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Financial innovation: The bright and the dark sides☆

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ABSTRACT

Based on data from 32 countries over the period 1996–2010, this paper is the first to assess the relationship between financial innovation, on the one hand, and bank growth and fragility, as well as economic growth, on the other hand. We find that different measures of financial innovation, capturing both a broad concept and specific innovations, are associated with faster bank growth, but also higher bank fragility and worse bank performance during the recent crisis. These effects are stronger in countries with larger securities markets and more restrictive regulatory frameworks. In spite of these seemingly ambiguous findings, our evidence points to a positive net effect of financial innovation on economic growth: financial innovation is associated with higher growth in countries and industries with better growth opportunities.

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."[1]

–Paul Volcker, former Chairman of the Federal Reserve

The Global Financial Crisis of 2007–2009 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 improve the quality and variety of banking services (Merton, 1992; Berger, 2003), facilitate risk sharing (Allen and Gale, 1991, 1994), complete the market (Duffie and Rahi, 1995; Elul, 1995; Grinblatt and Longstaff, 2000), and ultimately improve allocative efficiency (Ross, 1976; Houston et al., 2010), thus focusing on the bright side of financial innovation. The *innovation-fragility view*, on the other hand, focuses on the "dark" side. Specifically, it 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 et al., 2012), and by helping banks develop structured products to exploit investors' misunderstandings of financial markets (Henderson and Pearson, 2011). This paper uses different indicators of financial innovation and an array of bank-, industry and country-level data

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[1] See "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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and analyses to test these hypotheses in a sample of 32 countries over the period 1996–2010.

Given the active academic and policy debate on the role of financial innovation, there is a striking paucity of empirical studies of the real and financial implications of financial innovation, mainly due the lack of data.[3] 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 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 (Gerardi et al., 2010) or new organizational forms, such as Internet-only banks (e.g. DeYoung, 2001, 2005; DeYoung et al., 2007). These studies so far have yielded mixed findings.

On the one hand, there is supporting evidence that financial innovation increases bank growth and supports financial deepening. For example, DeYounget al. (2007) find that Internet adoption improved U.S. community banks' profitability – primarily through deposit-related charges. Several studies document that small business credit scoring increases the quantity of bank lending (Frame et al., 2001, 2004; Berger et al., 2005). Saretto and Tookes (2013) find that CDS trading increases bank credit supply, while Norden et al. (2014) show that banks that use credit derivatives as risk management tool pass these benefits on to their clients in form of lower interest spreads and cut lending less during the recent crisis. Using "counterfactual historic analysis", Lerner and Tufano (2011) document the positive contribution to financial deepening and economic growth of financial innovations, such as venture capital and equity funds, mutual and exchange-traded funds, and securitization.

On the other hand, 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 (2007a, 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 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 et al., 2008; Rajan, 2006; and Gennaioli et al., 2012). Subrahmanyam et al. (2014) find that CDS trading significantly increases credit risk as financial institutions reduce monitoring, while Wang and Xia (2014) document that banks exert less effort on ex post monitoring when they can securitize loans. Overall, there is no conclusive evidence on whether financial innovation is good or bad for the financial sector. Meanwhile, none of the existing papers has taken a holistic approach to financial innovation and its implications for bank growth and fragility. This paper attempts to fill this gap by providing cross-country evidence on the real and financial sector consequences of financial innovation, looking beyond individual innovations to broader measures of activities that result in new products, delivery channels and organizational forms.

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 product or output based measures of financial innovation.[4] Specifically, using OECD innovation survey data on banks' R&D expenditures across 32 mostly developed countries over the period 1996–2010 as a broad indicator of financial innovation, as well as a financial system's securitization capacity and the importance of off- to on-balance-sheet assets as gauges of innovation in specific areas, we relate financial innovation to bank growth and bank fragility over the period 1996–2010 and bank performance during the recent financial crisis. Using a sample of more than 2000 unique banks across 32 countries, we find that a higher level of financial innovation is associated with higher bank growth and higher fragility at the same time. 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.

