Bank Regulation and Systemic Risk:
Cross Country Evidence

Lei Chen[a*], Hui Li[b], Frank Hong Liu[c], Yue Zhou[d]

December 2018

Abstract

Using data for banks from 18 countries for the period 2001-2012, we investigate the impact of bank regulation and supervision on individual banks' contribution to systemic risk . Our cross-country empirical findings show that bank activity restriction, initial capital stringency and prompt corrective action are all positively related to systemic risk, measured by *Marginal Expected Shortfall (MES)*. Our results hold for the instrumental variable analysis and other robustness tests. We also find that the level of equity banks have can alleviate such effect, while bank size is likely to enhance the effect. Our results do not argue against bank regulation, but rather focus on the design and implementation of regulation.

JEL Classification: G21, G28, G01

Keywords: bank regulation and supervision, systemic risk, activity restrictions, capital shortfall

a Management School, University of Sheffield, Conduit Road, Sheffield S10 1FL, UK. Email: l.chen@sheffield.ac.uk

b School of Business and Economics, Loughborough University, Sir Richard Morris Building, Leicestershire, LE11 3TU, UK. Email: H.Li@lboro.ac.uk

c Business School, University of Aberdeen, S50 Edward Wright Building, Dunbar Street, Aberdeen, AB24 3QY, Scotland, UK. Email: hong.liu@abdn.ac.uk

d Adam Smith Business School, University of Glasgow, Gilbert Scott Building, Glasgow, G12 8QQ, UK. Email: y.zhou.3@research.gla.ac.uk

* Corresponding author.

1. Introduction

The inappropriate regulations and ineffective monitoring and supervision by official agencies have been regarded as a critical cause of the global financial crisis of 2007-2009 (Schwarcz, 2008; Acharya, 2009; Goodhart, 2008; Laeven and Levine, 2009). For example, Acharya (2009) argue that Basel regulations require banks to hold a certain ratio of capital to reduce individual banks' liquidity risk but overlook the correlated risk banks take which can lead to joint failures. Despite the increasing calls for renewed focus on systemic stability and macro-prudential regulation (e.g. Acharya et al., 2012), our understanding of how bank regulation and supervision affect systemic stability tends to be very limited (Arnold et al., 2012; Barth et al., 2013b).

A few studies have examined the impact of bank regulation and/or supervision on systemic stability (e.g., Barth et al., 2004; Demirgüç-Kunt and Detragiache, 2002; 2011). Based on bank regulation data from the World Bank Survey, Barth et al. (2004) find that banks operating in countries with higher regulatory restriction are more likely to experience a banking crisis. Demirgüç-Kunt and Detragiache (2011), on the other hand, fail to find relationship between the adherence to the Basel core principles and systemic risk measured by a system-wide Z-score. However, there is a lack of evidence on how the current bank regulatory system affects individual banks' contribution to the systemic risk. The study of Hoque et al. (2015) is among the first attempts to examine such an effect, but they only look at the period of financial crisis using cross sectional data. Our paper thus attempts to fill this gap in the literature by employing the *Marginal Expected Shortfall* (MES) developed by Acharya et al. (2017) as our systemic risk measure.

Bank regulation comprises two main aspects, capital regulation and supervision, and restrictions on non-banking activities. In this paper we argue that both aspects of bank regulation may be positively related to systemic risk. First, Acharya et al. (2012) and Brownlees and Engle (2016) define a bank's level of systemic risk as its capital shortfall, where a more undercapitalized bank compared to its risk level (but not government required level) contributes more to the whole financial system's (in)stability, conditional on severe distress in the entire system. In an environment of more stringent bank capital regulation and supervision, banks find it harder to raise capital when the entire system is undercapitalized (i.e. economy downturn or financial crisis), and hence are more likely to have capital shortfall.

The higher probability of banks' capital shortfall would increase the systemic instability of the country.

Second, the level of regulation stringency can limit the freedom of banks' activities. With stricter regulation, banks will have less opportunity to engage in a wider range of non-traditional bank activities. Based on the portfolio theory, the combined cash flows from non-correlated revenue sources should be more stable than the constituent parts (Baele et al., 2007). In other words, banks who are able to engage in different business lines tend to have more stable revenue flows compared to their peers and are thereby less likely to meet capital shortfall when external shock happens. In addition, banks who are allowed to engage in broader activities are able to raise capital from different sources, which therefore lowers their likelihood of experiencing capital shortfall. To put it in another way, when banks are only allowed to engage in limited activities, they are more likely to share a similar business structure, and such similarity in banks' business lines could result in lower systemic stability.

In order to investigate the impact of bank regulation on systemic risk, we use the new database by Barth et al. (2013a) on bank regulation and supervision for more than 180 countries over the period 1999-2011. Following Laeven and Levine (2009) and Li et al. (2017), we consider four aspects of bank regulation, including regulation on bank activities restriction, initial capital stringency, deposit insurer power and prompt corrective action. We then collapse the four regulation and supervision measures into a single measure of bank regulation using factor analysis. We use *Marginal Expected Shortfall* (MES), developed by Acharya et al. (2017), as our systemic risk measure.

We find that bank activity restriction, initial capital stringency and prompt corrective action are positively related to systemic risk. Such positive association is also found for the total regulation index we developed. This is consistent with our expectation based on the definition of systemic risk adopted in our study, suggesting that countries with more stringent regulation and supervision appear to suffer from higher systemic risk. Our findings hold robust after using alternative measure of systemic risk and employing the weighted-least-square regression analysis for checking sample bias.

We also conduct additional tests to check whether other factors exacerbate or mitigate the positive relationship between bank regulation and systemic risk. We posit that the positive impact of bank regulation on systemic risk will be intensified if the bank is larger since a larger bank needs a higher level of capital to smooth its contribution to the systemic risk, but reduced if the bank holds a higher level of capital, and if the bank has more diversified revenue flows. We thus introduce three interaction terms of our main regulation measures with bank size (measured by log total assets), bank equity to assets ratio and diversification (measured by non-interest income to total operation income, respectively, and include them in the main regressions. Our results confirm the hypotheses indicated above.

Our findings do not suggest that bank regulation and supervision are detrimental to systemic stability, but instead call for the proper design and implementation of bank regulation. We contribute to the literature in several ways.

First, the extant literature on bank regulation paid little attention to its impact on systemic risk. Although a few empirical studies have examined this relationship, the measures of systemic risk they used appear to be limited at the country level (Hoque et al., 2015). Our paper contributes to the literature in this regard, examining the impact of bank regulation on individual banks' contribution to the overall systemic risk and providing important evidence. Our findings suggest that the increased similarity in the banking system due to the restrictions on non-banking activities would increase systemic risk. This is consistent with the recent theoretical work on financial stability that highlights the importance of diversity in banking (Wagner, 2010, 2011; Allen et al., 2012), showing that some degree of diversification in banks' asset portfolios is socially optimal so that banks do not have to liquidate their identical assets at the same time when financial shocks happen and generate a fire-sale externality that lowers welfare. Our results also highlight the importance of bank regulation in allowing banks more capability to raise capital when the whole system is undercapitalized. This is consistent with the recent changes to Basel III regulation, which promote the build-up of buffers in good times that can be drawn down in periods of stress. Although our paper does not directly test the effect of government capital injection to the financial system during crisis periods, the implication of our results is supportive of government action to reduce the capital shortfall of the banking system. This is also consistent with the empirical evidence provided by Roman et al. (2018) that the U.S. Troubled Assets Relief Program (TARP) significantly reduced banks' contributions to systemic risk.

Second, our paper contributes to the recent emphasis on the determinants of bank systemic risk. Existing literature has found that bank systemic risk is affected by the degree of competition (Anginer et al., 2014), consolidation (Weiß et al., 2014), the structure of the financial network (Acemoglu et al., 2015), bank size and their capital level (Laeven et al., 2016). For example, Acemoglu et al. (2015) argue that the structure of the financial network is a determinant of systemic risk, with more diversified patterns of interbank liabilities leading to less fragility when the negative shock is below a critical threshold and vice versa. Laeven et al. (2016) show that systemic risk increases with bank size, but the systemic risk is significantly lower for well-capitalized banks. Although their work does not focus on the effect of regulation or supervision on bank systemic risk, it highlights the importance of appropriately designed regulation. Our paper provides further evidence in support of these arguments, showing that the regulatory and supervisory environment in which banks operate has significant impact on their systemic risk.

The remainder of the paper is structured as follows. Our data, variables and descriptive statistics are presented in section 2. Section 3 discusses the main results of our analyses, and section 4 concludes the paper.

2. Data, variables and descriptive statistics

2.1. Data and sample

The dataset used in this study is compiled from several sources. First, we obtain bank level financial information from Bankscope database (Bureau van Dijk). Second, the data of banking regulation and supervision are selected from the Bank Regulation and Supervision Survey database of the World Bank. This database is developed by Barth et al. (2013a) based on four world-wide surveys they completed before[1]. Following Barth et al. (2013b) and Li et al. (2017), we use the Survey I information for the value of the regulatory and supervisor variables for the year 2001, Survey II data for the period 2002-2004, Survey III data for the period 2005-2008 and Survey IV data for the period 2009-2012. Third, in order to measure the systemic risk, we collect the daily stock returns data from Compustat. Fourth, we obtain economic development measures from the World Bank's World Development Indicator (WDI) database.

