSTATE CORP	UNITED STATES	GREAT-WEST LIFECO INC	CANADA	PRUDENTIAL FINANCIAL, INCORPORATED	UNITED STATES
ALM. BRAND A/S	DENMARK	GRUPO CATALANA OCCIDENTE SA	SPAIN	POWSZECHNY ZAKLAD UBEZPIECZEN SA	POLAND
AMERICAN NATIONAL INSURANCE COMPANY	UNITED STATES	GRUPO PROFUTURO S.A.B. DE C.V.	MEXICO	QBE INSURANCE GROUP LIMITED	AUSTRALIA
AMERICAN FINANCIAL GROUP, INC.	UNITED STATES	HANNOVER RUECK SE	GERMANY	QUALICORP SA	BRAZIL
AMERICAN INTERNATIONAL GROUP, INC.	UNITED STATES	HANOVER INSURANCE GROUP INC	UNITED STATES	REINSURANCE GROUP OF AMERICA, INC.	UNITED STATES
AMP LIMITED	AUSTRALIA	HANWHA LIFE INSURANCE CO LTD	SOUTH KOREA	RELIANCE CAPITAL LTD	INDIA
AMTRUST FINANCIAL SERVICES, INC.	UNITED STATES	HAREL INSURANCE INVESTMENTS & FINANCIAL SERVICES LTD	ISRAEL	RENAISSANCERE HOLDINGS LTD.	UNITED STATES
ANADOLU HAYAT EMEKLILIK A.S.	TURKEY	HARTFORD FINANCIAL SERVICES GROUP INC	UNITED STATES	RSA INSURANCE GROUP PLC	UNITED KINGDOM
AON PLC	UNITED STATES	HASTINGS GROUP HLDG PLC	UNITED KINGDOM	SAHAM ASSURANCE SA	MOROCCO
APRIL SA	FRANCE	HELVETIA HOLDING AG	SWITZERLAND	SAMPO OYJ	FINLAND
ARCH CAPITAL GROUP LTD.	UNITED STATES	HISCOX PLC	UNITED KINGDOM	SAMSUNG FIRE & MARINE INSURANCE COMPANY LIMITED	SOUTH KOREA
ARTHUR J. GALLAGHER & CO.	UNITED STATES	HYUNDAI MARINE & FIRE INSURANCE COMPANY LIMITED	SOUTH KOREA	SAMSUNG LIFE INSURANCE COMPANY LIMITED	SOUTH KOREA
ASR NEDERLAND NV	NETHERLANDS	IDI INSURANCE COMPANY LTD	ISRAEL	SANLAM LIMITED	SOUTH AFRICA
ASSICURAZIONI GENERALI SPA	ITALY	INDUSTRIAL ALLIANCE INSURANCE AND FINANCIAL SERVICES	CANADA	SANTAM LIMITED	SOUTH AFRICA
ASSURANT, INC.	UNITED STATES	INSURANCE AUSTRALIA GROUP LIMITED	AUSTRALIA	SCOR SE	FRANCE
ASSURED GUARANTY LTD	UNITED STATES	INTACT FINANCIAL CORPORATION	CANADA	SKUPINA PRVA PRF	SLOVENIA
ATLANTA	MOROCCO	JADRANSKO OSIGURANJE D.D.	CROATIA	SOMPO HOLDINGS INC	JAPAN
AVIVA PLC	UNITED KINGDOM	JAPAN POST HOLDINGS CO LTD	JAPAN	SONY FINANCIAL HOLDINGS INC.	JAPAN
AVIVASA EMEKLILIK VE HAYAT AS	TURKEY	JAPAN POST INSURANCE CO LTD	JAPAN	ST. JAMES'S PLACE PLC	UNITED KINGDOM
AXA SA	FRANCE	JARDINE LLOYD THOMPSON GROUP PLC	UNITED KINGDOM	STANDARD LIFE PLC	UNITED KINGDOM
AXIS CAPITAL HOLDINGS LTD	UNITED STATES	JRP GROUP PLC	UNITED KINGDOM	STEADFAST GROUP LTD	AUSTRALIA
BALOISE HOLDING LTD	SWITZERLAND	LANCASHIRE HOLDINGS LTD	UNITED KINGDOM	STOREBRAND ASA	NORWAY
BANCA MEDIOLANUM SPA	ITALY	LEGAL & GENERAL GROUP PLC	UNITED KINGDOM	SUL AMERICA S.A.	BRAZIL
BB SEGURIDADE PARTICIPACOES SA	BRAZIL	LIBERTY HOLDINGS LIMITED	SOUTH AFRICA	SUN LIFE FINANCIAL INCORPORATED	CANADA
BEAZLEY PLC	UNITED KINGDOM	LINCOLN NATIONAL CORPORATION	UNITED STATES	SWISS LIFE HOLDING AG	SWITZERLAND
BERKSHIRE HATHAWAY INC. "B"	UNITED STATES	LOEWS CORPORATION	UNITED STATES	SWISS RE AG	SWITZERLAND
BROWN & BROWN, INC.	UNITED STATES	LPI CAPITAL BERHAD	MALAYSIA	T&D HOLDINGS INCORPORATED	JAPAN
BULSTRAD VIENNA INSURANCE GROUP AD	BULGARIA	MANULIFE FINANCIAL CORPORATION	CANADA	TALANX AG	GERMANY
CATTOLICA ASSICURAZIONI S.C.A.R.L.	ITALY	MAPFRE SA	SPAIN	TOKIO MARINE HOLDINGS INCORPORATED	JAPAN
CHALLENGER FINANCIAL SERVICES GROUP LTD	AUSTRALIA	MARKEL CORPORATION	UNITED STATES	TOPDANMARK A/S	DENMARK
CHESNARA PLC	UNITED KINGDOM	MARSH & MCLENNAN COMPANIES, INC.	UNITED STATES	TORCHMARK CORPORATION	UNITED STATES
CHINA LIFE INSURANCE CO LTD	CHINA	MAX FINANCIAL SERVICES LTD	INDIA	TRAVELERS COMPANIES INC	UNITED STATES
CHINA PACIFIC INSURANCE (GROUP) COMPANY LIMITED	CHINA	MEDIBANK PRIVATE LTD	AUSTRALIA	TRYG A/S	DENMARK
CHINA REINSURANCE GROUP CORP	CHINA	METLIFE, INC.	UNITED STATES	UNIPOL GRUPPO FINANZIARIO SPA	ITALY
CHINA TAIPING INSURANCE HOLDINGS COMPANY LIMITED	HONG KONG	MIGDAL INSURANCE & FINANCIAL HOLDINGS LIMITED	ISRAEL	UNIPOLSAI ASSICURAZIONI SPA	ITALY

CHUBB LTD	UNITED STATES	MMI HOLDINGS LTD	SOUTH AFRICA	UNIQA INSURANCE GROUP AG	AUSTRIA
CINCINNATI FINANCIAL CORPORATION	UNITED STATES	MS&AD INSURANCE GROUP HOLDINGS, INCORPORATED	JAPAN	UNUM GROUP	UNITED STATES
CLAL INSURANCE ENTERPRISES HOLDINGS LTD	ISRAEL	MUENCHENER RUCKVERSICHERUNGS-GESELLSCHAFT AG	GERMANY	VALIDUS HOLDINGS, LIMITED	UNITED STATES
CNA FINANCIAL CORPORATION	UNITED STATES	NEW CHINA LIFE INSURANCE CO LTD	CHINA	VAUDOISE ASSURANCES HOLDING	SWITZERLAND
CNP ASSURANCES	FRANCE	NN GROUP NV	NETHERLANDS	VIENNA INSURANCE GROUP	AUSTRIA
COFACE SA	FRANCE	NOVAE GROUP PLC	UNITED KINGDOM	VITTORIA ASSICURAZIONI SPA	ITALY
CROATIA OSIGURANJE D.D.	CROATIA	NUERNBERGER BETEILIGUNGS-AG	GERMANY	W. R. BERKLEY CORP	UNITED STATES
DAI-ICHI LIFE HOLDINGS INC	JAPAN	OLD MUTUAL PLC	UNITED KINGDOM	WAFA ASSURANCE SA	MOROCCO
DELTA LLOYD NV	NETHERLANDS	OLD REPUBLIC INTERNATIONAL CORPORATION	UNITED STATES	WHITE MOUNTAINS INSURANCE GROUP LTD	UNITED STATES
DIRECT LINE INSURANCE GROUP PLC	UNITED KINGDOM	THE PEOPLE S INSURANCE CO (GROUP) OF CHINA LTD	CHINA	WILLIS TOWERS WATSON PLC	UNITED STATES
DISCOVERY LTD	SOUTH AFRICA	PHOENIX GROUP HOLDINGS	UNITED KINGDOM	XL GROUP LTD	UNITED STATES
DONGBU INSURANCE CO., LTD.	SOUTH KOREA	PHOENIX HLDGS LTD	ISRAEL	ZAVAROVALNICA TRIGLAV DD	SLOVENIA
E L FINANCIAL CORPORATION LTD	CANADA	PICC PROPERTY AND CASUALTY COMPANY LTD	CHINA	ZURICH INSURANCE GROUP LIMITED	SWITZERLAND
ENDURANCE SPECIALTY HOLDINGS LTD.	UNITED STATES	PING AN INSURANCE (GROUP) COMPANY OF CHINA LTD	CHINA		

The list above is constructed by first selecting all the insurers that are constituents of the World Datastream Insurance Index. Next, all insurers with quarterly accounting data or daily stock prices unavailable in *Datastream* are omitted. The final dataset consists of 173 insurers from 33 countries. G-SIIs designated by the FSB in July 2013 are highlighted in the table. The names (item WC06001) and countries (item GEOGN) of the insurers are extracted from the *Worldscope* database.

2014a; Anginer, Demirguc-Kunt, and Zhu, 2014b; Weiβ and Mühlnickel, 2014; Mühlnickel and Weiβ, 2015; Bierth et al., 2015). We briefly explain the interpretation and calculation of the measures below.

Static MES

Acharya et al. (2017) defines static MES as the expected losses of a firm in the tail of the aggregate sector's loss distribution. In other words, it measures the extent to which an individual insurer is negatively impacted in terms of stock losses when the aggregate sector is under stress. The direction of risk is "system to firm," meaning that an individual insurer faces a systemic stress caused by the aggregate sector's impairment. Mathematically, static MES can be expressed as:

$$Static\ MES_{it} = -E\ [\ R_{it} \mid R_{mt} < VaR_{\alpha t}] \tag{1}$$

where $static\ MES_{it}$ is the static MES of firm i at time t, R_{it} is the return of firm i at time t, R_{mt} is the return of the market index at time t, and $VaR_{\alpha t}$ is the value-at-risk of the market index with confidence level $1 - \alpha\%$ at time t. In our study, we calculate the static MES on a quarterly basis for each insurer using its daily stock prices. We choose the World Datastream Financial Index as our proxy for market index. In the section "Additional Analysis", we will replace the World Datastream Financial Index with the World Datastream Market Index, World Datastream Bank Index, and World Datastream Insurance Index for robustness check. Following Weiβ and Mühlnickel (2014) and Bierth et al. (2015), we choose α to be 5. A higher value of static MES represents more systemic risk. Although the static MES is relatively easy to interpret, it only measures how much an insurer is exposed to a financial crisis, but does not measure how much an insurer contributes to a crisis. Hence, we also use ΔCoVAR as an alternative measure for systemic risk.

ΔCoVAR

ΔCoVAR measures an insurer's systemic risk as its contribution to the aggregate sector's value-at-risk. Adrian and Brunnermeier (2016) defines $CoVAR_{\alpha}^{i}$ as the value-at-risk of the market index with confidence level $1 - \alpha$ given the insurer i's stock return equals its VaR_{α}^{i}. $\Delta CoVAR_{\alpha}$ is then defined as the difference between $CoVAR_{\alpha}$ and $CoVAR_{50\%}$. In other words, $\Delta CoVAR_{\alpha}$ gauges the extent to which an individual insurer puts the aggregate sector under distress. The direction of risk is "firm to system," meaning that the aggregate sector faces a stress caused by the impairment of an individual insurer. Mathematically, the calculation of $\Delta\, CoVAR_{\alpha}$ is expressed below:

$$Pr\ (R_m \leq CoVAR_{\alpha}^{\ |Ri=VaRi\alpha}\ |\ R_i = VaR_{\alpha}{}^{i}) = \alpha\% \tag{2}$$

$$\Delta CoVAR_{\alpha}{}^{i} = CoVAR_{\alpha}^{\ |Ri=VaRi\alpha} - CoVAR_{\alpha}^{\ |Ri=VaRi50}\ . \tag{3}$$

For the empirical estimation of ΔCoVAR, Adrian and Brunnermeier (2016) show that equation (3) can be simplified to:

$$\Delta CoVAR_{a}^{i} = \hat{\beta}_{a}^{i}(VaR_{a}^{i} - VaR_{50}^{i}) \tag{4}$$

where $\hat{\beta}_{a}^{i}$ is the estimated coefficient of performing quantile regression with market return as the dependent variable and stock return of insurer *i* as the independent variable, and $VaR_{\alpha}{}^{i}$ is the value-at-risk of insurer *i* with confidence level $1 - \alpha\%$. We use the rolling window method to run quantile regressions on daily stock returns for each insurer to obtain $\hat{\beta}_{a}^{i}$ for each quarter, and subsequently compute the $\Delta CoVAR_{\alpha}{}^{i}$ on a quarterly basis. To be consistent with previous systemic risk measures, we choose α to be 5. A lower value of ΔCoVAR represents more systemic risk.

