Financial Innovation: The Bright and the Dark Sides

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Abstract:

Using data for 32 countries 1996-2006, this paper is the first to assess the relationship between financial innovation and real sector growth, sector volatility, and bank fragility. We find evidence for both bright and dark sides. On the one hand, financial innovation is associated with a stronger relationship between a country's growth opportunities and capital and GDP per capita growth and with higher growth in industries relying more on external financing. On the other hand, innovation is associated with higher sector growth volatility, with higher idiosyncratic bank fragility, and higher bank losses during the recent crisis. Benefits and costs of financial innovation are stronger in countries with market-based financial systems, more competitive banking systems and more restrictive regulatory frameworks.

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1. Introduction

"Everybody talks about financial innovation, but (almost) nobody empirically tests hypotheses about it."

Frame and White (2004)

"I wish somebody would give me some shred of evidence linking financial innovation with a benefit to the economy."

– Paul Volcker, former Chairman of the Federal Reserve[1]

The Global Financial Crisis of 2007 to 2009 has spurred renewed wide-spread debates on the "bright" and "dark" sides of financial innovation.[2] The traditional *innovation-growth view* posits that financial innovations help reduce agency costs, facilitate risk sharing, complete the market, and ultimately improve allocative efficiency and economic growth, thus focusing on the bright side of financial innovation. The *innovation-fragility view*, on the other hand, focuses on the "dark" side and has identified financial innovations as the root cause of the recent Global Financial Crisis, by leading to an unprecedented credit expansion that helped feed the boom and subsequent bust in housing prices (Brunnermeier, 2009), by engineering securities perceived to be safe but exposed to neglected risks (Gennaioli, Shleifer and Vishny, 2012), and by helping banks and investment banks design structured products to exploit investors' misunderstandings of financial markets (Henderson and Pearson, 2011). Paul Volcker, former chairman of the Federal Reserve, claims that he can find very little evidence that the financial innovations in recent years have done anything to boost the economy.

This paper gauges the relationship between financial innovation and economic growth and volatility, as well as between financial innovation and banks' risk taking and fragility. Specifically, using OECD innovation survey data on banks' R&D expenditures across 32

[1] Quoted in "Paul Volcker: Think More Boldly," *The Wall Street Journal*, December 14, 2009, p. R7.

[2] In early 2010, the Economist organized a 10-day online debate between Ross Levine and Joseph E. Stiglitz on the role and benefits of financial innovation: http://www.economist.com/debate/overview/166.

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mostly developed countries over the period 1996 to 2006 as well as several other product or output based measures, we relate financial innovative activities to GDP per capita growth, industry growth and volatility, and bank fragility and bank performance during the recent financial crisis. To our best knowledge, this is the first paper to systematically explore the consequences of financial innovation in a consistent cross-country setting. This allows us to thus test the different views on financial innovation .While not necessarily exclusive, the two views put the emphasis on different outcomes. While the *innovation-growth view* predicts a positive relationship between financial innovation, resource allocation and economic growth, the *innovation-fragility* view predicts higher financial and real sector fragility and volatility.

There is a striking paucity of empirical studies of determinants and consequences of financial innovation, mainly due the lack of data.[3] For example, after their thorough survey using fairly broad criteria and a long time horizon, Frame and White (2004) conclude that (p.116), "a striking feature of this literature, however, is the relative dearth of empirical studies that specifically test hypotheses or otherwise provide a quantitative analysis of financial innovation." Unlike in manufacturing, patents are scarcely used in the financial service industry or even unavailable, as in the European Union. As a consequence, most existing studies take a "case study" approach and focus on very specific innovations such as new forms of financial securities (e.g. Grinblatt and Longstaff, 2000; Schroth, 2003; Henderson and Pearson, 2011), the introduction of credit scoring techniques (Frame and White, 2004, 2009; Akhavein et al., 2005), new forms of mortgage lending (Rosen, 2007) or new organizational forms, such as Internet-only banks (e.g. DeYoung, 2001, 2005). Lerner and Tufano (2011) offer a careful long-term analysis of three specific financial innovations – venture capital and private equity, securitization and the mutual fund industry, focusing on possible counterfactuals. More recently, Laeven, Levine and Michalopoulos (2011) explore the relationship between the introduction of private credit bureaus and economic growth and show that this specific financial innovation results in faster convergence of countries to the

[3]Frame and White (2004 and 2009) conduct a thorough survey of the empirical literature on financial innovation. For theoretical literature related to financial innovation, Duffie and Rahi (1995) introduce a special issue of Journal of Economic Theory.

growth path of the most advanced country. None of these papers, however, has taken a holistic approach to the process of financial innovation and its implications for bank fragility and economic development. This paper attempts to fill this gap by providing cross-country evidence on the real and financial sector consequences of financial innovation.

The theoretical literature has provided different hypotheses on the effects of financial innovation. The traditional *innovation-growth view* posits that financial innovation improves the quality and variety of banking services (Merton, 1992; Berger, 2003), facilitates risk sharing (Allen and Gale, 1988, 1991 and 1994),completes the market (Duffie and Rahi, 1995; Elul, 1995; Grinblatt and Longstaff, 2000), and improves allocative efficiency (Ross, 1976, Houston et al., 2010). Dynan, Elmendorf, and Sichel (2006) suggest that financial innovation has played a key role in reducing the volatility of economic activity in the early parts of the 21st century.[4] Examples of financial innovation abound, ranging from new products, such as securities, over new processes, such as credit scoring, to new financial markets or institutions, such as Internet banks. As pointed out by Laeven, Levine and Michalopoulos (2011), financial innovation has been a driving force behind financial deepening and economic development over the past centuries, as the emergence of specialized lenders and investment banks to finance railroad expansion in the 19th century, the emergence of venture capital firms to finance high-technology firms in the 20th century and the financing of biotech firms through pharmaceutical companies in the 21st century show. As pointed out by Lerner and Tufano (2011), it is important in this context to note that financial innovations are related to each other and, similar as with real sector innovations, build on each other.

The *innovation-fragility view* has focused more on the dark sides of financial innovation. Financial innovations such as securitization change the ex-ante incentives of financial intermediaries to carefully screen and monitor the borrowers (Allen and Carletti, 2006). Wagner (2007 a, b) shows that financial innovation that reduces asymmetric information can actually increase risk-taking due to agency problems between bank owners and managers, or because of lower costs of fragility. In the context of the recent lending boom and subsequent

[4]However, see Den Haan and Sterk (2011) for evidence to the contrary.

Global Financial Crisis, several authors have pointed to distortions introduced by financial innovations, such as securitization and new derivative securities, and how they have contributed to aggressive risk taking, reduction in lending standards and thus fragility (e.g., Keys et al., 2010; Dell'Ariccia, Igan and Laeven, 2008; Rajan, 2006; and Gennaioli, Shleifer and Vishny, 2012). Recent research by Nadauld and Weisbach (2012) also concludes that securitization lowers the cost of corporate debt.

Rather than reducing market frictions, however, financial innovation can also arise as reaction to regulation (such as Euro market arose as response to regulation Q) or religious restrictions (such as Sharia-compliant financial products). Specifically, it has been argued that the main purpose of recent financial innovations has been to facilitate regulatory arbitrage by shifting off balance sheet investments that would be more costly were they held on balance sheet. In contrast to the traditional view that financial innovation is to provide more efficient diversification of risk, advocates of the regulatory arbitrage view argue that financial innovation serves to shift that risk to naïve investors who do not know what they are holding and to investors who are confident of being bailed out if things go wrong. For example, Henderson and Pearson (2011) provide evidence that financial innovations help banks and investment banks design structured products to exploit investors' misunderstandings of financial markets. Also related to this argument, Acharya et al. (2013) show that regulatory arbitrage was the main motive for banks to set up the Asset Backed Commercial Paper (ABCP) Conduits, which held risky assets the banks would have otherwise have to hold on their books. Financial innovation driven by regulatory arbitrage should not improve economic growth or resource allocation, but rather increase financial fragility and economic volatility.

The relationship between financial innovation and real and financial sector outcomes might also depend on the characteristics of the financial system and the regulatory framework. Financial innovation on the retail deposit or payment side might have limited impact on both growth and stability, while innovation on the lending, trading, or investment banking side might involve both growth benefits and stability risks. The effect of innovation might also

depend on the market environment, financial structure and regulatory framework that influence banks' incentives for risk-taking. On the one hand, market-based financial systems are more likely to stimulate product- or security-based financial innovation that facilitates risk sharing and transferring and improves access to finance. Hence, the positive effect might be stronger in market-based financial systems if such type of financial innovation helps complete financial markets, but it might also exacerbate the negative effects by encouraging more risk-taking, reducing screening and monitoring incentives, and reinforcing herding trends. On the other hand, the effects might be less profound in bank-based financial systems, which are more likely to focus on the innovation on the retail side to improve depositors' experiences through new technology and products. There might be limited growth benefits and stability risks with such kind of financial innovation. The effects of financial innovation might also vary with the bank regulatory framework. On the one hand, more restrictive regulation in terms of activity restrictions and capital might limit the possibilities to innovate as well as dampen both positive and negative effects. On the other hand, a more restrictive regulatory framework might provide banks stronger incentives to innovate around regulations (i.e. regulatory arbitrage), which might have negative effects on stability. Finally, stronger competition in the banking system might influence the effect of financial innovation on the real economy and financial stability. On the one hand, a high degree of competition might entice banks to innovate aggressively, with positive repercussions for real sector growth, but potentially also with more instability risks if competition entices aggressive risk taking and herding trends. On the other hand, under limited competition, banks might be more willing to innovate as they are more likely to reap the benefits of innovation over time, with rents not being competed away. If this is the case, financial innovation might be more likely to promote economic growth and financial stability in concentrated banking sector.

Our paper contributes to the literature by focusing on cross-country proxies for financial innovation gauging their relationship with real and financial sector outcomes across a sample

of 32 mostly high-income countries.[5] We follow Tufano's (2003) concept of financial innovation, which includes the process of invention (the ongoing research and development function) and diffusion (or adoption) of new products, services or ideas, and focus on R&D spending in the financial sector as well as several other product or output based measures of financial innovation (e.g. value of off-balance-sheet items, the number of credit default swaps (CDS) reference entities, the total value of asset-backed commercial paper (ABCP) conduits). While the level of R&D activity in the financial system is relatively low compared to other sectors in the economy across our sample of 32 mostly developed countries, we find significant and robust relationships with real and financial sector outcomes. Specifically, we find that a higher level of financial innovation is associated with a stronger relationship between a country's growth opportunities and GDP per capita growth and with higher growth of industries that rely more on external financing and industries more dependent on R&D activities. On the other hand, higher levels of financial innovation are also associated with higher growth volatility among industries that rely more on external financing and more on innovative activities. Using a sample of more than 2,000 banks across the same sample countries, we find that a higher level of financial innovation is associated with higher bank risk taking and fragility, especially among banks with smaller market shares and lower loan-asset ratios. This suggests that smaller banks and banks that diversify away from traditional intermediation are relatively more fragile in countries with higher levels of financial innovation. Consistent with these findings, we show that banks' profitability dropped at a higher rate during the recent crisis and the buy-and-hold stock returns during the crisis were lower in countries with higher pre-crisis levels of financial innovation. Overall, these findings are consistent with both the bright and the dark sides of financial innovation.

We also find important cross-country variation in the effects of financial innovation. Specifically, we find that the bright effects of financial innovation are stronger in more market-based economies and countries with stronger bank competition. However, financial innovation also seems to have stronger positive effects on growth in countries with stronger

[5] This is different from Laeven, Levine and Michalopoulos (2011), one of the few other cross-country papers in this area, who focus on one specific financial innovation – private credit bureaus.

restrictions on banks and overall capital stringency, suggesting that financial innovation can help banks work around regulatory restrictions to the benefit of the real economy. However, we also find that the fragility repercussions of higher financial innovation are stronger in countries with these same characteristics and the negative effects of financial innovation on bank performance during the Global Financial Crisis have been more pronounced in market-based financial systems.

Our paper is related to and contributes to several strands of the literature. First, we complement the literature on the importance of financial innovation. Banks are intensive users of both financial and IT technologies, and the rapid rate of financial innovation over the past few decades is widely recognized as a stylized fact (Miller, 1986 and 1992; Merton, 1992; Tufano, 2003; Frame and White, 2004 and 2009). There is an extensive descriptive literature that discusses financial innovation, but a relative dearth of empirical studies that are based on quantitative analysis. Our paper attempts to fill this gap by providing a consistent cross-country measure of financial innovation and relating it to an array of real and financial sector outcome variables. Second, we contribute to the literature on finance and economic growth started by King and Levine (1993).[6] Recent contributions have focused on the non-linearity of the finance-growth link, highlighting declining, insignificant or even negative associations of finance with economic growth at high levels of GDP per capita (Aghion et al., 2005, Rioja and Valev, 2004; Arcand, Berkes and Panizza, 2012). We find strong evidence that financial innovation is associated with higher levels of economic growth, even when controlling for aggregate indicators of financial development, in our sample of high-income countries. This suggests that it is not only the level of financial development, but also innovative activities of financial intermediaries, which help countries grow faster at high levels of income. However, we also show that this comes at the cost of higher growth volatility in industries that depend more on external finance and on innovative activity.[7]

Third, we add to the literature that explores the determinants of bank risk taking (e.g.

[6]See Levine (2004) for literature surveys.
[7]There is a small literature on the link between financial development and volatility. See, among others, Raddatz (2006); Beck, Lundberg and Majnoni (2006); Aghion et al. (2009) and Aghion et al. (2010).

Saunders, Strock, and Travlos, 1990; Houston and James, 1995; Laeven and Levine, 2008; Houston et al., 2010; Demirgüç-Kunt and Huizinga, 2010).While our study is not able to directly answer the larger questions regarding optimal risk taking, we do provide interesting insights into the channels through which financial innovative activity influences banks' business decisions, which in turn affect the level of growth and output volatility. Fourth, our paper is also related to the literature on financial crises, particularly the recent one (e.g. Brunnermeier, 2009; Johnson and Kwak, 2010; Keys et al., 2010). We find evidence that financial innovation increases bank fragility and profit volatility. Furthermore, we use the most recent global financial crisis as a relatively exogenous shock to examine the impacts of financial innovation on bank performance. Beltratti and Stulz (2012) discover a significant variation in the cross-section of bank stock returns during the recent crisis. Using measures of both stock returns and financial statements based profits we find that banks suffer more in countries with higher levels of pre-crisis financial innovation. Finally, we also contribute to the literature of banking regulation (Barth, Caprio and Levine, 2001, 2006 and 2008; Laeven and Levine, 2009). We find that in countries with more stringent capital regulation, financial innovation is more likely to cause bank instability and performance drops during financial crisis.

Before proceeding, we would like to address some potential concerns readers might have with our approach and findings. First, there is a concern that our measure of financial innovation is subject to potential measurement bias as the definition of innovative activity might be less clear in the financial sector than it is in the manufacturing sector. While our measure focuses on the process of financial innovation, we show that it is significantly correlated with specific forms of financial innovation, such as off-balance sheet items, and loan securitization and syndication. In addition, we confirm our results using several balance sheet based measures of financial innovation. A second potential problem for interpreting our results is the endogeneity challenge, which is often a concern in the finance and growth literature. We mitigate this concern by offering several tests of channels and mechanisms through which financial innovation is associated with real and financial sector outcome. Among other techniques, we focus on the differential effects of financial innovation

on industries with different needs for external finance and real innovative activity, thus a "smoking gun" approach (Rajan and Zingales, 1998), as well as differential effects of financial innovation across banks of different characteristics. Moreover, we test the robustness of the results using instrumental variable analyses as well as with a placebo test. Furthermore, we use the most recent financial crisis as a relatively exogenous shock and examine the effect of financial innovation on performance changes of banks in the financial crisis. Our results remain significant and consistent in all these tests. Though it is impossible to completely eliminate endogeneity, this seems unlikely to account for our main empirical findings.

The rest of the paper proceeds as follows. Section 2 discusses our cross-country indicator of financial innovation. Section 3 relates financial innovation to real-sector outcome variables, while Section 4 gauges its relationship between bank fragility. Section 5 concludes.

2. Measuring Financial Innovation

The literature on innovation in the manufacturing industry has focused mostly on patents (either outstanding or new ones), R&D expenditures, or share of research staff as indicators of innovative activity (e.g. Helpman, 1993; Cohen and Klepper, 1996; Branstetter et al., 2006). Gauging innovative activity in the financial sector is more challenging, as patents in the financial sector rarely exist and not at all in the European Union. R&D expenditures are typically not collected for financial institutions nor are data on research staff. This lack of data, as already pointed out by Frame and White (2004) has impeded the rigorous study of financial innovation across countries.

We fill this gap by collecting data on R&D expenditures in the financial intermediation industry from the Analytical Business Enterprise Research and Development database (ANBERD). ANBERD was developed to provide a consistent, internationally comparable data set of enterprise R&D expenditures across industries and over time, and builds on data provided to the OECD by its member countries through the joint OECD/Eurostat R&D

survey.[8] These data are collected from enterprise surveys via the OECD/Eurostat International Survey of Resources Devoted to R&D from 32 nations in the world from 1987 to 2006. R&D expenditure consists of total intramural and extramural expenditure on R&D following the definition in the Frascati Manual.[9]

We start our analysis from 1996 when data for nearly all sample countries are available, and we complement the data by OECD Science, Technology and R&D Statistics for some missing data in ANBERD. In particular, we obtain banking sector data of 32 countries from SourceOECD Statistics, including 26 OECD (as of 2009) and six non-member countries.[10]

Based on R&D expenditures, we use two different indicators of R&D activities across countries and years. Specifically, SourceOECD database reports financial R&D intensity relative to the value added in the financial intermediation sector (*Financial R&D Intensity (Value Added)*), and we rely on this as our main gauge of financial innovation.[11] We use an alternative indicator by standardizing financial R&D by total operating cost of banks to obtain *Financial R&D Intensity (Cost*), where total operating cost refers to total non-interest expenses.[12] The information is drawn from OECD Banking Statistics. For the missing values in some countries, we complement with data from BankScope, using aggregate information for the respective country and year. We note, however, that this alternative indicator may

[8]ANBERD contains OECD estimates that adjust for deficiencies and anomalies that exist in the official data. As pointed out by the explanatory notes of the database, research and development expenditures in some countries may be underestimated, for example due to different treatment of R&D institutes. Depending on the country, R&D institutes serving enterprises are either classified with the industry concerned, or grouped under "Research and Development" (ISIC rev.3.1, Division 73). When these R&D institutes are classified with the industry served, the evaluation of R&D in these industries is more complete and more comparable between countries for the industries concerned.

[9]Intramural expenditure includes all R&D expenses conducted within the firms and reported in R&D surveys. Extramural expenditure comprises acquisition of R&D and grants given to others for conducting R&D activities.

[10]The countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, Israel, Romania, Russian Federation, Singapore, and South Africa.

[11]Value added is the value of output less the value of intermediate consumption, and it is a measure of the contribution to GDP made by an individual producer, industry or sector. Due to the rounding problem in the data as reported by SourceOECD database, we calculate our measure using R&D expenditures and value added as reported in the database. Measuring the value-added (and therefore the size) of the financial sector, however, is challenging, as discussed, for example, by Basu et al. (2011).

[12]In regression analysis, we further multiply our measures of Financial R&D Intensity by 100 to scale the estimated coefficients for simplicity.

overestimate financial innovation, as we divide by costs related to the banking rather than the overall financial system.[13]

The descriptive statistics in Table 2(Panel A) shows that the mean value of Financial R&D Intensity (Value Added) is 0.33%, with a standard deviation of 0.39%. The high standard deviation is dominated by cross-country variation (0.34%), with a somewhat lower within-country standard deviation (0.20%). We note that these values are relatively low, though in line with an average R&D intensity of 0.428% in the service industry, excluding the financial sector. They compare to an average of 2.113% in manufacturing across the same sample of countries and years. This relatively limited R&D activity in the financial shows the relatively limited role of such activities in banking compared to other sectors of the economy, but will also bias our estimations against finding significant relationships between financial innovation and real and financial sector outcomes. *Financial R&D Intensity (Cost)* shows a higher average value (given the smaller denominator) with 1.18%.