The seemingly ambiguous relationship between financial innovation and bank performance raises the question of its impact on the real sector. An extensive literature in finance and growth finds a positive correlation between financial development and economic growth (e.g. King and Levine, 1993a, b; Beck et al., 2000), while an extensive banking crisis literature has established rapid credit growth as one of the most robust crisis predictors (e.g., Jorda et al., 2013).[5] Similarly, the net effect of financial innovation on economic growth remains an empirical question that goes beyond its effects on banking sector outcomes. We therefore directly investigate the association of financial innovation with economic growth to pin down the net impact of financial innovation on the real economy.[6] We try to mitigate the potential endogeneity problem, which is often a concern in the finance and growth literature, by offering several tests of channels and mechanisms through which financial innovation is associated with real sector outcomes. Specifically, we use the approach of Bekaert et al. (2005, 2007) to gauge the relationship between financial innovation, exogenous growth opportunities and GDP per capita growth, and follow the approach by Rajan and Zingales (1998) to focus on the differential effects of financial innovation on industries with different growth opportunities (Fisman and Love, 2004, 2007). We find that a higher level of financial innovation is associated with a stronger relationship between a country's exogenous growth opportunities and GDP per capita growth and with a higher growth of industries that have greater growth opportunities. We also show that cross-country and time-variation in financial innovation cannot be explained by growth opportunities. While the cross-country setting of our estimations does not allow the definite elimination of any endogeneity bias, this reduces concerns that our findings are driven by reverse causation or omitted variable bias.

The existing literature on financial innovation also predicts significant differences of its effects according to its nature and the regulatory environment and market structure in which financial innovation happens and which influence banks' incentives for

[3] See discussion in Frame and White (2004, 2009) who 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.

[4] This is different from Laeven et al. (2015), one of the few other cross-country papers in this area, who focus on one specific financial innovation – Private Credit bureaus. Loayza and Ranciere (2006) combine these two effects in a panel analysis and find a positive long-run relationship between financial development and growth, while the short-run coefficient on current financial development enters negatively. Rancière et al. (2008) find a robust positive link between the first moment of credit growth and economic growth, and a negative relationship between the second and third moment and GDP growth. Similarly, studies of financial liberalization show its positive effects on financial deepening and economic growth as well as dampening effects on consumption volatility, but also a higher likelihood of suffering systemic banking crises (Bekaert et al., 2005, 2007 Rancière et al., 2006).

[5] The existing literature focus on the effect of financial development (Private Credit), information sharing, financial openness and liberalization, financial integration among others on economic growth (e.g., King and Levine, 1993b; Bekaert et al., 2005; Bekaert et al., 2007; Djankov et al., 2007; Houston et al., 2010).

[6] See Levine (2005) for a literature survey.

risk-taking. First, risk-shifting and regulatory arbitrage using new forms of securities are easier to undertake in financial systems with larger and more liquid securities markets, which suggests a stronger relationship between financial innovation and banks' growth and fragility in countries with larger securities markets. Second, in times of increasing international integration of financial markets, financial innovation not only diffuses more easily across borders (as illustrated by the purchase of US-issued credit derivatives subsequently purchased by European banks), but its effects are also strengthened by financial integration. Third, financial innovation can 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. This cause of financial innovation implies that, 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, while, 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.

Our empirical analysis shows indeed important cross-country variation in the relationship of financial innovation with bank- and real sector outcomes. Specifically, we find that the real and financial effects of financial innovation are stronger in countries with larger security markets. We also find that financial innovation has stronger positive effects on growth in countries with stronger 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. We also find some evidence for an international diffusion channel of financial innovation.

Our paper is related and contributes to several strands of the literature. First, we complement the literature on the importance of financial innovation by providing consistent cross-country measures of financial innovation and relating them to an array of real and financial sector outcome variables. Second, we add to the literature that explores the determinants of bank behavior and fragility (e.g. Houston and James, 1995; Laeven and Levine, 2009; 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. Third, 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), as we explore whether variation in bank performance during the crisis can be explained by pre-crisis financial innovation.

Fourth, we contribute to the literature on finance and economic growth started by King and Levine (1993a, b).[7] 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 et al., 2015). 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. Finally, we also contribute to the literature of banking regulation (Barth et al., 2001, 2006, 2008; Laeven and Levine, 2009). We find that in countries with more activity restrictions and less stringent capital regulation, financial innovation is more likely to increase bank growth and risk taking.