We then match bank-level information, information about regulation and supervision in different countries and other national data based on data availability. Because of the

[1] Survey I was completed in 1999 and covered 118 countries; Survey II provided information on bank regulatory and supervisory policies in 151 countries for 2002; Survey III captured information on banking policies in 2006 for 142 countries; and Survey IV provided information in 125 countries for 2011 (Barth et al., 2013a).

incomplete overlap among the three datasets, there are a significant number of missing data and the final sample used in our study contains 4222 observations, including banks from 18 countries over the sample period of 2001-2012. It should be noted that the observations in our sample appear to be unbalanced and we attempt to address this concern in the robustness test.

2.2. Variables of bank regulation and supervision

We are concerned with four types of regulation and supervision: restriction on bank activities, initial capital stringency, prompt corrective action and deposit insurer power. Variables are defined following the work of Barth et al. (2004) and Barth et al. (2013b)[2].

2.2.1. Activity restriction

Activity restriction index captures the degree to which the national regulatory authorities in countries allow banks to engage in (1) Securities (2) Insurance (3) Real estate. A value of 1 to 4 is added if an activity is

(1) Unrestricted – A full range of activities in the given category can be conducted directly in the bank.
(2) Permitted – A full range of activities can be conducted, but all or some must be conducted in subsidiaries.
(3) Restricted – Less than a full range of activities can be conducted in the bank or subsidiaries.
(4) Prohibited – the activities cannot be conducted in either the bank or subsidiaries.

By adding the values together and then dividing by 12, the activity restriction index can range from 0 to 1 and a higher value indicates greater activity restriction.

2.2.2. Initial capital stringency

Initial capital stringency measures whether certain funds may be used to initially capitalize a bank and whether they are official. To be specific, questions include:

(1) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities?

[2] Detailed information about variable definition, including the specific survey questions used and how the variables are constructed, can be found in Appendix A. We only define the variables briefly in this sub-section.

(2) Can the initial disbursement or subsequent injections of capital be performed with assets other than cash or government securities?
(3) Can the initial disbursement of capital be performed with borrowed funds?

For question (1), we assign a value of 1 to a 'yes' answer and 0 to a 'no' answer. For question (2) and (3), we assign 0 to a 'yes' answer and 1 to a 'no' answer. By adding the values together and dividing by three, we get the Initial capital stringency index which ranges from 0 to 1, with higher value implying greater stringency.

2.2.3. Prompt corrective action

Prompt corrective action is used to measure whether a law establishes pre-determined levels of bank solvency deterioration which force automatic enforcement actions, such as intervention, and the extent to which supervisors have the requisite, suitable powers to take such actions. Specific questions include:

(1) Can the supervisory authority force a bank to change its internal organizational structure?
(2) Are there any mechanisms of cease and desist-type orders, whose infraction leads to the automatic imposition of civil and penal sanctions against the bank's directors and managers?
(3) Can the supervisory agency order the bank's directors or management to constitute provisions to cover actual or potential losses?
(4) Can the supervisory agency suspend the director's decision to distribute dividends?
(5) Can the supervisory agency suspend the director's decision to distribute bonuses?
(6) Can the supervisory agency suspend the director's decision to distribute management fees?

We assign a value of 1 if the answer is yes and a 0 otherwise. This variable is constructed by adding together these variables and then dividing by 6, with a range from 0 to 1. Higher value of the variable implies more promptness in responding to problems.

2.2.4. Deposit insurer power

Deposit insurer power is an index used to measure each country's deposit insurance regime and to trace its evolution from 1999 to 2011. The index is based on the answers to the following questions, for which we assign a value of 1 to a 'yes' answer and 0 to a 'no' answer:

(1) Does the deposit insurance authority make the decision to intervene in a bank?

(2) Can the deposit insurance agency/fund take legal action for violations of laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials?

(3) Has the deposit insurance agency/fund ever taken legal action for violations of laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials?

(4) Were any deposits not explicitly covered by the deposit insurance at the time of the failure compensated when the bank failed (excluding funds later paid out in liquidation procedures)?

This index is equal to {[(1)+(2)+(3)]/3 + (4)}/2, with a range from 0 to 1, where higher value indicates more power.

2.2.5. Total regulation

Based on the above four measures of specific types of bank regulation and supervision, we develop a single regulation measure using factor analysis. We estimate the following equation:

$$Y_{i,s,t} = \beta_i Regulation_{i,s,t} + \varepsilon_{i,t} \tag{1}$$

Where the subscripts i, s, and t refer to countries, the four regulation measures, and years, respectively. The left-hand-side variables ($Y_{i,s,t}$) are the four regulation measures, all of which are stacked into a single factor, whereas *Regulation* is not observed and is estimated along with the factor loadings β. We follow the standard practice of normalizing proxy measures included on the left-hand side to have a mean of zero and a variance of one before we conduct the factor analysis. The estimation of Equation (1) generates predicted values for both a set of factors ($Regulation_{ist}$) and a set of factor loadings β_i. As our data are well described by a one-factor model that captures approximately 55% of the variation in the four regulation measures, we take the factor with the greatest explanatory power as our measure of total regulation. Higher value means greater stringency.

2.3. Measure of systemic risk

Following Acharya et al. (2017), our study adopts the *Marginal Expected Shortfall (MES)* as the measure for determining the systemic risk exposure of individual banks. Different approaches have been used in academic research to measure the exposure or contribution of individual financial institutions to systemic risk. However, the reason that the gap between theoretical models of systemic risk and the practical needs of regulators "has been so wide" (Acharya et al., 2017, p. 3) is that many approaches appear to be either too complex or too difficult to apply because of data availability. For example, one of the most popular systemic risk measures is *ΔCoVaR* developed by Adrian and Brunnermeier (2016), which captures the externality a bank causes on the system. Although *ΔCoVaR* is useful to assess risk transmission from the individual institution to the financial system, it may lead to some undesirable properties in rankings the systemic risk of firms because it is conditional on a given firm's stress and can vary cross-sectionally (Acharya et al., 2017). Moreover, the application of *ΔCoVaR* requires access to some specific national information data which might be difficult to obtain in developing countries.

The systemic expected shortfall of an institution describes the capital shortage a financial institution would experience when there is a systemic event. The capital shortfall depends on the institution's leverage and equity loss conditional on an aggregate market decline. *Marginal Expected Shortfall (MES)* of a financial institution is the expected loss to which an equity investor in a financial institution would be exposed if the systemic declined substantially. Following Acharya et al. (2017), we adopt MES as our systemic risk measure. MES evaluates the average daily return for the market as whole in the tail of its loss distribution:

$$MES_t^i = E\left(R_t^i \middle| R_t^m < C\right) \qquad (2)$$

R_t^i is the equity return of financial firm i, and R_t^m is the aggregate market index return. A systemic event is defined as a drop of the market index below a threshold, C, over a given time horizon. We estimate the MES by following Acharya et al. (2017) at a standard risk level of 5%, using daily data for equity return from Compustat. For better interpretation of our results, we take the negative value of MES to ensure that our measures are increasing in systemic risk.

2.4. Other control variables

We control for a set of bank-specific and country-specific variables in the regression analysis, including bank size, profitability, market-to-book value, loan loss provision, GDP growth, inflation and economic freedom, which have been used in some previous studies of bank regulation and risk (e.g. Barth et al., 2004; Delis et al., 2011; Anginer et al., 2014). For example, Anginer et al. (2014) find that larger banks pose greater systemic risk, while banks with higher market-to-book value tend to have lower systemic risk exposure. Nijskens and Wagner (2011) find that banks with higher ROA tend to use CDS to protect against defaults on their portfolios, and this helps to decrease individual risk, while increasing the joint risks.

Bank size is measured by the natural logarithm of individual bank's total assets. We use return on average assets (ROAA) to capture the profitability of banks, and market-to-book value (MTBV) to control for bank growth opportunities. Loan loss provisioning is an accounting indicator that directly influences the volatility and cyclicality of bank earnings, as well as information properties of banks' financial reports with respect to reflecting loan portfolios' risk attributes (Bushman and Williams, 2012).

With regard to the country-level factors, GDP growth is defined as the annual growth rate of GDP, and inflation is defined as the percentage change of GDP deflator. Following Li et al. (2017), we derive the variable of Economic Freedom from the Heritage Foundation. It is the average value of an index of economic freedom based on trade freedom, business freedom, investment freedom, and property rights for the period 2001-2012. It measures the extent of the freedom individuals and firms can obtain from their governments to conduct their business. All variable definitions can be found in Appendix A.

2.5. Descriptive statistics

Figure 1 presents the change of average MES from 2001 to 2012 at the worldwide level.