While our sample is a relatively homogenous sample of mostly high-income countries, we find high cross-country variation in financial innovation. Appendix Table A1 reports the summary statistics of financial R&D expenditures in absolute numbers (millions USD) across countries, averaged over the sample period 1996 to 2006. While Hungarian banks report R&D expenditures of 1.01 million USD, the numbers are 1,358 and 2,042 million USD for the UK and US, respectively. Also banks in Australia, Canada, Denmark, and South Africa report R&D expenditures of more than 100 million USD.[14] Appendix Figure A1 shows an increasing trend in financial innovation over time across our sample countries, almost doubling between 1996 and 2006, consistent with anecdotal evidence on increasing innovative activity within the banking system during this period. Behind this overall trend, however, are important cross-country differences, with Australia, South Africa and the UK

[13] In unreported robustness tests, we also used a gauge of financial innovation based on revenue, with qualitatively similar results.

[14] The high expenditure in Denmark might be related to the high share of mortgage credit in this economy, while South African banks have undertaken significant attempts at expanding outreach after the end of apartheid.

experiencing increasing levels of financial innovation and Switzerland experiencing decreasing levels.

[Tables 1 and 2 here]

While most countries in our sample have developed financial systems, we still find a positive correlation between Private Credit and our two indicators of financial R&D intensity, significant at least at the 5% level. The pairwise correlation coefficients are 0.321 (*Financial R&D Intensity (Value Added)*, p-value=0.000), and 0.122 (*Financial R&D Intensity (Cost*), p-value=0.021), respectively. We also find significantly positive correlations between R&D intensity in the financial sector and in other sectors of the economy, including the service industry (without financial sector) and manufacturing. Finally, we find that financial intermediaries in countries with a higher level of GDP per capita report a higher level of financial R&D, though the correlation is not as strong as that between financial depth and financial innovation. The correlations are reported in Appendix Table A2.

We recognize that our indicators of financial innovation are subject to potential measurement error, even though they have been adjusted for irregularities. Most importantly, the data on innovative activity are survey-based and might thus be driven by country-specific concepts of what constitutes financial innovation, even though our sample is a relatively homogeneous one of industrialized economies. We therefore use three alternative indicators of financial innovation that refer to the "output" of financial innovation. First, we use the natural logarithm of the total value of off-balance-sheet items among all the individual banks, aggregated for each country, using data from BankScope. Some forms of financial innovation, such as credit card receivables, or subprime residential mortgages are often portrayed as having arisen in part as a means of "arbitraging" regulatory capital requirements by booking assets off the balance sheets of regulated banks (Calomiris, 2009). Appendix Figure A2 shows a positive and close correlation between the value of off-balance-sheet items and

financial R&D expenditure. Second, we use the natural logarithm of the number of credit default swaps (CDS) reference entities for each country, based on the Markit CDS database. CDS has emerged as an important innovative insurance contract over the past years, both seen as critical for risk diversification and as tool for regulatory arbitrage and increasing systemic fragility, as best illustrated by the systemic importance of AIG, bailed-out by U.S. authorities in 2008, as issuer of CDS. As this is a relatively new instrument, we have data available only from 2001 to 2006. Appendix Figure A3 shows a positive correlation between the number of reference entities and log of financial R&D expenditures. Third, we use the natural logarithm of the total value of asset-backed commercial paper (ABCP) conduits, based on data by Acharya, Schnabl and Suarez (2013). ABCP has emerged as a popular and important funding instrument for special purpose vehicles established by banks for securitization purposes. It is a major component of the shadow banking system. As shown by Acharya et al., however, these vehicles were ultimately used by banks to retain risks on their balance sheet (through explicit guarantees to these vehicles) but reduce capital requirements. Appendix Figure A4 shows a positive correlation between the log of total value of ABCP and the log of total financial R&D expenditures. While these three alternative measures thus refer to very specific dimensions of financial innovation, they are all highly correlated with innovative activity in the financial sector as gauged by our survey-based indicators.

As additional test for the validity of our survey-based measures, we compare manufacturing R&D intensity from the same OECD survey with patent data in manufacturing from the World Intellectual Property Organization (WIPO) Statistics Database. We find a close and statistically significant relationship between the two (Appendix Figure A5). This reduces concerns that our survey data are driven by country-specific concepts of innovative activity. Overall, this gives us confidence that our indicator is a good proxy for innovative activity in the financial sector.

3. Financial Innovation and the Real Economy

This section assesses empirically the relationship between financial innovation, on the one hand, and real sector growth and volatility, on the other hand. In doing so, we will employ different panel data sets (i) across countries and over time and (ii) across countries and across industries. In each case, we will first explain the methodology, then describe data and finally discuss the results.

3.1. Does financial innovation help exploit growth opportunities?

Bekaert et al. (2005, 2007) show that exogenous growth opportunities predict subsequent GDP growth and more so in countries with liberalized capital accounts, banking systems and equity markets. We build on this work and gauge the relationship between financial innovation, growth opportunities and GDP per capita growth. We follow Bekaert et al.'s (2007) methodology and measure exogenous growth opportunities for each country by the weighted average of industry price-earnings ratios using data across our sample countries, as we describe in more detail below. We then relate a country's growth opportunities and financial innovation to GDP per capita growth in the following regression model:

$$Growth_{i,t} = \beta_1 GGO\_MA_{i,t} + \beta_2 FI_{i,t} + \beta_3 GGO\_MA_{i,t} * FI_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where $Growth_{i,t}$ is the five-year moving average annual real GDP per capita growth in country *i* and period *t*; *GGO_MA* is a measure of global growth opportunities and *FI* is one of our indicators of financial innovation. Following Bekaert et al. (2007), we use overlapping five year samples to exploit the time-series information in our sample to a maximum and adjust standard errors accordingly. Since Bekaert et al. (2007) find that domestic banking development, equity market development and financial liberalization are important for exploiting growth opportunities, we also control for the interaction of GGO_MA and (i) Private Credit to GDP, which is calculated as the natural logarithm of financial institutions' claims on the private sector divided by GDP, (ii) a measure of financial liberalization, defined as a dummy that takes on a value of one if there has been a positive change towards financial liberalization index in the respective year (Abiad et al., 2010), and (iii) stock market

capitalization to GDP to gauge the size of equity markets. We therefore pick up any additional direct effect of financial innovation on growth, beyond the effect through financial development or financial liberalization.

The estimate of the regression coefficients β allows us to differentiate between different hypotheses regarding the role of financial innovation. Specifically, a positive β_2 would be evidence in favor of the innovation-growth hypothesis. In addition and consistent with predictions by Laeven et al. (2011), a positive and statistically significant β_3 would provide evidence for a channel through which financial innovation enhances economic growth, namely through the exploitation of growth opportunities.

We follow Bekaert et al. (2007) in constructing our indicator of growth opportunities. This measure is based on the assumptions that a country's growth potential is reflected in the growth potential of its industry mix and that price-earnings (PE) ratios contain valuable information about an industry's growth opportunities.[15] We compute the global growth opportunities of a country *i* in year *t* as the PE ratios computed on global data on listed companies, averaged across 35 sectors weighed by annual country-specific industry weights based on lagged market capitalization. As this measure might be driven by differences in persistent discount rates, we follow Bekaert et al. (2007) and remove a 60-month moving average from this measure. The descriptive statistics show an average GGO_MA of 0.094 across countries and over time, with a standard deviation of 0.427 (Table 2, Panel B). We use annual real per capita GDP growth rates, using data from the World Development Indicators (WDI). The average real per capita GDP growth rate (5-year moving average) is 1.7%, ranging from -2.1 % in Israel in 2003-2007 to 8.4% in Russia in 2002-2006, with a standard deviation of 2.1%.

The results in Table 3 show a positive and significant relationship between the interaction of global growth opportunities of a country and financial innovation and GDP per capita growth. The interaction between *Financial R&D Intensity* (*Value Added)* and growth opportunities enters positively and statistically significant in the regressions of GDP per

[15] For a more detailed discussion on the advantages of PE ratios over other measures of growth opportunities and details on their construction, see Bekaert et al. (2007).

capita (columns 1 and 2). The level of financial innovation, on the other hand, does not enter significantly, which suggests that it is not financial innovation per se that is associated with faster economic growth and more rapid capital growth, but rather higher levels of financial innovation in countries and periods with high growth opportunities. Critically, the positive interaction of global growth opportunities and financial innovation is significant controlling for the interaction of growth opportunities with banking sector and equity market development and financial liberalization, none of which enters significantly.[16]

[Table 3 here]

The effect is not only statistically, but also economically significant. At the mean of financial innovation (0.33%), a move from a country and period with growth opportunities at the mean of 0.09 to a country and period with growth opportunities of one standard deviation above the mean (0.52) predicts an increase in annual real per capita GDP growth by 0.6 percentage points. The same increase in growth opportunities in a country with financial innovation one standard deviation above the mean, on the other hand, will lead to an increase of real per capita GDP growth by one percentage point.[17] The results are confirmed by using our alternative indicators of financial innovation, *Financial R&D Intensity* (*Cost)* and *Log(Off-Balance Sheet Items).*[18] The finding that it is financial innovation rather than financial depth that is associated with higher rates of economic growth in our sample of high-income countries is consistent with other evidence that shows a declining effect of financial development on economic growth at higher levels of income per capita or even an insignificant effect (Aghion et al., 2005; Rioja and Valev, 2004; Arcand, Berkes and Panizza, 2012). In summary, the evidence presented in Table 3 is consistent with the innovation-growth hypothesis. The relationship between growth opportunities and actual

[16] Note that the insignificance of the interactions of growth opportunities with Private Credit and financial liberalization might be driven by the limitation of the sample to high-income countries.
[17] To compute these economic effects, we add up the level and the interaction effects of financial innovation.
[18]Since we exploit cross-country and cross-time variation in these regressions, we cannot use the other two indicators of financial innovation, as they are available over shorter time periods.

GDP growth is stronger in countries where banks invest more in financial innovation.

3.2. Does financial innovation help or hurt industries that rely more on external finance and innovation?

In addition to cross-country estimations, we follow the seminal work by Rajan and Zingales (1998) to test the effect of financial innovation on the growth of industries with different needs for external financing and industries that depend to a different degree on R&D activities. Rajan and Zingales (1998) show that industries that are naturally heavy users of external finance benefit disproportionately more from financial development than industries that are not naturally heavy users of external finance. The methodology has been widely used in the recent literature to explore the differential impact of financial development or specific financial sector characteristics on the differential growth of industries of different characteristics.[19] Larrain (2006) and Raddatz (2006) also look at the effects of bank and financial development on industrial volatility, and we follow their work and investigate the effects of financial innovation on growth volatility.Specifically, we estimate the following two models:

$$Growth_{i,k} = \sum_j \alpha_j Country_j + \sum_l \beta_l Industry_l + \gamma Share_{i,k} + \delta_1 (EFD_k * FI_i) + \delta_2 (EFD_k * FD_i) + \varepsilon_{i,k}, \quad (2)$$

$$Volatility_{i,k} = \sum_j \alpha_j Country_j + \sum_l \beta_l Industry_l + \gamma Share_{i,k} + \delta_1 (EFD_k * FI_i) + \delta_2 (EFD_k * FD_i) + \varepsilon_{i,k}, \quad (3)$$

where $Growth_{i,k}$ is the average annual growth rate of value addedin industry *k* and country *i*, over the period 1996 to 2006, and $Volatility_{i,k}$ is the standard deviation of the annual growth rate of value added over the same period. *Country* and *Industry* are country and industry dummies, respectively, and $Share_{i,k}$ is the share of industry *k* in manufacturing in country *i* in 1996. We interact the external financial dependence (EFD) of an industry with both (a) a measure of overall financial development (*FD*) and (b) an indicator of financial innovation

[19] See, e.g., Cetorelli and Gambera (2001); Beck and Levine (2002); Raddatz (2006); Kroszner, Laeven and Klingebiel (2007).

(FI), measured at the beginning of the sample period. We do not include financial development or financial innovation on their own, since we focus on within-country, within-industry variation. The dummy variables for industries and countries control for country and industry specific characteristics that might determine industry growth patterns. We thus isolate the effect that the interaction of EFD and financial development/innovation has on industry growth rates and their volatility relative to country and industry means. We include several additional interaction terms of external dependence with country characteristics, including stock market capitalization to GDP, the Herfindahl index of bank concentrationand entry into banking requirements to thus control for market structure and competition in banking and in line with previous literature (Cetorelli and Gamberra, 2001). The sample excludes the industrial sectors in US, which serves as the benchmark (Rajan and Zingales, 1998).We compute heteroskedasticity-robust standard errors clustered on the country-level.

In a second step, we will run both regressions with R&D intensity (RDI), as measured for a sample of U.S. firms, as industry characteristics to gauge the hypothesis that financial innovation helps disproportionately manufacturing industries that rely more on innovative activity. This hypothesis is based on Laeven, Levine and Michalopoulos (2011) that financial and real sector innovations are positively correlated with each other. On the other hand, higher financial innovation might also expose industries more reliant on external finance or R&D activities to higher growth volatility.

A positive and statistically significant δ_1 in regression (2) would be evidence for the innovation-growth hypothesis, as it would not only suggest a positive impact of financial innovation on industries that are most in need of external finance or more reliant on R&D activities, but such effect would be in addition to the positive effect of financial depth, gauged by δ_2, an effect shown by Rajan and Zingales and confirmed by other authors. A positive and statistically significant δ_1 in regression (3), on the other hand, would be evidence for the innovation-fragility hypothesis, as it would imply higher growth volatility for

industries more reliant on external finance or more dependent on R&D activities in countries with higher levels of financial innovation.

Following Rajan and Zingales (1998), we calculate the average growth rate in real value added for 1996 to 2006 for each industry in each country (*Average Growth Rate in Real Value Added*). The industry level data on *External Financial Dependence (EFD)* are calculated by Rajan and Zingales (1998), who construct their index at the industry level for a sample of US firms as the fraction of capital expenditures not financed with internal funds for U.S. firms in each three-digit ISIC industry between 1980 and 1990. A higher value of this ratio therefore represents a higher level of external financial dependence. Rajan and Zingales (1998) argue that for technological reasons such as scale economies, gestation period, the cash harvest period, and intermediate product intensity, some industries might rely more heavily on external finance than others and that the financial dependence of U.S. industries can serve as an appropriate benchmark because the relatively frictionless, sophisticated, and developed U.S. financial markets should allow U.S. firms to encounter fewer obstacles to achieving their desired financial structure than firms in other countries. This approach thus provides a valid and exogenous way to gauge the extent of an industry's demand for external finance anywhere in the world. Similarly, we use Computstat data to calculate the average R&D intensity (RDI) across the sample period for each four-digit ISIC industry, defined as weighted-average (based on firm size) R&D intensity (calculated as R&D expenditures divided by total asset) of all the firms with non-missing R&D expenditures in each four-digit ISIC industry. The final sample used in our average growth regression analysis includes 735 industry observations across 28 countries (Table 2, Panel C).[20]

The results in columns 1, 2 and 3 of Table 4 Panel A show that industries with higher external financial dependence grow faster in countries with higher levels of financial innovation, even controlling for the interaction of external dependence with indicators of financial intermediary development, equity market development and banking sector competition and contestability. However, only the interactions of the value added and

[20] There are more observations in the industry regressions with RDI, since the matching of industries from SIC to ISIC is a different one than the one used by Rajan and Zingales.

cost-based Financial R&D Intensity measures enter significantly, while the interaction of external dependence with the log(Off-Balance-Sheet Items) enters positively but insignificantly.[21] Again, the effect is not only statistically, but also economically significant. Following Rajan and Zingales (1998), we compute the growth difference between industries at the 25th and 75th percentiles of External Dependence and countries at the 25th and 75th percentiles of financial innovation. This growth difference is 1.2%, compared to the average growth of 0.05% in our sample. While the interactions of external dependence with Private Credit and with most other country-level variables do not enter significantly, we find that industries more dependent on external finance grow more slowly in countries with higher bank concentration. We do not find the insignificant coefficient on EFD x Private Credit surprising, for several reasons. First, our sample is limited to mostly high-income countries; recent research has shown that there is no significant relationship between financial development and economic growth in this country group (e.g., Arcand, Berkes and Panizza, 2012; Aghion et al., 2005). Moreover, our findings that financial development enters insignificantly, while financial innovation enters significantly suggest that it is not so much the level of financial deepening but the innovative activity of financial intermediaries that constitutes the finance-growth link in high-income countries. In unreported robustness tests, we also control for reverse causation by focusing on a sample of industries below the respective country's median industry share in total manufacturing. By focusing on industries with a smaller share we control for the possibility that larger industries' demand will drive supply of credit by financial institutions. Our results are confirmed for the sample of "small" industries.

[Table 4 here]

The results in Table 4 Panel A also show that industries more dependent on R&D activities grow faster in countries with higher levels of financial innovation. The interaction

[21]As in the previous regressions, we do not include the other two measures of financial innovation given the more limited sample period.

terms between R&D intensity (RDI) and financial innovation enter positively and significantly in the regressions of columns (4) and (5) in Table 4, while the log of Off-Balance Sheet Items enters insignificantly in column (6). As before, the effect is also economically significant and even stronger than in the case of external dependence, as the growth difference between the industry at the 25th and the 75th percentile of R&D intensity and countries at the 25th and 75th percentiles of Financial Innovation is 2.4%. While the interaction of external dependence with neither Private Credit to GDP nor with Stock Market Capitalization to GDP enters significantly, the results suggest that industries that are more R&D intensive grow faster in countries with more concentrated but also more contestable banking systems. As in the case of external dependence, we confirm our results focusing on sample of industries below the respective country's median industry share in total manufacturing, thus reducing concerns of reverse causation.

The regressions in Panel B of Table 4 show that the positive relationship between financial innovation and the relative growth of industries more dependent on external dependence is driven by market-based financial systems. Here we split the sample into countries whose financial systems are more dominated by stock markets and countries whose financial systems are more dominated by banking system. Following Beck and Levine (2002), we use the ratio of Stock Market Value Traded to Bank Credit as gauge for financial structure and denote financial systems as market (bank) based if the average value of this ratio over the sample period is above (below) the median. It is only in the subsample of market-based financial systems, that our measures of financial innovation, including the log of Off-Balance Sheet Items, enter positively and significantly, while they enter insignificantly in the subsample of bank-based financial systems.

The results in Panel C of Table 4 show that the relationship between financial innovation and the growth of industries dependent on external finance varies with several dimensions of the financial system and the underpinning regulatory framework. Specifically, we find that while the interaction between financial innovation and external dependence enters positively and significantly in all regressions, it only enters significantly in the subsamples of countries

with high restrictions on banks' activities, high capital stringency and high bank competition. This suggests that a more competitive banking system is critical to reaping the benefit of financial innovation. However, it also suggests that financial innovation in countries where banks are more restricted in expanding beyond traditional intermediation and in countries with overall more stringent capital requirements can be beneficial, maybe as counterweight to these restrictions.

The results in columns 1 and 2 of Table 5 show that industries that rely more on external finance experience higher growth volatility in countries with higher levels of financial innovation. Here, we report regressions of the standard deviation of industry growth over the period 1996 to 2006 on the interaction of financial innovation and external dependence, controlling for the same interactions of external dependence with other country characteristics as in Table 4. To the same extent that financial innovation helps industries more dependent on external finance grow faster, it could introduce a higher degree of growth volatility in these industries, similar to the effect of financial deepening on growth fluctuations in externally dependent industries (Braun and Larrain, 2005; Kroszner et al., 2007). The coefficients on the interaction of *Financial R&D Intensity (Value Added)* and *External Financial Dependence* enters positively and significantly at the 1% level in column 1, as does the interaction with Financial *R&D Intensity (Cost)*. The interaction with log of Off-Balance Sheet Items, on the other hand, enters insignificantly. The economic effect is similarly significant. We undertake the same exercise as in Table 4, computing the growth volatility difference between industries at the 25^{th} and 75^{th} percentiles of External Dependence and countries at the 25^{th} and 75^{th} percentiles of Financial Innovation. This difference in growth volatility is 3.3%, compared to the average growth volatility of 23.7% in our sample. In relative terms, thus, financial innovation explains a smaller share of cross-country cross-industry variation in growth volatility than in industry growth.

[Table 5 here]

The results in columns 4 and 5 of Table 5 show that manufacturing industries that rely more on innovative activity experience higher growth volatility in countries with higher levels of financial innovation. The coefficients on the interaction of *Financial R&D Intensity (Value Added)*/ *Financial R&D Intensity (Cost)* and *R&D Intensity* enter positively and significantly at the 10% level, while the interaction with log of Off-Balance Sheet Items does not enter significantly in column 6. The effect is also economically significant. The growth volatility difference between industries at the 25th and 75th percentiles of R&D Intensity and countries at the 25th and 75th percentiles of Financial Innovation is 5.2%, thus larger than the effect of industry differences in external dependence.