Independent Variables

As we attempt to capture the effect of the new regulation on G-SII's systemic risk, the variable of our interest is the interaction term *Policy x GSII*, where *Policy* is a dummy variable that takes the value of 1 for the time period on or after the first quarter of 2012, and *GSII* is a dummy variable that takes the value of 1 if the insurer has been designated by the FSB as global systemically important. As the G20 publicly declared the need to tighten up on G-SII supervision during the meetings in November 2011 and June 2012, the IAIS responded by publishing three different policy measures governing the supervision of G-SIIs in July 2013, October 2014, and October 2015. The regulatory attention paid to the supervision of G-SIIs is expected to generate incentives for G-SIIs to change their risk-taking behaviors from 2012 Q1 to the end of our sample period, and, hence, the *Policy* dummy remains at 1 during this period. The estimated coefficient for the interaction term *Policy x GSII* measures the systemic risk reduction of G-SIIs relative to non-G-SIIs due to the G-SII regulation. The effect of any regulation or event affecting both G-SIIs and non-G-SIIs is not picked up by the interaction term. If the G-SII regulation successfully reduced the systemic risk of G-SIIs, we should expect the estimated coefficient for the interaction term to be negative when systemic risk is measured by static MES and positive when systemic risk is measured by ΔCoVAR.

Apart from the interaction term, we add a bunch of insurer-specific characteristics as control variables. We use the natural logarithm of total assets as a proxy for an insurer's size because Weiβ and Mühlnickel (2014) find that insurers' contribution to systemic risk is mainly driven by their size. We also measure leverage of an insurer by the ratio of market value of assets to market value of equities, as Bierth et al. (2015) find that leverage is the primary driver for insurers' systemic risk. Other important control variables include non-insurance activities and other incomes besides operating income, as the IAIS (2011) suggests that non-insurance activities are more likely to amplify and contribute to systemic risk than insurance activities. We use non-policyholder liabilities scaled by total liabilities as a proxy for non-insurance activities. We also scale other incomes besides operating income by net sales. If an insurer does not operate only in its domestic country, it is intuitive to argue that the financial distress of the insurer is more likely to be contagious to the financial systems in other countries. Hence, we use the amount of foreign sales scaled by total sales as a proxy for global activities. Fahlenbrach, Prilmeier, and Stulz (2012) argue that banks with short-term funding are more likely to be in financial distress during a crisis. Hence, we use the ratio of long-term debts to total debts as a proxy for liquidity. Trigeorgis and Lambertides (2014) suggest that market-to-book ratio seems to proxy for distress variables, and therefore we include market-to-book ratio as a control variable. Pamela, Neale, Schorno, and Semaan (2017) find that the interconnectedness of insurers varies by the type of insurance business, with life insurers having higher systemic risk than property and casualty insurers. To control for the different characteristics between life and non-life insurers, we use a *Life* dummy that takes the value of 1 for life insurers (with SIC code 6311 or 6321) and 0 for non-life insurers. To assess the quality of an insurer's insurance portfolio, we include the loss ratio as a control variable. We also include investment income because an exceptionally high investment income may imply excessive risk-taking in the insurer's investment portfolio. In addition, we control for the performance of insurer by its return on assets (ROA) and the quality of management by the ratio of operating expenses to net sales. To control for country-specific macroeconomic characteristics, we use annual GDP growth and inflation as control variables, as Baselga-Pascual, Trujillo-Ponce, and Cardone-Riportella (2015) show that falling GDP and high inflation rates increase bank risk. Table 2 documents the definition of the above variables.

Table 2. Definition of Variables

Variables	Definitions
(*Datastream* data items in brackets)	
ΔCoVAR	ΔCoVAR captures the tail dependency between insurers and market index. Refer to Measures of Systemic Risk for detailed methodology and calculation.
Asset indicator	Total assets (WC02999) scaled by the aggregation of assets for the whole sample
Dynamic MES	Dynamic marginal expected shortfall measures the losses of an insurer in the tail of the aggregate sector's loss distribution and takes into account the fat idiosyncratic tails with the DCC GARCH model. Refer to Appendix A for detailed methodology and calculation.
Financing cash flow indicator	Cash flow from financing activities (WC04890) scaled by the aggregation of cash flow from financing activities for the whole sample
Foreign sale indicator	Foreign sale (WC07101) scaled by the aggregation of foreign sales for the whole sample
GDP growth	Annual percentage growth of gross domestic product
Global activities	Foreign sales scaled by total sales (WC08731)
G-SII (1/0)	The G-SII dummy, which equals 1 if the insurer has been designated by the FSB as global systemically important, and 0 otherwise
Inflation	Inflation measured by change in consumer price index
Investment cash flow indicator	Sum of cash paid for investment purchases (WC04760) and cash received from investment sales (WC04440), scaled by the aggregation of investment purchases and sales for the whole sample
Investment income	[investment income (WC01006)] / [total assets (WC02999)]
Investment volatility	[equity investment (WC02230)] / [total investment (WC02255)]
Investment volatility indicator	Investment volatility scaled by the aggregation of investment volatility for the whole sample
Large (1/0)	The large dummy, which equals to 1 if the insurer's total assets (WC02999) or insurance reserves (WC03030) belong to the upper quartile of the whole sample, and 0 otherwise
Leverage	[book value of asset (WC02999) – book value of equity (WC03501) + market value of equity (WC08001)] / [market value of equity (WC08001)]
Leverage indicator	Leverage scaled by the aggregation of leverage for the whole sample
Life (1/0)	The life dummy, which equals to 1 for life insurers (SIC code 6311 or 6321), and 0 for non-life insurers
Liquidity	[long term debts (WC03251)] / [total debts (WC03255)]
Log(Assets in billions)	Natural logarithm of total assets (WC02999) in billions
Loss ratio	The aggregate of claims and change in reserve divided by earned premium (WC15549)

Table continues

Table 2. (*continued*)

Variables	Definitions
Market-to-book ratio	[market value of equity (WC08001)] / [book value of equity (WC03501)]
Non-insurance activities	[total liabilities (WC03351) – insurance reserves (WC03030)] / [total liabilities (WC03351)]
Non-insurance revenue indicator	Other incomes besides operating incomes (WC01262) scaled by the aggregation of other incomes besides operating incomes for the whole sample
Non-policyholder liability indicator	The difference between total liabilities (WC03351) and insurance reserves (WC03030), scaled by the aggregation of the difference between total liabilities and insurance reserves for the whole sample
Operating expenses	[operating expenses (WC01249)] / [net sales or revenues (WC01001)]
Other incomes	[other incomes besides operating incomes (WC01262)] / [net sales or revenues (WC01001)]
Policy (1/0)	The policy dummy, which equals to 1 from 2012 Q1 to 2015 Q4, and 0 on or before 2011 Q4
Reinsurance indicator	Reinsurance reserve (WC01005) scaled by the aggregation of reinsurance reserve for the whole sample
Revenue indicator	Net sales or revenues (WC01001) scaled by the aggregation of sales for the whole sample
ROA	Return on assets (WC08326)
Short term funding indicator	The difference between total debt (WC03255) and long-term debt (WC03251), scaled by the aggregation of the difference between total debt and long-term debt for the whole sample
Static MES	Static marginal expected shortfall is the losses of an insurer in the tail of the aggregate sector's loss distribution. Refer to Measures of Systemic Risk for detailed methodology and calculation.

Descriptive Statistics

The descriptive statistics are summarized in Table 3. Panels A, B, and C report the statistics of systemic risk measures, firm characteristics, and country-specific macroeconomic variables, respectively. The mean of static MES and ΔCoVAR are 2.16% and –0.98%, respectively. The time evolution of these systemic risk measures is reported separately for G-SIIs and non-G-SIIs in Figures 1 and 2. Before the financial crisis in 2008, systemic risk of insurers remained at a low level. However, both measures indicate that systemic risk increased sharply during the financial crisis in 2008. The peaks of static MES occurred in the third and fourth quarters of 2008, while the troughs of ΔCoVAR occurred in the fourth quarter of 2008 and the first

Table 3. Summary Statistics

	Moments				Percentiles					
Variable	Mean	Std. dev	Skewness	Kurtosis	10th	25th	50th	75th	90th	N
Panel A: Systemic risk measures										
Static MES (%)	2.16	2.10	3.47	33.44	0.17	0.85	1.68	2.86	4.44	5,386
ΔCoVAR (%)	–0.98	0.85	–1.76	4.31	–2.03	–1.32	–0.77	–0.39	–0.15	5,386
Panel B: Firm characteristics										
Log (Assets in billions)	3.28	1.90	–0.38	0.18	0.78	2.07	3.28	4.68	5.83	5,354
Leverage	10.13	13.44	6.40	73.02	2.01	3.09	5.90	11.99	22.34	5,333
Non-insurance activities	0.30	0.27	7.50	115.97	0.09	0.15	0.24	0.39	0.58	4,896
Other incomes	0.00	0.04	–9.28	161.24	–0.01	0.00	0.00	0.00	0.02	5,354
Global activities	0.28	0.30	0.81	–0.28	0.00	0.00	0.15	0.50	0.73	4,110
Liquidity	0.82	0.28	–1.87	2.53	0.41	0.76	0.95	1.00	1.00	5,021
Market-to-book ratio	1.74	1.36	3.13	14.55	0.74	0.94	1.34	2.07	3.09	5,333
Life (1/0)	0.42	0.49	0.34	–1.89	0.00	0.00	0.00	1.00	1.00	5,386
Loss ratio	1.85	23.43	32.52	1,094.53	0.52	0.66	0.80	1.02	1.43	4,835
Investment income	0.03	0.02	0.85	22.99	0.01	0.02	0.03	0.04	0.04	4,956
ROA (%)	2.57	3.41	3.16	20.39	0.28	0.69	1.57	3.52	5.99	5,292
Operating expenses	0.88	0.12	–0.97	20.60	0.76	0.83	0.89	0.94	0.97	5,195
Panel C: Country-specific macroeconomic variables										
GDP growth (%)	1.78	2.69	0.21	2.93	–1.67	0.82	1.97	2.62	4.68	5386
Inflation (%)	2.25	1.97	1.51	4.47	0.05	1.10	2.07	3.16	4.48	5386

This table presents the summary statistics for the variables used in our regression analysis. The sample is constructed by first selecting all the insurers that are constituents of the World Datastream Insurance Index. Next, all insurers with quarterly accounting data or daily stock prices unavailable in *Datastream* are omitted. The final dataset consists of 173 insurers from 33 countries. The variables are defined in Table 2.

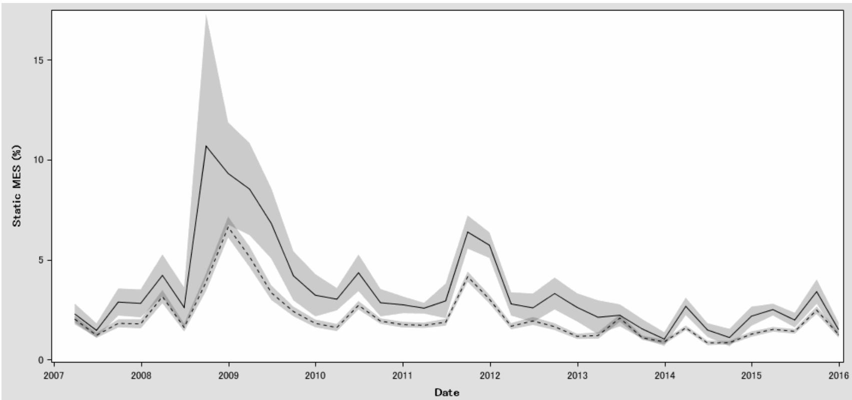

Fig. 1. Time evolution of static MES with 90% confidence bands. Solid line and dotted line represent the average systemic risk of G-SIIs and non-G-SIIs, respectively, with 90% confidence bands in grey.