<Insert Figure 1 Here>

It can be seen that, overall, the changes of the systemic risk highly correspond to the subprime financial crisis from 2007 to 2009. There is a slow decline in average MES from 2001 to 2005, followed by dramatic increases. It reaches the summit in 2008 after a sharp growth in 2007. After 2008, the average MES appears to decrease significantly. Although there is a rise in the trend from 2010 to 2011, it drops again afterwards, and in 2012 reaches the lowest level of the entire study period. This trend is consistent with Marshall's (2009) study, which shows that the value of subprime mortgages almost tripled in 2005 compared to 2001, which contributed significantly to the financial bubble. Anginer et al. (2014) also identify a significant increase in systemic risk leading up to the subprime financial crisis.

Table 1 summarises the mean value for the regulation variables in each country during the sample period 2001-2012. We observe a wide variation in the four specific regulation measures and also the total regulation index. *Activity Restriction* varies from a low value of 0.156 in Thailand and of 0.163 in Germany to a high value of 0.75 in China and of 0.756 in Indonesia, indicating that Indonesia and China forbid banks from engaging in most non-bank activities, while banks in Germany and Thailand have relatively more freedom to extend their operations into securities, insurance or real estate markets. Canada has the highest *Initial Capital Stringency*, with a value of 0.835, while the mean value of *Initial Capital Stringency* in China is equal to zero, representing that Chinese banks can include assets other than cash or government securities and borrowed funds as regulatory capital. With respect to *Prompt Corrective Action*, Indonesia has the highest value of 0.986, while Italy has the lowest value of 0.256. *Deposit insurer power* varies from the lowest value of zero in five countries, including Brazil, China, India, Israel and Italy, to the highest value of 0.607 in Indonesia. This suggests that in Brazil, China, India, Israel and Italy, deposit insurer power is very limited. Among the sample countries, Canada has the highest *Total Regulation Index* value (1.398), while China has the lowest (0.347).

<Insert Table 1 Here>

Table 2 provides the summary statistics for the variables of systemic risk, regulation, bank-specific and country-specific factors for the entire sample. To minimize the effect of outliers, we winsorize the continuous variables at five percent level. We observe a wide variation in the systemic risk measure for the sample banks over the period of 2001 to 2012, from the lowest value of -0.814 to the highest of 4.429.

<Insert Table 2 Here>

The mean value of the *Activity Restriction* variable is 0.427, showing that the average level of restriction on bank activities is medium. Banks on average have a value of 0.579 for *Initial Capital Stringency*, suggesting that more than half of the banks in the sample can include funds other than cash, government securities and borrowed funds as regulatory capital. The *Prompt Corrective Action* variable shows a mean value of 0.752, indicating that on average the supervision power is high in the sample banks. However, the power of deposit insurer in most countries appears to be limited as the average value of *Deposit Insurer Power* is only 0.173.

In terms of control variables, the average of *Market-to-book-value (MTBV)* is 1.359, ranging from a minimum of 0.39 to a maximum of 3.4. We use the natural logarithm of total assets to measure the size of the banks. On average, the logarithm value of total assets is 9.282, with a standard deviation of 2.301. We observe large variation in the *LLP* variable, with an average value of 0.982%, a minimum of 0 and maximum of 5.07%, respectively. *GDP growth* and *Inflation* reports the mean value as 0.718 and 1.908 respectively. The *Economic Freedom Index* presents significant variation from 53.2 to 79.9, with 65.73 on average.

3. Empirical results

3.1. Baseline results

We start with five baseline models using OLS to examine the association between bank regulation and systemic risk. More specifically, we estimate the following equation:

$$MES_{ijt} = \alpha + \beta \times regulations_{jt} + \Omega \times bank\ and\ country\ controls_{ijt} + \gamma_i + \lambda_t + \varepsilon_{ijt} \quad (3)$$

The dependent variable is the systemic risk measured by *MES* of bank *i* in country *j* in year *t*. The main independent variable is the regulation variables, namely *Activity Restriction, Initial Capital Stringency, Prompt Corrective Action*, *Deposit Insurer Power* and the *Total Regulation Index*, respectively. Control variables include bank-level and country-level variables since these factors could potentially affect systemic risk. γ_i is bank fixed effects to control time invariant bank heterogeneity and λ_t is calendar year fixed effects. The standard errors for the regressions are estimated as heteroscedasticity-robust standard errors clustered for banks and presented in brackets. Table 3 reports the results.

<Insert Table 3 Here>

We find a positive relationship between the majority of regulation stringency variables (*Activity Restriction*, *Initial Capital Stringency*, *Prompt Corrective Action* and *Regulation Total*) and systemic risk. In column (1), we observe a positive relation between *Activity Restriction* and MES, suggesting that banks in countries with tough activity restriction are exposed to higher systemic risk. Traditional portfolio theory predicts that the combined cash flows from non-correlated revenue sources should be more stable than the constituent parts (Baele et al., 2007). Activity restrictions may result in herding behavior and greater correlated risk taking (Anginer et al., 2014), as the structure of bank portfolios will become more similar and risks are highly correlated among those banks. Wagner (2010) argues that diversification in banks' activities can reduce systemic risk and increase welfare, while similarity cannot. Less restriction on bank activities allows banks to engage in a broad range of activities, which has the potential to decrease conglomerate risk (Kwan and Laderman, 1999). Our results provide evidence to support the above arguments. This is also consistent with findings of previous empirical work. Based a country-level database to analyse the influence of bank activity restrictions on the likelihood of a banking crisis, Barth et al. (2004) find that greater regulatory restrictions on bank activities are associated with an increase in the likelihood of suffering a major crisis. Beck et al. (2006a) show that imposing fewer restrictions on bank activities can reduce banking system fragility.

Similarly, we find a significantly positive association between *Initial Capital Stringency* and systemic risk in column (2). Capital requirement has been one of the most important bank regulatory instruments under the work of the Basel Committee of Banking Supervision. Capital, as a buffer for losses in bad times and also an incentive adjustor, is likely to reduce the principal-agent problem between shareholders and debt-holders and prevent excessive risk taking (Chortareas et al., 2012; Ellis et al., 2014). In this sense, better capitalized banks seem to contribute less to systemic risk (Laeven et al., 2016).

However, if systemic risk is defined as capital shortfall, greater capital stringency may lead to increased systemic risk as it can create challenges for banks, especially in the crisis time. When the system is undercapitalized, it will no longer supply credit for the routine business. Banks under greater capital stringency will find more difficult to raise capital, and hence will be more likely to experience capital shortfall and exposure to greater systemic instability. Moreover, stringent regulation design in banking can cause the boundary problem (Goodhart, 2008). If regulations are asymmetric between the banking industry and other financial sectors, such as the insurance sector, banks will be tempted to engage in regulatory arbitrage which could conceivably lead to an increase in overall systemic risk (Allen and Gale, 2007). Therefore, it is not surprising that a positive association between Initial Capital Stringency and systemic risk is found in this study, suggesting that banks under greater initial capital stringency tend to have higher systemic risk.

Our results in Column (3) show that the enhanced *Prompt Corrective Power* can also contribute negatively to the financial stability of the market in the sample countries. There are strong theoretical explanations arguing for greater official supervision power. Banks are difficult to monitor, especially for the debtholders who are not in a position to monitor managers because they are small and uninformed (Dewatripont and Tirole, 1993; Santos, 2001). From this perspective, a strong official supervision can monitor and discipline banks, prevent managers from excessive risk-taking behaviour, and thus reduce market failure (Beck et al., 2006b).

However, such an argument is based on the assumption that the supervisory agencies are acting according to public interest. Under the private interest or regulatory capture view (Agoraki et al., 2011; Barth et al., 2004), governments and supervisors may act in the interest of a few specific groups, e.g. powerful banks, rather than the society. If this held true then a stronger supervisory power might actually have uncertain and even adverse implications for bank's lending behaviour (Agoraki et al., 2011; Beck et al., 2006b). In the study by Barth et al. (2004), no significant association is found between official supervisory power and the likelihood of suffering a crisis. Greater government intervention may also undermine the self-regulation faction in the banking system and increase moral hazard due to a decline in market discipline (Gropp and Vesela, 2004; Hryckiewicz, 2014). Hryckiewicz (2014) investigates the impact of policy injections into banks in 23 countries during the 2007-2009 financial crisis, and find that government interventions are strongly correlated with subsequent risk increase in the bank sector. He argues that the increased role of the government in the banking sector might encourage politicians to act in self-interests. Our results provide evidence to support the view of private interest, showing higher prompt corrective power leads to increased systemic risk.

Last, the coefficient for the *Total Regulation Index* shown in column (5) is significantly positive, consistent with the aforementioned results. All these results suggest that banks under strict regulation and supervision tend to have higher systemic risk. One potential reason is that under more stringent regulation and supervision, banks will have more difficulty in raising capital and be more likely to experience capital shortfall.