Summarizing, the results in Table 5 are consistent with the innovation-fragility view, as industries more reliant on external finance and on innovative activity experience higher growth volatility in countries where financial intermediaries invest more in financial innovation. Together, the results from our industry regressions in Tables 4 and 5 show a clear trade-off in the effects of financial innovation on the real economy – higher growth, but also higher volatility. In the following, we explore one possible explanation for the positive relationship between financial innovation and volatility, the relationship between financial innovation and banks' fragility and performance during the recent crisis.

4. Financial Innovation and Bank Fragility

This section explores the relationship between financial innovation and bank fragility. Specifically, we relate country-level variation in financial innovation to (i) bank-level variation over time in bank fragility as gauged by the Z-score, including exploring bank-level differences in this relationship, and (ii) bank-level variation in changes in profitability between 2006 and 2008. In doing so, we do not only test the innovation-fragility hypothesis, but also explore mechanisms of why we found a positive relationship between financial innovation and growth volatility in industries that rely more on external finance and on innovative activity.

4.1. Does financial innovation make banks more fragile?

First, following Laeven and Levine (2008) and Houston et al. (2010), we relate a bank-level stability indicator to financial innovation and an array of bank- and country-level control variables:

$$Z_{i,k,t} = \alpha X_{k,t-1} + \beta Y_{i,t-1} + \gamma FI_{i,t-1} + \nu_i + \sigma_t + \varepsilon_{i,k,t}, \qquad (4)$$

In this setup, the indices *i, k,* and *t* stand respectively for country, bank and time. Z is the log of the z-score of bank *k* in country *i* in period *t*, *X* is a vector of bank characteristics, *Y* is a vector of country characteristics and *FI* is our country-level indicator of financial innovation.The *Z-score* represents the number of standard deviations by which profits would have to fall below the mean so as to deplete equity capital (Boyd et al., 2006) and is defined as (ROA+CAR)/σ(ROA), where ROA is the rate of return on assets, CAR is the ratio of equity to assets, and σ(ROA) is the standard deviation of ROA. The Z-score is a measure of a bank's distance from insolvency (Roy, 1952) and has been widely used in the recent literature (e.g. Laeven and Levine, 2009; Houston et al., 2009; Demirguc-Kunt and Huizinga, 2010). Since the Z-score is highly skewed, we follow Laeven and Levine (2009) and use the natural logarithm of the Z-score as the risk measure.[22] For brevity, we use the label "Z-score" in referring to the logged Z-score in the remainder of the paper. In our analysis, we use data for more than 2,000 banks across 32 countries over the period from 1996 to 2007 using the BankScope database. We further divide the total of 12 years into three four-year non-overlapping sub-periods, which results in around 6,000 bank-time observations.

Looking at the summary statistics in Panel D of Table 2, we find that the mean log Z-score is 3.72, and that the standard deviation is 1.03.[23] The fairly high standard deviation and the wide range in Z-scores suggest that there is considerable cross-sectional variation in the level of bank risk.

[22]Some papers have used the transformation ln(1+Z-score) to avoid truncating the dependent variable at zero. Following Beck et al. (2013), we take the natural logarithm after winsorizing the data at the 1% level. As none of the Z-scores is lower than zero after winsorizing, this approach is similar, save for a rescaling, to the former approach and winsorizing after the transformation.

[23]These summary statistics are similar to those reported by Beck et al. (2011) – looking at a larger sample of more than 80,000 bank-year observations in 79 countries from 1994 to 2009 they report a mean of 4.0057 and a standard deviation of 1.3178, and also to the one by Houston et al. (2010) –a sample of 2,386 banks in 69 countries they report a mean of 3.24.

In regression (4), we also include country and time fixed effects$\nu_i$and σ_t, to control for omitted or unobservable country-specific and time-specific variables by capturing the maximum extent of unobservable heterogeneity, following Beck et al. (2013). We also control for several bank-level factors that the literature has shown to predict financial fragility, including the bank's market share in total deposits, growth in revenue, the loan to asset ratio and the ratio of non-loan earning assets to the sum of loan and other earning assets to control for banks' business models, the tier 1 capital to asset ratio, and a too-big-to-fail proxy (a dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%). We include two measure of markets structures, namely the Herfindahl index (HHI) and the share of foreign-owned banks, where the latter allows us to control for the spillover effects of financial innovation from one country to another. We also control for several regulatory variables that might be related with banks' risk-taking decisions and thus fragility, including restrictions on banks' activities, requirementson entry into banking, official supervisory power, a tight capital regulation dummy and an index of financial statement transparency, all from the first three waves of the Barth, Caprio and Levine (2008) Bank Regulation and Supervision Database.[24] Although we control for an array of country characteristics, the stability of individual banks within a country might be driven by an omitted factor or might be otherwise correlated with each other. We therefore allow for clustering, i.e. we relax the restrictions that the error terms of banks within a country and period are independent of each other, following Petersen (2009). A negative and statistically significant coefficient estimate γ would be evidence in favor of the innovation-fragility view, suggesting that an increase in financial innovation within a country is related to increased bank fragility, controlling for other time-varying bank and country-level factors. A positive and statistically significant γ, on the other hand, would suggest that a higher level of financial innovation is associated with more stable banking.

Whileweuse OLS for our baseline regressions, we address the problem of omitted

[24] Specifically, the values of regulation and foreign bank ownership variables for the period of 1996 to 1999 are taken from the first survey recorded in 1998/1999. The values for the period of 2000 to 2003 are taken from the second survey that assesses the state of regulation as of the end of 2002, and the measures for the period of 2004 to 2006 are taken from the third survey that was recorded in 2005/2006.

variable bias by interacting our country-level indicators of financial innovation with bank characteristics. In other words, we explore whether the relationship between financial innovation and bank fragility is particularly strong for some specific types of banks. First, we gauge the effect of financial innovations on bank fragility across heterogeneous bank sizes and market power and interact *Bank Market Share* with financial R&D intensity. On the one hand, banks with dominant market positions might be more tempted to translate higher financial innovation into more risk-taking, exploiting their market power. On the other hand, smaller banks might be more affected by risk-taking following from financial innovation, given the lack of risk diversification possibilities. Second, we interact *Bank Growth* with financial R&D intensity (*Value Added*), as the effect of financial innovations on risk taking and fragility should be more pronounced for high growth banks. Thirdly, we interact *Loan-Asset Ratio*with financial R&D intensity (*Value Added*) to explore whether the effect of financial innovation on bank [25]fragility is more or less pronounced for banks with higher loan to asset ratios. Banks with higher loan to asset ratios are banks with a smaller portfolio of securities. As widely discussed in the recent literature, many of the securities (e.g. CDOs) are products of financial innovation. In the presence of more credit-risky securities, we therefore expect a stronger effect of financial innovation on bank fragility for banks with lower loan-asset-ratios.

The results in Table 6 show that banks in countries with higher levels of financial innovation are closer to insolvency, thus providing evidence for the innovation-fragility hypothesis. All three indicators of financial innovation – *Financial R&D Intensity (Value Added), Financial R&D Intensity (Cost)* and *log(Off-Balance Sheet Items)* - enter negatively and significantly at least at the 5% level. The effect is not only statistically significant but also economically meaningful. For instance, as shown in column 1, a one standard deviation increase in *Financial R&D Intensity (Value Added)* is associated with a reduction in Z-scores of about 23% (=-0.615*0.39).

[25] In robustness tests, reported in Appendix Table A4, we confirm our finding, using only two sub-periods of six years each.

Turning to bank- and country-level control variables, we find banks with higher loan-asset ratios, higher revenue growth, higher Tier 1 capital ratios, high non-lending earning assets and too-big-to-fail status have higher z-scores. On the other hand, banks in countries with tighter capital regulation and higher financial transparency have lower Z-scores.[26]

[Table 6 here]

The results in columns 4 to 7 of Table 6 show that the relationship between financial innovation and banks' Z-score is stronger for banks with smaller market shares and higher loan-asset ratios. Since we include country-year fixed effects, the financial innovation measures are not included by themselves, but just in interaction with the bank characteristics. Including such country-year fixed effects thus allows controlling for omitted variables that vary over time on the country-level. As shown in column 4, the interaction term between market share and financial innovation enters the regression significantly at 1% level and shows a positive effect, indicating that the negative relationship between financial innovation and banks' z-score decreases in size. Consistent with our expectation, we find that the relationship between financial innovation and fragility is less pronounced for banks with high loan-asset ratios (column 6). The interaction between banks' revenue growth and financial innovation, on the other hand, does not enter significantly (column 5). Our findings are confirmed when we include all three interactions terms simultaneously in column 7. All in all, the results in Table 6 are consistent with the innovation-fragility hypothesis and show that the effect of financial innovation on fragility is stronger for smaller banks and banks that focus less on traditional intermediation.

The Table 7 results document that as in the case of the relationship between financial innovation and real sector growth, there are important differential effects across countries

[26]In sensitivity analyses, available on request, we also test for the robustness of these findings to endogeneity by using instrumental variables. Specifically, we try two instruments: 1) genetic distance of the country to US, as used in Spolaore and Wacziarg (2009), and 2) neighbor-country financial innovation, and the results are robust and consistent.

with different financial structures and regulatory policies and market structures. The results in Table 7 Panel A show that the fragility enhancing effect of financial innovation is driven by the experience of market-based financial systems. Here we split the sample as in Table 4 into countries below and above the median of our financial structure gauge (Stock Market Value Traded to Bank Credit) and re-run the regressions for the two sub-samples. While all three indicators of financial innovation enter negatively across both sub-samples, the coefficient estimates are only significant in the sub-sample of market-based financial systems. This is consistent with the industry growth regressions of Table 4, suggesting that both the benefits and risks of financial innovation fall more heavily on market-based financial systems.

[Table 7 here]

The results in Panel B of Tables 7 show that – consistent with Table 5 Panel C – the fragility implications of higher financial innovation are stronger in countries with higher bank competition and higher capital stringency. When splitting the sample according to banks' activity restrictions, we find negative and significant coefficients in both sub-samples, but a larger coefficient size for countries with high activity restrictions. Similarly, we find a stronger link between financial innovation and bank risk taking in countries with more stringent capital regulation. As stringent regulation and activity restrictions generate incentives for regulatory arbitrage, the evidence suggests that the financial innovation caused by regulatory arbitrage motive (i.e. to get around with the stringent regulation) might result in higher levels of financial instability. Taken together, both the bright and dark sides of financial innovation are thus concentrated in countries with more market-based and competitive financial systems and more stringent regulatory frameworks.

4.2.Did financial innovation hurt banks during the global crisis?

In two final tests of the innovation-fragility hypothesis, we gauge the relationship between banks' profitability during the recent crisis and the intensity of financial innovation before the crisis. First, we regress the difference in ROA between 2008 and 2006 on financial innovation in 2006 to assess whether banks in countries with higher average levels of financial innovation in the banking sector were affected more negatively during the first year of the global financial crisis. Specifically, we run the following regression

$$\Delta R_{i,k} = \alpha X_k + \beta Y_{i,} + \gamma FI_i + \varepsilon_{i,k}, \qquad (5)$$

where R is ROA and the right-hand side variables are taken for 2006. A negative sign on γ would indicate that banks in countries with higher levels of financial innovation suffered more during the global financial crisis, consistent with the innovation-fragility hypothesis. This regression set-up does not only allow us to gauge the effects of financial innovation on bank performance during the crisis, but can also be seen as a way to overcome the identification challenge in the panel regressions of the previous section, with the financial crisis serving as shock exogenous to individual banks. Unlike in the previous specifications, we will also use two additional indicators of financial innovation, (i) the log of the number of reference entities holding CDS and (ii) the log of total ABCP outstanding.

We use a bank-level panel to assess the relationship between pre-crisis financial innovation and changes in banks' profitability between 2006 and 2008. Descriptive statistics for this sample of 1,536 banks across 32 countries are reported in Panel E of Table 2. On average, banks' ROA dropped by 1.2% between 2006 and 2008.

The results in Table 8 Panel A suggest that higher pre-crisis financial innovation is associated with higher drops in profitability during 2008. All five indicators of financial innovation enter negatively in the regressions of changes in ROA and significantly at least at the 5% level. The economic effect of this relationship is also large. Taking the Column1 estimate, for example, it suggests that a one standard deviation in *Financial R&D Intensity (Value Added)* is associated with a 0.5 percentage point drop in ROA, compared to average drops of 1.2 percentage point in ROA.

[Table8 here]

The Panel B regressions of Table 8 show that the performance dampening effect of financial innovation was, in general, more significant in market-based financial systems. As in previous specifications, we split the sample into market- and bank-based financial systems. Across the five measures of financial innovation, we find a negative and significant relationship of bank performance during the crisis in market-based but not in bank-based financial systems. Somewhat surprisingly, we find a positive and significant relationship of bank performance with financial innovation, as measured by the number of reference entities holding CDS in bank-based financial systems.

A second test of the impact of pre-crisis financial innovation on banks' crisis performance builds on work by Beltratti and Stulz (2012). Specifically, they regress the buy-and-hold stock return over the crisis period from July 2007 to December 2008 on an array of bank and country characteristics. We follow their methodology with a larger sample of banks and include our measures of financial innovation to gauge whether banks in countries with higher levels of financial innovation performed worse during the crisis. We include a similar set of same bank- and country-level variables as Beltratti and Stulz (2012), though use a larger sample. Specifically, we include 487 banks in Bankscope with returns available from Datastream, with a loan-to-assets ratio larger than 10% and a deposit-to-assets ratio larger than 20%. Bank characteristics are computed using data from 2006 and thus prior to the beginning of the financial crisis, while the financial innovation measures are averaged over the available years before 2007.

The results in Table 9 suggest that banks in countries with a higher level of financial innovation pre-crisis had lower buy-and-hold returns during the crisis. All five measures of financial innovation enter negatively and significantly at least at the 5% level. We also find that banks that rely more on deposits for funding, higher z-scores, higher diversity in interest- and non-interest income, a higher share of non-lending assets and a lower Tier 1 capital ratio have higher buy-and hold stock returns. Banks with a lower pre-crisis beta (defined as the

slope of the regression of weekly excess stock returns on the MSCI World excess return for the period 2004–2006) and a higher real estate beta (defined as the slope of the regression of weekly excess stock returns on the Fama and French real estate industry excess return in a regression that controls for the MSCI World excess return for the period 2004–2006) and thus exposure to U.S. mortgage market have higher buy-and hold stock returns during the crisis.

[Table 9 here]

In a final test whether our findings in this section are not driven by omitted variable bias, we replace the financial innovation indicator with R&D intensity in manufacturing as a placebo test. If our indicator of financial innovation reflects a general attitude towards risk-taking in society and the findings in this section are thus driven by a spurious correlation, the indicator of R&D intensity in manufacturing should also enter negatively and significantly. This test is biased in favor of this hypothesis as R&D intensity in manufacturing is positively and significantly correlated with Financial R&D intensity, as discussed earlier.

The results in Appendix Table A3 show that Financial R&D intensity does not proxy for general innovative attitude in the economy. Here, we replicate the regressions of the Z-score for the panel of Table 6 and the regressions of change in ROA and change in ROE for the panel of Table 9. R&D intensity in manufacturing enters positively and insignificantly in the Z-score regressions. Similarly, it also enters positivelyand insignificantly in the regressions of the changes in ROA and ROE from 2008 to 2006. Thus all ofthe results have a sign opposite to those in Tables 6 and 9. Overall, these findings provide additional evidence that the relationship between financial innovation and bank fragility is not driven by a spurious correlation.

5. What Explains Cross-country Variation in Financial Innovation?

So far we have gauged the real and financial sector consequences of financial innovation. But what explains the cross-country variation in financial innovation? While we want to

leave a more rigorous analysis of the determinants of financial innovation for future work, Table 10 presents exploratory OLS regressions, relating country-time variation in *Financial R&D Intensity (Value Added)* to an array of country characteristics, including many that we used as control variables in previous tables. In column 7, we use our alternative indicator of financial innovation - *Financial R&D Intensity (Cost)* – and confirm most of the findings, described in the following.

[Table 10 here]

The regressions in Table 10 show that cross-country and over time variation in financial innovation is associated with different features of the regulatory framework, the ownership structure, financial structure, monetary stability and income levels. Specifically, we find higher levels of financial innovation in countries with higher restrictions on banks' activities, with less powerful supervisors, but higher capital stringency and lower accounting standards. Overall, this provides some evidence that banks in countries with more stringent regulation on capital requirements and activities restrictions are more likely to conduct financial innovation to get around the regulatory constraints. Banks are also more likely to innovate in countries with weak supervisors and higher informational opacity. While not all of these regulatory indicators enter consistently across all specifications, the share of government-owned enters negatively and highly significantly in all regressions, suggesting that – for better or worse – financial innovation is associated with private bank ownership. While the intensity of financial innovation does not vary with the level of banking sector development (as proxied by Private Credit to GDP) and market structure (as proxied by the Herfindahl index and its square), we find a positive relationship between stock market development and financial innovation. This relationship turns insignificant, however, once we control for financial structure, i.e. the degree to which a financial system is market-based. Maybe surprisingly, we find a negative association of financial innovation with income levels, while there is positive relationship with inflation, though this variable does not enter

significantly in all regressions. We also find some evidence that financial innovation is lower in countries with higher growth volatility and in countries and years of recession. We cannot find any significant relationship of financial innovation with growth opportunities.

In summary, this exploratory work of time-variant country characteristics that can explain cross-country over-time variation in financial innovation shows that economies with a higher share of privately-owned banks, more market-based financial systems and stronger regulatory restrictions experience higher levels of financial innovation. Lower transparency and weaker supervisors are also associated with higher financial innovation. Economic factors, such as growth opportunities and business cycle play less of a role in explaining variation in financial innovation, which is reassuring in terms of reverse causation concerns raised above. The fact that that some of the same characteristics that make a country more or less susceptible to the benefits and costs of financial innovation also explain why banks in this country invest more in financial innovation shows the importance of a differentiated and context-specific regulatory approach towards financial innovation.

6. Conclusions

The recent Global Financial Crisis has spurred renewed debates on the "bright" and "dark" sides of financial innovation. Despite its crucial importance and the continuing debate, however, there is a striking paucity in the empirical study of financial innovation and its effect on financial fragility and economic development. Using bank-, industry- and country-level data in 32 countries over the last decade, this paper is the first to explicitly assess the empirical relationshipbetween financial innovation and banks' risk taking and fragility as well as real sector growth and volatility.

We find supportive evidence for both the *innovation-growth* and the *innovation-fragility* views. In support of the *innovation-growth view*, we find that a higher level of financial innovation is associated with a stronger relationship between a country's growth opportunities and GDP per capita growth and with higher growth of industries that rely more on external financing and depend more on R&D activity. In support of the

innovation-fragility view, we find that a higher level of financial innovation is associated with higher growth volatility among industries that rely more on external financing and depend more on R&D activity and with higher bank fragility. In addition, banks in countries with higher pre-crisis levels of financial innovation experienced larger drops in ROA between 2006 and 2008 and lower stock returns during the crisis. We also find that these findings are driven by countries with market-based financial systems, more restrictive regulatory systems and more competitive banking systems. At the same time, we also find that financial innovative activity is higher in countries that rely more on market finance and have more restrictive regulatory regimes.

Overall, our results suggest that there are both "bright" and "dark" sides to financial innovation. Financial innovation appears to encourage banks to take on more risks, which helps provide valuable credit and risk diversification services to firms and households, which in turnenhances capital allocation efficiency and economic growth. On the downside, the "dark" side of greater risk taking is that it significantly increases the bank profit volatility and their lossesduring a banking crisis, which translates into higher volatility in industries that also benefit more from financial innovation.

References:

Abiad, Abdul, Enrica Detragiache, and Thierry Tressel, 2010. A new database of financial reforms.*IMF Staff Papers* 57, 281–302.

Abiad, A., Mody, A., 2005. Financial reform: What shakes it? What shapes it? *American Economic Review* 95, 66-88

Acharya, Viral V., Philipp Schnabl, and Gustavo Suarez, 2013. Securitization without risk transfer.*Journal of Financial Economics* 107, 515-536.

Acharya, Viral V., Paul Wachtel, and Ingro Walter, 2009. International Alignment of Financial Sector Regulation, in "*Restoring Financial Stability: How to Repair a Failed System*", edited by Viral V. Acharya and Matthew Richardson, New York University Stern School of Business, John Wiley & Sons, March 2009.

Aghion, Philippe, Peter Howitt, and David Mayer-Foulkes, 2005. The effect of financial development on convergence: Theory and evidence. *Quarterly Journal of Economics* 120, 173-222.