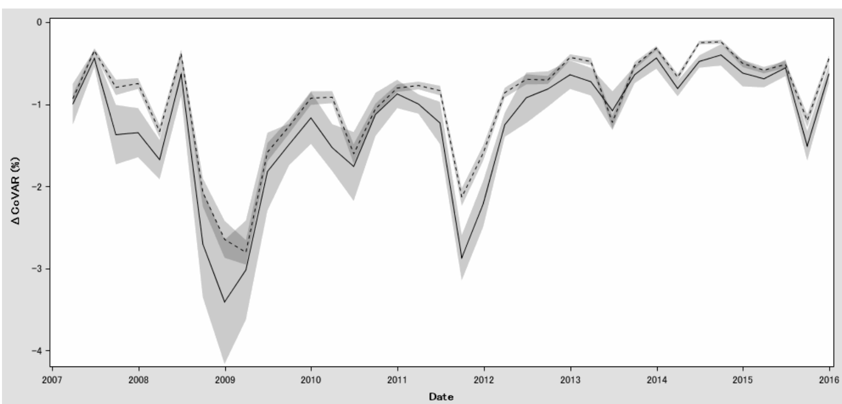

Fig. 2. Time evolution of Δ CoVAR with 90% confidence bands. Solid line and dotted line represent the average systemic risk of G-SIIs and non-G-SIIs, respectively, with 90% confidence bands in grey.

quarter of 2009. Although the systemic risk decreased temporarily after the financial crisis, another peak occurred near the end of 2011. Subsequently, the G20 made a declaration after the meeting on 4 November 2011 explicitly expressing the need to develop a supervisory framework for internationally active insurance groups. On 19 June 2012, the G20 reiterated the need to supervise G-SIIs. In response, the IAIS published various policy measures to govern G-SIIs in 2013, 2014, and 2015. Coincidentally, we observe a downward trend on insurers' systemic risk in the same period. Whether the new regulation contributed to the downward trend of G-SIIs observed between 2012 and 2015 is the main research question we will address in later sections.

Univariate Analysis

Before performing multivariate regression in the following section, we conduct the univariate analysis in this subsection. In particular, we attempt to investigate whether G-SIIs and non-G-SIIs are different in nature. We also investigate whether systemic risk and insurer-specific characteristics changed for G-SIIs before and after the new regulation. We repeat the same analysis on non-G-SIIs as well. The results are reported in Table 4.

Columns 1 to 3 report the difference of systemic risk and insurer characteristics between G-SIIs and non-G-SIIs; columns 4 to 6 report the difference of systemic risk and insurer characteristics before and after the regulation for G-SIIs; columns 7 to 9 report the difference of systemic risk and insurer characteristics before and after the regulation for non-G-SIIs. As indicated by all the risk measures, G-SIIs had more systemic risk than non-G-SIIs, both before and after the new regulation. The systemic risk of insurers decreased dramatically after the policy reform. Static MES and ΔCoVAR of G-SIIs were respectively reduced from 4.47% and –1.63% to 2.18% and –0.76% after the new regulation, which represented over 50% reduction of systemic risk. We also observe a downward trend of systemic risk among non-G-SIIs, but the magnitude of risk reduction was not as much as that for G-SIIs. The significant reduction of systemic risk among G-SIIs was accompanied by an 11.32 reduction of leverage and 7% reduction of global activities. The univariate analysis results strongly suggest that the characteristics as well as systemic risk of G-SIIs changed after the introduction of the new regulation. We also observe that G-SIIs are very different from non-G-SIIs. G-SIIs are generally bigger in size, operate on higher leverage, engage in more non-insurance activities, have stronger global presence, greater need for liquidity, lower book-to-market ratio, lower loss ratio, lower ROA, and higher operating expenses than non-G-SIIs. These insurer-specific characteristics probably play some roles in affecting the systemic risk of insurers, and the univariate analysis results motivate us to control for these characteristics in the multivariate regressions in the following section.

EMPIRICAL MODEL AND RESULTS

With G-SIIs as the treated group and non-G-SIIs as the control group, we employ the difference-in-difference model to investigate the effect of

Table 4. Univariate Analysis of Insurers Before and After the New Regulation

	Total			G-SIIs			Non-G-SIIs		
	G-SIIs (1)	Non-G-SIIs (2)	Difference (3)	Before regulation (4)	After regulation (5)	Difference (6)	Before regulation (7)	After regulation (8)	Difference (9)
Static MES (%)	3.45	2.07	−1.38*** (−7.39)	4.47	2.18	−2.29*** (−7.20)	2.67	1.42	−1.25*** (−24.67)
ΔCoVAR (%)	−1.25%	−0.96	0.29*** (5.52)	−1.63	−0.76	0.87*** (10.43)	−1.28	−0.60	0.68*** (32.36)
Log (Assets in billions)	6.39	3.08	−3.31*** (−88.20)	6.30	6.50	0.20*** (3.82)	2.95	3.22	0.27*** (5.48)
Leverage	22.26	9.37	−12.89*** (−7.30)	27.13	15.81	−11.32*** (−3.70)	9.43	9.30	−0.13 (−0.43)
Non-insurance activities	0.38	0.29	−0.09*** (−9.34)	0.38	0.38	0.002 (0.11)	0.31	0.27	−0.04*** (−4.52)
Other incomes (%)	0.41	0.04	−0.37** (−2.29)	0.44	0.36	−0.08 (−0.30)	0.13	−0.07	−0.20 (−1.52)
Global activities	0.44	0.26	−0.18*** (−14.14)	0.47	0.40	−0.07*** (−2.96)	0.30	0.23	−0.07*** (−7.45)
Liquidity	0.72	0.83	0.11*** (8.25)	0.71	0.74	0.03 (1.64)	0.83	0.83	0.002 (0.25)
Market-to-book ratio	1.58	1.75	0.17** (2.47)	1.66	1.48	−0.18 (−1.42)	1.76	1.75	−0.01 (0.38)
Loss ratio	1.06	1.90	0.84** (2.33)	1.06	1.06	0.00 (0.01)	0.96	2.92	1.96*** (2.60)
Investment incomes	0.03	0.03	−0.002 (−1.09)	0.03	0.03	0.002 (0.77)	0.03	0.03	−0.001 (−1.60)
ROA (%)	0.63	2.70	2.07*** (23.76)	0.54	0.73	0.19 (1.42)	2.68	2.71	0.03 (0.29)
Operating expenses	0.91	0.87	−0.04*** (−8.03)	0.91	0.91	−0.005 (−0.57)	0.88	0.87	−0.01*** (−3.05)

The table above reports the univariate analysis of the three systemic risk measures and insurer characteristics before and after the new regulation. It also compares the systemic risk and characteristics of G-SIIs and non-G-SIIs. The variables are defined in Table 2. t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

the new regulation on G-SIIs. The baseline empirical set-up is expressed as follows.

$$Systemic\ risk_{it} = \beta_0 + \beta_1\ Policy_t\ x\ GSII_i + \beta_2\ GSII_i + \beta_3\ Policy_t + \beta_4\ Insurer\ characteristics_{it-1} + \beta_5\ Country\text{-}specific\ macroeconomic\ characteristics_{it-1} + e_{it} \quad (5)$$

where *i* represents an insurer, *t* represents a quarter, *systemic risk* is measured by either static MES or ΔCoVAR, *Policy* is a dummy that equals to 1 on or after 2012 Q1, *GSII* is a dummy that equals to 1 for insurers designated as G-SIIs, *Insurer characteristics* and *Country-specific macroeconomic characteristics* are variables described above, and *e* is the error term. We allow for a time-lag of one quarter for characteristics because $Systemic\ risk_{it}$ measures the systemic risk from the beginning of period *t* to the end of period *t* while the $Insurer\ characteristics_{t-1}$ and $Country\text{-}specific\ macroeconomic\ characteristics_{t-1}$ are based on figures at the end of period $t - 1$. We cluster standard errors at the country level to control for heteroscedasticity. To control for unobserved time-invariant insurer characteristics, time-invariant country characteristics, and insurer-invariant time effect, we also perform additional analysis by including different combinations of firm-fixed effect, country-fixed effect, and time-fixed effect. If the new regulation is effective in reducing the systemic risk of G-SIIs, we expect β_1 to be negative when systemic risk is measured by static MES and positive when systemic risk is measured by ΔCoVAR. The results of performing the baseline regression on the whole sample are reported in Table 5.

Columns 1–4 and 5–8 report the coefficient estimates when systemic risk is measured by static MES and ΔCoVAR, respectively. Out of the 8 columns, 7 of them indicate that the estimated coefficients for the interaction term *Policy x GSII* are statistically significant within the 1% confidence level, while the remaining column (i.e., column 5) indicates that the estimated coefficient for the interaction term *Policy x GSII* is statistically significant at the 12% confidence level. All the estimated coefficients indicate that the systemic risk of G-SIIs, relative to that of non-G-SIIs, decreased after the new regulation. The magnitude of G-SIIs' systemic risk reduction, relative to that of non-G-SIIs, is also economically significant. As the R^2 in columns 4 and 8 have the highest value when systemic risk is measured by static MES and ΔCoVAR, respectively, we use the estimated coefficients in these two columns to demonstrate the economic significance. The difference between the static MES of G-SIIs and non-G-SIIs decreased by 0.68%, which represents 37.8% of average difference between the static MES of G-SIIs and non-G-SIIs before the new regulation. The difference between the ΔCoVAR of G-SIIs and non-G-SIIs was also reduced by 0.21%, which

Table 5. Baseline Regression of Systemic Risk on the Whole Sample

	Dependent variable							
	Static MES (%)				ΔCoVAR (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy x GSII	−0.648***	−0.739***	−0.824***	−0.680***	0.127	0.200***	0.225***	0.214***
	(−3.92)	(−3.77)	(−4.18)	(−4.36)	(1.62)	(3.30)	(3.48)	(3.87)
GSII	0.682**	0.732**	0.602*		−0.02	−0.053	0.010	
	(2.66)	(2.73)	(2.04)		(−0.17)	(−0.52)	(0.13)	
Policy	−1.202***				0.688***			
	(−17.9)				(9.48)			
Log (Assets in billions)	0.113*	0.136**	0.144***	0.177	−0.075***	−0.089***	−0.106***	−0.163**
	(1.88)	(2.72)	(3.40)	(1.04)	(−3.04)	(−3.97)	(−5.39)	(−2.44)
Leverage	0.024***	0.024***	0.023***	0.029***	0.001	0.002	0.003***	0.002**
	(5.62)	(5.55)	(5.09)	(11.34)	(0.75)	(1.68)	(3.58)	(2.32)
Non-insurance activities	0.232	0.37*	0.312*	−0.056	−0.052	−0.133**	−0.052**	−0.009
	(1.45)	(1.71)	(1.77)	(−0.48)	(−1.23)	(−2.33)	(−2.10)	(−0.2)
Other incomes	−1.689	−2.738	−1.941	−1.560	0.779	1.22**	0.644**	0.778**
	(−1.42)	(−1.58)	(−1.13)	(−0.91)	(1.19)	(2.42)	(2.31)	(2.67)
Global activities	0.383*	0.303	0.46***	0.464	−0.104	−0.072	0.000	0.062
	(1.96)	(1.66)	(4.25)	(1.33)	(−1.23)	(−0.98)	(0.01)	(0.55)
Liquidity	−0.205	−0.181	−0.168	−0.124	0.007	−0.025	0.021	0.011
	(−0.94)	(−0.99)	(−0.96)	(−0.52)	(0.13)	(−0.54)	(0.43)	(0.14)
Market-to-book ratio	−0.019	0.009	0.088*	−0.003	0.034	0.006	−0.009	0.02
	(−0.28)	(0.14)	(2.01)	(−0.03)	(1.19)	(0.28)	(−0.89)	(0.85)
Life	0.005	0.040	0.229**		−0.054	−0.073*	−0.105**	
	(0.04)	(0.35)	(2.38)		(−1.15)	(−1.75)	(−2.68)	
Loss ratio	0.000	−0.000	−0.000	−0.001***	−0.000	0.000*	0.000**	−0.000
	(0.58)	(−0.24)	(−0.43)	(−4.8)	(−0.72)	(1.99)	(2.32)	(−0.23)
Investment incomes	0.115	5.041**	3.404**	7.223**	0.686	−1.817*	−1.02	−0.852
	(0.06)	(2.73)	(2.06)	(2.58)	(0.71)	(−1.87)	(−1.02)	(−0.71)
ROA (%)	−0.09	−0.025	−0.037	−0.028	0.006	−0.023***	−0.019***	−0.025**
	(−1.08)	(−0.52)	(−0.75)	(−0.75)	(0.62)	(−3.29)	(−4.09)	(−2.7)
Operating expenses	0.277	0.269	0.446	0.53	−0.198	−0.107	−0.156	−0.183
	(0.29)	(0.33)	(0.61)	(0.79)	(−1.24)	(−0.49)	(−1.59)	(−0.69)