The only regulation variable for which no significant relationship exists is *Depositor Insurer Power*. T Following the establishment of the first national insurance system in the U.S. in 1934, explicit deposit insurance schemes to prevent widespread bank runs have been adopted in different countries since the 1980s (Barth et al., 2004; Demirgüç-Kunt and Detragiache, 2002). However, it has been widely recognised that deposit insurance can aggravate the moral hazard problem in the banking sector by encouraging excessive risk-taking behaviour (Anginer et al., 2014; Bisias et al., 2012; Barth et al., 2004). Depositors can monitor bank risk-taking behaviour by charging higher interest rates, but they may have less incentive to monitor banks if deposits are insured, and the lack of market discipline is likely to result in excessive risk taking culminating in banking crises (Anginer et al., 2014). The higher the individual risk, the greater the capital shortfall when banks are in distress, and consequently the more they contribute to systemic instability.

More empirical evidence tends to support this argument (e.g. Barth et al., 2004; Demirgüç-Kunt and Detragiache, 2002). For example, Barth et al. (2004) find a positive association between the generosity of the deposit insurance scheme and the possibility of suffering a major banking crisis, and such a relationship is economically large. More recently, Anginer et al. (2014) find that deposit insurance increases systemic fragility in the former period, but lower bank systemic risk in countries with deposit insurance coverage during crisis. Their findings suggest that the ‘‘moral hazard effect’’ of deposit insurance dominates in good times, while the ‘‘stabilization effect’’ of deposit insurance dominates in turbulent times. The cancelling effects of deposit insurance power in the sample countries may explain why there is no significant relationship found in our study.

In terms of control variables, the signs and significance levels of these variables are in line with our expectations. For bank specific characteristics, the coefficient on bank size (measured as logarithm of total assets) appears to be positive and statistically significant in all regressions, indicating that larger banks are more likely to be exposed to higher systemic risk. Besides, we observe a positive coefficient on GDP growth and economic freedom level, which suggests that banks in countries with higher GDP growth or more economic freedom tend to be exposed to higher systemic risk. Similar results are reported by Anginer et al. (2014).

3.2 Additional Evidence: Basel II implementation and systemic risk

The results from our baseline regression analysis have documented a positive relationship between regulation stringency and systemic risk. In this section, we conduct additional analysis by employing the stagger implementation of Basel II cross countries. Basel II was designed to improve the way that regulatory capital requirements could reflect underlying risks and address the financial innovation accrued in previous years[3]. Following the release of Basel II in June 2004, different countries adopt this new framework at a staggered process. In our sample, Australia is the first country implementing Basel II in 2005, followed by Japan, Brazil and other countries which implemented it in 2007. This allows us to use countries that had not adopted it at a point of time to control for potentially confounding effects. We estimate the difference in systemic risk exposure of banks in a country before and after the Basel II implementation to such differences for banks in countries where Basel II has not been implemented during same time period. If strict regulation and supervision increase the individual banks' contribution to systemic risk, we would expect an increase in systemic risk after the implementation of Basel II. We manually collect the time of individual countries implementing Basel II, and then introduce a dummy variable of Basel II, which equals to one for the time after the country adopted Basel II and 0 otherwise. The baseline regression was re-run by replacing the variable of $Regulations_{i,t}$ with Basel II Dummy. The result is reported in column (1) of Table 4.

<Insert Table 4 Here>

As expected, the coefficient of Basel II Dummy is positive and significant at 99% confidence level, showing that the adoption of Basel II is related to higher MES, which means the implementation of Basel II tends to increase systemic risk in a country.

Although the staggered adoption of Basel II represents an exogenous shock to bank regulation, country-level factors that manifest differently cross countries could affect the timing of Basel II adoption in different countries. To ensure there is no trend before the event data, we further examine the dynamic of the relation between Basel II implementation and bank systemic risk exposure by including a series of dummy variables in equation (3) to trace out the year-by-year effects of Basel II implementation on systemic risk. Specifically, we conduct analysis for the following equation (4):

[3] Basel II comprises three pillars: a) Minimum Capital Requirements, which seeks to develop and expand the standardised rules on the calculation of total minimum capital requirements for credit, market and operational risk; b) supervisory review process, which is intended to encourage banks to develop and use better risk management techniques in monitoring and managing their risks; c.) Market Discipline, which aims to promote effective use of disclosure as a lever to strengthen market discipline and encourage sound banking practices (Basel Committee on Banking Supervision, 2004).

$$Y_{it} = \alpha + \beta_{-4} Basel\ \text{II}_{i\,t-4} + \beta_{-3}\text{Basel II}_{i\,t-3} + \beta_{-2}\text{Basel II}_{i\,t-2} + \beta_0\text{Basel II}_{i\,t} + \cdots + \beta_5\text{Basel II}_{i\,t+5} + \Omega \times bank\ and\ country\ controls_{ijt} + \gamma_i + \lambda_t + \varepsilon_{ijt}\ (4)$$

Where the $Basel$ II $_{i\,t}$ equals to one in the years after the country in which bank is located implement the Basel II in year t and zero otherwise. $Basel$ II $_{i\,t-4}$ is set to one for years up to and including four years prior to Basel II implementation and zero otherwise. The omitted variable in this regression is the year before Basel II implementation (t-1). Therefore, we can estimate the dynamic effect of Basel II implementation on systemic risk relative to the year of implementation. If there is an increasing systemic risk simultaneously happened with the implementation of Basel II, we should observe a trend before and after the implementation of Basel II. Otherwise, the result derive from column (1) should not result from reverse causality.

Regression results for model (4) are reported in column (2) of Table 4. Overall, we find that the coefficients on Basel II are insignificant for years before implementation except years up to and 4 years prior after control year-fixed effect. On the other side, we observe that the coefficients become significantly positive since the first year and after of Basel II implemented. Compared to that for first year after the implementation, the coefficients for the second year of implementation and afterwards almost double, indicating that implementation of Basel II has a positive impact on banks' contribution to systemic risk.

3.3. Robustness test

In this section, we conduct a series of additional regression analyses to verify the robustness of our main results. As mentioned in section 2.1, the countries included in our sample are based on data availability. As a result, there might be concerns with our baseline results c=because of the existence of unbalanced observations cross countries. Therefore, we firstly run the analysis for equation (3) by employing the weighted-least-square regression to address the issue of unbalance panel data. We take the inverse of the number of the observations for a country as the weight for each bank in the country so that each country receives the equal weight in the estimation. The results are reported in Table 5. Consistent with our main regression results presented in section 3.1, the position relationship between the majority of regulation variables and systemic risk are positive and significant, showing that our main findings are robust and are less likely to be biased due to unbalanced observation cross countries.

<Insert Table 5 Here>

Second, regressions are run to test the relationship between systemic risk and the five variables of bank regulation and supervision based on two subsamples. For the first subsample, we exclude countries with less than 10 observations in each year, and the results are shown in the left side of Table 6. The total observations of Japan account for around 36% of the full sample and the predominance of the banks in Japan may bias our result. So we run the regressions after dropping banks in Japan from our sample. Results of regression analyses with the subsample of excluding Japan are presented in the right side of Table 6. All regressions include year and bank fixed effects. Our main findings still hold for both subsamples.

<Insert Table 6 Here>

Third, we employ an alternative measure of systemic risk, namely SRISK, to assess the relationship between bank regulation and systemic risk. Brownless and Engle (2016) introduce SRISK to measure an individual financial institution's contribution to the systemic risk. SRISK is concerned with the capital shortfall of a firm conditional on a severe market decline, and is a function of its size, leverage and risk. Specifically, SRISK measures how much capital the financial institution would need in a crisis time to maintain a given capital-to-assets ratio. The measure can readily be computed using balance sheet information and an appropriate LRMES (Long Run Marginal Expected Shortfall) estimator. Following previous studies such as Brownless and Engle (2016) and Roman et al. (2017), we measure SRISK based on the following equation:

$$
\begin{aligned}
SRISK_{i,t} &= E_{t-1}(Capital\ Shortfall_i | Crisis) \\
&= E_{t-1}(k(Debt_i + Equity_i) - Equity_i | Crisis) \\
&= k(Debt_{i,t-1} - (1-k)\big(1 - LRMES_{i,t}\big)Equity_{i,t}
\end{aligned}
\tag{5}
$$

where k is the capital requirement, and we set k=5.5% in this research. $LRMES_{i,t}$ is the long-run marginal expected shortfall at time t for bank i, defined as the decline in equity values conditional on a financial crisis. Higher value of SRISK indicates greater contribution of systemic risk.

We run the baseline regression by using SRISK as the systemic risk measure. The results are reported in Table 7. Overall, the results are largely consistent with the main results. We find that the coefficients for Activity Restriction, Prompt Corrective Action and total Regulation index are still significantly positive, suggesting that the stringency of regulation and supervision have a positive impact on banks' systemic risk as measured by SRISK.

<Insert Table 7 here>

3.4. Interaction effects

In previous section, we present results of our main regression analyses and robustness tests, showing that stringent regulation and supervision can increase systemic risk through greater capital shortfall. In this section, we conduct further empirical tests to support our arguments by looking at three interaction terms.