Aghion, Philippe, Philippe Bacchetta, Romain Ranciere and Kenneth Rogoff. 2009. Exchange rate volatility and productivity growth: Therole of financial development. *Journal of Monetary Economics* 56, 494-513.

Aghion, Philippe, Marios Angeletos, Abhijit Banerjee and Kalina Manova. 2010. Volatility and growth: Credit constraints and the composition of growth. *Journal of Monetary Economics* 57, 246-65.

Akhavein, Jalal, W. Scott Frame, and Lawrence J. White, 2005. The diffusion of financial innovations: An examination of the adoption of small business credit scoring by large banking organizations. *The Journal of Business* 78, 577-596.

Allen,Franklin, and Carletti, Elena, 2006. Credit risk transfer and contagion. *Journal of Monetary Economics* 53, 89-111

Allen, Franklin and Gale, Douglas, 1991. Arbitrage, short sales and financial innovation. *Econometrica* 59, 1041-1068.

Allen, Franklin and Gale, Douglas, 1994. *Financial Innovation and Risk Sharing.*MIT Press, Cambridge, MA.

Arcand, Jean-Louis, Berkes, Enrico and Panizza, Ugo, 2012. Too much finance?. IMF Working Paper No. 12/161.

Barth, James R., Caprio, Gerard Jr., Levine, Ross, 2001. Bank regulation and supervision: anew database, in Robert Litan and Richard Herring, eds., Brookings-Wharton Papers on Financial Services, 2001.

Barth, James R., Caprio, Gerard Jr., Levine, Ross, 2006. *Rethinking Bank Regulation: Till Angels Govern.* Cambridge University Press

Barth, James R., Caprio, Gerard Jr., Levine, Ross, 2008. Bank regulations are changing: for better or worse? World Bank Research Working papers, December 2008.

Basu, S., Inklaar, R. & C. Wang, 2011. The value of risk: Measuring the services of U.S. commercial banks, *Economic Inquiry*, 49(1), 226-245.

Beck, Thorsten, Olivier De Jonghe, and Glenn Schepens, 2013. Bank competition and stability: Cross-country heterogeneity, *Journal of Financial Intermediation*, forthcoming.

Beck, Thorsten, Demirgüç-Kunt A., and Levine R., 2000. A new database on financial development and structure. *World Bank Economic Review* 14, 597-605.

Beck Thorsten, Mattias Lundberg and Giovanni, Majnoni, 2006. Financial intermediary development and growth volatility: Do intermediaries dampen or magnify shocks. *Journal of International Money and Finance* 25,1146-67.

Beck, Thorsten and Ross Levine, 2002. Industry growth and capital allocation: does having a market- or bank-based system matter? *Journal of Financial Economics* 64,147-180.

Bekaert, Geert, Campbell R. Harvey, Christian Lundblad, 2005. Does financial liberalization spur growth? *Journal of Financial Economics* 77, 3-55.

Bekaert, Geert, Campbell R. Harvey, Christian Lundblad, and Stephan Siegel, 2007. Global growth opportunities and market integration, *Journal of Finance* 62, 1081-1137.

Beltratti, Andrea, and René M. Stulz, 2012. The credit crisis around the globe: Why did some banks perform better? *Journal of Financial Economics* 105, 1-17.

Berger, Allen N., 2003. The economic effects of technological progress: evidence from the banking industry. *Journal of Money, Credit and Banking*, 35,. 141-176.

Boot Arnould and Anjan Thakor, 1997. Banking scope and financial innovation. *Review of Financial Studies* 10, 1099-1131.

Boyd, John H., Gianni De Nicolo, and Abu Al Jalal, 2006. Bank risk taking and competitionrevisited: new theory and new evidence. IMF Working Paper No. 297.

Braun, M., Larrain, B., 2005. Finance and the business cycle: International, inter-industry evidence. *Journal of Finance* 60, 1097-1128

Brunnermeier, Markus K., 2009. Deciphering the liquidity and credit crunch 2007-2008.*Journal of Economic Perspectives* 23, 77-100.

Cohen,W.M., Klepper, S., 1996. Firm size and the nature of innovation within industries:the case of process and product R&D. *Review of Economics and Statistics* 78,232 – 243.

Dell'Ariccia, G., I. Deniz, and L. A. Laeven. 2008. Credit booms and lending standards: evidence from the subprime mortgage market. Working Paper, International Monetary Fund.

Demirgüç-Kunt, Asli and Huizinga, Harry, 2010. Bank activity and funding strategies: the impact on risk and returns. *Journal of Financial Economics* 98, 626-50.

DeYoung, Robert., 2001. The financial performance of pure play internet banks.*Econ. Perspect.* Fed. Reserve Bank Chicago 25: First Quarter, pp. 60-75.

DeYoung, Robert, 2005. The performance of internet-based business models: evidence from thebanking industry, *Journal of Business* 78, 893-947.

Djankov, S., McLiesh, C., Shleifer, A., 2007. Private credit in 129 countries. *Journal of Financial Economics* 84, 299-329.

Duffie, D. and R. Rahi, 1995. Financial market innovation and security design: an introduction. *Journal of Economic Theory* 65, 1-42.

Dynan Karen E., Elmendorf Douglas W. and Sichel Daniel E., 2006. Can financial innovation help to explain the reduced volatility of economic activity? *Journal of Monetary Economics* 53, 123-150.

Elul, R., 1995. Welfare effects of financial innovation in incomplete markets economies with several consumption goods. *Journal of Economic Theory* 65:43- 78.

Frame W. Scott and White Lawrence J., 2004. Empirical studies of financial innovation: lots of talk, little action? *Journal of Economic Literature* 42, 116-144

Frame W. Scott and White Lawrence J., 2009. Technological change, financial innovation, and diffusion in banking. Federal Reserve Bank of Atlanta working paper 2009-10. March 2009.

Gennaioli, Nicola, Andrei Shleifer, and Robert Vishny, 2012. Neglected risks, financial innovation, and financial fragility. *Journal of Financial Economics* 104, 452-468.

Graham, J. R., Li, S., Qiu, J., 2008. Corporate misreporting and bank loan contracting. *Journal of Financial Economics* 88, 44–61.

Grinblatt, Mark, and Longstaff Francis A., 2000. Financial innovation and the role of derivative securities: An empirical analysis of the Treasury STRIPS program. *Journal of Finance* 55, 1415-1436.

Helpman, E., 1993. Innovation, imitation, and intellectual property rights. *Econometrica* 61, 1247 ‐ 1280.

Henderson, B. J. and Pearson, N. D., 2011. The dark side of financial innovation: acase study of the pricing of a retail financial product. *Journal of Financial Economics* 100, 227-47.

Houston, Joel, Christopher James, 1995. CEO compensation and bank risk: Is compensation in banking structured to promote risk taking? *Journal of Monetary Economics* 36, 405-431.

Houston, Joel, Chen Lin, Ping Lin, and Yue Ma, 2010. Creditor rights, information sharing, and bank risk taking. *Journal of Financial Economics* 96, 485-512.

Houston, Joel, Chen Lin and Yue Ma, 2011. Regulatory arbitrage and international bank flows. *Journal of Finance*, forthcoming.

Huizinga, Harry & Laeven, Luc & Nicodeme, Gaetan, 2008. Capital structure and international debt shifting. *Journal of Financial Economics* 88, 80-118.

Johnson S. and Kwak J., 2010. *13 Bankers: The Wall Street Takeover and the Next Financial Meltdown.* Pantheon Books, New York.

Keys, B.J., Mukherjee, T., Seru, A., Vig, V., 2010. Did securitization lead to lax screening? Evidence from subprime loans. *Quarterly Journal of Economics* 125, 307-362.

Kroszner, Randall, Luc Laeven, and Daniela Klingebiel, 2007. Banking crises, financial dependence, and growth, *Journal of Financial Economics* 84, 187–228.

La Porta, R., López de Silanes, F., Shleifer, A., Vishny, R., 1999. The quality of government. *Journal of Law, Economics & Organization* 15, 222-279.

LaPorta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer, 2006. What works in securities laws?, *Journal of Finance* 61, 1-32.

La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer, 2008. The economic consequences of legal origins. *Journal of Economic Literature* 46, 285–332.

Laeven, Luc and Ross Levine, 2009. Bank governance, regulation and risk taking. *Journal of Financial Economics* 93,259-75.

Laeven, Luc, Ross Levine, and Stelios Michalopoulos, 2011, Financial innovation and endogenous growth. Mimeo

Larrain,Borga, 2006. Do banks affect the level and composition of industrial volatility? *Journal of Finance* 61, 1897-1925.

Lerner, Josh and Peter Tufano, 2011. The consequences of financial innovation: a counterfactual research agenda, *Annual Review of Financial Economics* 3, 41-85.

Levine, Ross, 2005. Finance and growth: Theory and evidence. In Aghion, P., and Durlauf, S., (Eds.), *Handbook of Economic Growth.* Amsterdam: North-Holland Elsevier Publishers.

Merton, Robert C., 1992. Financial innovation and economic performance. *Journal of Applied Corporate Finance* 4, 12-22.

Miller, Merton H. 1986. Financial innovation: the last twenty years and the next. *Journal of Finance and Quantitative Analysis* 21, 459-71.

Miller, Merton H., 1992. Financial innovation: achievements and prospects. *Journal of Applied Corporate Finance* 4, 4-12.

Nadauld, Taylor, Weisbach, Michael., 2012. Did securitization affect the cost of corporate debt? *Journal of Financial Economics* 105, 332-352

OECD, 2011. *Bank Profitability: Financial Statements of Banks 2010*. OECD Publishing. Doi: 10.1787/bank_fin-2010-en-fr.

Petersen, Mitchell A., 2009. Estimating standard errors in finance panel data sets: Comparing approaches.*Review of Financial Studies* 22, 435-480.

Raddatz, Claudio, 2006. Liquidity needs and vulnerability to financial underdevelopment. *Journal of Financial Economics* 80, 677-722.

Rahi, Rohit, and Jean-Pierre Zigrand, 2009. Strategic financial innovation in segmented markets.*Review of Financial Studies* 22, 2941-2971.

Rajan, Raghuram G., 2006. Has finance made the world riskier? *European Financial Management* 12, 499-533.

Rajan, Raghuram, and Luigi Zingales 1998. Financial dependence and growth.*American Economic Review* 88, 559-586.

Rioja, Felix, and Neven Valev, 2004. Finance and the sources of growth at various stages of economic development. *Economic Inquiry* 42,127-140.

Rosen, Richard, 2007. The role of securitization in mortgage lending. Chicago Fed Letter, Federal Reserve Bank of Chicago.

Ross, Stephen A., 1976. Options and efficiency. *Quarterly Journal of Economics* 1, 75-89.

Ross, Stephen A., 1989. Institutional markets, financial marketing, and financial innovation. *Journal of Finance* 44, 541-556.

Roy Andrew D., 1952. Safety first and the holding of assets. *Econometrica* 20,431–49.

Schaeck, K., and M. Cihak, 2010.Competition, efficiency, and soundness in banking: an industrialorganization perspective. European Banking Center Discussion Paper No. 2010-20S.

Schroth, Enrique. 2003. Innovation, differentiation, and the choice of an underwriter: Evidence from equity-linked securities. Mimeo, HEC, U. Lausanne.

Shleifer, Andrei, and Robert W. Vishny. 2010. Unstable banking. *Journal of Financial Economics* 97, 306-318.

Silber William L., 1983. The process of financial innovation. *The American Economic Review* 73, 89-95.

Spolaore, Enrico, and Romain Wacziarg, 2009. The diffusion of development. *The Quarterly Journal of Economics* 124, 469-529.

Staiger, D. and Stock, J., 1997. Instrumental variables with weak instruments. *Econometrica* 65, 557–86.

Stein, Jeremy. 2010. Monetary policy as financial-stability regulation. Harvard University working paper.

Stock, J. H., Wright, J. H., & Yogo, M., 2002. A survey of weak instruments and weak identification in generalized method of moments. *Journal of Business and Economic Statistics* 20, 518–529.

Tufano, Peter, 2003. Financial innovation: the last 200 years and the next. In *The Handbook of the Economics of Finance*, edited by George M. Constantinides, Milton Harris and René M. Stulz. JAI Press, Inc., 2003.

Wagner, Wolf, 2007a. Financial development and the opacity of banks, *Economics Letters* 97, 6-10.

Wagner, Wolf, 2007b. The liquidity of bank assets and banking stability. *Journal of Banking and Finance* 31, 121-139.

Table 1
Variable definitions and data sources

Variable	Definition	Original Sources
Financial Innovation Measures		
Financial R&D Intensity (Value Added)	Banking industry's business enterprise R&D expenditure scaled by financial intermediation sector's total value added in the previous year in each country each year from 1996 to 2006 (reported in SourceOECD Statistics 2010). We further multiply by 100 to scale the estimated coefficients in our empirical results. The R&D data are presenting research and development expenditure statistics in financial intermediation industry collected from enterprise and bank surveys via the OECD/Eurostat International Survey of Resources Devoted to R&D from 32 nations in the world from 1996 to 2006. We complement the data by OECD Science, Technology and R&D Statistics for some missing data. R&D and related concepts follow internationally agreed standards defined by the Organization for Economic Cooperation and Development (OECD), published in the 'Frascati' Manual.	SourceOECD Statistics 2010
Financial R&D Intensity (Cost)	Banking industry's business enterprise research and development expenditure scaled by banking sector's total revenue in each country each year from 1996 to 2006. Operating cost refers to total non-interest expenses. The information is drawn from OECD Banking Statistics. For the missing values in some countries, we complement by the data from BankScope. Specifically, we aggregate all the banks' operating expenses for each country each year in BankScope. We further multiply Financial R&D Intensity by 100 to scale the estimated coefficients in our empirical results.	SourceOECD Statistics 2010, OECD Banking Statistics, BankScope
Log (Off-Balance-Sheet Items)	The natural logarithm of the total value of off-balance-sheet items among all the individual banks. The measure is aggregated for each country for the country-level measure.	BankScope
Log (# of Reference Entities Holding CDS)	The natural logarithm of the number of reference entities holding CDS for each country, averaged from 2001 to 2006.	Markit CDS database
Log (Total ABCP Outstanding)	The natural logarithm of the total value asset-backed commercial paper (ABCP) for each country, averaged from 2001 to 2006.	Acharya, Schnabl and Suarez (2013)
Exogenous Growth Opportunities Analysis Variables		
Annual Real GDP Growth (5-year horizon)	Growth of real per capita gross domestic product. Available for all countries from 1980 to 2007.	World Development Indicators (2010)
GGO_MA	We measure exogenous growth opportunities as GGO_MA, estimated similarly as in Bekaert et al. (2007). Specifically, GGO_MA is the log of the inner product of the vector of global industry PE ratios and the vector of country-specific industry weights, less a 60-month moving average. Country-specific industry weights are determined by relative equity market capitalization.	Datastream
Private Credit	Private credit divided by GDP.	Beck, Demirgüç-Kunt and Levine (2000), updated in 2008
Stock Market Cap	Value of listed shares to GDP.	Beck, Demirgüç-Kunt and Levine (2000), updated in 2008

Financial Liberalization	Financial liberalization is an indicator with one indicating financial reform takes place in the year in the country. Specifically, it takes a value of one when the change of financial liberalization index is larger than zero (Abiad et al., 2008). Financial liberalization index recognizes the multifaceted nature of financial reform and records financial policy changes along seven different dimensions: credit controls and reserve requirements, interest rate controls, entry barriers, state ownership, policies on securities markets, banking regulations, and restrictions on the financial account. Liberalization scores for each category are then combined in a graded index. The index ranges from 0 to 21, with a larger number indicating larger extent of financial liberalization. The index was introduced by Abiad and Mody (2005) and extended in Abiad et al. (2008). The extended version covers 91 economies over the period 1973–2005.	Abiad and Mody (2005), Abiad et al. (2008)
Industrial Level Analysis Variables		
Average Growth Rate in Real Value Added	The average growth rate in real value added for 1996-2006 for each industry in each country. The sample excludes the industrial sectors in the US, which serves as the benchmark (Rajan and Zingales, 1998).	UNIDO INDSTAT4, 2010
Growth Volatility in Real Value Added	The standard deviation of real value added growth for 1996-2006 for each industry in each country. The sample excludes the industrial sectors in the US, which serves as the benchmark (Rajan and Zingales, 1998).	UNIDO INDSTAT4, 2010
EFD	External Financial Dependence (EFD), firstly developed by Rajan and Zingales (1998), is the fraction of capital expenditures not financed with internal funds for U.S. firms in each three-digit ISIC industry between 1980 and 1990.	Rajan and Zingales (1998), Compustat
RDI	RDI is measured by the R&D intensity for U.S. firms in each four-digit ISIC industry. The calculation uses weighted-average (based on firm size) R&D intensity (calculated as R&D expenditures divided by total asset) of all the firms with non-missing R&D intensity in each four-digit ISIC industry.	Compustat
HHI	To control for competition we use a Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country, averaged over the period 1996 to 2006.	BankScope
Private Credit	Private credit divided by GDP.	Beck, Demirgüç-Kunt and Levine (2000), updated in 2008
Stock Market Cap	Value of listed shares to GDP.	Beck, Demirgüç-Kunt and Levine (2000), updated in 2008

Entry into Banking Requirements	The index is developed based on eight questions regarding whether various types of legal submission are required to obtain a banking license. Which of the following are legally required to be submitted before issuance of the banking license? (1) Draft by- laws? (2) Intended organization chart? (3) Financial projections for first three years? (4) Financial information on main potential shareholders? (5) Background/ experience of future directors? (6) Background/ experience of future managers? (7) Sources of funds to be disbursed in the capitalization of new bank? (8) Market differentiation intended for the new bank? The index ranges from zero (low entry requirement) to eight (high entry requirement). Higher values indicate greater stringency.	Barth, Caprio, and Levine (2001, 2006 and 2008)
Industry's Initial Share of Total Manufacturing VA	The industry's share of total value added in manufacturing in 1996 for each industry in each country, which corrects for base effects in industry growth.	UNIDO INDSTAT4, 2010
Financial Structure	Value Traded divided by GDP/ Bank Credit to GDP. A country is coded as market-based system if the value is larger than the sample median, and bank-based system otherwise.	Global Financial Development Database (GFDD)
Overall Activities Restrictions	The index measures the degree to which banks face regulatory restrictions on their activities in (a) securities markets, (b) insurance, (c) real-estate, and (d) owning shares in non-financial firms. For each of these four sub-categories, the value ranges from a 0 to 4, where a 4 indicates the most restrictive regulations on this sub-category of bank activity. Thus, the index of overall restrictions can potentially range from 0 to 16.	Barth, Caprio, and Levine (2001, 2006 and 2008)
Overall Capital Stringency	The index is constructed from seven variables that indicate whether the capital requirement reflects certain risk elements and deducts certain market value losses from capital adequacy is determined. For example, this measure takes into account whether the minimum capital-asset ratio requirement is in line with the Basel guidelines; whether the minimum ratio varies as a function of an individual bank's credit risk and market risk; and whether the market value of loan losses not realized in accounting books, unrealized losses in securities portfolios, and/or unrealized foreign exchange losses are deducted from the book value of capital. Higher values indicating greater stringency.	Barth, Caprio, and Levine (2001, 2006 and 2008)
Bank Level Analysis Variables		
Log Z-score	Equals to log of (ROA+CAR)/σ(ROA), where ROA=π/A is return on assets and CAR = E/A is capital-asset ratio, both over 1996-2007. σ(ROA) is the standard deviation of ROA over a four-year non-overlapping window across 1996-2007. Higher z implies more stability.	BankScope
σ(ROA)	Equals to the standard deviation of return on asset of a bank, computed over a four-year non-overlapping window from 1996 to 2007.	BankScope
Change in ROA	ROA change between 2008 and 2006, which is calculated as ROA_{2008} - $ROA_{2006.}$	BankScope
Buy-and-Hold Stock Returns July 2007-December 2008	Buy-and-hold stock for each bank over the period returns July 2007-December 2008.	Datastream, BankScope
Bank Market Share	The share of each bank's deposits to total deposits within a given country.	BankScope