GDP growth (%)	–0.101*	–0.061*	–0.048	–0.036	0.035**	0.016	–0.015	–0.022
	(–1.97)	(–1.75)	(–0.99)	(–0.65)	(2.75)	(1.17)	(–0.92)	(–1.48)
Inflation (%)	0.202***	0.025	–0.029	–0.04	–0.074***	0.008	0.018	0.022
	(3.47)	(0.67)	(–0.38)	(–0.55)	(–7.69)	(0.39)	(0.84)	(1.36)
Firm-fixed effect	No	No	No	Yes	No	No	No	Yes
Country-fixed effect	No	No	Yes	No	No	No	Yes	No
Time-fixed effect	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	3,439	3,439	3,439	3,439	3,439	3,439	3,439	3,439
R^2	0.274	0.503	0.535	0.570	0.270	0.639	0.665	0.690

The table above reports the result of running the baseline regression on the whole sample. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

represents 60% of the average difference between the ΔCoVAR of G-SIIs and non-G-SIIs before the new regulation. The magnitude of systemic risk reduction estimated from the difference-in-difference setting is smaller than that suggested by the univariate analysis because some of the reduction in systemic risk is explained by changes in insurer characteristics and country-specific macroeconomic characteristics. It is also interesting to note that changes in insurer characteristics are endogenous and the new regulation may generate incentive for G-SIIs to change their characteristics. For example, Table 4 suggests that the average leverage of G-SIIs decreased by 11.32 after the new regulation while the average leverage of non-G-SIIs did not change much. Table 5 also suggests that a decrease in leverage reduces the systemic risk of insurers. Hence, some of the effect of the new regulation is captured by changes in insurer characteristics, and the coefficient for the interaction term *Policy x GSII* underestimates the effect of the new regulation on G-SIIs' systemic risk. The actual reduction of the difference between the systemic risk of G-SIIs and non-G-SIIs should be greater than 0.68% of static MES and 0.21% of ΔCoVAR. We will further discuss the change in insurer characteristics below.

The regression results are consistent with the argument that the costs of complying with the new regulation are higher than the benefits of being perceived by the market as safer after the G-SII designation. Otherwise, G-SIIs would have intentionally taken more risks to enjoy the lower external funding costs associated with the G-SII designation. The results suggest that investors perceive G-SIIs to be less systemically risky after the new regulation.

ADDITIONAL ANALYSIS

In this section, we investigate whether the empirical results in the previous section are caused by spurious correlation and perform additional analysis on the baseline regression. In particular, we examine whether the systemic risk of G-SIIs and non-G-SIIs moved in parallel in the pre-treatment period, which is a prerequisite for employing the difference-in-difference model in the previous section. In addition, we investigate whether the observations in that section are sensitive to the choice of market proxy or mainly driven by the data of the financial crisis. We also examine whether the empirical results are biased by the data of insurers from countries without G-SIIs and check the robustness of the time period of the *Policy* dummy. We further perform regression analysis on life insurers and non-life insurers separately, investigate whether the systemic risk of G-SIIs was reduced by the new regulation on a worldwide basis, and examine whether large insurers were affected by the new regulation regardless of their G-SII status. Finally, we examine whether the missing data problem biases our empirical findings, whether the empirical results are sensitive to the choice of systemic risk measure, and whether G-SIIs changed their characteristics after the new regulation to reduce their systemic importance.

Was there a parallel trend for the systemic risk of G-SIIs and non-G-SIIs in the pre-treatment period?

In this subsection, we examine a key assumption of the difference-in-difference analysis employed in the section above, which is the existence of a parallel trend of systemic risk for the treated and control group in the pre-treatment period.

As noted in Figures 1 and 2, the systemic risk of G-SIIs comoved with that of non-G-SIIs for the entire sample period. The systemic risk of G-SIIs was always higher than that of non-G-SIIs, but the gap was narrowed down in the post-treatment period (i.e., from 2012 to 2015). More importantly, we observe a parallel trend of comovement for the systemic risk of G-SIIs and non-G-SIIs for the pre-treatment period. To formally verify the existence of a parallel trend, we perform four placebo tests for the pre-treatment period. Assuming that the four placebo treatments took place in the beginning of 2008, 2009, 2010, and 2011 respectively, we repeat the baseline regression on the subsample in the pre-treatment period and replace the *Policy* dummy with the *Placebo* dummy. If the systemic risk of G-SIIs and non-G-SIIs moved in parallel in the pre-treatment period, we should observe statistically insignificant coefficients for the interaction term *G-SII x Placebo*. The results of the placebo tests are reported in Table 6.

With static MES as dependent variable, columns 1–4 report the results when placebo treatments took place in the beginning of 2011, 2010, 2009, and 2008, respectively. Similar placebo test results are reported in columns 5–8 with ΔCoVAR as dependent variable. We note that all the estimated coefficients of the interaction term *G-SII x Placebo* are statistically insignificant, except for the placebo test that took place in the beginning of 2008. The regression results suggest that the gap between the systemic risk of G-SIIs and non-G-SIIs was relatively narrow in 2007 and began to widen in 2008 during the financial crisis. The gap remained relatively stable thereafter for the remaining pre-treatment period. In other words, the systemic risk of G-SIIs and non-G-SIIs moved in parallel between 2008 and 2011.

As the employment of the difference-in-difference model requires the treated and control groups to move in parallel in the pre-treatment period, one may criticize that insurers' data in 2007 should be excluded from our sample. However, the trade-off of excluding the 2007 data is that our whole sample does not contain any pre–financial crisis data. As the reduced sample does not cover data for the whole economic cycle, one may be

Table 6. Regression Results of Placebo Tests

	Dependent variable							
	Static MES (%)				ΔCoVAR (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GSII x $Placebo_{2011}$	0.044				–0.117			
	(0.24)				(–1.19)			
GSII x $Placebo_{2010}$		–0.583				–0.024		
		(–1.34)				(–0.25)		
GSII x $Placebo_{2009}$			–0.388				0.042	
			(–0.78)				(0.31)	
GSII x $Placebo_{2008}$				0.866***				0.008
				(3.47)				(0.07)
Log (Assets in billions)	–0.648	–0.784*	–0.741	–0.539	–0.025	–0.012	0.003	–0.006
	(–1.61)	(–1.77)	(–1.55)	(–1.35)	(–0.15)	(–0.07)	(0.01)	(–0.03)
Leverage	0.03***	0.029***	0.03***	0.028***	0.001	0.001	0.001	0.001
	(7.93)	(7.59)	(7.55)	(6.99)	(1.13)	(1.20)	(1.05)	(1.03)
Non-insurance activities	–0.144	–0.168	–0.163	–0.119	0.011	0.014	0.016	0.015
	(–0.84)	(–0.93)	(–0.88)	(–0.72)	(0.31)	(0.38)	(0.44)	(0.41)
Other incomes	–2.428	–1.873	–2.195	–2.633	1.021	1.016	0.970	0.992
	(–0.89)	(–0.73)	(–0.83)	(–0.95)	(1.54)	(1.46)	(1.46)	(1.53)
Global activities	0.653	0.591	0.650	0.632	0.227*	0.233*	0.236*	0.236*
	(1.28)	(1.15)	(1.27)	(1.25)	(1.88)	(1.93)	(1.98)	(1.94)
Liquidity	0.253	0.327	0.311	0.179	–0.068	–0.072	–0.081	–0.076
	(0.70)	(1.06)	(1.01)	(0.45)	(–0.60)	(–0.63)	(–0.71)	(–0.68)
Market-to-book ratio	0.067	0.054	0.060	0.070	0.001	0.002	0.004	0.003
	(0.41)	(0.33)	(0.36)	(0.44)	(0.04)	(0.09)	(0.12)	(0.10)
Loss ratio	–0.01	–0.006	–0.007	–0.015	0.042*	0.042*	0.041*	0.042*
	(–0.07)	(–0.04)	(–0.05)	(–0.11)	(1.95)	(1.85)	(1.80)	(1.84)
Investment incomes	10.547**	10.283**	10.612**	10.111**	–2.256*	–2.202*	–2.202*	–2.196*
	(2.39)	(2.41)	(2.42)	(2.33)	(–1.94)	(–1.87)	(–1.96)	(–1.95)
ROA (%)	–0.021	–0.027	–0.024	–0.024	–0.031*	–0.031*	–0.031*	–0.031*
	(–0.40)	(–0.48)	(–0.44)	(–0.43)	(–1.97)	(–1.93)	(–1.94)	(–1.97)

Operating expenses	1.321	1.040	1.147	1.399	−0.409	−0.392	−0.363	−0.38
	(1.58)	(1.15)	(1.29)	(1.70)	(−0.96)	(−0.89)	(−0.82)	(−0.92)
GDP growth (%)	0.041	0.050	0.044	0.040	−0.019	−0.020	−0.021	−0.021
	(0.59)	(0.76)	(0.66)	(0.59)	(−0.94)	(−0.98)	(−1.01)	(−0.99)
Inflation (%)	−0.155*	−0.151*	−0.153*	−0.156*	0.055**	0.055**	0.054**	0.055**
	(−1.96)	(−1.94)	(−1.95)	(−1.99)	(2.65)	(2.63)	(2.60)	(2.66)
Firm-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,627	1,627	1,627	1,627	1,627	1,627	1,627	1,627
R^2	0.558	0.559	0.558	0.559	0.646	0.646	0.646	0.646

The table above reports the result of running the placebo tests on the subsample in the pre-treatment period. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm fixed effect and time fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

skeptical of the appropriateness of our sample coverage. Given that the narrow gap of systemic risk in 2007 biases against our empirical findings in the previous section[4] and a parallel trend existed for the treated and control groups between 2008 and 2011, we consider it appropriate to employ the difference-in-difference analysis to the whole sample.

Are the empirical results sensitive to the choice of proxy for market index?

For the systemic risk measures calculated in the second section, the World Datastream Financial Index is served as a proxy for market index. In this subsection, we use the World Datastream Market Index, which covers over 6,000 constituent entities over the world, as an alternative proxy for market index. As a robustness check, we also use the World Datastream Bank Index and the World Datastream Insurance Index as alternative proxies for market index to examine whether the empirical results in the baseline regression are sensitive to the choice of market proxy. The static MES and ΔCoVAR are recalculated for each insurer with the above market indices and we repeat the regression analysis with the updated systemic risk measures. The results are reported in Table 7.

Columns 1 to 2 report the results when the World Datastream Market Index serves as a proxy for the market index; columns 3 to 4 report the results when the World Datastream Bank Index serves as a proxy for the market index; columns 5 to 6 report the results when the World Datastream Insurance Index serves as a proxy for the market index. The estimated coefficients of the interaction term *Policy x GSII* in columns 1 to 6 indicate that the systemic risk of G-SIIs decreased after the new regulation regardless of the choice of proxy for the market index. The estimated coefficients of the interaction term are statistically significant for all the regressions, and the magnitude of most of the estimated coefficients is similar to that reported in Table 5. The regression results in Table 7 suggest that our baseline regression results are robust to different choices of proxy for the market index.

Are the empirical results mainly driven by data from the financial crisis?

As noted in Figures 1 and 2, static MES reached its peaks while ΔCoVAR reached its trough during the financial crisis in 2008 and 2009. Insurer's stock returns and accounting figures also experienced exception-

[4]To further substantiate the claim that the 2007 data biases against the empirical results reported above, we repeat the baseline regression for the subsample that excludes the 2007 data and find that all the estimated coefficients for the interaction term Policy x GSII have higher economic and statistical significance than the estimated coefficients reported in the previous section.