First, we argue that if the greater capital shortfall results in an increase in systemic risk, the effect is likely to be amplified for larger banks since larger banks may need a higher level of capital to smooth their contributions to the systemic instability. It is probably more difficult for larger banks to raise sufficient capital during hard times as they could experience a larger capital gap compared with small banks. Hence, we introduce the interaction term between regulatory variables and bank size measured by logarithm value of their total assets. The results are presented in Panel A of Table 8.

<Insert Table 8 Here>

We find a significant and positive coefficient of the interaction between bank size and *Activity Restriction, Prompt Corrective Action and Deposit Insurer Power*, respectively, indicating that the positive effect of bank regulation on systemic risk is amplified for large banks. It supports our main argument that stringent regulation and supervision can increase banks' systemic risk through their potentially greater capital shortfall.

Second, if the increase in banks' systemic risk is due to their greater capital shortfall, we would expect that such an impact is likely to be alleviated for banks which hold more capital as capital can absorb the potential loss and thereby reduce capital shortfall. To validate this hypothesis, we introduce the interaction between regulatory variables and *Equity-to-Assets ratio*. The results are presented in Panel B of Table 8. We observe that the interaction terms are significant and negative (except the interaction between *Initial Capital Stringency* and *Equity-to-Assets ratio* which is insignificant), indicating that the positive impact of regulation on systemic risk will be reduced if banks hold more capital. These results support our assumption that bank regulation increases systemic risk through banks having greater capital shortfall.

Last, if the capital shortfall is the channel through which regulation and supervision increase systemic risk, we would expect that diversification of banks can alleviate such impact. First, based on the portfolio theory, the combined cash flows from non-correlated revenue sources should be more stable than the constituent parts (Baele et al., 2007). If banks can maintain stable income flows, the likelihood of suffering capital shortage will be lower. In addition, diversification also provides more choices for banks to raise capital. In other words, banks who succeed in diversifying their business lines tend to have more channels to raise capital when they meet capital shortage, and thereby tend to be safer compared to their counterparts who rely on onefold source. We then introduce the interaction between regulatory variables and *Diversification* which is measured by non-interest income divided by total operating income. If our argument holds true, we would expect a negative relationship between the interaction term and the dependent variable in the regression models. Panel C of Table 8 shows the results of this heterogeneity test. We observe that the coefficients of interaction terms are negative and significant in columns (2), (4) and (5). These results suggest that the positive influence of regulation and supervision on systemic risk can be alleviated for better diversified banks, which is consistent with our earlier expectation. Overall, our heterogeneity tests provide further evidence to support our main argument that stringent regulation and supervision can increase systemic risk and such an impact is likely to occur through intensified capital shortfall.

4. Conclusions

There has been increasing interest in academic research on bank regulation and supervision since the financial crisis of 2007-2009. However, the theoretical debates on whether bank regulation and supervision can help to maintain financial stability remain open due to limited evidence on the relationship between bank regulation and systemic risk. Hoque et al. (2015) argue that the correlation in the risk-taking behavior of banks is much more relevant than the absolute level of risk that individual banks take. The paper aims to investigate how some specific types of bank regulation and supervision affect individual banks' contribution to the systemic risk across countries. Based on a new database developed by Barth et al. (2013a), we provide robust evidence on the impact of bank activity restriction, capital requirements, official supervision and deposit insurance on systemic risk in 18 countries during the period 2001-2012. We also develop a *Total Regulation Index* based on the four specific regulation variables in order to examine the combined effect of regulatory and supervisory policies.

We find that more stringent regulation and supervision lead to higher systemic risk. Specifically, countries with more restrictions on bank activities, higher initial capital stringency or stronger prompt correction power tend to suffer from higher systemic risk. We also find that the *Total Regulation Index* is positively related to the systemic index measure, confirming that increased systemic risk is more likely to happen in a stringent regulatory and supervisory environment. This is consistent with our expectation based on the view that systemic risk can be defined as the capital shortfall of a firm conditional on a severe market decline (Acharya et al., 2017; Brownlees and Engle, 2017) and a bank is more likely to have capital shortfall when it is in an environment with higher regulation. Our findings appear to be robust after employing WLS to control the potential effect of unbalanced panel data, regressing on subsamples and using alternative systemic risk measure. We also provide further evidence through examining interaction effects. By interacting regulatory variables with bank size, equity-to-asset ratio and diversification, we find the positive impact of bank regulation and supervision on systemic risk would be amplified if the bank is large, but reduced if the bank holds more capital and has a diversified income flow.

Our findings contribute to the limited understanding of the association between bank regulation and systemic stability, and have important implications for governments and regulators. Since the financial crisis of 2007-2009, we have seen a growing awareness of the need for a macroprudential approach to regulation (Arnold et al., 2012). Governments in different countries have introduced a variety of regulatory and supervisory polices to regulate the banking industry and manage the financial cycle. However, these stringent regulations have potential drawbacks. They may indeed decrease banks' standalone risks but fail to look at the correlated risks they take. Our findings show that, opposite to what governments and regulators have expected, stringent regulatory and supervisory policies result in less systemic stability, although such effect could be alleviated by the banks having a greater level of equity.

Our paper has important implications for policy makers. Despite the significant policy reforms introduced after the financial crisis, there have been increasing concerns on whether regulatory mechanisms designed according to stringent regulatory and supervisory policies, such as activity restrictions, based only on the perspective of individual bank risk, are effective in reducing the probability of systemic crises. Our findings suggest that the currently designed tight regulation appears to have effects opposite to the expectations of governments. In order to sustain the stability of banking, regulatory and supervisory mechanisms should be designed based on inter-bank correlation. This is consistent with other researchers' call for prudential regulation that operates at a collective level (e.g. Acharya, 2009).

References:

Acemoglu, D., Ozdaglar, Tahbaz-Salehi, A. 2015. Systemic risk and stability in financial networks. *American Economic Review. 105*(2), 564-608.

Acharya, V.V. 2009. A theory of systemic risk and design of prudential bank regulation. *Journal of Financial Stability.* 5, 224–255.

Acharya, V., Engle, R., Richardson, M. 2012. Capital shortfall: a new approach to ranking and regulating systemic risks. *American Economic Review.* 102(3), 59-64.

Acharya V.V., Pedersen, L.H., Philippon, T., Richardson, M. 2017. Measuring systemic risk. *Review of Financial Studies.* 30, 2-47.

Adrian, T., Brunnermeier, M.K. 2016. CoVaR. *American Economic Review.* 106(7), 1705-1741.

Agoraki, M.K., Delis, M.D., Pasiouras, F. 2011. Regulations, competition and bank risk-taking in transition countries. *Journal of Financial Stability.* 7, 38-48.

Allen, F., Babus, A., Carletti, E. 2012. Asset commonality, debt maturity and systemic risk. *Journal of Financial Economics.* 104(3), 519-534.

Allen, F., Gale, D. 2007. An introduction to financial crises. *Wharton Financial Institutions Center Working Paper*, 07-20.

Anginer, D., Demirgüç-Kunt, A., Zhu, M. 2014. How does competition affect bank systemic risk? *Journal of Financial Intermediation.* 23(1), 1-26.

Arnold, B., Borio, C., Ellis, L., Moshirian, F. 2012. Systemic risk, macroprudential policy frameworks, monitoring financial systems and the evolution of capital adequacy. *Journal of Banking and Finance.* 36, 3125–3132.

Baele, L., De Jonghe, O., Vander Vennet, R. 2007. Does the stock market value bank diversification? *Journal of Banking and Finance.* 31, 1999–2023.

Barth, J.R., Caprio Jr., G., Levine, R. 2004. Bank regulation and supervision: what works best? *Journal of Financial Intermediation.* 13, 205-248.

Barth, J.R., Caprio, G., Levine, R. 2013a. Bank regulation and supervision in 180 countries from 1999 to 2011. *Journal of Financial Economic Policy.* 5(2), 111-219.

Barth, J.R., Lin, C., Ma, Y., Seade, J., Song, F.M. 2013b. Do bank regulation, supervision and monitoring enhance or impede bank efficiency? *Journal of Banking and Finance.* 37, 2879-2892.

Basel Committee on Banking Supervision, 2004. International convergence of capital measurement and capital standards: a revised framework. *Basel Committee on Banking Supervision, Bank for International Settlements*.

Beck, T., Demirgüç-Kunt, A., Levine, R. 2006a. Bank concentration, competition and crisis: first results. *Journal of Banking and Finance.* 30, 1581–1603.

Beck, T., Demirgüç-Kunt, A., Levine, R. 2006b. Bank supervision and corruption in lending. *Journal of Monetary Economics.* 53, 2131–2163.

Bisias, D., Flood, M., Lo, A.W., Valavanis, S. 2012. A survey of systemic risk analytics. *Annual Review of Financial Economics.* 4(1), 255–296.

Boyd, J.H., Chang, C., Smith, B.D. 1998. Moral hazard under commercial and universal banking. *Journal of Money, Credit and Banking.* 30(3.2), 426–468.