Bank Growth	Total revenue growth rate of a bank.	BankScope
Loan to Asset Ratio	The ratio of loans to total assets.	BankScope
Tier 1 Capital Ratio	The ratio of tier 1 capital to total assets.	BankScope
Other Earnings Assets	The ratio between the sum of derivatives, other securities, and other remaining assets and the sum of loans and other earning assets.	BankScope
Too-big-to-fail	A dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%.	BankScope
HHI	To control for competition we use a Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country, over the period 1996 to 2007.	BankScope
Foreign Bank Ownership	The percentage of total shares held by the foreign country.	Barth, Caprio, and Levine (2006)
Overall Activities Restrictions	The index measures the degree to which banks face regulatory restrictions on their activities in (a) securities markets, (b) insurance, (c) real-estate, and (d) owning shares in non-financial firms. For each of these four sub-categories, the value ranges from a 0 to 4, where a 4 indicates the most restrictive regulations on this sub-category of bank activity. Thus, the index of overall restrictions can potentially range from 0 to 16.	Barth, Caprio, and Levine (2001, 2006 and 2008)
Official Supervisory Power	Principal component indicator of 14 dummy variables. The index measures the degree to which the country's commercial bank supervisory agency has the authority to take specific actions. It is composed of information on many features of official supervision based on the questions such as: 1. Does the supervisory agency have the right to meet with external auditors to discuss their report without the approval of the bank? 2. Are auditors required by law to communicate directly to the supervisory agency any presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse? 3. Can supervisors take legal action against external auditors for negligence? 4. Can the supervisory authority force a bank to change its internal organizational structure? 5. Are off-balance sheet items disclosed to supervisors? The index has a maximum value of 14 and a minimum value of 0, where larger numbers indicate greater power.	Barth, Caprio, and Levine (2001, 2006 and 2008)
Entry into Banking Requirements	The index is developed based on eight questions regarding whether various types of legal submission are required to obtain a banking license. Which of the following are legally required to be submitted before issuance of the banking license? (1) Draft by- laws? (2) Intended organization chart? (3) Financial projections for first three years? (4) Financial information on main potential shareholders? (5) Background/ experience of future directors? (6) Background/ experience of future managers? (7) Sources of funds to be disbursed in the capitalization of new bank? (8) Market differentiation intended for the new bank? The index ranges from zero (low entry requirement) to eight (high entry requirement). Higher values indicate greater stringency.	Barth, Caprio, and Levine (2001, 2006 and 2008)

Overall Capital Stringency	The index is constructed from seven variables that indicate whether the capital requirement reflects certain risk elements and deducts certain market value losses from capital adequacy is determined. For example, this measure takes into account whether the minimum capital-asset ratio requirement is in line with the Basel guidelines; whether the minimum ratio varies as a function of an individual bank's credit risk and market risk; and whether the market value of loan losses not realized in accounting books, unrealized losses in securities portfolios, and/or unrealized foreign exchange losses are deducted from the book value of capital. Higher values indicating greater stringency.	Barth, Caprio, andLevine (2001, 2006 and 2008)
Financial Statement Transparency	The transparency of bank financial statements practices. It includes the information on whether accrued, though unpaid, interest/principal enter the income statement; whether financial institutions are required to produce consolidated accounts covering all bank and any non-bank financial subsidiaries; whether off-balance sheet items are disclosed to the public; whether banks are required to disclose their risk management procedures to the public; and whether bank directors are legally liable if information disclosed is erroneous or misleading. Higher values indicate better transparency.	Barth, Caprio, and Levine (2001, 2006 and 2008)
Tangible Equity	Equity minus intangible assets whenever available or equity when intangible assets are not available divided by total assets.	BankScope
Deposits	Total deposits divided by total assets.	BankScope
Non-interest	The share of operating income not due to interest income.	BankScope
Income Diversity	One minus the absolute value of the ratio of the difference between net interest income and other operating income to total operating income.	BankScope
Beta	The slope of the regression of weekly excess stock returns on the MSCI World excess return for the period 2004–2006.	Datastream
Real Estate Beta	The slope of the regression of weekly excess stock returns on the Fama and French real estate industry excess return in a regression that controls for the MSCI World excess return for the period 2004–2006.	Datastream
Log GDP	Natural logarithm of the real GDP (US Dollars)	World Development Indicators (2010)
Log GDP Per Capita	Natural logarithm of GDP per capita (US Dollars)	World Development Indicators (2010)
GDP Growth Volatility	Standard deviation of growth rates in real GDP in the previous five years.	World Development Indicators (2010)

R&D Intensity in Manufacturing Industry (Placebo Test)	Manufacturing industry's business enterprise R&D expenditure scaled by manufacturing sector's total value added in the previous year in each country each year from 1996 to 2006 (reported in SourceOECD Statistics 2010). We further multiply by 100 to scale the estimated coefficients in our empirical results. The R&D data are presenting research and development expenditure statistics in manufacturing industry collected from enterprise surveys via the OECD/Eurostat International Survey of Resources Devoted to R&D from 32 nations in the world from 1996 to 2006. We complement the data by OECD Science, Technology and R&D Statistics for some missing data. R&D and related concepts follow internationally agreed standards defined by the Organization for Economic Cooperation and Development (OECD), published in the 'Frascati' Manual.	SourceOECD Statistics 2010

Table 2
Summary statistics

Panel A. Measures of financial innovation

Variable	Mean	Standard Deviation	Min	Max	No. of Countries	No. of Obs.
Financial R&D Intensity (Value Added), 1996-2006	0.329%	0.392%	0	1.813%	32	345
Financial R&D Intensity (Cost), 1996-2006	1.179%	2.759%	0	15.833%	32	352
Log (Off-Balance-Sheet Items), 1996-2006	12.544	1.209	10.419	15.442	32	346
Log (# of Reference Entities Holding CDS), 2001-2006	2.501	1.614	0	7.139	32	189
Log (Total ABCP Outstanding, in US$ millions), 2001-2006	9.536	1.788	4.331	12.630	16	102

Panel B. Exogenous growth opportunity analysis 1997-2007

Variable	Mean	Standard Deviation	Min	Max	No. of Countries	No. of Obs.
Annual Real GDP Growth (5-year horizon)	0.017	0.021	-0.021	0.084	31	217
Annual Real Investment Growth (5-year horizon)	0.040	0.040	-0.046	0.176	31	207
GGO_MA	0.094	0.427	-0.395	2.785	31	217
Private Credit	0.920	0.504	0.093	2.114	32	204
Stock Market Cap	0.732	0.574	0.020	3.034	31	191
Financial Liberalization	0.187	0.391	0	1	32	203

Note: The 31 countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

Panel C. Industrial growth and volatility analysis 1996-2006

Variable	Mean	Standard Deviation	Min	Max	No. of Countries	No. of Obs.
Average Growth Rate in Real Value Added	0.047%	11.516%	-40.104%	50.988%	28	735
Growth Volatility in Real Value Added	23.734%	25.969%	5.368%	196.629%	28	734
EFD	0.343	0.397	-0.450	1.490	28	751
RDI	0.031	0.025	0.002	0.109	28	1,134
Private Credit	0.920	0.504	0.093	2.114	28	1,134
Stock Market Cap	0.732	0.574	0.020	3.034	28	1,134
HHI	0.370	0.232	0.121	0.878	28	1,134
Entry into Banking Requirements	7.413	0.888	4.091	8.000	28	1,134
Industry's Initial Share of Total Manufacturing VA	0.023	0.022	0.000	0.101	28	1,134

Note: The 28 countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Singapore, South Africa, Spain, Sweden, Turkey, and United Kingdom.

Panel D. Bank risk taking analysis 1996-2007 (three four-year periods)

Variable	Mean	Standard Deviation	Min	Max	No. of Countries	No. of Obs. (Bank-time)
Bank Level Data						
Log z-score	3.722	1.034	1.252	6.061	32	6,065
ROA	0.010	0.008	-0.063	0.102	32	6,065
σ(ROA)	0.576	0.672	0.006	7.634	32	6,065
Too-big-to-fail	0.041	0.192	0	1	32	6,061
Tier 1 Captial Ratio	0.086	0.038	0.026	0.321		6,065
Bank Market Share	0.011	0.042	4.780E-06	0.266	32	6,061
Bank Growth	0.089	0.313	-1	1	32	6,065
Loan to Asset Ratio	0.642	0.146	0.043	0.944	32	6,063
Country Level Data						
Overall Activities Restrictions	7.845	1.037	3	10	32	6,065
Official Supervisory Power	12.711	1.891	5.333	14.5	32	6,065
Entry into Banking Requirements	7.769	0.391	6	8	32	6,065
Overall Capital Stringency	4.457	0.782	1	7	32	6,047
Financial Statement Transparency	5.010	0.339	3	6	32	6,065
HHI	0.049	0.069	0.019	0.762	32	6,065
Information Sharing	0.983	0.127	0	1	32	6,065
Log GDP Per Capita	10.397	0.429	7.777	10.778	32	6,065
Log GDP	29.422	1.266	24.703	30.151	32	6,065
Foreign Bank Ownership	0.143	0.105	0.000	0.888	32	6,065
R&D Intensity in Manufacturing Industry (Placebo Test)	0.082	0.020	0.005	0.132	32	5,853

Note: The 32 countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

Panel E. Bank performance change during crisis period analysis

Variable	Mean	Standard Deviation	Min	Max	No. of Countries	No. of Obs. (Bank-time)
Bank Level Data						
Change in ROA (ROA_{2008} - ROA_{2006})	-0.012	0.026	-0.212	0.032	32	1,536
Buy-and-Hold Stock Returns July 2007-December 2008	-0.420	0.289	-0.975	0.528	20	487
Bank growth	0.168	0.458	-0.986	0.992	32	1,537
Too-big-to-fail	0.056	0.230	0	1	32	1,537
Bank Market Share	0.018	0.050	0	0.531	32	1,537
Loan to Asset Ratio	0.604	0.227	-0.004	0.990	32	1,537
Country Level Data						
Overall Activities Restrictions	6.881	1.769	3.273	9.727	32	1,537
Official Supervisory Power	11.119	2.338	6.364	14.136	32	1,537
Entry into Banking Requirements	7.494	0.675	4.091	8.000	32	1,537
Capital Regulatory Index	6.641	1.191	3.273	9.636	32	1537
Financial Statement Transparency	4.984	0.571	3.636	6	32	1,537
HHI	0.098	0.063	0.045	0.275	32	1,537
Log GDP Per Capita	10.071	0.726	7.758	10.697	32	1,537
Log GDP	28.100	1.593	24.667	29.946	32	1,537
Foreign Bank Ownership	0.143	0.105	0	0.888	32	1,537
R&D Intensity in Manufacturing Industry (Placebo Test)	28.100	1.593	24.667	29.946	32	1,196

Note: The 32 countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

Table 3
Exogenous growth opportunities and financial innovation in predicting growth

The sample includes 31 countries between 1997 and 2007. The dependent variables are either the 5-year average growth rate of real per capita gross domestic product or investment. 5-year average is used to minimize the influence of higher frequency business cycles in our sample. We maximize the time-series content of our estimates by using overlapping 5-year periods. Our measures of financial innovation are lagged by three years relative to the dependent variables. We measure exogenous growth opportunities as GGO_MA, estimated similarly as in Bekaert et al. (2007). Specifically, GGO_MA is the log of the inner product of the vector of global industry PE ratios and the vector of country-specific industry weights, less a 60-month moving average. Country-specific industry weights are determined by relative equity market capitalization. Data to construct these measures come from Datastream. Financial liberalization is an indicator with one indicating financial reform takes place in the year in the country. Specifically, it takes a value of one when the change of financial liberalization index is larger than zero (Abiad et al., 2008). Financial liberalization index recognizes the multifaceted nature of financial reform andrecords financial policy changes along seven different dimensions: creditcontrols and reserve requirements, interest rate controls, entry barriers, stateownership, policies on securities markets, banking regulations, andrestrictions on the financial account. Liberalization scores for eachcategory are then combined in a graded index. The index ranges from 0 to 21, with a larger number indicating larger extent of financial liberalization. The index covers 91 economies over the period 1973 – 2005. Private credit is a log of private credit divided by GDP. Detailed variable definitions and descriptions can be found in Table 1. We include in the regressions, but do not report, country fixed effects. We report the coefficient on the growth opportunities measure and interaction terms with two measures of financial R&D intensity, private credit/GDP, stock market cap/GDP, and financial liberalization.Observations denote the number of country-years. Heteroskedasticity-robust standard errors double-clustering within countries and years are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

	Annual Real GDP Growth (5-Year Horizon)			
	Model 1	Model 2	Model 3	Model 4
GGO_MA	0.009	0.009	0.007	0.005
	[0.009]	[0.009]	[0.009]	[0.007]
GGO_MA × Financial R&D Intensity (Value Added)	0.021***	0.021**		
	[0.006]	[0.009]		
GGO_MA × Financial R&D Intensity (Cost)			0.004*	
			[0.002]	
GGO_MA × Log (Off-Balance-Sheet Items)				0.045**
				[0.022]
GGO_MA × Private Credit	-0.019	-0.021	-0.011	-0.011
	[0.011]	[0.018]	[0.016]	[0.014]
GGO_MA × Stock Market Cap		0.002	-0.008	-0.028
		[0.026]	[0.023]	[0.023]
GGO_MA × Financial Liberalization		0.000	0.002	0.005
		[0.004]	[0.003]	[0.004]
Financial R&D Intensity (Value Added)	0.017	0.017		
	[0.013]	[0.014]		
Financial R&D Intensity (Cost)			0.000	
			[0.002]	
Log (Off-Balance-Sheet Items)				-0.002
				[0.080]
Private Credit	-0.037***	-0.038***	-0.028**	-0.024*
	[0.012]	[0.013]	[0.013]	[0.014]
Stock Market Cap		-0.003	-0.001	-0.004
		[0.007]	[0.007]	[0.004]
Financial Liberalization		-0.000	-0.001	-0.001
		[0.003]	[0.003]	[0.006]
Counrty Fixed Effects	Yes	Yes		Yes
Observations	194	191	198	101
Adjusted R-squared	0.746	0.747	0.734	0.839

Table 4

Financial innovation and industry growth

The dependent variable is the average growth rate in real value added or growth in average size across 1996-2006 for each ISIC industry in each country, using the data from UNIDO INDSTAT4, 2010. The sample excludes the industrial sectors in the US, which serves as the benchmark (Rajan and Zingales, 1998). This table reports the impacts of financial R&D intensity on sectoral growth. Financial innovation is measured using the initial available value across 1996 to 2006. External Financial Dependence (EFD), firstly developed by Rajan and Zingales (1998), is the fraction of capital expenditures not financed with internal funds for U.S. firms in each three-digit ISIC industry between 1980 and 1990. R&D intensity (RDI)is measured bythe R&D intensity for U.S. firms in each four-digit ISIC industry.The calculation uses weighted-average (based on firm size) R&D intensity of all the firms with non-missing R&D intensity in each four-digit ISIC industry. Industry's Initial Share of Total Manufacturing VA is the industry's share of total value added in manufacturing in 1996, which corrects for base effects in industry growth. Private credit is private credit divided by GDP averaged over 1996 and 2006. Panel A reports the effects of financial innovation on industry growth. Panels B and C report the subsample analysis based on market-based vs. bank-based system, and other institutional factors, respectively. A country is coded as market-based system if the value of financial structure is larger than the sample median value, and bank-based system otherwise. Financial structure is calculated as Value Traded divided by GDP/ Bank Credit to GDP. Other institutional factors include anti-director rights and disclosure requirements (La Porta et al., 2006), overall activities restrictions, overall capital stringency, and competition. A country is placed into “More competition” subsample if its HHI is smaller than the sample median value, and “Less competition” subsample otherwise. A country is placed into “High” subsample if its anti-director rights, disclosure requirements, overall activities restrictions, or overall capital stringency is larger than the sample median value, and “Low” subsample otherwise. Detailed variable definitions and descriptions can be found in Table 1. Country and industry specific fixed effects are included in the regressions but not reported. All regressions are cross-sectional with one observation per industry in each country. The sample size is reduced in some models due to data limitation. Heteroskedasticity-robust standard errors clustering within countries are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Panel A. Financial innovation and industry growth

	Growth in Real Value Added					
	EFD ×			RDI ×		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EFD (or RDI) × Financial R&D Intensity (Value Added)	0.097**			2.143**		
	[0.040]			[1.093]		
EFD (or RDI) × Financial R&D Intensity (Cost)		0.022***			0.408*	
		[0.005]			[0.212]	
EFD (or RDI) × Log (Off-Balance-Sheet Items)			0.006			-0.043
			[0.012]			[0.137]
EFD (or RDI) × Private Credit	-0.010	-0.000	-0.010	-0.462	-0.483	-0.241
	[0.019]	[0.018]	[0.025]	[0.445]	[0.456]	[0.472]
EFD (or RDI) × Stock Market Cap	-0.030	-0.064*	-0.012	0.440	0.160	0.657
	[0.041]	[0.035]	[0.052]	[0.362]	[0.491]	[0.475]
EFD (or RDI) × HHI	-0.116**	-0.052	-0.078*	1.676**	2.000***	1.859**
	[0.043]	[0.032]	[0.040]	[0.839]	[0.767]	[0.845]
EFD (or RDI) × Entry into Banking Requirements	0.005	0.012	0.013	-0.929**	-0.931**	-0.488
	[0.013]	[0.010]	[0.012]	[0.424]	[0.413]	[0.356]
Industry's Initial Share of Total Manufacturing VA	0.557*	0.559*	0.553*	0.353	0.374	0.174
	[0.276]	[0.274]	[0.275]	[0.303]	[0.303]	[0.317]
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	692	692	692	1,134	1,134	1,134
Adjusted R^2	0.245	0.247	0.240	0.382	0.380	0.377

Panel B. Market-based vs. bank-based system

	Growth in Real Value Added					
	Market-based	Bank-based	Market-based	Bank-based	Market-based	Bank-based
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EFD × Financial R&D Intensity (Value Added)	0.128***	0.006				
	[0.040]	[0.053]				
EFD× Financial R&D Intensity (Cost)			0.018**	0.005		
			[0.007]	[0.039]		
EFD × Log (Off-Balance-Sheet Items)					0.020***	-0.015
					[0.006]	[0.022]
EFD × Private Credit	-0.139***	-0.005	-0.056	-0.004	-0.114***	-0.009
	[0.041]	[0.073]	[0.048]	[0.072]	[0.038]	[0.070]
EFD × Stock Market Cap	-0.030	0.016	-0.033	0.016	-0.031	0.024
	[0.024]	[0.025]	[0.025]	[0.026]	[0.025]	[0.030]
EFD × HHI	-0.038	-0.055	-0.050	-0.055	0.003	-0.039
	[0.043]	[0.048]	[0.049]	[0.047]	[0.059]	[0.042]
EFD × Entry into Banking Requirements	-0.013	0.016	0.001	0.016	-0.055	0.015*
	[0.034]	[0.013]	[0.030]	[0.012]	[0.038]	[0.008]
Industry's Initial Share of Total Manufacturing VA	0.870**	0.090	0.888**	0.089	0.874**	0.093
	[0.320]	[0.448]	[0.321]	[0.447]	[0.327]	[0.451]
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	360	332	360	332	360	332
Adjusted R^2	0.192	0.333	0.191	0.333	0.188	0.335

Panel C. Other institutional factors

	Growth in Real Value Added					
	High overall activities restrictions	Low overall activities restrictions	High overall capital stringency	Low overall capital stringency	More competition	Less competition
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EFD × Financial R&D Intensity (Value Added)	0.063***	0.058	0.102*	0.063	0.084*	0.037
	[0.022]	[0.074]	[0.058]	[0.053]	[0.049]	[0.037]
EFD × Private Credit	0.049***	-0.055**	-0.001	-0.026	-0.066**	0.044***
	[0.015]	[0.025]	[0.029]	[0.035]	[0.027]	[0.009]
EFD × Stock Market Cap	-0.079***	0.101*	-0.015	0.011	0.082*	-0.107***
	[0.025]	[0.055]	[0.056]	[0.072]	[0.050]	[0.021]
EFD × HHI	0.023	-0.187***	-0.131	-0.164**		
	[0.055]	[0.048]	[0.087]	[0.064]		
EFD × Entry into Banking Requirements	0.003	0.032***	0.016	-0.020	0.011	0.004
	[0.010]	[0.008]	[0.013]	[0.017]	[0.016]	[0.011]
Industry's Initial Share of Total Manufacturing VA	0.158	0.960**	0.217	1.064**	0.670	0.429**
	[0.281]	[0.445]	[0.328]	[0.492]	[0.646]	[0.205]
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	241	451	367	325	376	316
Adjusted R^2	0.511	0.295	0.358	0.345	0.223	0.481