Table 7. Regression of Systemic Risk with Different Datastream Indices as Proxies for the Market

	World Datastream Market Index		World Datastream Bank Index		World Datastream Insurance Index	
	Dependent variable					
	Static MES (%)	ΔCoVAR (%)	Static MES (%)	ΔCoVAR (%)	Static MES (%)	ΔCoVAR (%)
	(1)	(2)	(3)	(4)	(5)	(6)
Policy x GSII	–0.581***	0.134**	–0.615***	0.222***	–0.735***	0.241***
	(–5.63)	(2.58)	(–4.12)	(4.51)	(–4.75)	(3.98)
Log (Assets in billions)	0.139	–0.110**	0.287**	–0.147*	0.054	–0.137*
	(0.98)	(–2.52)	(2.05)	(–2.04)	(0.30)	(–1.88)
Leverage	0.027***	0.002**	0.029***	0.002*	0.024***	0.003**
	(8.39)	(2.15)	(11.82)	(2.01)	(10.38)	(2.64)
Non-insurance activities	–0.119	–0.010	–0.036	0.014	–0.142	–0.022
	(–1.48)	(–0.44)	(–0.32)	(0.26)	(–0.91)	(–0.50)
Other incomes	–2.181	0.807***	–1.482	1.074**	–0.952	0.861*
	(–1.6)	(2.95)	(–0.77)	(2.69)	(–0.52)	(1.79)
Global activities	0.052	0.040	0.382	0.060	0.118	0.024
	(0.19)	(0.55)	(1.17)	(0.47)	(0.38)	(0.32)
Liquidity	–0.010	0.002	–0.132	–0.002	–0.108	–0.034
	(–0.06)	(0.03)	(–0.56)	(–0.02)	(–0.64)	(–0.36)
Market-to-book ratio	–0.025	0.008	–0.028	0.031	–0.141	0.025
	(–0.33)	(0.44)	(–0.42)	(1.34)	(–1.66)	(1.12)
Loss ratio	–0.002***	–0.000	–0.002***	0.000	–0.002***	0.000
	(–8.14)	(–1.42)	(–4.69)	(0.53)	(–9.86)	(0.50)
Investment incomes	6.591***	0.106	6.97***	–0.237	5.768**	–0.310
	(2.95)	(0.10)	(2.90)	(–0.17)	(2.38)	(–0.26)
ROA (%)	0.015	–0.022**	–0.036	–0.027**	–0.023	–0.028**
	(0.41)	(–2.75)	(–0.86)	(–2.49)	(–0.53)	(–2.16)
Operating expenses	1.029	–0.28	0.403	–0.23	0.160	–0.120
	(1.54)	(–1.43)	(0.54)	(–0.75)	(0.21)	(–0.43)
GDP growth (%)	0.039	–0.022*	–0.033	–0.039**	–0.068	–0.008
	(1.15)	(–1.88)	(–0.67)	(–2.13)	(–1.11)	(–0.66)
Inflation (%)	–0.026	0.010	–0.011	0.022	–0.043	0.024
	(–0.38)	(0.89)	(–0.15)	(1.35)	(–0.58)	(1.21)
Firm-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,439	3,439	3,439	3,439	3,439	3,439
R^2	0.569	0.690	0.552	0.679	0.627	0.701

The table above reports the result of running the baseline regression on the whole sample, with static MES and ΔCoVAR computed by using the World Datastream Market Index, the World Datastream Bank Index, and the World Datastream Insurance Index as proxies for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

ally high volatilities during such period. Hence, one may be skeptical of whether our regression results are biased by the extreme systemic risk values and uncommon fluctuations in accounting figures caused by the financial crisis. In addition, one may also doubt that our empirical findings simply demonstrate that the systemic risk of large insurers increased significantly during the financial crisis and reverted to a normal level during the subsequent period of general market recovery. In other words, mean-reversion, instead of the new G-SII regulation, can explain the empirical findings. Although this concern is partially mitigated by the difference-in-difference model set-up, we further exclude the data from the financial crisis and re-perform the regression analysis in this subsection. As the NBER determined the recent business cycle contraction began in December 2007 and ended in June 2009 (NBER, 2010), we drop the data during this period. The regression results with the updated dataset are reported in Table 8.

Columns 1 and 2 report the estimated coefficients of regressions with the subsample excluding data from the financial crisis. The estimated coefficients for the interaction term *Policy x GSII* are significant for all the regressions, except that the estimated magnitude of systemic risk reduction is slightly smaller than that of the baseline regression reported in Table 5. Hence, we conclude that the empirical results still support the claim that the systemic risk of G-SIIs decreased significantly after the new regulation even if we exclude data from the financial crisis.

Are the empirical results biased by the data of insurers from countries without G-SIIs?

As noted in Table 1, nine insurers from six different countries have been designated by the FSB as G-SIIs, while all the insurers in the remaining 27 countries are non-G-SIIs. One may criticize that we should only include the data of insurers from those six countries, as the interaction term *Policy x GSII* in equation (5) captures the systemic risk reduction of G-SIIs relative to non-G-SIIs between 2012 Q1 and 2015 Q4, and such reduction may be country-specific. Hence, including the data of insurers from countries without G-SIIs may bias the estimated systemic risk reduction of G-SIIs relative to non-G-SIIs. To address this concern, we include the country-fixed effect in some of the regressions in Table V. In this subsection, we exclude the data of insurers from countries without G-SIIs and repeat the regression analysis with the smaller subsample. The results are reported in Table 9.

Columns 1 and 2 document the regression results with the subsample excluding the data of insurers from countries without G-SIIs. We observe results similar to that of the baseline regression documented in Table 5.

Table 8. Regression of Systemic Risk Excluding Data from the Financial Crisis

	Dependent variable	
	Static MES (%)	ΔCoVAR (%)
	(1)	(2)
Policy x GSII	–0.448***	0.186***
	(–3.61)	(5.10)
Log (Assets in billions)	0.336***	–0.102*
	(2.99)	(–2.01)
Leverage	0.01***	0.004***
	(3.07)	(6.97)
Non-insurance activities	0.031	0.025
	(0.27)	(0.47)
Other incomes	–1.844	0.718*
	(–1.61)	(1.95)
Global activities	0.113	0.029
	(0.43)	(0.27)
Liquidity	–0.07	–0.032
	(–0.41)	(–0.58)
Market-to-book ratio	–0.096*	0.042**
	(–1.86)	(2.22)
Loss ratio	–0.001***	–0.000
	(–2.88)	(–0.93)
Investment incomes	3.207	0.238
	(1.50)	(0.20)
ROA (%)	0.053**	–0.018*
	(2.33)	(–2.02)
Operating expenses	0.795	0.017
	(1.63)	(0.07)
GDP growth (%)	–0.003	–0.02
	(–0.08)	(–1.33)
Inflation (%)	0.008	0.016
	(0.16)	(1.14)
Firm-fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
Observations	2,924	2,924
R^2	0.556	0.673

The table above reports the result of running the regression on the sample excluding data from the financial crisis. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

Table 9. Regression of Systemic Risk Excluding Data of Insurers from Countries without G-SIIs

	Dependent variable	
	Static MES (%)	ΔCoVAR (%)
	(1)	(2)
Policy x GSII	–0.711***	0.254***
	(–3.83)	(3.09)
Log (Assets in billions)	–0.088	–0.26***
	(–0.38)	(–3.06)
Leverage	0.028***	0.002***
	(8.35)	(2.87)
Non-insurance activities	–0.629	–0.142
	(–0.88)	(–0.6)
Other incomes	–4.72	1.383*
	(–1.32)	(1.8)
Global activities	–0.311	0.278**
	(–0.94)	(2.37)
Liquidity	0.046	0.023
	(0.11)	(0.35)
Market-to-book ratio	0.133	0.035
	(0.88)	(1.47)
Loss ratio	–0.001	–0.0002
	(–1.33)	(–1.23)
Investment incomes	1.918	1.292
	(0.37)	(0.87)
ROA (%)	–0.04	–0.033**
	(–0.38)	(–2.07)
Operating expenses	0.484	–0.044
	(0.20)	(–0.12)
GDP growth (%)	–0.128**	–0.056***
	(–2.20)	(–2.71)
Inflation (%)	–0.077	–0.02
	(–0.88)	(–0.85)
Firm-fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
Observations	1,909	1,909
R^2	0.576	0.689

The table above reports the result of running the regression on the sample excluding data of insurers from countries without G-SIIs. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the firm level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

Both the magnitude of risk reduction suggested by the estimated coefficients for the interaction term *Policy x GSII* and the statistical significance of the estimated coefficients are similar to that of the baseline regression. Hence, we conclude that the baseline empirical results are not biased by the data of insurers from countries without G-SIIs.

Were G-SIIs aware of their designation before July 2013?

As the first G-SII designation was announced by the FSB in July 2013, one may be skeptical that insurers were not aware of their G-SII status and, therefore, that they were not motivated to change their risk-taking behaviors from 2012 Q1 to 2013 Q2 and our *Policy* dummy is not defined properly. We argue that G-SIIs should have an educated guess of their likelihood of being designated as G-SIIs long before the designation in July 2013. According to the IAIS's policy document (IAIS, 2013a), the G-SII designation announced in July 2013 was based on insurers' year-end 2011 data, which was collected from several selected insurers as early as 2012. Insurers that did not receive information requests from the IAIS had no chance of being designated as G-SIIs. After initial assessment, the IAIS came up with a potential G-SII list and requested further insurer-specific information for analysis as the initial assessment was not sufficient to determine if every candidate on the potential G-SII list was systemically important. Those insurers that received additional information requests at this stage were aware that they could potentially be designated as G-SIIs. In addition, the IAIS consulted the industry about the proposed G-SII identification methodology in May 2012 (IAIS, 2012). Hence, the proposed identification methodology was accessible to the public and potential G-SIIs could conduct self-assessment as early as May 2012. Based on the above arguments, we believe that the G-SII designation in July 2013 was not a surprise to most G-SIIs. Nevertheless, to cast doubt on whether our *Policy* dummy is defined properly, we change the time period of the dummy from 2012 Q1 – 2015 Q4 to 2013 Q4 – 2015 Q4 to ensure that all G-SIIs were certain of their designation in the revised time period. We then repeat the regression analysis with the revised *Policy* dummy in this subsection. The results are reported in Table 10.

Columns 1 and 2 report the regression results with the revised *Policy* dummy. The estimated coefficients for the interaction term *Policy x GSII* in Table 10 are similar to those reported in Table 5, in terms of both magnitude and statistical significance. The results suggest that our conclusion about the effectiveness of the new regulation remains unchanged even if we revise the time period of the *Policy* dummy to ensure that all G-SIIs were certain of their designation in the revised time period.

Table 10. Regression of Systemic Risk with Revised Time Period for the *Policy* Dummy

	Dependent variable	
	Static MES (%)	ΔCoVAR (%)
	(1)	(2)
Policy x GSII	–0.643***	0.188***
	(–4.65)	(3.62)
Log (Assets in billions)	0.203	–0.172**
	(1.17)	(–2.53)
Leverage	0.029***	0.002*
	(10.76)	(1.96)
Non-insurance activities	–0.046	–0.012
	(–0.40)	(–0.26)
Other incomes	–1.479	0.751**
	(–0.86)	(2.68)
Global activities	0.482	0.056
	(1.35)	(0.49)
Liquidity	–0.136	0.014
	(–0.56)	(0.19)
Market-to-book ratio	0.001	0.019
	(0.01)	(0.82)
Loss ratio	–0.001***	–0.000
	(–4.85)	(–0.32)
Investment incomes	7.346***	–0.89
	(2.81)	(–0.77)
ROA (%)	–0.030	–0.025**
	(–0.79)	(–2.69)
Operating expenses	0.497	–0.172
	(0.74)	(–0.65)
GDP growth (%)	–0.037	–0.022
	(–0.66)	(–1.47)
Inflation (%)	–0.044	0.024
	(–0.61)	(1.43)
Firm-fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
Observations	3,439	3,439
R^2	0.570	0.689

The table above reports the result of running the baseline regression with the revised time period for the *Policy* dummy. To ensure that all G-SIIs were certain of their designation during the time period for the *Policy* dummy, we revise the dummy so that it equals to 1 from 2013 Q4 to 2015 Q4. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2 except the *Policy* dummy.

Separate regression analysis on the life and non-life insurers subsample

As the baseline regressions in the section "Empirical Model and Results" combine life insurers, non-life insurers, reinsurers, and insurance financial groups, one may be concerned that it is not appropriate to include different kinds of insurance providers with different characteristics into one regression model. Although the *Life* dummy/firm-fixed effect included in Table 5 partially alleviates the above concern, we divide our whole sample into different categories and perform regression analysis separately in this subsection.

According to the SIC codes and the description of each insurer in *Datastream*, we divide our whole sample into four categories (i.e., life insurers, non-life insurers, reinsurers, and insurance financial groups).[5] As no firms from the reinsurers and insurance financial groups subsamples have been designated as G-SIIs, we can only perform regression analysis on the life insurers and non-life insurers subsamples. The regression results are reported in Table 11.

Columns 1 and 2 report the regression results on life insurers, while columns 3 and 4 report the regression results on non-life insurers. The estimated coefficients in all columns indicate that the systemic risk of G-SIIs decreased after the policy reform. They are also statistically significant. However, we should be cautious about the regression results as there are only 2 G-SIIs in the non-life insurers subsample. The limited number of G-SIIs in this subsample limits the reliability of the regression results.