Brownlees, C., Engle, R.F. 2016. SRISK: A conditional capital shortfall measure of systemic risk. *The Review of Financial Studies*. 30(1), 48–79.

Bushman, R.M., Williams, C.D. 2012. Accounting discretion, loan loss provisioning, and discipline of banks' risk-taking. *Journal of Accounting and Economics.* 54, 1-18

Chortareas, G.E., Girardone, C., Ventouri, A. 2012. Bank supervision, regulation, and efficiency: Evidence from the European Union. *Journal of Financial Stability.* 8, 292-302.

Demirgüç-Kunt, A., Detragiache, E. 2002. Does deposit insurance increase banking system stability? An empirical investigation. *Journal of Monetary Economics*. 49(7), 1373-1406.

Demirgüç-Kunt, A., Detragiache, E. 2011. Basel core principles and bank soundness: Does compliance matter? *Journal of Financial Stability*. 7, 179–190.

Dewatripont, M., Tirole, J. 1993. Efficient governance structure: implications for banking regulation. In: Mayer, C., Vives, X. (Eds.), *Capital Markets and Financial Intermediation*, Cambridge University Press, Cambridge.

Delis, M., Molyneux, P., Pasiouras, F. 2011. Regulations and productivity growth in banking: evidence from transition economies. *Journal of Money, Credit and Banking*. 43(4), 735-764.

Ellis, L., Haldane, A., Moshirian, F. 2014. Systemic risk, governance and global financial stability. *Journal of Banking and Finance*. 45, 175–181.

Goodhart, C. 2008. The boundary problem in financial regulation. *National Institute Economic Review*. 206(1), 48-55.

Gropp, R., Vesela, J. 2004. Deposit insurance, moral hazard and market monitoring. *Review of Finance*. 8, 571–602.

Hryckiewicz, A. 2014. What do we know about the impact of government interventions in the banking sector? An assessment of various bailout programs on bank behavior. *Journal of Banking and Finance*. 46, 246-265.

Hellmann, T., Murdock, K., Stiglitz, J. 2000. Liberalization, moral hazard in banking, and prudential regulation: are capital requirements enough? *American Economic Review*. 90(1), 147-165.

Hoque, H., Andriosopoulos, D., Andriosopoulos, K., Douady, R. 2015. Bank regulation, risk and return: Evidence from the credit and sovereign debt crises. *Journal of Banking AND Finance*, 50, 455–474.

Kwan, S.H., Laderman, E.S. 1999. On the portfolio effects of financial convergence: a review of the literature. *Federal Reserve Bank of San Francisco Economic Review*. 2, 18–31.

Laeven, L., Levine, R. 2009. Bank governance, regulation and risk taking. *Journal of Financial Economics*. 93, 259-275.

Laeven, L., Ratnovski, L., Tong, H. 2016. Bank size, capital, and systemic risk: some international evidence. *Journal of Banking and Finance*. 69, S25-S34.

Li, H., Liu, H. and C. Veld. 2017. "The Effects of Bank Regulation Stringency on Seasoned Equity Offering Announcements." *SSRN working paper*.

Marshall, J. 2009. The financial crisis in the US: key events, causes and responses. *UK House of Commons Library Research Papers*. House of Commons Library, London.

Nijskens, R., Wagner, W. 2011. Credit risk transfer activities and systemic risk: how banks became less risky individually but posed greater risks to the financial system at the same time. *Journal of Banking and Finance*. 35, 1391-1398.

Roman, R., Berger, A., Sedunov, J. 2016. Do bank bailouts reduce or increase systemic risk? The effects of TARP on financial system stability. *The Federal Reserve Bank of Kansas City Research Working Papers*.

Santos, J.A.C. 2001. Bank capital regulation in contemporary banking theory: a review of the literature. *Financial Markets, Institutions and Instruments*. 10(2), 41-84.

Schwarcz, S., 2008. Systemic risk. *Georgetown Law Journal*. 97, 193-248.

Wagner, W. 2010. Diversification at financial institutions and systemic crises. *Journal of Financial Intermediation*. 19, 373–386.

Wagner, W. 2011. Systemic liquidation risk and the diversity-diversification trade-off. *The Journal of Finance*. 66(4), 1141-1175.

Weiß, G., Neumann, S., Bostandzic, D. 2014. Systemic risk and bank consolidation: international evidence. *Journal of Banking and Finance*. 40, 165-181.

Appendix A

Variable name	Description
MES	Average return on sample banks conditioned on 5% worse returns on the market.
Activity Restriction	A measure of a bank's ability to engage in the businesses of securities underwriting, insurance, and real estate and of the regulatory restrictiveness of banks to own shares in non-financial firms. The level of regulatory restrictiveness can be defined as “unrestricted” and coded as a score of 1. If the full range of activities can be conducted, but some or all must be conducted in subsidiaries, then it can be defined as “permitted” and coded as a score of 2. If less than a full range of activities can be conducted in a bank or subsidiaries, then it can be defined as “restricted” and counted as a score of 3. If the activity cannot be conducted in either the bank or subsidiaries, then it is defined as “prohibited” and counted as a score of 4. Activity restriction is calculated by the sum of the answers to these questions divided by 12. Greater values signify more restrictions.
Initial Capital Stringency	Whether the source of funds that count as regulatory capital can include assets other than cash or government securities and borrowed funds and whether the regulatory supervisory authorities verify the sources of capital. This index is based on the following question (for question (1), Yes=1 No=0; for question (2) and (3), Yes=0 No=1): (1) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities? (2) Can the initial disbursement or subsequent injections of capital be performed with assets other than cash or government securities? (3) Can the initial disbursement of capital be performed with borrowed funds? Initial capital stringency is calculated by the sum of the answers to these questions divided by 3. Higher values indicate greater stringency.
Prompt Corrective Action	Prompt corrective action measures the extent to which the law establishes pre-determined levels of bank solvency deterioration that force automatic enforcement actions, such as intervention, and the extent to which supervisors have the requisite, suitable powers to do so. This variable is based on several questions (Yes=1, No=0): (1) Can the supervisory authority force a bank to change its internal organizational structure? Are there any mechanisms of cease and desist-type orders, whose infraction leads to the automatic imposition of civil and penal sanctions against the bank’s directors and managers? Can the supervisory agency order the bank’s directors or management to constitute provisions to cover actual or potential losses? Can the supervisory agency suspend the director’s decision to distribute dividends? Can the supervisory agency suspend the director’s decision to distribute bonuses? Can the supervisory agency suspend the director’s decision to distribute management fees? Prompt corrective action is calculated as the sum of the score for each question and divided by 6. A higher value indicates greater supervisory power.
Deposit Insurer Power	The deposit insurer power scheme is an index of the deposit insurer power to measure each country’s deposit insurance regime and to trace its evolution from 1999 to 2011. This index is based on the answer to the following questions (Yes=1, No=0): (1) Does the deposit insurance authority make the decision to intervene in a bank? (2)Can the deposit insurance agency/fund take legal action for violations of laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials? (3)Has the deposit insurance agency/fund ever taken legal action for violations of laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials? (4)Were any deposits not explicitly covered by the deposit insurance at the time of the failure compensated when the bank failed (excluding funds later paid out in liquidation procedures)? Deposit insurer power is equal to $\{[(1)+(2)+(3)]/3 + (4)\}/2$. This variable ranges from 0 to 1, where higher values indicate more power.

Appendix A *(Continued)*	
Total Regulation	We collapse the four regulation measures into a single measure of bank regulation using factor analysis. We estimate the following equation: $Y_{i,s,t}=\beta_i \text{ Regulation}_{s,s,t}+\varepsilon_{i,t}$, where the subscripts i, s, and t correspond to the country, the four regulation measures (Activity Restriction, Initial Capital Stringency, Deposit Insurer Power, and Prompt Corrective Action), and years, respectively. The left-hand-side variables are the four regulation measures, all of which are stacked into a single factor, whereas regulation is not observed and estimated along with the factor loadings β. We follow the standard practice of normalizing the proxy measures included on the left-hand side to have a mean of zero and a variance of one before we conduct the factor analysis. We focus on the single factor that has the greatest explanatory power. It turns out that our data are well described by a one-factor model, which captures approximately 55% of the variation in the four regulation measures. We take this factor as our final measure of overall bank regulation.
LgTA	A natural logarithm of total assets denominated in US dollars
ROAA	Return on average asset. Net income/ Total assets in %
MTBV	Market-to-book value, measured as Market value of equity / Book value of equity
LLP	Loan loss provision ratio, measured as total loan loss provision/net loan in %
GDP Growth	The log value of annual growth rate of GDP.
Inflation	The percentage change of GDP deflator.
Economic Freedom	An index based on trade freedom, business freedom, investment freedom, and property rights (ranging from 1 to 5). Calculated as 6 minus the economic freedom index of the Heritage Foundation.
Equity/Assets	Total equity to total assets ratio
Log z-score	Log value of z-score. The z-score is the average bank return on assets (net income divided by total assets) plus bank equity to assets ratio, scaled by the standard deviation of return on assets.
Diversification	Non-interest income divided by total operating income in %

Figure 1. Changes of average MES from 2001 to 2012

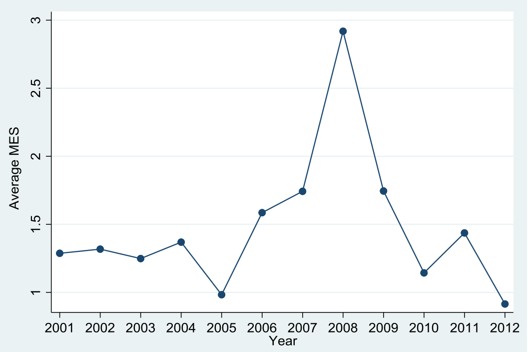

Figure 1. Change of average MES from 2001 to 2012

Table 1: Summary statistics for the regulation variables

This table includes the countries that are included in our study. Column N represents the number of observations from this country in the sample period 2001 to 2012. The remainder of the table reports the mean figures (in percentage form) of the regulation variables over the sample period for each country. A detailed description of the definitions of the variables is included in Appendix A.