The rest of the paper proceeds as follows. Section 2 discusses our cross-country indicators of financial innovation. Section 3 relates financial innovation to bank growth and fragility, while Section 4 gauges its relationship between real-sector outcome and economic growth. 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). 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 using an array of different indicators reflecting both input into and output of financial innovations. First, we collect 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 2009. R&D expenditure consists of total intramural (within firm) and extramural (acquired from outside) expenditures on R&D following the definition in the Frascati Manual.

We start our analysis from 1996 when data for nearly all sample countries are available, and we complement with data from the 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.[9]

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.[10] 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

[7] ANBERD contains OECD estimates that adjust for deficiencies and anomalies that exist in the official data and might lead to underestimates.

[8] 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.

[9] 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).

[10] 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.

total non-interest expenses. 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 overestimate financial innovation, as we divide by costs related to the banking rather than the overall financial system.

The descriptive statistics in 1 Panel A shows that the mean value of Financial R&D Intensity (Value Added) is 0.4%, with a standard deviation of 0.56%. There is both important cross-country and within-country variation over time, as indicated by the cross-country standard deviation (0.42%) and somewhat lower within-country standard deviation (0.34%). We note that these values are relatively low, though in line with an average R&D intensity of 0.455% in the service industry, excluding the financial sector. They compare to an average of 4.812% in manufacturing across the same sample of countries and years. This relatively low R&D activity in the financial sector 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 1.06%.

While our sample is a relatively homogenous sample of mostly high-income countries, we find high cross-country variation in financial innovation. Appendix Table A2 reports the summary statistics of financial R&D expenditures in absolute numbers (millions USD) across countries, averaged over the sample period 1996–2009. While Hungarian banks report R&D expenditures of 1.01 million USD, the numbers are 1358 and 2042 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.[11] Fig. 1 shows an increasing trend in financial innovation over time across our sample countries, more than doubling between 1996 and 2008, before decreasing in 2009, 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 experiencing increasing levels of financial innovation and Switzerland experiencing decreasing levels.

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 0.290 (*Financial R&D Intensity (Value Added)*, p-value = 0.000), and 0.098 (*Financial R&D Intensity (Cost)*, p-value = 0.048), respectively, in line with the innovation-growth hypothesis that financial innovation contributes to financial deepening. 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 A3.

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 Fig. A1). 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.

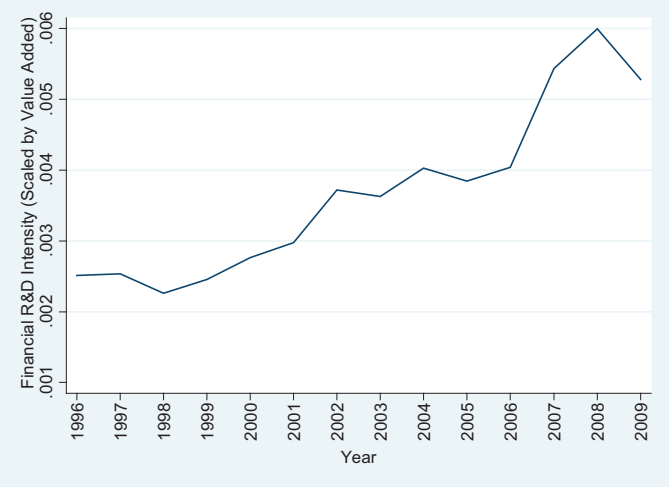


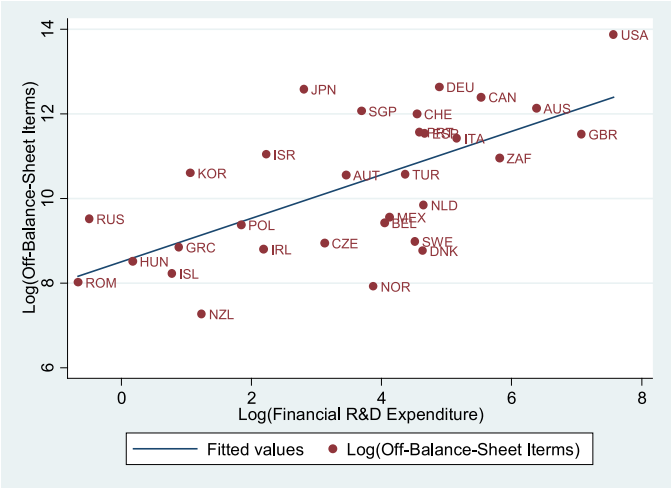
Fig. 1. Overall trend of average Financial R&D Intensity in 32 countries from 1996 to 2009.
The figure shows the overall trend of averaged Financial R&D Intensity (value added) in 32 countries over the period from 1996 to 2009. The 32 countries include Australia, Austria, Belgium, Canada, Czech Republic, 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.