Does the new regulation affect G-SIIs on a worldwide basis?

Since the financial crisis in 2008, much of the public attention about G-SIIs has been placed on the financial distress of American International Group and the subsequent bailout from the U.S. government. The regulation of G-SIIs in the U.S. also keeps ahead of international standards. For example, the U.S. passed the Dodd-Frank Wall Street Reform and Consumer Protection Act to tighten up regulation on systemically important financial institutions on 21 July 2010, and the Financial Stability Oversight Council (FSOC) of the U.S. named the American International Group as systemically important on 8 July 2013. Both the G-SII regulation and designation in the U.S. are one step ahead of the FSB and the IAIS. Some industry practitioners even consider that the rest of the globe follows the U.S. lead in the regulation of G-SIIs (PricewaterhouseCoopers, 2013).

[5]The SIC codes for life insurers are 6311 and 6321; the SIC codes for non-life insurers are 6324, 6331, 6351, 6361, 6371, and 6399; the SIC codes for insurance financial groups are 6029, 6282, and 6411; as no SIC code specifically categories reinsurers, we identify reinsurers from the firm description in *Datastream*.

Table 11. Regression of Systemic Risk on Life Insurers and Non-Life Insurers Separately

	Life insurers		Non-life insurers	
	Dependent variable			
	Static MES (%)	ΔCoVAR (%)	Static MES (%)	ΔCoVAR (%)
	(1)	(2)	(3)	(4)
Policy x GSII	–0.608***	0.141**	–0.827***	0.295***
	(–3.08)	(2.50)	(–4.07)	(3.71)
Log (Assets in billions)	0.367	–0.169	0.117	–0.173**
	(0.93)	(–1.58)	(0.78)	(–2.43)
Leverage	0.029*	–0.003	0.027***	0.003***
	(2.06)	(–0.80)	(8.23)	(5.3)
Non-insurance activities	–0.64	0.003	–0.018	–0.037
	(–1.39)	(0.04)	(–0.14)	(–0.82)
Other incomes	–2.392	0.331	–2.42	1.392***
	(–0.93)	(0.35)	(–1.31)	(4.05)
Global activities	0.672	–0.179*	0.314	0.207
	(1.43)	(–2.05)	(0.86)	(1.64)
Liquidity	–0.518	0.001	0.099	–0.002
	(–0.83)	(0.00)	(0.48)	(–0.03)
Market-to-book ratio	–0.097	0.079**	0.063	0.044
	(–0.47)	(2.29)	(0.47)	(1.50)
Loss ratio	–0.001	0.00	–0.643	0.194
	(–1.67)	(0.14)	(–1.24)	(1.26)
Investment incomes	6.316	–1.787	15.338**	–1.45
	(1.63)	(–1.39)	(2.3)	(–0.63)
ROA (%)	0.280	–0.184**	–0.059	–0.017*
	(1.22)	(–2.39)	(–1.24)	(–2.03)
Operating expenses	1.487	–0.569	0.955	–0.374
	(0.89)	(–0.99)	(1.37)	(–1.43)
GDP growth (%)	–0.108	–0.014	–0.046	–0.011
	(–1.66)	(–0.61)	(–0.76)	(–0.76)
Inflation (%)	–0.194**	0.049*	0.035	0.000
	(–2.33)	(1.79)	(0.47)	(0.00)
Firm-fixed effect	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Observations	1,380	1,380	1,791	1,791
R^2	0.671	0.750	0.493	0.647

The table above reports the result of running the baseline regression on the life insurers and non-life insurers separately. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

Hence, one may be skeptical of whether the new regulation can effectively reduce the systemic risk of G-SIIs outside the U.S. This subsection attempts to address this concern by performing regression separately on U.S. insurers and non-U.S. insurers. The results are reported in Table 12.

Columns 1 and 2 report the regression results on U.S. insurers only. As all insurers in the U.S. subsample belong to the same country, we cluster the standard errors at the insurer level instead of the country level in columns 1 and 2. All the estimated coefficients for the interaction term *Policy x GSII* suggest that the systemic risk of U.S. G-SIIs decreased significantly after the policy reform. However, we should be cautious about the inference of the estimated coefficients in columns 1 and 2 because we only have three G-SIIs (i.e., American International Group, Inc., Metlife, Inc., and Prudential Financial, Incorporated) in the U.S. subsample. The limited sample size may cause difficulties in interpreting the inference of estimated coefficients.

Columns 3 and 4 report the regression results on non-U.S. insurers. All the estimated coefficients for the interaction term *Policy x GSII* are statistically significant and indicate that the systemic risk of non-U.S. G-SIIs decreased after the policy reform. However, the magnitude of risk reduction is smaller than that in the U.S. subsample. Taken together, the regression results from columns 1 to 4 suggest that the new policy measures not only affect G-SIIs in the U.S., but also affect G-SIIs on a worldwide basis.

Does the new regulation affect large insurers regardless of their G-SII status?

In this subsection, we investigate whether the reduction in systemic risk due to the new regulation is confined to insurers designated as G-SIIs only. If the compliance costs with the new regulation are higher than the benefits of being perceived as safer by the market, we expect that the threat of being designated as G-SIIs motivates large insurers to change their risk-taking behaviors so that they could avoid the G-SII designation in the next round of review by the IAIS. To examine this issue, we define an insurer as large if its total assets belong to the upper quartile of the whole sample. The baseline regression is then performed on the whole sample, with the *GSII* dummy replaced by the *Large* dummy. For robustness, we also use insurance reserves as an alternative yardstick to define large insurers and repeat the same analysis. The empirical results are reported in Table 13.

Columns 1 and 2 report the regression results when the size of insurers is defined by total assets, while columns 3 and 4 report the regression results when the size of insurers is defined by insurance reserves. The estimated coefficients for the interaction term *Policy x GSII* in all the regressions are statistically significant and suggest that the systemic risk

Table 12. Regression of Systemic Risk on U.S. Insurers and Non-U.S. Insurers Separately

	US insurers		Non-US insurers	
	Dependent variable			
	Static MES (%)	ΔCoVAR (%)	Static MES (%)	ΔCoVAR (%)
	(1)	(2)	(3)	(4)
Policy x GSII	–1.257***	0.314***	–0.630**	0.255***
	(–3.15)	(2.93)	(–2.39)	(4.54)
Log (Assets in billions)	0.279	–0.196**	0.417*	–0.156*
	(1.38)	(–2.5)	(1.91)	(–1.85)
Leverage	0.019**	0.004**	0.026***	0.001
	(2.51)	(2.53)	(3.20)	(0.51)
Non-insurance activities	–1.823	0.470	–0.113	0.002
	(–1.46)	(1.40)	(–0.93)	(0.05)
Other incomes	–0.812	0.669	–1.604	0.479
	(–0.27)	(1.56)	(–0.75)	(1.28)
Global activities	–0.401	0.246	0.752*	–0.063
	(–0.79)	(1.19)	(1.78)	(–0.54)
Liquidity	–0.657	0.21	0.095	–0.054
	(–0.90)	(1.09)	(0.49)	(–0.88)
Market-to-book ratio	–0.398	0.104**	–0.074	0.023
	(–1.27)	(2.07)	(–0.81)	(1.08)
Loss ratio	–2.612	0.666**	–0.002***	0.000
	(–1.47)	(2.23)	(–6.92)	(0.3)
Investment incomes	41.528**	–11.576**	5.667***	–1.021
	(2.05)	(–2.20)	(4.21)	(–0.87)
ROA (%)	–0.013	–0.013	0.020	–0.017*
	(–0.08)	(–0.50)	(0.38)	(–1.76)
Operating expenses	3.637	–0.705	0.872	–0.156
	(1.04)	(–1.26)	(0.82)	(–0.53)
GDP growth (%)	67.917	81.875**	0.016	–0.006
	(0.64)	(2.06)	(0.40)	(–0.41)
Inflation (%)	–406.472	–488.012**	0.011	0.01
	(–0.65)	(–2.06)	(0.19)	(0.59)
Firm-fixed effect	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Observations	1,009	1,009	2,430	2,430
R^2	0.684	0.657	0.616	0.727

The table above reports the result of running the baseline regression on U.S. insurers and non-U.S. insurers separately. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level for regressions on non-U.S. insurers and at the insurer level for regressions on U.S. insurers. t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

Table 13. Regression of Systemic Risk with Focus on Large Insurers instead of G-SIIs

	Define large insurers based on total assets		Define large insurers based on insurance reserves	
	Dependent variable			
	Static MES (%) (1)	ΔCoVAR (%) (2)	Static MES (%) (3)	ΔCoVAR (%) (4)
Policy x Large	–0.532***	0.172**	–0.425**	0.179**
	(–3.00)	(2.57)	(–2.56)	(2.58)
Log (Assets in billions)	0.217	–0.176***	0.226	–0.179***
	(1.30)	(–2.96)	(1.35)	(–3.08)
Leverage	0.029***	0.002**	0.029***	0.002**
	(10.48)	(2.08)	(10.18)	(2.24)
Non-insurance activities	–0.024	–0.019	–0.044	–0.013
	(–0.20)	(–0.52)	(–0.35)	(–0.36)
Other incomes	–1.473	0.751**	–1.516	0.773***
	(–0.82)	(2.73)	(–0.85)	(2.80)
Global activities	0.418	0.077	0.442	0.074
	(1.36)	(0.79)	(1.42)	(0.77)
Liquidity	–0.054	–0.012	–0.066	–0.012
	(–0.25)	(–0.19)	(–0.30)	(–0.19)
Market-to-book ratio	–0.028	0.028	–0.024	0.029
	(–0.30)	(1.20)	(–0.24)	(1.21)
Loss ratio	–0.002***	–0.000	–0.002***	0.000
	(–5.85)	(–0.06)	(–6.18)	(0.03)
Investment incomes	7.571***	–0.964	7.707***	–1.047
	(2.97)	(–0.95)	(3.12)	(–1.08)
ROA (%)	–0.029	–0.025***	–0.027	–0.026***
	(–0.76)	(–3.04)	(–0.71)	(–3.05)
Operating expenses	0.454	–0.158	0.540	–0.19
	(0.76)	(–0.69)	(0.90)	(–0.83)
GDP growth (%)	–0.039	–0.021	–0.040	–0.02
	(–0.68)	(–1.51)	(–0.70)	(–1.49)
Inflation (%)	–0.028	0.018	–0.031	0.019
	(–0.37)	(1.05)	(–0.42)	(1.07)
Firm-fixed effect	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Observations	3,439	3,439	3,439	3,439
R^2	0.572	0.691	0.571	0.691

The table above reports the result of running the regression on the whole sample, with the GSII dummy replaced by the Large dummy. An insurer is considered as large if its total assets or insurance reserves belong to the upper quartile of the whole sample. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

of large insurers was reduced after the policy reform. Even if large insurers are not designated as G-SII and are not subject to the new policy measures, the threat of being designated as G-SII in the IAIS's future review motivates them to change their risk-taking behaviors.

Do the missing data bias our empirical findings?

As noted in Table 3, some of the quarterly accounting data are missing from our sample of insurers in *Datastream* for unknown reasons. The extent of the missing data problem varies across different variables. The variable *Global activities* has the most missing data, as around 24% of our sample does not have quarterly data regarding the amount of foreign sales. As a result, the number of firm-quarter observations available for regression decreases by 24% because of the missing data problem arising from a single explanatory variable. If the accounting data are not missing completely at random ("MCAR"), the regression results could potentially be biased for ignoring the missing data (see Little and Rubin, 2002; Yeh, 2009). Data are considered as MCAR if the missing pattern of the quarterly accounting data does not depend on the values of other variables in our sample. To examine whether the accounting data in our sample are MCAR, we apply the Little's MCAR test (Little, 1988) to all the variables in Table 3. We obtain a chi-square statistic of 6146, which is highly significant (at a 99% critical value of ${\chi_{369}}^2 = 435.12$) to reject the null of MCAR. Therefore, we conclude that the missing accounting data in our sample are not MCAR.

To test whether the missing data problem biases our baseline regression results, we apply the multiple imputation method proposed by Rubin (1987) and use the information revealed from the non-missing data in our sample to impute the missing values. As we have more than 20% of missing information for the quarterly accounting data, we follow Graham, Olchowski, and Gilreath (2007)'s suggestion to implement 20 imputations for each missing data value, with the willingness to tolerate 1% power falloff. With the imputed values for missing accounting data, we repeat the regression analysis with the larger sample. The results are reported in Table 14.