Country	N	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Australia	247	0.428	0.783	0.883	0.175	0.866
Austria	75	0.360	0.387	0.775	0.0356	0.460
Brazil	82	0.549	0.589	0.869	0	0.690
Canada	81	0.549	0.835	0.487	0.877	1.398
China	25	0.750	0	0.833	0	0.347
France	280	0.336	0.655	0.474	0.530	0.986
Germany	250	0.163	0.524	0.462	0.0920	0.522
Greece	75	0.317	0.644	0.533	0.0444	0.625
Hong Kong	53	0.480	0.736	0.827	0.132	0.826
India	472	0.448	0.333	0.796	0	0.439
Indonesia	157	0.756	0.333	0.986	0.607	1.012
Israel	91	0.413	0.685	0.820	0	0.666
Italy	348	0.499	0.728	0.256	0	0.736
Japan	1531	0.481	0.616	0.930	0.143	0.751
Malaysia	104	0.276	0.667	0.672	0.401	0.875
Portugal	39	0.255	0.718	0.756	0.154	0.725
Spain	110	0.260	0.358	0.553	0.558	0.770
Thailand	202	0.156	0.495	0.785	0.0363	0.441
Total	4222	0.427	0.579	0.752	0.173	0.722

Table 2 Summary statistics for the regulation, bank-specific and country-specific variables

This table provides the summary statistics for the control variables of the regulation, bank-specific and country-specific variables over the sample period of 2001 to 2012. The sample consists of 911 banks in 18 countries. The variables are defined as outlined in Appendix A. Total assets are in billion U.S. dollars. N denotes the number of observations.

Variable	N	Mean	Standard Deviation	Min	Medium	Max
MES	4222	1.392	1.084	-0.814	1.287	4.429
Activity Restriction	4222	0.427	0.194	0	0.500	1
Initial Capital Stringency	4222	0.579	0.211	0	0.667	1
Prompt Corrective Action	4222	0.752	0.269	0	0.833	1
Depositor	4222	0.173	0.263	0	0	1
Regulation Total	4222	0.722	0.263	0.347	0.694	1.607
MTBV	4222	1.359	0.784	0.390	1.140	3.400
LgTA	4222	9.282	2.301	5.881	8.784	13.51
LLP	4222	0.982	1.281	0	0.519	5.070
ROAA	4222	0.713	0.890	-0.870	0.530	2.950
GDP Growth	4222	0.718	0.947	-1.239	0.785	2.163
Inflation	4222	1.908	3.146	-1.715	1.650	8.481
Economic Freedom	4222	65.73	7.204	53.20	66.70	79.90
SRISK	4222	-1.053	30.15	-1238	-0.00312	9.988
Basel II Dummy	4222	0.185	0.389	0	0	1

Table 3 Baseline Results

This table reports the panel regression results of the estimation of different regulations and systemic risk from 18 countries for the period from 2001 to 2012. The dependent variable is the systemic risk measure by MES. Control variables include *MTBV, lgTA, LLP, ROAA, GDP Growth Inflation and Economic Freedom*. Detailed definitions of the variables can be found in Appendix A. Bank fixed effect and year fixed effects are both included. The standard errors for the regressions are estimated as heteroskedasticity-robust standard errors clustered for banks and are presented in brackets *, **, and *** represent statistical significance at the 10%, 5%, and 1% significance level, respectively.

	(1)	(2)	(3)	(4)	(5)
	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Regulation	0.231*	0.448***	0.712***	-0.022	0.286***
	(0.120)	(0.115)	(0.119)	(0.112)	(0.095)
MTBV	0.060	0.059	0.078**	0.064*	0.059
	(0.037)	(0.038)	(0.038)	(0.038)	(0.037)
lgTA	0.225***	0.231***	0.275***	0.221***	0.228***
	(0.071)	(0.071)	(0.074)	(0.072)	(0.071)
LLP	-0.033	-0.036*	-0.035	-0.034	-0.035*
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
ROAA	0.011	0.009	0.023	0.007	0.009
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
GDP Growth	0.216***	0.179***	0.263***	0.204***	0.198***
	(0.033)	(0.032)	(0.034)	(0.033)	(0.033)
Inflation	-0.034*	-0.025	-0.019	-0.043**	-0.031*
	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)
Economic Freedom	0.045***	0.044***	0.044***	0.041***	0.038***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
_cons	-3.780***	-3.920***	-4.679***	-3.435***	-3.446***
	(0.952)	(0.942)	(0.974)	(0.956)	(0.934)
Bank-fixed effect	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes
N	4222	4222	4222	4222	4222
adj. R-sq	0.247	0.250	0.257	0.246	0.248

Table 4: Additional Evidence: Basel II implementation and systemic risk

This table presents the panel regression results of the estimation of Basel II implementation and systemic risk from 18 countries for the period from 2001 to 2012. The dependent variable is the systemic risk measure by MES. Column (1) and (2) report the results of estimation Basel II implementation and systemic risk. Basel II Dummy which equals to one for the time after the country adopted Basel II and 0 otherwise. Column (3) and (4) report the dynamic change of systemic risk prior/after the Basel II implementation. $Basel$ II $_{i\,t}$ is set to one for years prior/after Basel II implementation and zero otherwise. Control variables include MTBV, lgTA, LLP, ROAA, GDP Growth Inflation and Economic Freedom. Detailed definitions of the variables can be found in Appendix A. Bank fixed effect and year fixed effects are both included. The standard errors for the regressions are estimated as heteroskedasticity-robust standard errors clustered for banks and are presented in brackets *, **, and *** represent statistical significance at the 10%, 5%, and 1% significance level, respectively

	(1)	(2)
Dependent Variable	MES	MES
Basel II Dummy	0.714***	
	(0.141)	
Basel II t-4		-0.467**
		(0.208)
Basel II t-3		0.015
		(0.146)
Basel II t-2		-0.037
		(0.100)
Basel II t		-0.181
		(0.149)
Basel II t+1		0.504**
		(0.199)
Basel II t+2		1.108***
		(0.265)
Basel II t+3		1.427***
		(0.304)
Basel II t+4		1.268***
		(0.352)
Basel II t+5		1.518***
		(0.432)
_cons	-3.405***	-2.943***
	(0.941)	(0.988)
Control variables	Yes	Yes
Bank fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
N	4222	4222
adj. R-sq	0.256	0.274

Table 5 Robustness test: WLS regression

This table reports estimation of different regulations and systemic risk results by using the weighted-least-squares from 18 countries for the period from 2001 to 2012. The weight is the inverse of the number of observations for a country. The dependent variable is the systemic risk measure by MES. Control variables include *MTBV, lgTA, LLP, ROAA, GDP Growth Inflation and Economic Freedom*. Detailed definitions of the variables can be found in Appendix A. Bank fixed effect and year fixed effects are both included. The standard errors for the regressions are estimated as heteroskedasticity-robust standard errors clustered for banks and are presented in brackets *, **, and *** represent statistical significance at the 10%, 5%, and 1% significance level, respectively.