We recognize that the survey-based nature of our indicators of financial innovation makes them susceptible to potential measurement error, even though they have been adjusted for irregularities. Furthermore, these gauges relate to different forms of financial innovation, which might have different effects on bank growth, risk-taking and fragility. We therefore use two alternative indicators of financial innovation that refer to the "output" and specific forms of financial innovation. First, we use the ratio of the total value of off-balance-sheet items and total assets, using data from BankScope. Some forms of financial innovation, such as credit card receivables, or subprime residential mortgages are often portrayed as having led in part to attempts at "arbitraging" regulatory capital requirements by booking assets off the balance sheets of regulated banks (Calomiris, 2009). Fig. 2 shows a positive correlation between the importance of off-balance sheet items in a country's banking system and financial innovative activity, as captured by *Financial R&D Expenditures*. Given that the original data for both are on the bank-level (while the denominators used to construct the indicators are different), we present the raw data for both.[12] Banks in countries with higher R&D expenditures in the financial sector also have larger volumes of off-balance sheet items. While in our bank-level analysis, we use this variable on the bank-level, we use the aggregate value (weighted by total assets) in our country-level regressions.

Second, we construct an indicator of the securitization capacity of a country, proxied by the sum of the outstanding values of all securitized assets in a country, including asset-backed securities (ABS), collateralized debt obligations (CDO), mortgage-back securities, and enterprise-backed securitized assets, divided by GDP. Securitization has emerged as a major conduit for financial innovations, used, on the one hand, to reduce balance sheet constraints on lending; on the other hand, some types of securitization, such

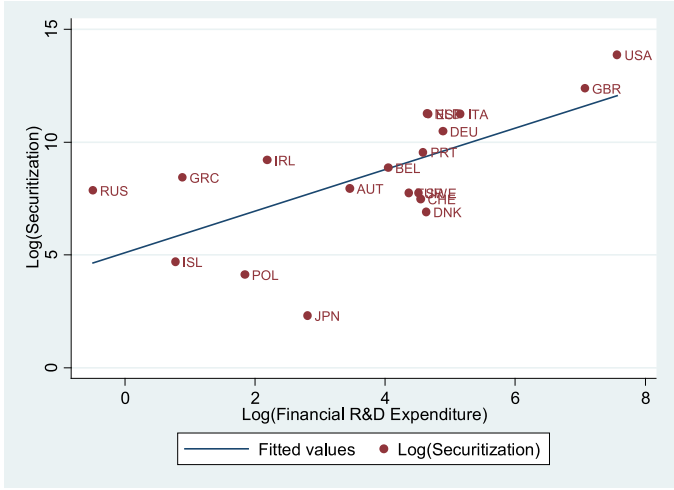
[11] To control for the large size differences across financial systems in our sample, we use the log for both variables.

[12] Following Bekaert et al. (2005, 2007) we also try overlapping regressions, and our results are qualitatively similar.



Note: Correlation coefficient: 0.6520; P-value: 0.0001

Fig. 2. 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$ millions) and natural logarithm of financial R&D expenditure (in US$ millions). The vertical axis is the natural logarithm of the total value of off-balance-sheet items among all the individual banks averaged over 1996–2009 per country, and the horizontal axis is the natural logarithm of financial R&D expenditures of all banks averaged over 1996–2009 per country. The data of off-balance-sheet items come from BankScope. Observations are labeled with country codes, as defined in Appendix Table A2.