Table 5

Financial innovation and industry growth volatility

The dependent variable is the standard deviation of the annual growth rate in real value added across 1996-2006 for each ISIC industry in each country, using the data from UNIDO INDSTAT4, 2010. The sample excludes the industrial sectors in the US, which serves as the benchmark (Rajan and Zingales, 1998). This table reports the impacts of financial R&D intensity on sectoral growth volatility. Financial innovation is measured using the initial available value across 1996 to 2006. External Financial Dependence (EFD), firstly developed by Rajan and Zingales (1998), is the fraction of capital expenditures not financed with internal funds for U.S. firms in each three-digit ISIC industry between 1980 and 1990. R&D intensity (RDI)is measured bythe R&D intensity for U.S. firms in each four-digit ISIC industry.The calculation uses weighted-average (based on firm size) R&D intensity of all the firms with non-missing R&D intensity in each four-digit ISIC industry. Industry's Initial Share of Total Manufacturing VA is the industry's share of total value added in manufacturing in 1996, which corrects for base effects in industry growth. Private credit is private credit divided by GDP averaged over 1996 and 2006. Detailed variable definitions and descriptions can be found in Table 1. Country and industry specific fixed effects are included in the regressions but not reported. All regressions are cross-sectional with one observation per industry in each country. The sample size is reduced in some models due to data limitation. Heteroskedasticity-robust standard errors clustering within countries are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

	Volatility in Real Value Added Growth					
	EFD ×			RDI ×		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EFD (or RDI) × Financial R&D Intensity (Value Added)	0.274***			4.628*		
	[0.062]			[2.801]		
EFD (or RDI) × Financial R&D Intensity (Cost)		0.039***			0.946*	
		[0.011]			[0.513]	
EFD (or RDI) × Log (Off-Balance-Sheet Items)			-0.004			-0.509
			[0.024]			[0.330]
EFD (or RDI) × Private Credit	-0.080**	-0.059	-0.067	-0.633	-0.718	-0.001
	[0.035]	[0.038]	[0.055]	[1.000]	[0.995]	[1.209]
EFD (or RDI) × Stock Market Cap	-0.024	-0.066	0.025	1.504	0.827	1.565
	[0.088]	[0.090]	[0.115]	[1.322]	[1.660]	[1.344]
EFD (or RDI) × HHI	-0.191*	-0.035	-0.080	5.576***	6.296***	4.854**
	[0.098]	[0.075]	[0.090]	[2.160]	[1.990]	[2.052]
EFD (or RDI) × Entry into Banking Requirements	0.010	0.030	0.033	-1.936**	-2.007**	-0.667
	[0.031]	[0.024]	[0.027]	[0.972]	[0.903]	[0.596]
Industry's Initial Share of Total Manufacturing VA	-0.757	-0.754	-0.757	-1.180	-1.243	-1.379
	[0.907]	[0.904]	[0.897]	[2.067]	[2.060]	[1.922]
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	688	688	688	1,128	1,128	1,144
Adjusted R^2	0.309	0.305	0.301	0.318	0.317	0.309

Table 6

Financial innovation and bank risk taking: OLS regressions

The sample period is from 1996 to 2007, which has a total of 12 years and provides threefour-year non-overlapping sub-periods. The dependent variable is log z-score. Z-score= (ROA+CAR)/ σ(ROA), where ROA= π/A as return on asset, and CAR= E/A as capital-asset ratio. σ(ROA) is standard deviation of ROA over a 4-year window. Higher z-score implies more stability and less bank risk taking. Bank market share is the share of each bank's deposits to total deposits within a given country. Bank growth is the total revenue growth rate of a bank. Loan to asset ratio is defined as the ratio of loans to total assets. Too-big-to-fail is a dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%. HHI is the Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country. Other country controls include log GDP, log GDP per capita, GDP growth volatility, and information sharing. GDP growth volatility is the standard deviation of GDP growth in the previous five years. Detailed variable definitions and descriptions can be found in Table 1. This table reports the impacts of financial R&D intensity on bank risk taking across around 6,000 bank-time observations in 32 countries. Three measures are applied for financial innovation. We control for unobserved heterogeneity at the country and time level by including country and time fixed effects and the coefficients are not reported for brevity. The estimation is based on OLS. All regressions are cross-sectional time-series with one observation per bank each time period. Heteroskedasticity-robust standard errors clustering within countries and time are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

	Log Z-score						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Financial R&D Intensity (Value Added)	-0.615***						
	[0.200]						
Financial R&D Intensity (Cost)		-0.060**					
		[0.030]					
Log (Off-Balance-Sheet Items)			-0.053***				
			[0.015]				
Financial R&D Intensity (Value Added) × Bank Market Share				2.282***			1.812***
				[0.447]			[0.519]
Financial R&D Intensity (Value Added) × Bank Growth					-0.016		0.067
					[0.396]		[0.332]
Financial R&D Intensity (Value Added) × Loan to Asset Ratio						1.785**	1.550*
						[0.743]	[0.796]
Bank Market Share	-0.469	-0.496	1.232	-1.625*	-0.366	-0.577	-1.549*
	[0.749]	[0.744]	[1.052]	[0.846]	[0.831]	[0.854]	[0.850]
Bank Growth	0.156**	0.142**	0.162**	0.226***	0.226*	0.230***	0.217*
	[0.068]	[0.063]	[0.072]	[0.085]	[0.122]	[0.085]	[0.117]
Loan to Asset Ratio	0.456***	0.427**	0.161	0.289	0.358**	-0.189	-0.170
	[0.167]	[0.172]	[0.225]	[0.183]	[0.174]	[0.262]	[0.272]
Overall Activities Restrictions	0.082	0.067	0.003				
	[0.059]	[0.051]	[0.052]				
Entry into Banking Requirements	0.071	0.101	-0.001				
	[0.097]	[0.092]	[0.105]				
Official Supervisory Power	0.047	0.050	0.051				
	[0.049]	[0.047]	[0.049]				
Tight Capital Regulation	-0.689***	-0.684***	-0.497**				
	[0.163]	[0.169]	[0.210]				
Financial Statement Transparency	-0.380***	-0.395***	-0.375***				
	[0.110]	[0.113]	[0.122]				

Tier 1 Capital Ratio	2.762**	2.775**	1.138	3.239**	3.257**	3.262**	3.250**
	[1.325]	[1.316]	[1.269]	[1.483]	[1.482]	[1.469]	[1.473]
Other Earning Assets	2.040***	2.013***	1.719***	2.065***	2.122***	1.993***	1.966***
	[0.190]	[0.197]	[0.183]	[0.224]	[0.212]	[0.229]	[0.236]
Too-Big-To-Fail	0.276**	0.281**	0.121	0.284*	0.267	0.282*	0.294*
	[0.140]	[0.138]	[0.151]	[0.156]	[0.162]	[0.168]	[0.161]
HHI	0.725	0.381	-0.086				
	[1.049]	[1.142]	[1.224]				
Foreign Bank Ownership	1.089	0.986	0.954				
	[0.727]	[0.699]	[0.689]				
Other Country Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	No	No	No	No
Time Fixed Effects	Yes	Yes	Yes	No	No	No	No
Country-Time Fixed Effects	No	No	No	Yes	Yes	Yes	Yes
Observations	6,043	6,082	4,611	6,061	6,061	6,061	6,061
Adjusted R^2	0.207	0.209	0.194	0.144	0.143	0.145	0.146

Table 7
Financial innovation and bank risk taking: Subsample analysis based on market-based vs. bank-based system and other institutional factors

The sample period is from 1996 to 2007, which has a total of 12 years and provides threefour-year non-overlapping sub-periods. The dependent variablesare log z-score. Z-score= (ROA+CAR)/ σ(ROA), where ROA= π/A as return on asset, and CAR= E/A as capital-asset ratio. σ(ROA) is standard deviation of ROA over a 4-year window. Higher z-score implies more stability and less bank risk taking. Bank market share is the share of each bank's deposits to total deposits within a given country. Bank growth is the total revenue growth rate of a bank. Loan to asset ratio is defined as the ratio of loans to total assets. Too-big-to-fail is a dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%. HHI is the Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country. Other country controls include log GDP, log GDP per capita, GDP growth volatility, and information sharing. GDP growth volatility is the standard deviation of GDP growth in the previous five years. Panels A and B report the subsample analysis based on market-based vs. bank-based system, and other institutional factors, respectively. A country is coded as market-based system if the value of financial structure is larger than the sample median value, and bank-based system otherwise. Financial structure is calculated as Value Traded divided by GDP/ Bank Credit to GDP. Other institutional factors include anti-director rights and disclosure requirements (La Porta et al., 2006), overall activities restrictions, overall capital stringency, and competition. A country is placed into "More competition" subsample if its HHI is smaller than the sample median value, and "Less competition" subsample otherwise. A country is placed into "High" subsample if its anti-director rights, disclosure requirements, overall activities restrictions, or overall capital stringency is larger than the sample median value, and "Low" subsample otherwise. Detailed variable definitions and descriptions can be found in Table 1. This table reports the impacts of financial R&D intensity on bank risk taking across around 6,000 bank-time observations in 32 countries. Three measures are applied for financial innovation. We control for unobserved heterogeneity at the country and time level by including country and time fixed effects and the coefficients are not reported for brevity. The estimation is based on OLS. All regressions are cross-sectional time-series with one observation per bank each time period. Heteroskedasticity-robust standard errors clustering within countries and time are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Panel A. Market-based vs. bank-based system

	Log Z-score					
	Market-based	Bank-based	Market-based	Bank-based	Market-based	Bank-based
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Financial R&D Intensity (Value Added)	-9.238***	-0.053				
	[0.037]	[0.119]				
Financial R&D Intensity (Cost)			-3.732***	-0.003		
			[0.014]	[0.014]		
Log (Off-Balance-Sheet Items)					-0.064***	-0.011
					[0.003]	[0.019]
Overall Activities Restrictions	-5.588***	-0.011	-3.777***	-0.037	14.517***	-0.091
	[0.225]	[0.051]	[0.188]	[0.052]	[0.352]	[0.056]
Entry into Banking Requirements	-3.868***	0.088	-2.057***	0.146*	16.364***	0.088
	[0.222]	[0.081]	[0.186]	[0.076]	[0.355]	[0.085]
Official Supervisory Power	14.248***	0.064	13.491***	0.059	8.561***	0.048
	[0.101]	[0.040]	[0.083]	[0.040]	[0.094]	[0.049]
Tight Capital Regulation	0.471***	0.116	0.471***	0.080	0.831***	0.105
	[0.001]	[0.096]	[0.001]	[0.101]	[0.006]	[0.104]
Financial Statement Transparency	-130.985***	-0.223**	-128.045***	-0.212**	-94.136***	-0.262***
	[0.748]	[0.090]	[0.616]	[0.087]	[0.767]	[0.093]
Bank Leverage	1.883***	1.529**	1.883***	1.529**	1.140***	1.324
	[0.056]	[0.634]	[0.056]	[0.633]	[0.072]	[0.798]
Tier 1 Capital Ratio	7.725***	-0.388	7.714***	-0.403	5.512***	-1.014
	[0.082]	[0.885]	[0.089]	[0.864]	[0.155]	[0.939]
Other Earning Assets	2.349***	1.038**	2.347***	1.018**	1.801***	0.946
	[0.019]	[0.504]	[0.017]	[0.493]	[0.035]	[0.612]
Bank Market Share	-4.429	-0.628	-4.923**	-0.676	10.289**	-0.722
	[1.906]	[1.077]	[1.523]	[1.079]	[3.633]	[1.114]
Loan to Asset Ratio	0.638***	0.239	0.633***	0.221	-0.017	0.294
	[0.041]	[0.301]	[0.036]	[0.299]	[0.045]	[0.289]
Bank Growth	0.043***	0.521***	0.044***	0.510***	0.060***	0.537***
	[0.004]	[0.119]	[0.004]	[0.103]	[0.004]	[0.103]
Too-Big-To-Fail	1.853**	0.157	1.969***	0.175	-1.378	0.201
	[0.448]	[0.157]	[0.358]	[0.160]	[0.843]	[0.181]
HHI	-416.755***	-1.046	-416.528***	-1.051	-426.048***	-0.662
	[1.061]	[1.111]	[0.858]	[1.135]	[0.594]	[1.063]
Foreign Bank Ownership	142.776***	1.345**	134.850***	1.389**	85.721***	1.894***
	[0.995]	[0.576]	[0.828]	[0.563]	[0.966]	[0.607]
Other Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,789	1,174	4,793	1,197	3,439	1,090
Adjusted R^2	0.220	0.305	0.220	0.304	0.206	0.310

Panel B. Other institutional factors

	Log Z-score					
	High overall activities restrictions	Low overall activities restrictions	High overall capital stringency	Low overall capital stringency	High competition	Low competition
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Financial R&D Intensity (Value Added)	-3.200***	-0.379*	-0.363*	-0.012	-22.469***	-0.059
	[1.058]	[0.197]	[0.210]	[0.680]	[4.717]	[0.110]
Overall Activities Restrictions	0.321	0.016	-0.053	0.006	-1.419***	-0.032
	[0.310]	[0.070]	[0.061]	[0.131]	[0.416]	[0.033]
Entry into Banking Requirements	0.748	0.195	0.084	0.280	0.000	0.060
	[0.641]	[0.143]	[0.164]	[0.199]	[0.001]	[0.078]
Official Supervisory Power	0.281	0.015	-0.027	0.032	1.423***	0.061**
	[0.181]	[0.052]	[0.077]	[0.040]	[0.073]	[0.028]
Tight Capital Regulation	0.779***	-0.756***			0.542	0.113
	[0.214]	[0.079]			[0.341]	[0.096]
Financial Statement Transparency	0.824**	-0.494***	-0.329**	-0.209	0.000	-0.172**
	[0.376]	[0.136]	[0.159]	[0.171]	[0.001]	[0.080]
Tier 1 Capital Ratio	5.554***	1.190	1.947	3.445*	5.578***	-1.932***
	[0.826]	[1.865]	[1.740]	[1.918]	[0.464]	[0.596]
Other Earning Assets	2.511***	1.831***	1.970***	2.117***	2.516***	0.854**
	[0.271]	[0.286]	[0.248]	[0.313]	[0.192]	[0.397]
Bank Market Share	-0.646	0.235	-0.609	0.344	-6.076	-0.358
	[1.943]	[0.895]	[0.963]	[1.227]	[5.727]	[0.786]
Loan to Asset Ratio	0.782***	0.292*	0.239	0.590***	0.820***	0.191
	[0.287]	[0.171]	[0.244]	[0.189]	[0.196]	[0.246]
Bank Growth	0.111	0.220***	0.172***	0.185	0.025	0.478***
	[0.136]	[0.075]	[0.061]	[0.166]	[0.049]	[0.101]
Too-Big-To-Fail	0.108	0.173	0.241	0.221	0.000	0.171
	[0.399]	[0.141]	[0.160]	[0.219]	[0.001]	[0.121]
HHI	-4.380	-1.430	0.632	-2.133		
	[2.811]	[1.310]	[1.015]	[2.822]		
Foreign Bank Ownership	-0.411	1.869**	2.652**	-1.157	0.000	1.421***
	[1.356]	[0.846]	[1.031]	[1.061]	[0.001]	[0.485]
Other Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,772	3,270	3,275	2,768	4,715	1,328
Adjusted R^2	0.141	0.294	0.274	0.157	0.221	0.315

Table 8

Financial innovation and bank performance change in crisis period: Change in ROA

The dependent variable is the performance change (ROA)between 2008 and 2006 for each bank, calculated as thedifference of ROA value between 2008 and 2006. ROA refers to return on asset. Five measures of financial innovation are applied. Financial R&D intensity (value added), financial R&D intensity (cost), and Log (Off-Balance-Sheet Items) are averaged from 1996 to 2006, while the other two measures of financial innovation are averaged from 2001 to 2006. Bank market share is the share of each bank'sdeposits to total deposits within a given country. Bank growth is the total revenue growth rate of a bank. Loan to asset ratio is defined as the ratio of loans to total assets. Too-big-to-fail is a dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%.HHI is the Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country. Other country controls include log GDP, log GDP per capita, GDP growth volatility, creditor rights, and information sharing. GDP growth volatility is the standard deviation of GDP growth in the previous five years. Panels A reports the effects of financial innovation on bank performance change, and Panel B reports the subsample analysis based on market-based vs. bank-based system. A country is coded as market-based system if the value of financial structure is larger than the sample median value, and bank-based system otherwise. Financial structure is calculated as Value Traded divided by GDP/ Bank Credit to GDP. Detailed variable definitions and descriptions can be found in Table 1. This table reports the impacts of financial R&D intensity onchanges ofROA across more than 1,500banksin 32countries. Heteroskedasticity-consistent standard errors clustered at the country levelare reported in brackets.*, **, *** represent statistical significance at the 10%, 5% and 1% level respectively.

Panel A: Financial innovation and bank performance change in crisis period

	Change in ROA				
	Model 1	Model 2	Model 3	Model 4	Model 5
Financial R&D Intensity (Value Added)	-0.012***				
	[0.003]				
Financial R&D Intensity (Cost)		-0.001**			
		[0.000]			
Log (Off-Balance-Sheet Items)			-0.003**		
			[0.001]		
Log (# of Reference Entities Holding CDS)				-0.004**	
				[0.002]	
Log (Total ABCP Outstanding)					-0.002***
					[0.000]
Overall Activities Restrictions	-0.000	0.000		0.000	-0.004***
	[0.001]	[0.001]		[0.001]	[0.001]
Entry into Banking Requirements	0.001	0.000		0.001	-0.001
	[0.001]	[0.001]		[0.001]	[0.001]
Official Supervisory Power	0.000	0.000		-0.001***	0.003***
	[0.001]	[0.001]		[0.001]	[0.000]
Capital Regulatory Index	0.001	-0.001		-0.001	-0.010***
	[0.002]	[0.002]		[0.002]	[0.001]
Financial Statement Transparency	0.002*	0.002**		0.002	0.005***
	[0.001]	[0.001]		[0.001]	[0.001]
Bank Leverage	0.072***	0.072***	0.075***	0.061***	0.088***
	[0.018]	[0.018]	[0.019]	[0.021]	[0.025]
Bank Market Share	0.006	0.009	0.006	0.024	-0.006
	[0.020]	[0.020]	[0.021]	[0.022]	[0.039]
Loan to Asset Ratio	0.014***	0.014***	0.015***	0.014***	0.014***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Bank Growth	-0.006***	-0.006***	-0.006***	-0.004**	-0.004*
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Too-Big-To-Fail	0.002	0.001	0.002	-0.002	0.003
	[0.003]	[0.003]	[0.003]	[0.003]	[0.007]
HHI	-0.008	-0.046		-0.128***	0.087***
	[0.025]	[0.028]		[0.027]	[0.015]
Foreign Bank Ownership	-0.001	-0.000		-0.000	-0.011**
	[0.003]	[0.003]		[0.005]	[0.005]
Other Country Controls	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	Yes	No	No
Observations	1,536	1,536	1,552	1,306	1,193
Adjusted R^2	0.117	0.115	0.173	0.079	0.130

Panel B. Market-based vs. bank-based system

	Change in ROA									
	Market-based	Bank-based	Market-based	Bank-based	Market-based	Bank-based	Market-based	Bank-based	Market-based	Bank-based
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Financial R&D Intensity (Value Added)	-0.010***	-0.000								
	[0.003]	[0.011]								
Financial R&D Intensity (Cost)			-0.001***	-0.001						
			[0.000]	[0.003]						
Log (Off-Balance-Sheet Items)					-0.002***	-0.002				
					[0.001]	[0.001]				
Log (# of Reference Entities Holding CDS)							-0.004***	0.010***		
							[0.000]	[0.002]		
Log (Total ABCP Outstanding)									-0.003***	0.002
									[0.000]	[0.002]
Overall Activities Restrictions	-0.000	0.002	0.001	0.002*			-0.010***	-0.003***	-0.003***	0.001
	[0.001]	[0.001]	[0.001]	[0.001]			[0.003]	[0.000]	[0.000]	[0.001]
Entry into Banking Requirements	0.010*	-0.000	0.013***	-0.000			0.000	0.002***	0.000	0.000
	[0.005]	[0.000]	[0.004]	[0.001]			[0.000]	[0.000]	[0.000]	[0.000]
Official Supervisory Power	0.001	-0.001**	0.000	-0.001			-0.002***	0.001***	0.001***	0.000
	[0.001]	[0.001]	[0.001]	[0.001]			[0.001]	[0.000]	[0.000]	[0.000]
Capital Regulatory Index	0.004**	-0.003	0.006***	-0.003			-0.005***	-0.005*	0.000	0.000
	[0.002]	[0.006]	[0.002]	[0.004]			[0.001]	[0.003]	[0.000]	[0.000]
Financial Statement Transparency	0.004	-0.003	0.003	-0.002			0.050***	0.000	0.007***	0.000
	[0.003]	[0.002]	[0.003]	[0.002]			[0.017]	[0.000]	[0.001]	[0.000]
Bank Leverage	0.079***	0.031	0.079***	0.031	0.076***	0.041	0.066***	0.032	0.084***	0.125*
	[0.019]	[0.056]	[0.019]	[0.056]	[0.017]	[0.052]	[0.021]	[0.059]	[0.026]	[0.066]