Columns 1 and 2 report the estimated coefficients of regression with imputed values for all the missing quarterly accounting data. As noted from the estimated coefficients for the interaction term *Policy x GSII*, the regression results are similar to that of the baseline regression reported in Table 5. The variable of interest in the first row of Table 14 is statistically significant and the magnitude is similar to that reported in Table 5, suggesting that our claim about the effectiveness of the new regulation remains unchanged after addressing the missing data problem. Taken together, we

Table 14. Regression of Systemic Risk with the Multiple Imputation Method

	Dependent variable	
	Static MES (%)	ΔCoVAR (%)
	(1)	(2)
Policy x GSII	–0.711***	0.232***
	(–4.53)	(4.30)
Log (Assets in billions)	–0.025	–0.093***
	(–0.33)	(–3.88)
Leverage	0.032***	0.002**
	(12.57)	(2.57)
Non-insurance activities	–0.291**	–0.029
	(–2.17)	(–0.81)
Other incomes	–0.029	–0.133
	(–0.05)	(–0.62)
Global activities	0.125	0.076**
	(0.92)	(2.12)
Liquidity	–0.097	0.004
	(–0.84)	(0.08)
Market-to-book ratio	–0.014	0.023*
	(–0.21)	(1.76)
Loss ratio	–0.002*	0.000
	(–1.84)	(1.21)
Investment incomes	6.299*	–0.376
	(1.99)	(–0.55)
ROA (%)	–0.013	–0.006
	(–0.56)	(–1.08)
Operating expenses	–0.116	0.092
	(–0.35)	(0.95)
GDP growth (%)	–0.046	–0.015
	(–1.38)	(–1.18)
Inflation (%)	–0.04	0.006
	(–0.76)	(0.36)
Firm-fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
Observations	5,386	5,386
R^2	0.543	0.645

The table above reports the result of regression analysis with the multiple imputation method to address the missing data problem. Static MES and ΔCoVAR are computed with the World Datastream Financial Index as proxy for market index. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

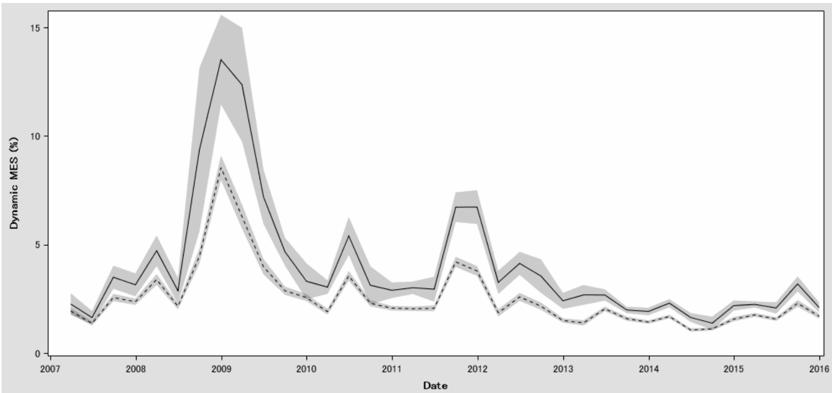

Fig. 3. Time evolution of dynamic MES with 90% confidence bands. Solid line and dotted line represent the average systemic risk of G-SIIs and non-G-SIIs, respectively, with 90% confidence bands in grey.

conclude that although the quarterly accounting data in our sample are not MCAR, our regression results are not biased by the missing data.

Are the empirical results sensitive to the choice of systemic risk measure?

Instead of using static MES and ΔCoVAR to measure systemic risk, we use dynamic MES proposed by Brownlees and Engle (2017) as an alternative measure of systemic risk in this subsection to examine if our empirical results are sensitive to the choice of systemic risk measure. Dynamic MES is similar to static MES in the sense that both of them measure the expected losses of a firm in the tail of the aggregate sector's loss distribution. The direction of risk is also "system to firm." However, the estimation of static MES is completely model-free, while the estimation of dynamic MES is subject to the dynamic conditional correlation (DCC) GARCH model proposed by Engle (2002). The advantage of the dynamic MES over static MES is more stable estimation procedures, as they rely on the DCC-GARCH model. Hence, the dynamic MES for each insurer is calculated on a quarterly basis according to the procedures documented in Appendix A. A higher value of dynamic MES represents more systemic risk. The time evolution of dynamic MES is reported separately for G-SIIs and non-G-SIIs in Figure 3. The baseline regression is repeated with dynamic MES as a measure of systemic risk, and the results are reported in Table 15.

Columns 1 to 4 of Table 15 report the regression results with different combination of *GSII* dummy, *Policy* dummy, firm-fixed effect, country-fixed effect, and time-fixed effect. The regression results in Table 15 with

Table 15. Baseline Regression with Dynamic MES as an Alternative Measure of Systemic Risk

	Dependent variable			
	Dynamic MES (%)			
	(1)	(2)	(3)	(4)
Policy x GSII	−0.647**	−0.769**	−0.854**	−0.740**
	(−2.59)	(−2.47)	(−2.74)	(−2.70)
GSII	0.648*	0.728**	0.687*	
	(2.02)	(2.08)	(1.82)	
Policy	−1.459***			
	(−19.89)			
Log (Assets in billions)	0.114**	0.142***	0.129***	−0.116
	(2.27)	(3.44)	(3.40)	(−0.79)
Leverage	0.026***	0.025***	0.025***	0.032***
	(5.26)	(4.88)	(5.27)	(7.17)
Non-insurance activities	0.202	0.389*	0.403**	−0.036
	(1.38)	(1.86)	(2.29)	(−0.33)
Other incomes	−1.672	−2.788	−1.914	−1.131
	(−1.10)	(−1.62)	(−1.27)	(−0.70)
Global activities	0.433*	0.325*	0.465***	0.107
	(2.01)	(1.76)	(2.97)	(0.25)
Liquidity	−0.264	−0.21	−0.038	0.037
	(−0.99)	(−0.99)	(−0.19)	(0.20)
Market-to-book ratio	0.012	0.045	0.096**	−0.012
	(0.19)	(0.86)	(2.40)	(−0.16)
Life	−0.008	0.036	0.219**	
	(−0.06)	(0.29)	(2.28)	
Loss ratio	−0.000	−0.000	−0.000	−0.002***
	(−0.01)	(−0.99)	(−0.74)	(−6.02)
Investment incomes	−1.231	4.505***	2.798*	6.131***
	(−0.66)	(2.90)	(1.99)	(2.93)
ROA (%)	−0.108	−0.027	−0.045	−0.043
	(−1.24)	(−0.54)	(−0.88)	(−1.31)
Operating expenses	0.426	0.404	0.185	−0.168
	(0.36)	(0.46)	(0.25)	(−0.27)
GDP growth (%)	−0.109*	−0.039	−0.056	−0.048
	(−1.70)	(−0.90)	(−1.20)	(−0.94)
Inflation (%)	0.294***	0.066*	−0.034	−0.041
	(4.65)	(1.70)	(−0.61)	(−0.90)
Firm-fixed effect	No	No	No	Yes
Country-fixed effect	No	No	Yes	No
Time-fixed effect	No	Yes	Yes	Yes
Observations	3,439	3,439	3,439	3,439
R^2	0.336	0.663	0.690	0.733

The table above reports the result of running the baseline regression on the whole sample. Dynamic MES is computed with the World Datastream Financial Index as proxy for market index. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

dynamic MES as dependent variable are very similar to the regression results in Table 5 with static MES as dependent variable. Hence, with dynamic MES as an alternative measure of systemic risk, our conclusion about the effectiveness of the new regulation remains unchanged.

Does the new regulation affect the characteristics of G-SIIs?

As the construction of static MES, dynamic MES, and ΔCoVAR is based on stock returns, one potential criticism is that all the risk measures only reflect the insurers' systemic risk perceived by the investors, but do not reflect their systemic importance generated by the insurer-specific characteristics. It remains unclear whether the new regulation changes the characteristics of G-SIIs.

To address this question, we follow Bramer and Gischer (2013) to construct the systemic importance score based on accounting data. As their proposed score is intended to measure the systemic importance of banks, we modify the proposed score according to the indicators suggested by the IAIS (2016) to measure the systemic importance of insurers. While we are unable to include all the IAIS's suggested indicators because of the limited data availability from *Datastream*, we consider that the modified systemic importance score captures many of the IAIS's suggested indicators and reflects the insurers' relative systemic importance. In addition, we also follow Kubitza and Regele (2018) to include characteristics of insurers, such as leverage, non-core insurance activities (represented by non-policyholder liabilities and non-insurance revenue), investment volatility, and reinsurance. The systemic importance score for insurer i is constructed from eleven indicators and is calculated as follows:

$$\begin{aligned} Score_{it} = \; & Asset\ indicator_{it} + Revenue\ indicator_{it} + Foreign\ sale\ indicator_{it} + Reinsurance\ indicator_{it} \\ & + Non\text{-}policyholder\ liabilities\ indicator_{it} + Non\text{-}insurance\ revenue\ indicator_{it} + Short\ term\ funding\ indicator_{it} \\ & + Investment\ cash\ flow\ indicator_{it} + Financing\ cash\ flow\ indicator_{it} + Leverage\ indicator_{it} \\ & + Investment\ volatility\ indicator_{it} \end{aligned} \tag{6}$$

$$Variable\ Indicator_{it} = \frac{Variable_{it}}{\Sigma_i^n Variable_{it}} \tag{7}$$

where n is the total number of insurers at time t. An insurer having a higher score value is more systemically important.

To investigate the effect of the new regulation on insurers' systemic importance, we perform the baseline regression and replace the systemic risk measures with the systemic importance score. To further examine how insurer characteristics react to G-SII regulation, we also conduct additional analysis by replacing the systemic importance score with individual variable indicator. The results are documented in Table 16.

As noted in column 1 of Table 16, the difference between the systemic importance score of G-SIIs and non-G-SIIs decreased by 0.069 after the new regulation, which corresponds to 22% of average difference between the systemic importance score of G-SIIs and non-G-SIIs before the policy reform. Further analysis on the constituent indicators from columns 2 to 12 reveals that G-SIIs reduced their systemic importance by decreasing their assets, revenues, volume of assumed reinsurance business, short-term funding, investment, and financing cash flow. It is interesting to note that all of these indicators are size-related—i.e., downsizing the balance sheet can reduce the score for these indicators. This finding is consistent with G-SIIs' mergers and acquisitions observed in the market after the G-20's announcement to tighten up supervision on G-SIIs. For example,[6] Assicurazioni Generali SpA sold Migdal Insurance and Financial Holdings Ltd., which is an insurance company in Israel, to Eliahu 1959 Ltd. for US$890.43 million in 2012 and Generali U.S. Holdings Inc., which is a reinsurance company in the United States, to SCOR Global Life Americas Holding Inc. for US$779 million in 2013. In addition, Assicurazioni Generali SpA also sold its Swiss private banking unit BSI to Banco BTG Pactual for US$1.4 billion in 2015, and subsequently the FSB removed Assicurazioni Generali SpA from the G-SII list in November 2015. The FSB opined that such removal reflected the changes in the level and type of activities undertaken by Assicurazioni Generali SpA (Riemsdijk, 2015); American International Group, Inc. reduced its shareholding in AIA Group Limited, which is an insurer focusing on the Asia-Pacific market, by selling US$8 billion of AIA Group Limited's shares to certain big investors in 2012. In addition, American International Group, Inc. sold AerCap Holdings N.V., which is an aircraft leasing company, in a public offering for US$750 million in 2015; Aviva plc sold CxG Aviva Corporacion Caixa Galicia de Seguros y Reaseguros S.A., which offers life insurance and pension funds in Spain, to Abanca Corporacion Bancaria, S.A. for US$369 million in 2014; MetLife, Inc. sold MetLife Assurance Limited, which is an insurance company in the United Kingdom, to Rotheasy Life Limited for US$705 million in 2014. Both the regression results and the mergers and acquisitions observed in the market suggest that downsizing is an important channel for G-SIIs to reduce their systemic importance. This argument is consistent with the finding of Irresberger, Bierth, and Weiβ (2017) in the sense that "firm size is the only significant predictor of the decision of regulators to designate a

[6]Details of the mergers and acquisitions are extracted from S&P Capital IQ.