	(1)	(2)	(3)	(4)	(5)
	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Regulation	0.622***	0.599***	0.944***	-0.015	0.476***
	(0.138)	(0.130)	(0.140)	(0.149)	(0.119)
MTBV	0.074	0.076	0.085*	0.078	0.077
	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
lgTA	0.171*	0.178*	0.208**	0.161*	0.180*
	(0.091)	(0.091)	(0.093)	(0.091)	(0.092)
LLP	-0.058*	-0.060*	-0.059*	-0.059*	-0.061*
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
ROAA	-0.009	-0.011	-0.003	-0.012	-0.012
	(0.049)	(0.049)	(0.048)	(0.049)	(0.049)
GDP Growth	0.240***	0.187***	0.322***	0.218***	0.206***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Inflation	-0.051**	-0.056***	-0.009	-0.076***	-0.054**
	(0.023)	(0.021)	(0.021)	(0.022)	(0.022)
Economic Freedom	0.035***	0.031***	0.031***	0.026***	0.024***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
_cons	-2.528**	-2.267**	-3.137***	-1.616	-1.773*
	(1.062)	(1.071)	(1.116)	(1.035)	(1.061)
Bank-fixed effect	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes
N	4222	4222	4222	4222	4222
adj. R-sq	0.208	0.207	0.212	0.205	0.207

Table 6 Robustness test: Subsamples

This table presents the results of regression analyses of the relationship between systemic risk and regulations by using the subsample a.) without countries which have less than 10 observations in each observation year; b.) the subsample excluded observations of Japan since it counts around 36% of the full sample. Detailed definitions of the variables can be found in Appendix A. Bank fixed effect and year fixed effects are both included. The standard errors for the regressions are estimated as heteroskedasticity-robust standard errors clustered for banks and are presented in brackets. . *, **, and *** represent statistical significance at the 10%, 5%, and 1% significance level, respectively

	Without observations less than 10 per country-year					Without Japan				
	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Regulation	0.257**	0.486***	0.721***	0.001	0.358***	0.248**	0.466***	0.842***	-0.064	0.307***
	(0.123)	(0.118)	(0.127)	(0.121)	(0.101)	(0.117)	(0.136)	(0.125)	(0.111)	(0.102)
MTBV	0.058	0.058	0.077*	0.062	0.058	0.050	0.049	0.076	0.057	0.045
	(0.039)	(0.040)	(0.040)	(0.040)	(0.040)	(0.049)	(0.050)	(0.049)	(0.049)	(0.049)
lgTA	0.220***	0.225***	0.273***	0.216***	0.225***	0.240***	0.227***	0.318***	0.238***	0.225***
	(0.072)	(0.072)	(0.075)	(0.073)	(0.072)	(0.079)	(0.079)	(0.082)	(0.080)	(0.079)
LLP	-0.036*	-0.040*	-0.038*	-0.038*	-0.040*	-0.017	-0.021	-0.020	-0.019	-0.021
	(0.021)	(0.021)	(0.022)	(0.021)	(0.021)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
ROAA	0.008	0.005	0.019	0.004	0.006	0.021	0.015	0.051	0.018	0.017
	(0.037)	(0.036)	(0.037)	(0.037)	(0.037)	(0.046)	(0.045)	(0.046)	(0.046)	(0.045)
GDP Growth	0.215***	0.173***	0.270***	0.203***	0.197***	0.055	0.036	0.098**	0.037	0.056
	(0.034)	(0.034)	(0.035)	(0.035)	(0.035)	(0.044)	(0.044)	(0.046)	(0.043)	(0.044)
Inflation	-0.043**	-0.034**	-0.022	-0.052***	-0.038**	-0.043**	-0.035**	-0.026	-0.053***	-0.040**
	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)	(0.017)	(0.016)	(0.017)	(0.017)
Economic Freedom	0.044***	0.043***	0.043***	0.039***	0.036***	0.086***	0.085***	0.094***	0.081***	0.080***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.012)	(0.011)	(0.011)	(0.012)	(0.011)
_cons	-3.640***	-3.764***	-4.611***	-3.220***	-3.260***	-6.544***	-6.543***	-8.345***	-6.112***	-6.102***
	(0.959)	(0.944)	(0.985)	(0.968)	(0.940)	(1.193)	(1.159)	(1.211)	(1.207)	(1.163)
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4115	4115	4115	4115	4115	2691	2691	2691	2691	2691
adj. R-sq	0.233	0.236	0.242	0.232	0.235	0.308	0.311	0.325	0.306	0.309

Table 7 Alternative measure of systemic risk: SRISK

This table reports the panel regression results of the estimation of different regulations and systemic risk measured by SRISK from 18 countries for the period from 2001 to 2012. The dependent variable is the systemic risk measure by MES. Control variables include *MTBV, lgTA, LLP, ROAA, GDP Growth Inflation and Economic Freedom*. Detailed definitions of the variables can be found in Appendix A. Bank fixed effect and year fixed effects are both included. The standard errors for the regressions are estimated as heteroskedasticity-robust standard errors clustered for banks and are presented in brackets *, **, and *** represent statistical significance at the 10%, 5%, and 1% significance level, respectively.

	(1)	(2)	(3)	(4)	(5)
	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Regulation	0.877*	0.171	1.268**	0.073	0.422*
	(0.473)	(0.307)	(0.570)	(0.484)	(0.254)
MTBV	-0.130**	-0.119**	-0.092*	-0.117**	-0.125**
	(0.061)	(0.060)	(0.053)	(0.058)	(0.061)
lgTA	0.632	0.622	0.719	0.617	0.628
	(0.458)	(0.455)	(0.493)	(0.454)	(0.459)
LLP	-0.040	-0.045	-0.046	-0.045	-0.046
	(0.067)	(0.068)	(0.066)	(0.069)	(0.068)
ROAA	-0.394**	-0.407**	-0.378**	-0.408**	-0.405**
	(0.174)	(0.176)	(0.171)	(0.177)	(0.176)
GDP Growth	-0.048	-0.101	0.012	-0.092	-0.101
	(0.084)	(0.103)	(0.088)	(0.089)	(0.092)
Inflation	-0.176*	-0.200*	-0.164**	-0.207**	-0.189**
	(0.096)	(0.103)	(0.080)	(0.100)	(0.092)
Economic Freedom	0.015	0.001	0.005	-0.003	-0.004
	(0.020)	(0.017)	(0.019)	(0.016)	(0.018)
_cons	-7.118	-5.857	-7.991	-5.497	-5.726
	(4.882)	(4.406)	(5.357)	(4.184)	(4.493)
Bank-fixed effect	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes
N	4222	4222	4222	4222	4222
adj. R-sq	0.025	0.024	0.027	0.024	0.024

Table 8: Interaction effects

This table reports the panel regression results of the estimation of different regulations and systemic risk measure by MES. In Panel A, we introduce the interaction between the bank size measured by lgTA and regulation stringency level. In Panel B, we introduce the interaction between the bank regulation stringency and Equity-to-Assets ratio. In Panel C, we introduce the interaction between the bank regulations and bank diversification. The standard errors for the regressions are estimated as heteroskedasticity-robust standard errors clustered for banks and are presented in brackets. . *, **, and *** represent statistical significance at the 10%, 5%, and 1% significance level, respectively.

	(1)	(2)	(3)	(4)	(5)
Panel A:	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Regulation	-1.849***	1.184**	-2.754***	-0.677	-0.254
	(0.501)	(0.517)	(0.454)	(0.428)	(0.349)
Regulation*lgTA	0.207***	-0.080	0.355***	0.064*	0.055
	(0.050)	(0.054)	(0.044)	(0.039)	(0.034)
lgTA	0.123*	0.270***	-0.007	0.202***	0.189**
	(0.072)	(0.078)	(0.081)	(0.071)	(0.076)
_cons	-2.504***	-4.265***	-1.843*	-3.516***	-3.251***
	(0.934)	(0.948)	(0.978)	(0.927)	(0.966)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes
N	4222	4222	4222	4222	4222
adj. R-sq	0.252	0.249	0.276	0.246	0.248

	(1)	(2)	(3)	(4)	(5)
Panel B:	Activity Restriction	Initial Capital Stringency	Prompt Corrective Action	Depositor	Regulation Total
Regulation	0.703***	0.363**	1.380***	0.493***	0.649***
	(0.206)	(0.171)	(0.172)	(0.147)	(0.132)
Regulation × Equity/Assets	-0.051***	0.010	-0.064***	-0.063***	-0.045***
	(0.020)	(0.015)	(0.014)	(0.014)	(0.011)
Equity/Assets	0.045***	0.023*	0.080***	0.037***	0.057***
	(0.013)	(0.013)	(0.016)	(0.011)	(0.013)
_cons	-4.902***	-4.931***	-6.176***	-4.613***	-4.918***
	(0.995)	(1.001)	(1.011)	(0.991)	(1.006)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes
N	4222	4222	4222	4222	4222
adj. R-sq	0.253	0.253	0.268	0.256	0.255

Continue:

Panel C:	(1) Activity Restriction	(2) Initial Capital Stringency	(3) Prompt Corrective Action	(4) Depositor	(5) Regulation Total
Regulation	0.061	0.804***	0.632***	0.352**	0.593***
	(0.215)	(0.208)	(0.222)	(0.174)	(0.150)
Regulation*Diversification	0.438	-1.027*	0.243	-1.223***	-1.016**
	(0.573)	(0.534)	(0.535)	(0.454)	(0.402)
Diversification	-0.544*	0.121	-0.619	-0.251	0.241
	(0.305)	(0.375)	(0.434)	(0.217)	(0.349)
_cons	-3.607***	-4.151***	-4.637***	-3.373***	-3.643***
	(0.972)	(0.956)	(1.000)	(0.966)	(0.943)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes
N	4214	4214	4214	4214	4214
adj. R-sq	0.248	0.252	0.258	0.250	0.251