Bank Market Share	0.003	0.027	0.004	0.027	0.003	0.007	0.031	0.028	-0.012	-0.031
	[0.032]	[0.030]	[0.032]	[0.030]	[0.026]	[0.042]	[0.034]	[0.043]	[0.058]	[0.067]
Loan to Asset Ratio	0.018***	0.004	0.018***	0.004	0.017***	0.000	0.017***	0.005	0.015***	0.009
	[0.005]	[0.006]	[0.005]	[0.006]	[0.004]	[0.006]	[0.006]	[0.007]	[0.005]	[0.010]
Bank Growth	-0.005*	-0.008***	-0.005*	-0.008***	-0.004*	-0.010***	-0.002	-0.008***	-0.003	-0.007***
	[0.003]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.001]
Too-Big-To-Fail	0.005	-0.004	0.004	-0.004	0.004	0.003	0.001	-0.005	0.007	-0.005
	[0.005]	[0.003]	[0.005]	[0.003]	[0.005]	[0.009]	[0.006]	[0.004]	[0.010]	[0.004]
HHI	0.053	-0.088	-0.015	-0.082*			0.000	0.000	0.000	0.000
	[0.063]	[0.067]	[0.048]	[0.048]			[0.000]	[0.000]	[0.000]	[0.000]
Foreign Bank Ownership	-0.015**	0.011**	-0.020***	0.010***			0.000	0.000	-0.045***	0.000
	[0.006]	[0.005]	[0.005]	[0.003]			[0.000]	[0.000]	[0.003]	[0.000]
Other Country Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	Yes	Yes	No	No	No	No
Observations	1,110	426	1,110	426	1,110	442	921	385	944	249
Adjusted R^2	0.133	0.086	0.134	0.086	0.123	0.063	0.090	0.081	0.125	0.169

Table 9
Financial innovation and bank stock performance change in crisis period: Buy-and-hold stock returns July 2007-December 2008

The dependent variable is buy-and-hold stock for each bank over the period returns July 2007-December 2008. The sample includes the 487 banks in Bankscope with returns available from Datastream, with a loan-to-assets ratio larger than 10%, a deposit-to-assets ratio larger than 20%. Bank characteristics are computed using data from 2006, prior to the beginning of the financial crisis. Five measures of financial innovation are applied. Financial R&D intensity (value added), financial R&D intensity (cost), and Log (Off-Balance-Sheet Items) are averaged from 1996 to 2006, while the other two measures of financial innovation are averaged from 2001 to 2006.Bank growth is the total revenue growth rate of a bank. Loan to asset ratio is defined as the ratio of loans to total assets. Too-big-to-fail is a dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%. HHI is the Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country. Other country controls include log GDP, log GDP per capita, GDP growth volatility, creditor rights, and information sharing. GDP growth volatility is the standard deviation of GDP growth in the previous five years. Detailed variable definitions and descriptions can be found in Table 1. This table reports the impacts of financial R&D intensity onbuy-and-hold stock returns across about 500 banks in 32 countries. Heteroskedasticity-consistent standard errors clustered at the country level are reported in brackets. *, **, *** represent statistical significance at the 10%, 5% and 1% level respectively.

	Buy-and-hold Stock Returns July 2007-December 2008				
	Model 1	Model 2	Model 3	Model 4	Model 5
Financial R&D Intensity (Value Added)	-0.201*				
	[0.113]				
Financial R&D Intensity (Cost)		-0.033**			
		[0.015]			
Log (Off-Balance-Sheet Items)			-0.029***		
			[0.005]		
Log (# of Reference Entities Holding CDS)				-1.485***	
				[0.114]	
Log (Total ABCP Outstanding)					-0.042**
					[0.016]
Tangible Equity	0.974	1.061	2.205**	2.737***	2.752***
	[0.691]	[0.698]	[0.868]	[0.347]	[0.365]
Deposits	0.577***	0.586***	0.628***	0.668***	0.663***
	[0.112]	[0.107]	[0.083]	[0.071]	[0.082]
Funding Fragility	0.152*	0.135*	0.100	0.158*	0.104
	[0.076]	[0.078]	[0.100]	[0.081]	[0.082]
Loan to Asset Ratio	-0.325***	-0.322***	-0.182	-0.354*	-0.198
	[0.095]	[0.090]	[0.118]	[0.168]	[0.127]
Log Assets	-0.006	-0.006	-0.017*	-0.007	-0.006
	[0.006]	[0.006]	[0.010]	[0.007]	[0.007]
Log Z-score	0.077***	0.078***	0.076***	0.076***	0.077***
	[0.006]	[0.006]	[0.006]	[0.005]	[0.005]
Non-interest	-0.426***	-0.435***	-0.266*	-0.193	-0.192
	[0.096]	[0.102]	[0.142]	[0.127]	[0.115]
Income Diversity	0.420***	0.422***	0.361***	0.291***	0.289***
	[0.060]	[0.061]	[0.072]	[0.060]	[0.066]
Other Earning Assets	0.321***	0.325***	0.439***	0.284	0.422**
	[0.105]	[0.105]	[0.135]	[0.202]	[0.167]
Tier 1 Capital Ratio	-1.284**	-1.436**	-3.046***	-3.875***	-3.893***
	[0.561]	[0.561]	[0.840]	[0.033]	[0.039]
2006 Return	0.047*	0.044*	0.041	0.057*	0.054*

	[0.024]	[0.024]	[0.025]	[0.031]	[0.028]
Beta	-0.181***	-0.186***	-0.181***	-0.184***	-0.183***
	[0.022]	[0.022]	[0.022]	[0.022]	[0.024]
Real Estate Beta	0.166***	0.168***	0.092***	0.112***	0.122***
	[0.036]	[0.033]	[0.029]	[0.012]	[0.017]
Overall Activities Restrictions	0.018	0.011		0.305***	0.068*
	[0.018]	[0.022]		[0.034]	[0.030]
Entry into Banking Requirements	0.121***	0.115***		1.087***	0.208***
	[0.024]	[0.030]		[0.074]	[0.052]
Official Supervisory Power	0.044**	0.052**		-0.265***	0.050*
	[0.019]	[0.020]		[0.011]	[0.026]
Capital Regulatory Index	-0.070***	-0.072***		-0.281***	-0.037**
	[0.020]	[0.018]		[0.015]	[0.015]
Financial Statement Transparency	0.265***	0.293***		-0.716***	-0.224*
	[0.051]	[0.046]		[0.055]	[0.115]
HHI	0.398	0.325		-3.101***	-0.000
	[0.313]	[0.267]		[0.162]	[0.000]
Foreign Bank Ownership	-0.291	-0.384		-0.000	-0.000
	[0.354]	[0.380]		[0.000]	[0.000]
Other Country Controls	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	Yes	No	Yes
Observations	486	486	487	455	460
Adjusted R^2	0.210	0.211	0.215	0.222	0.213

Table 10

OLS estimates of the determinants of financial innovation 1996-2006

The dependent variable is Financial R&D Intensity, which is defined as the financial R&D expenditure scaled by total value added of the financial intermediation industry in the previous year. We further multiply Financial R&D Intensity by 100 to scale the estimated coefficients in our empirical results. All independent variables except measures of banking regulation are lagged by one year. Recession is a dummy variable indicating whether a country is experiencinga recession in a particular year, which is constructed following Braun and Larrain (2005). GDP growth volatility is the standard deviation of GDP growth in the previous five years. Detailed variable definitions and descriptions can be found in Table 1. This table reports the impacts of bank regulation, tax rates, bank ownership and other variables of interest on financial R&D intensity across time and 32 countries. All regressions are time-series cross-sectional with one observation per country per year. The estimation is based on OLS regressions. Time fixed effects are included but not reported. The sample size is reduced in some models due to data limitation. Heteroskedasticity-robust standard errors clustering within countries and years are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

	Financial R&D Intensity (Value Added)						Financial R&D Intensity (Cost)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Overall Activities Restrictions	0.013				0.026**	0.039***	0.168**
	[0.011]				[0.010]	[0.013]	[0.086]
Official Supervisory Power		-0.023***			-0.025***	-0.033***	-0.085
		[0.007]			[0.008]	[0.010]	[0.076]
Overall Capital Stringency			0.037***		0.043***	0.056***	0.416***
			[0.014]		[0.014]	[0.015]	[0.094]
Financial Statement Transparency				-0.038*	-0.027	-0.050*	0.172
				[0.022]	[0.023]	[0.030]	[0.229]
Statutory Corporate Tax Rates	0.003	0.001	0.005	0.004	0.001	-0.001	0.011
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.028]
Government Bank Ownership	-0.713***	-0.678***	-0.598***	-0.728***	-0.632***	-0.506***	-2.481***
	[0.112]	[0.106]	[0.096]	[0.106]	[0.109]	[0.135]	[0.947]
HHI	-0.426	-0.526	-0.149	-0.545	0.025	-0.367	-7.931***
	[0.453]	[0.402]	[0.422]	[0.409]	[0.444]	[0.457]	[2.658]
HHI^2	0.398	0.488	0.239	0.473	0.091	0.434	5.634***
	[0.379]	[0.336]	[0.357]	[0.342]	[0.368]	[0.384]	[2.153]
Private Credit	0.095	0.097	0.104*	0.090	0.123**	0.205***	-0.073
	[0.064]	[0.063]	[0.061]	[0.063]	[0.061]	[0.077]	[0.429]
Stock Market Cap	0.147**	0.132**	0.175***	0.161**	0.181**	0.086	2.547***
	[0.064]	[0.061]	[0.068]	[0.065]	[0.071]	[0.079]	[0.701]
Inflation Rate	0.197*	0.252**	0.177	0.179*	0.133	0.421***	2.485*
	[0.107]	[0.106]	[0.109]	[0.103]	[0.108]	[0.145]	[1.310]

log GDP	-0.050**	-0.037**	-0.047**	-0.055***	-0.027	-0.067**	-0.409**
	[0.020]	[0.019]	[0.019]	[0.019]	[0.019]	[0.028]	[0.182]
log GDP Per Capita	0.015	0.013	-0.017	0.014	-0.023	-0.014	-0.500
	[0.049]	[0.048]	[0.047]	[0.048]	[0.046]	[0.057]	[0.506]
Financial Structure						0.162***	-0.138
						[0.050]	[0.330]
GDP Growth Volatility						-6.292***	-17.583
						[2.107]	[14.883]
Recession						-0.161**	-0.667
						[0.082]	[0.552]
Growth Opportunity (GGO_MA)						-0.046	-0.057
						[0.035]	[0.183]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	284	282	278	288	272	226	231
Adjusted R-squared	0.236	0.254	0.266	0.237	0.306	0.420	0.356

Appendix Table A1

Summary statistics for financial R&D expenditure across countriesover 1996-2006

The table reports the summary statistics for financial R&D expenditure (in Million USD) across 32 countries, over the period from 1996 to 2006.

Country	Country Code	Mean	SD
Australia	AUS	364.23	263.60
Austria	AUT	31.69	10.63
Belgium	BEL	41.86	25.44
Canada	CAN	227.19	72.69
Czech Republic	CZE	9.57	19.51
Denmark	DNK	102.69	74.76
Germany	DEU	83.22	83.46
Greece	GRC	2.86	3.32
Hungary	HUN	1.01	0.98
Iceland	ISL	1.74	0.93
Ireland	IRL	6.13	7.77
Israel	ISR	5.37	0.96
Italy	ITA	166.02	93.42
Japan	JPN	16.08	5.78
Korea	KOR	3.43	4.77
Luxembourg	LUX	58.32	15.32
Mexico	MEX	60.72	49.94
Netherlands	NLD	88.88	34.44
New Zealand	NZL	3.44	2.17
Norway	NOR	48.25	28.23
Poland	POL	4.10	4.80
Portugal	PRT	47.33	38.67
Romania	ROM	0.56	0.52
Russian Federation	RUS	0.36	0.59
Singapore	SGP	25.96	35.35
South Africa	ZAF	250.53	152.01
Spain	ESP	78.41	80.25
Sweden	SWE	89.79	8.48
Switzerland	CHE	94.05	19.76
Turkey	TUR	38.38	24.21
United Kingdom	GBR	1358.27	1258.72
United States	USA	2042.43	825.53

Appendix Table A2
Correlation matrix

This table reports the correlation matrix between measures of financial R&D intensity and other variables in our analysis. Observations are for each country each year from 1996 to 2006. Detailed variable definitions and descriptions can be found in Table 1. P-values are reported in the parenthesesbelow the correlation coefficients. *, **, *** represent statistical significance at the 10%, 5% and 1% level respectively.

	1	2	3	4	5
Financial R&D Intensity (Value Added)	1.000				
R&D Intensity in Service Industry	0.418***	1.000			
	(0.000)				
R&D Intensity in Manufacturing Industry	0.418***	0.213***	1.000		
	(0.000)	(0.001)			
Financial Development (Private Credit)	0.321***	0.205***	0.522***	1.000	
	(0.000)	(0.001)	(0.000)		
Log GDP Per Capita	0.343***	0.398***	0.603***	0.648***	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	

Appendix Table A3

Placebo test

This table reports the placebo test, using R&D intensity in manufacturingindustry as the measure instead of Financial R&D Intensity. The dependent variables are Log Z-score as in Table 6and ROA Change as in Table 9. Detailed variable definitions and descriptions can be found in Table 1.The sample size is reduced in some models due to data limitation. Heteroskedasticity-robust standard errors clustering within countries are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

	Log Z-score	Change in ROA
	Model 1	Model 2
R&D Intensity in Manufacturing Industry	1.778	0.005
	[13.101]	[0.009]
Overall Activities Restrictions	0.031	0.001***
	[0.065]	[0.000]
Entry into Banking Requirements	0.101	0.003***
	[0.103]	[0.001]
Official Supervisory Power	0.035	-0.001***
	[0.055]	[0.000]
Capital Regulatory Index	-0.694***	0.001***
	[0.163]	[0.000]
Financial Statement Transparency	-0.331**	-0.004***
	[0.133]	[0.001]
Bank Leverage		0.061***
		[0.024]
Bank Market Share	0.369	0.025
	[1.131]	[0.017]
Bank Growth	0.125**	-0.005*
	[0.054]	[0.002]
Loan to Asset Ratio	-1.295***	0.013***
	[0.195]	[0.004]
Too-Big-To-Fail	0.232	-0.002
	[0.194]	[0.004]
HHI	1.024	-0.054***
	[1.155]	[0.013]
Foreign Bank Ownership	0.499	-0.003
	[0.961]	[0.003]
Other Country Controls	Yes	Yes
Country Fixed Effects	Yes	No
Time Fixed Effects	Yes	No
Observations	5,853	1,196
Adjusted R^2	0.182	0.083

Appendix Table A4

Financial innovation and bank risk taking: Robustness checks

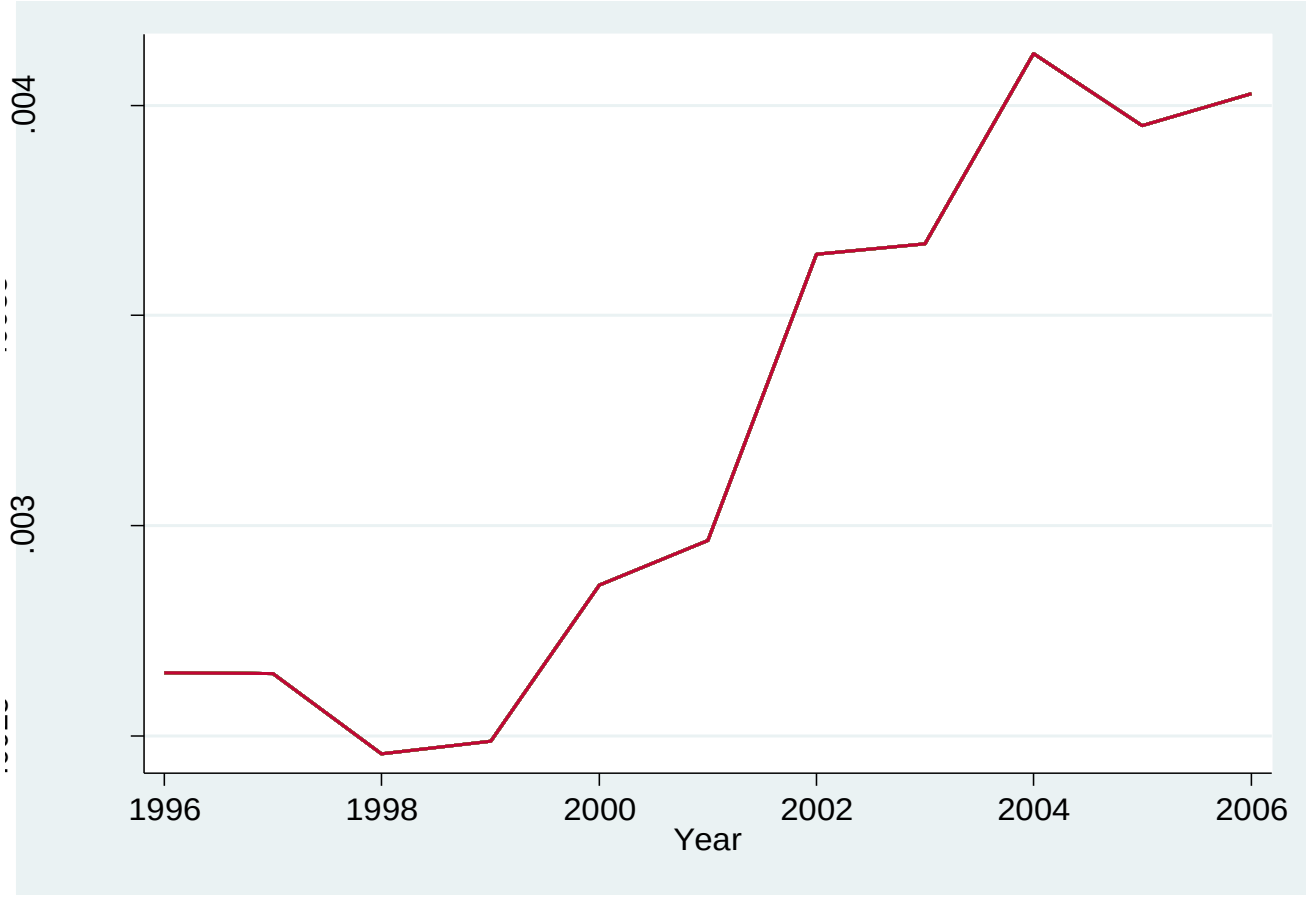
The sample period is from 1996 to 2007, which has a total of 12 years and provides 2six-year non-overlapping sub-periods. The dependent variable is log z-score. Z-score= (ROA+CAR)/ σ(ROA), where ROA= π/A as return on asset, and CAR= E/A as capital-asset ratio. σ(ROA) is standard deviation of ROA over a 6-year window. Higher z-score implies more stability and less bank risk taking. Bank market share is the share of each bank's deposits to total deposits within a given country. Bank growth is the total revenue growth rate of a bank. Loan to asset ratio is defined as the ratio of loans to total assets. Too-big-to-fail is a dummy variable that takes a value of one if the bank's share in the country's total deposits exceeds 10%. HHI is the Herfindahl index, defined as the sum of the squared shares of bank deposits to total deposits within a given country. Other country controls include log GDP, log GDP per capita, GDP growth volatility, and information sharing. Detailed variable definitions and descriptions can be found in Table 1. This table reports the impacts of financial R&D intensity on bank risk taking across around 4,000 bank-time observations in 32 countries. Three measures are applied for financial innovation. We control for unobserved heterogeneity at the country and time level by including country and time fixed effects and the coefficients are not reported for brevity.All regressions are cross-sectional time-series with one observation per bank each time period. Heteroskedasticity-robust standard errors clustering within countries and time are reported in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