Table 16. Regression with Systemic Importance Score and IAIS Indicators as Dependent Variables

	Dependent variable											
	Systemic importance score (%)	Asset indicator (%)	Revenue indicator (%)	Foreign sale indicator (%)	Reinsurance indicator (%)	Non-policy-holder liabilities indicator (%)	Non-insurance revenue indicator (%)	Short-term funding indicator (%)	Investment cash flow indicator (%)	Financing cash flow indicator (%)	Leverage indicator (%)	Investment volatility indicator (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Policy x GSII	−6.851***	−0.608*	−0.438**	−0.443	−0.842**	−0.680	0.572	−2.715***	−0.796**	−1.326*	−0.406	0.015
	(−3.32)	(−1.87)	(−2.14)	(−0.64)	(−2.54)	(−1.01)	(0.62)	(−4.46)	(−2.08)	(−1.86)	(−1.46)	(0.05)
Log (Assets in billions)	7.215***		0.549***	0.695***	0.913***	1.011*	0.115	1.175	0.625***	0.736**	0.378**	0.183
	(3.47)		(5.50)	(3.03)	(5.00)	(1.96)	(0.51)	(1.62)	(4.53)	(2.07)	(2.26)	(1.37)
Leverage	0.115***	0.001	−0.001	0.004	0.007***	−0.001	0.036***	0.029***	−0.0004	0.001		−0.001
	(5.63)	(1.47)	(−0.82)	(0.9)	(4.20)	(−0.62)	(2.97)	(4.30)	(−0.13)	(0.37)		(−0.68)
Non-insurance activities	2.619**	0.103	0.101**	0.154	0.158		0.098	0.492	0.180	0.214	0.111	0.099*
	(2.16)	(0.79)	(2.21)	(1.53)	(1.00)		(0.55)	(1.16)	(1.68)	(1.13)	(1.71)	(1.88)
Other incomes	5.125	−0.656	−1.792***	−3.193**	1.019	−0.443		0.925	−0.313	−8.419	−0.928	−0.871
	(0.76)	(−0.73)	(−6.19)	(−2.55)	(0.75)	(−0.60)		(0.37)	(−0.18)	(−1.3)	(−0.97)	(−1.10)
Global activities	3.836***	0.202	0.242**		0.233	0.251	0.093	−0.418	0.326	0.093	0.328	−0.105
	(3.84)	(1.46)	(2.09)		(0.40)	(1.61)	(0.32)	(−0.88)	(0.99)	(0.75)	(1.22)	(−0.87)
Liquidity	−3.51	−0.254	−0.018	0.364	−0.195	−0.687	−0.027		0.145	−0.157	−0.018	0.134
	(−1.54)	(−0.98)	(−0.19)	(1.60)	(−0.53)	(−1.32)	(−0.18)		(0.65)	(−0.54)	(−0.13)	(0.57)
Market-to-book ratio	0.437	0.000	−0.022	0.048*	−0.026	0.070	0.228	−0.067	−0.012	0.039	−0.191	0.094**
	(0.92)	(0.00)	(−0.6)	(1.89)	(−0.30)	(1.12)	(0.99)	(−0.83)	(−0.36)	(0.92)	(−1.27)	(2.11)
Loss ratio	−0.26	−0.008	0.010	−0.02	−0.102	−0.016	−0.159***	0.091	−0.006	−0.022	0.064**	−0.019
	(−1.36)	(−0.49)	(0.88)	(−0.46)	(−0.89)	(−0.88)	(−3.82)	(1.63)	(−0.25)	(−0.47)	(2.27)	(−1.43)
Investment incomes	−3.92	−1.906	0.902**	4.601**	−1.170	−2.153	1.209	−1.79		0.177	−1.494	2.04
	(−0.45)	(−1.55)	(2.45)	(2.14)	(−1.27)	(−1.33)	(0.78)	(−0.6)		(0.09)	(−0.99)	(0.75)
ROA (%)	−0.087	−0.024*	0.019*	0.013	−0.017	0.011	−0.024	−0.031	−0.008	0.052	−0.024	0.022
	(−0.77)	(−1.83)	(1.83)	(0.58)	(−0.45)	(0.43)	(−0.94)	(−0.75)	(−0.52)	(1.38)	(−0.94)	(1.39)
Operating expenses	0.804	−0.047	0.604**	1.035**	−0.309	0.484	−1.407	−0.386	0.299	1.842	1.462**	0.566
	(0.46)	(−0.19)	(2.11)	(2.09)	(−0.35)	(1.12)	(−1.37)	(−0.52)	(0.86)	(1.33)	(2.54)	(1.55)

GDP growth (%)	0.084	–0.012	–0.006	0.05**	0.018	0.030	0.008	0.024	0.021	–0.033	0.012	0.031
	(0.82)	(–0.97)	(–0.82)	(2.35)	(0.37)	(1.12)	(0.23)	(1.03)	(0.62)	(–1.02)	(0.46)	(1.23)
Inflation (%)	0.008	–0.021	–0.012*	0.011	0.034	–0.007	–0.04	0.062	0.010	–0.009	0.003	0.002
	(0.09)	(–1.67)	(–1.73)	(0.41)	(0.75)	(–0.38)	(–1.47)	(0.94)	(0.29)	(–0.33)	(0.10)	(0.12)
Firm-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,118	2,160	2,160	2,219	2,118	2,160	2,160	2,250	2,160	2,160	2,160	2,160
R^2	0.942	0.944	0.956	0.906	0.880	0.827	0.437	0.700	0.914	0.824	0.667	0.897

The table above reports the result of running the baseline regression on the whole sample, with systemic importance score and various indicators as dependent variables. Firm-fixed effect and time-fixed effect are included. Standard errors are clustered at the country level and t-statistics are reported in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The variables are defined in Table 2.

financial institution as systemically important." It is also consistent with the view of the Federal Reserve Chair, Janet Yellen, who opined that American International Group Inc.'s threat to the financial stability of the United States was reduced after it shrank its assets substantially (Price, 2017).

CONCLUSION

The issue of whether the recent regulators' focus on tightening up supervision on G-SIIs and the subsequent policy measures are effective in reducing the systemic risk of G-SIIs is controversial. On the one hand, some insurers fought hard to get rid of the G-SII designations, reflecting insurers' incentive to avoid the heavy compliance cost associated with the new regulation. For example, MetLife, Inc. appealed to the U.S. court attempting to overturn the decision made by the FSOC earlier designating MetLife, Inc. as a systemically important financial institution (Tracy, 2016). Assicurazioni Generali S.p.A. was also successfully removed from the list of G-SIIs in November 2015 by shrinking its business and selling its reinsurance and banking operations (Jenkins, 2016). On the other hand, there is wide consensus among researchers that systemic important institutions enjoy the benefits of lower funding costs (Araten and Turner, 2013; Ueda and Di Mauro, 2013; Moenninghoff, Ongena, and Wieandt, 2015). If the benefits of G-SII designation exceed the compliance costs, the new regulation may unintentionally encourage insurers to take on more risks.

We shed light on the literature on systemic risk and insurance regulation by addressing the question of whether the new regulation is effective in reducing G-SIIs' systemic risk. By analyzing a panel dataset covering 173 international insurers from 33 countries, we provide empirical evidence supporting the effectiveness of the new regulation. In particular, after controlling for insurer characteristics and country-specific macroeconomic characteristics, we find that the stock market participants' perception of G-SIIs' systemic risk, relative to non-G-SIIs' systemic risk, decreased by around 37.8% to 60.0% after the new regulation. The finding is robust to various systemic risk measures, alternative proxies for market index, different time periods of the treatment effect, separate analysis of life and non-life insurers, exclusion of data for insurers from countries without G-SIIs, and the multiple imputation method addressing the missing data problem. The regression results are also similar no matter if we include data from the financial crisis or not. Interestingly, we find that the effect of the new regulation is on a worldwide basis, although the magnitude of systemic risk reduction for U.S. G-SIIs is larger than that of non-U.S. G-SIIs.

We also find that the systemic risk of large insurers decreased after the new regulation regardless of their G-SII status, suggesting that the threat of being designated as G-SII motivates large insurers to change their risk-taking behaviors. As the systemic risk measures used in this study gauge the tail dependence of stock returns and only reflect the stock market participants' perception of insurers' systemic risk, we further analyze the changes of insurers' characteristics and find that downsizing is an important channel for G-SIIs to reduce their systemic importance.

From a public policy standpoint, our findings have important implications for the regulation of G-SIIs and reduction of systemic risk in the insurance sector. Our results show that the recent policy measures proposed by the IAIS are perceived by the market as heading in the right direction. Despite the numerous criticisms on the IAIS's proposed supervisory framework on G-SIIs (e.g., Jobst, 2014; Weiβ and Mühlnickel, 2014; Bierth et al., 2015), the empirical evidence in this study suggests that the new regulation at least deserves some credit for reducing the systemic risk of the insurance industry.

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APPENDIX A

Procedures to Calculate the Dynamic MES

We follow Brownlees and Engle (2017) to construct dynamic MES. The relevant procedures are summarized below.

Step 1: We model the daily stock returns using the GARCH-DCC model, which is specified as:

$$\begin{bmatrix} r_{it} \\ r_{mt} \end{bmatrix} \Bigg| F_{t-1} \sim D\left(0, \begin{bmatrix} \sigma_{it}^2 & \rho_{it}\sigma_{it}\sigma_{mt} \\ \rho_{it}\sigma_{it}\sigma_{mt} & \sigma_{mt}^2 \end{bmatrix}\right) \tag{8}$$

where $r_{it} = \log(1+R_{it})$, $r_{mt} = \log(1+R_{mt})$, σ_{it} is the volatility of firm i at time t, σ_{mt} is the volatility of the market index at time t, and ρ_{it} is the conditional correlation of the volatility adjusted returns $\varepsilon_{it} = r_{it} / \sigma_{it}$ and $\varepsilon_{mt} = r_{mt} / \sigma_{mt}$. Both σ_{it}, and σ_{mt} as well as ρ_{it} are subject to the following equations:

$$\sigma_{it}^2 = \omega_{Vi} + \alpha_{Vi} r_{it-1}^2 + \gamma_{Vi} r_{it-1}^2 I_{it-1}^- + \beta_{Vi}\sigma_{it-1}^2 \tag{9}$$

$$\sigma_{mt}^2 = \omega_{Vm} + \alpha_{Vm} r_{mt-1}^2 + \gamma_{Vm} r_{mt-1}^2 I_{mt-1}^- + \beta_{Vm}\sigma_{mt-1}^2 \tag{10}$$

$$Cor\begin{pmatrix} \varepsilon_{it} \\ \varepsilon_{mt} \end{pmatrix} = \begin{bmatrix} 1 & \rho_{it} \\ \rho_{it} & 1 \end{bmatrix} = diag(Q_{it})^{-\frac{1}{2}} Q_{it} diag(Q_{it})^{-\frac{1}{2}} \tag{11}$$

where $I_{it}^- = 1$ if r_{it} is negative, $I_{mt}^- = 1$ if r_{mt} is negative and Q_{it} is the correlation matrix with the following dynamics:

$$Q_{it} = (1 - \alpha_{Ci} - \beta_{Ci})S_i + \alpha_{Ci}\begin{bmatrix} \varepsilon_{it-1} \\ \varepsilon_{mt-1} \end{bmatrix}\begin{bmatrix} \varepsilon_{it-1} \\ \varepsilon_{mt-1} \end{bmatrix}' + \beta_{Ci} Q_{it-1} \tag{12}$$

where S_i measures the unconditional correlation matrix of r_i and r_m.

Step 2: Based on the GARCH-DCC model, we construct the standardized innovations ε_{mt} and ξ_{it}, which have zero mean and unit variance. They are also cross-sectionally and serially uncorrelated.

$$\varepsilon_{mt} = \frac{r_{mt}}{\sigma_{mt}} \tag{13}$$

$$\xi_{it} = \frac{\left(\frac{r_{it}}{\sigma_{it}} - \rho_{it}\frac{r_{mt}}{\sigma_{mt}}\right)}{\sqrt{1-\rho_{it}^2}}. \tag{14}$$

Step 3: We simulate S samples of one-period GARCH-DCC standardized innovations ξ_{it} and ε_{mt}, which are expressed as

$$\begin{bmatrix} \xi_{iT+1}^S \\ \varepsilon_{mT+1}^S \end{bmatrix} \quad s = 1, \ldots, S.$$

Step 4: With the last values of σ_{it}, σ_{mt}, and ρ_{it} as initial conditions, we use the samples of standardized innovations as inputs and generate S samples of one-period returns under the GARCH-DCC model, which are expressed as

$$\begin{bmatrix} r_{iT+1}^S \\ r_{mT+1}^S \end{bmatrix} \Bigg| F_T \quad s = 1, \ldots, S.$$

Step 5: Finally, the dynamic MES is calculated as the Monte Carlo average of the insurer's returns conditional on the systemic event.

$$\text{Dynamic MES} = \frac{\Sigma_{s=1}^S r_{iT+1}^S I\{r_{mT+1}^S < C\}}{\Sigma_{s=1}^S I\{r_{mT+1}^S < C\}} \tag{15}$$

where the systemic event C is the value-at-risk of the market index with 95% confidence level.