	Log Z-score		
	Model 1	Model 2	Model 3
Financial R&D Intensity (Value Added)	-0.718**		
	[0.287]		
Financial R&D Intensity (Cost)		-0.120**	
		[0.059]	
Log (Off-Balance-Sheet Items)			-0.078***
			[0.013]
Overall Activities Restrictions	0.029	0.051	0.055
	[0.073]	[0.069]	[0.084]
Entry into Banking Requirements	0.153	0.081	0.099
	[0.182]	[0.149]	[0.156]
Official Supervisory Power	-0.139**	-0.138**	-0.135*
	[0.071]	[0.069]	[0.076]
Tight Capital Regulation	-0.213*	-0.196*	-0.161**
	[0.126]	[0.110]	[0.080]
Financial Statement Transparency	-0.401**	-0.636***	-0.671***
	[0.166]	[0.150]	[0.181]
Bank Market Share	0.918	1.079	2.766***
	[0.721]	[0.705]	[0.822]
Loan to Asset Ratio	0.194***	0.222***	0.234***
	[0.060]	[0.072]	[0.088]
Bank Growth	0.594**	0.587**	0.022
	[0.284]	[0.281]	[0.221]
Tier 1 Capital Ratio	4.602***	4.737***	3.099**
	[1.225]	[1.189]	[1.234]
Other Earning Assets	2.231***	2.249***	1.762***
	[0.287]	[0.273]	[0.196]
Too-Big-To-Fail	-0.125	-0.158	-0.189
	[0.173]	[0.171]	[0.190]
HHI	-2.157**	-1.983**	-2.630***
	[1.001]	[0.848]	[0.939]
Foreign Bank Ownership	7.560***	7.476***	7.404***
	[1.198]	[1.236]	[1.679]
Other Country Controls	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	4,349	4,486	3,262
Adjusted R^2	0.185	0.189	0.190

Appendix Figure A1

Overall trend of average financial R&Dintensity in 32countries from 1996 to 2006

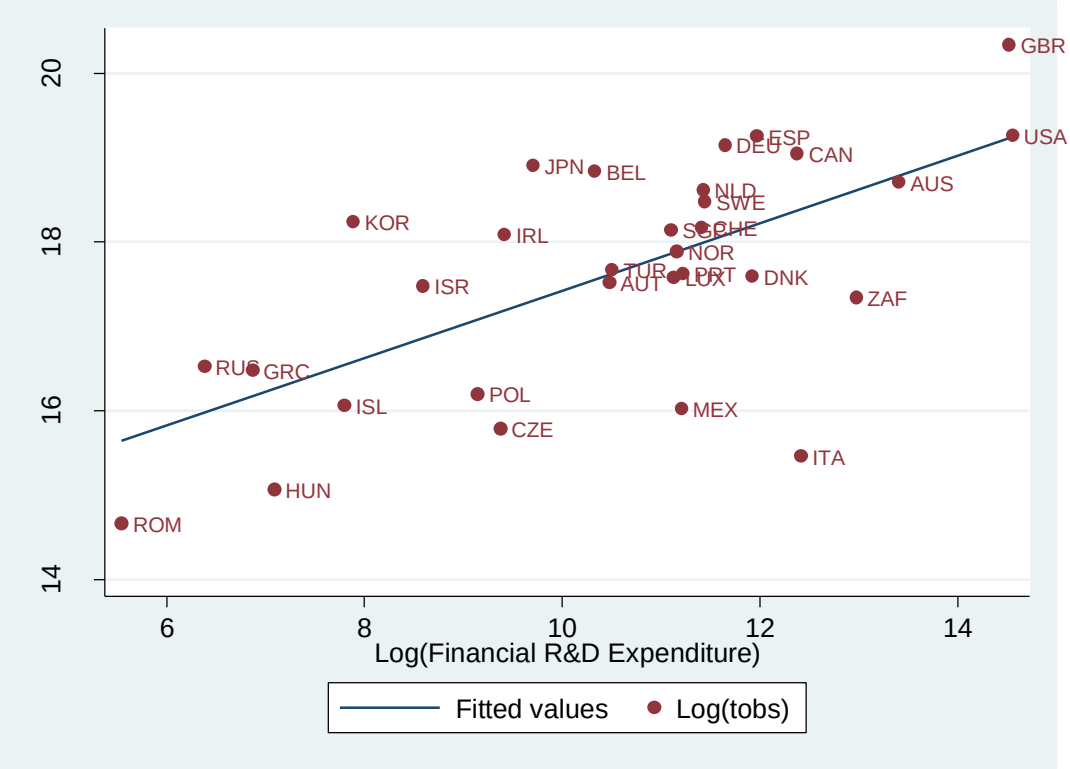
The figure shows the overall trend of averaged financial R&D intensity (value added) in 32 countries over the period from 1996 to 2006. The 32 countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.



Appendix Figure A2

Log (Off-balance-sheet items) and Log (Financial R&D expenditure)

The figure shows the correlation between natural logarithm of off-balance-sheet items (in US$ thousands) and natural logarithm of financial R&D expenditure (in US$ thousands). The vertical axis is the natural logarithm of the total value of off-balance-sheet items among all the individual banks averaged over 1996-2006 per country, and the horizontal axis is the natural logarithm of financial R&D expendituresof all banks averaged over 1996-2006 per country. The data of off-balance-sheet items come from BankScope. Observations are labeled with country codes, as defined in Appendix Table A1.

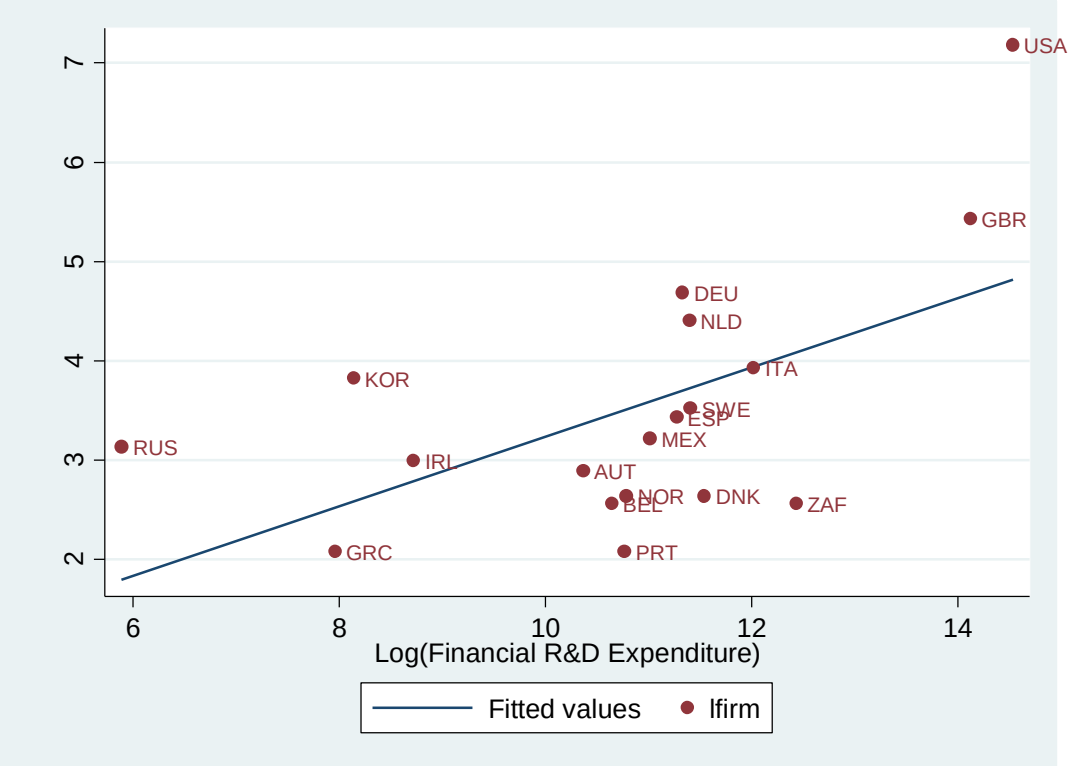


Note: Correlation coefficient: 0.6546; P-value: 0.0001

Appendix Figure A3
CDS and Log (Financial R&D expenditure)

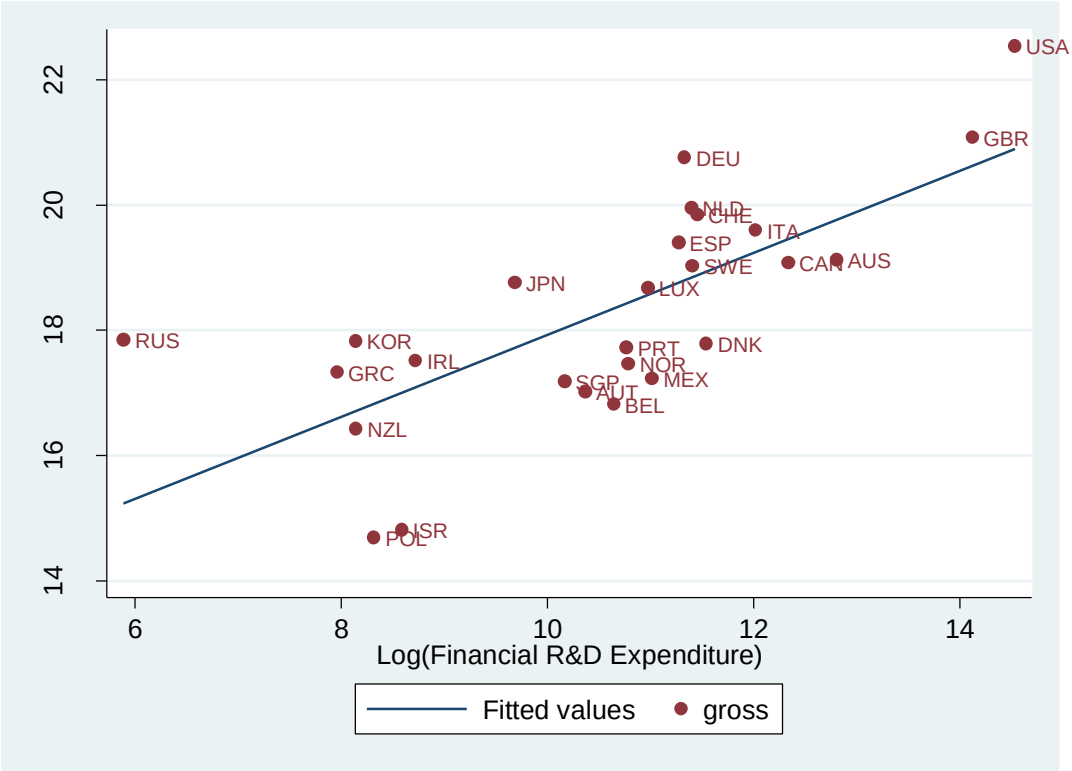
The figure shows the correlation between CDS and natural logarithm of financial R&D expenditure (in US$ thousands). The vertical axis in Panel A is the natural logarithm of the number of reference entities holding CDSfor each country averaged from 2001 to 2006, and the data is from Markit. The vertical axis is the natural logarithm of the gross notional value of CDS in Panel B and the natural logarithm of the net notional value of CDS in Panel C in aggregate for each country in 2008, and the data is provided by the Depository Trust & Clearing Corporation (DTCC). Gross notional values are the sum of CDS contracts bought (or equivalently sold) for all Warehouse contracts in aggregate. Aggregate gross notional value and contract data provided are calculated on a per-trade basis. Net notional value with respect to any single reference entity is the sum of the net protection bought by net buyers (or equivalently net protection sold by net sellers). The aggregate net notional data provided is calculated based on counterparty family.In all the panels, the horizontal axis is the natural logarithm of financial R&D expendituresof all banks averaged over 1996-2006 per country. Observations are labeled with country codes, as defined in Appendix Table A1.

Panel A. Log (# of Reference Entities Holding CDS)



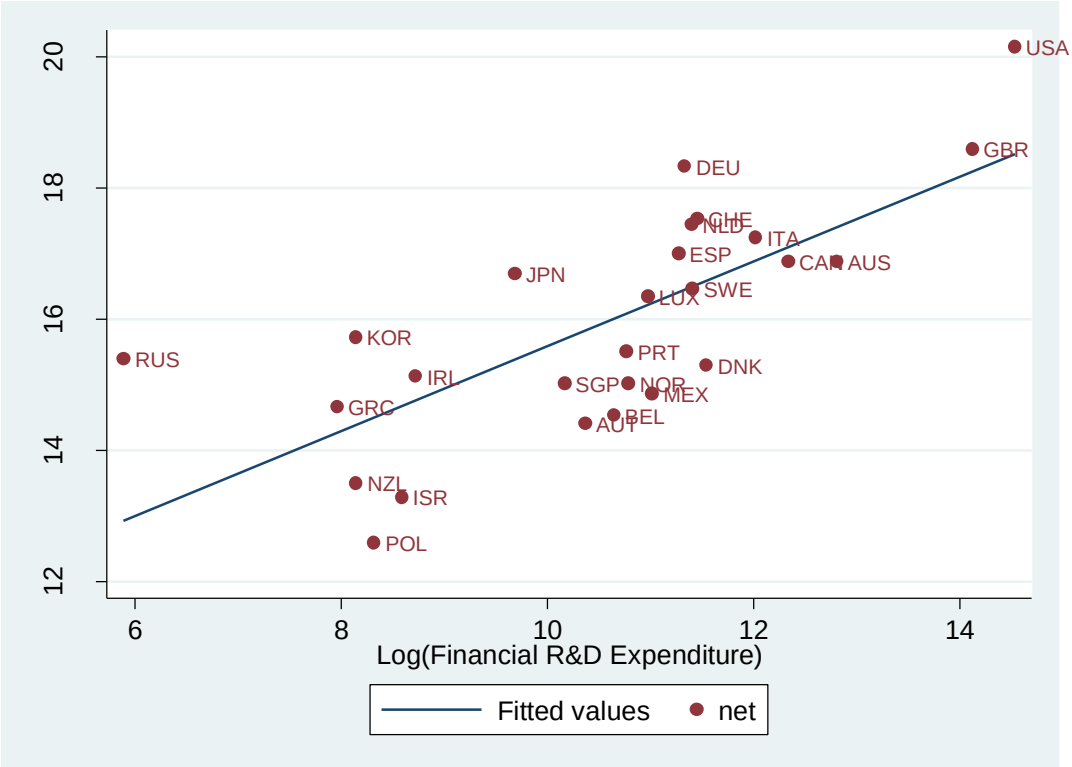
Note: Correlation coefficient: 0.5711; P-value: 0.0133

Panel B. Log (Gross Notional Value of CDS)



Note: Correlation coefficient: 0.7217; P-value: 0.0000

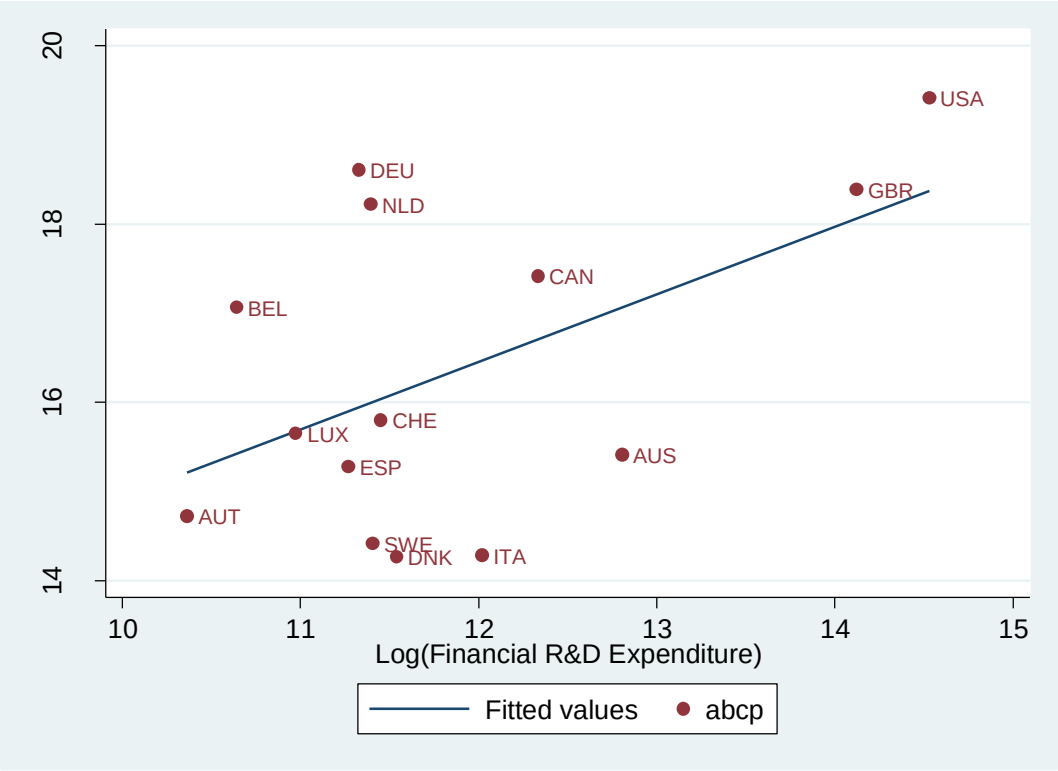
Panel C. Log (Net Notional Value of CDS)



Note: Correlation coefficient: 0.7331; P-value: 0.0000

Appendix Figure A4
ABCP and Log (Financial R&D expenditure)

The figure shows the correlation between ABCP and natural logarithm of financial R&D expenditure (in US$ thousands). The vertical axis is the natural logarithm of the total value of outstanding ABCP (in US$ millions)for each country averaged from 2001 to 2006, and the data is from by Acharya, Schnabl and Suarez (2013). The horizontal axis is the natural logarithm of financial R&D expendituresof all banks averaged over 1996-2006 per country. Observations are labeled with country codes, as defined in Appendix Table A1.

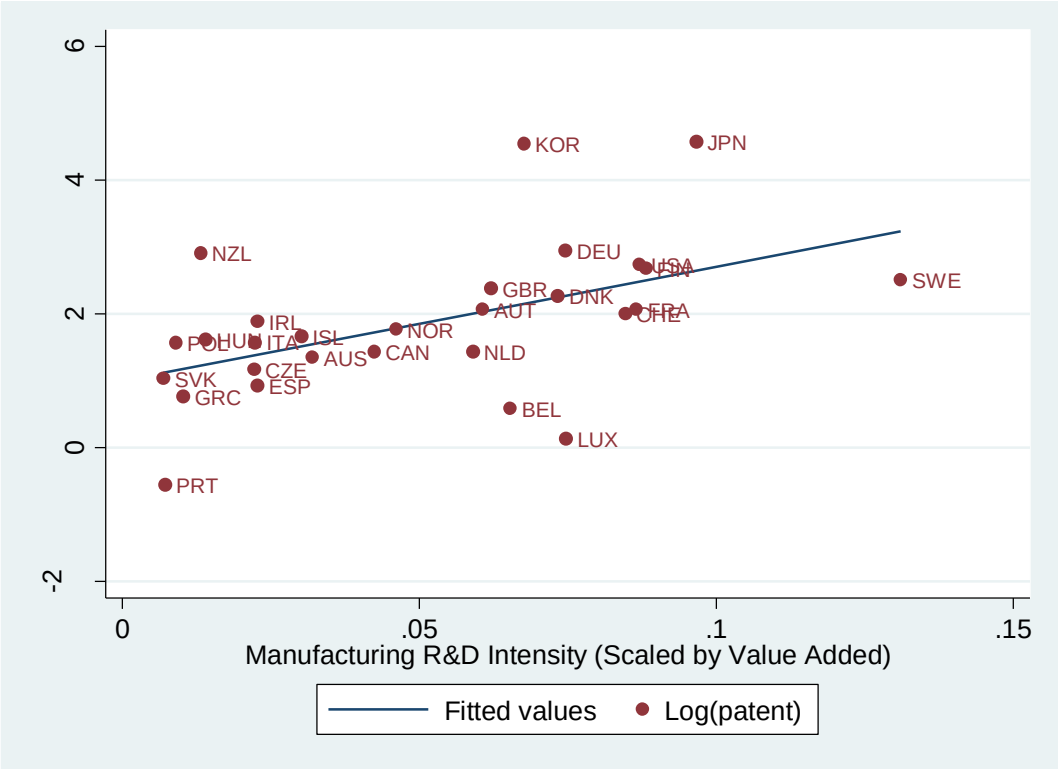


Note: Correlation coefficient: 0.5161; P-value: 0.0589

Appendix Figure A5

Log (#patents filings per $billion GDP) and manufacturing R&D intensity

The figure shows the correlation between Log (#patents filings per $billion GDP) and manufacturing R&D intensity. The vertical axis is a log of the number of patents filings per $Billion GDP averaged over the period 1997-2007 per country, and the horizontal axis is R&D intensity in manufacturing sector scaled by value added in manufacturing, averaged over 1996-2006. Patents data come from the World Intellectual Property Organization (WIPO) Statistics Database. Observations are labeled with country codes, as defined in Appendix Table A1.



Note: Correlation coefficient: 0.5097; P-value: 0.0056