Note: Correlation coefficient: 0.6545; P-value: 0.002

Fig. 3. Log (Securitization) and Log (Financial R&D expenditure).
The figure shows the correlation between securitization and natural logarithm of financial R&D expenditure (in US$ millions). The vertical axis is the natural logarithm securitization (in US$ millions) for each country averaged from 1999 to 2009. Securitization measures the securitization capacity of a country, proxied by the summation of the outstanding value of all the securitization assets, including Asset-Backed Securities (ABS) (including auto, consumer, credit cards, leases, and others), CDO, Mortgage-Backed Securities (MBS) (including CMBS, mixed, and RMBS), Small and Medium Enterprises (SME), and Whole Business Securitization (WBS). The data is available from 1999 to 2009 for about 20 countries in our sample. The data comes from European Securitization database, prepared by the Securities Industry and Financial Markets Association (SIFMA) in partnership with the Association for Financial Markets in Europe (AFME). The horizontal axis is the natural logarithm of financial R&D expenditures of all banks averaged over 1996–2009 per country. Observations are labeled with country codes, as defined in Appendix Table A2.

as ABCP, have been used by banks to retain risks on their balance sheet (through explicit guarantees to these vehicles) but reduce capital requirements (Acharya et al., 2013). We have data available from 1999 to 2009 for 20 countries in our sample, with data on securitized assets from the European Securitization Database, prepared by the Securities Industry and Financial Markets Association and the Association for Financial Markets in Europe (AFME). Fig. 3 shows that countries with higher R&D expenditures in the financial sector have also higher outstanding securitized assets. Interestingly, while we find a significant relationship between the raw data of Financial R&D Expenditures, total off-balance sheet items and securitized assets, neither the ratio of off-balance sheet items to total assets nor securitization/GDP are significantly correlated with *Financial R&D Intensity (Value Added)* nor with each other, which suggests that these indicators capture different dimensions of financial innovations. Using these alternative indicators of financial innovation thus not only strengthens our confidence in any consistent results we find, but the lack of a significant correlation also allows us to include them in robustness tests in the same regression.

With the exception of off-balance sheet items to total assets, which we use on the bank-level in the bank-level analysis, our indicators of financial innovation are on the country-level, though financial innovation itself takes place on the bank-level. However, we do not see this as a shortcoming; rather, the interconnectedness of banks and the fact that many financial innovations carry externalities (e.g., completing markets through new securities) beyond the creator of financial innovations justify considering financial innovation on the country – rather than bank-level.

3. Financial innovation and bank performance

This section explores the relationship between financial innovation and bank performance. Specifically, we relate country-level variation in financial innovation to (i) bank-level variation over time in bank growth as measured by growth in bank assets, loans and profits, (ii) bank-level fragility as gauged by the distance to default, and (iii) book- and market-based bank performance during the Global Financial Crisis. This allows us to test for both the innovation-growth and innovation-fragility hypotheses. While the innovation-growth hypothesis would predict higher bank growth in countries with higher levels of financial innovation, the innovation-fragility hypothesis would predict higher bank fragility in countries with higher levels of financial innovation, as well as lower book- and market-based performance during the recent crisis.

3.1. Financial innovation and bank growth

Our first test relates bank-level growth to country-level indicators of financial innovation in a large bank-time panel dataset. Specifically, we regress bank growth on different measures of financial innovation and an array of bank- and country-level control variables:

$$Growth_{i,k,t} = \alpha X_{k,t-1} + \beta Y_{i,t-1} + \gamma FI_{i,t-1} + \delta FI_{i,t-1}, Y_{i,t-1} + \nu_i + \tau_t + \varepsilon_{i,k,t}. \quad (1)$$

In this setup, the indices *i*, *k*, and *t* stand respectively for country, bank and time. Growth is growth in total assets, total loans or total profits of bank *k in* country *i* and period *t*. *X* is a vector of bank characteristics, *Y* is a vector of country characteristics and *FI* is our country-level or bank-level indicator of financial innovation. In our analysis, we use data for more than 2000 banks across 32 countries over the period from 1996 to 2010 using the BankScope database. We divide the total of 15 years into three five-year non-overlapping sub-periods, which results in around 6000 bank-time

observations.[13] We report heteroscedasticity-robust standard errors, clustered within both countries and time periods (double clustering) and include both country- and period fixed effects, so that our regressions effectively capture variation in financial innovation and bank growth within countries and controlling for the positive trends towards higher financial innovation over time, documented in Fig. 1. We also gauge the differential effect of financial innovation on bank growth across countries with different financial market characteristics, degrees of integration into international capital markets, and different regulatory frameworks, by assessing the statistical and economic significance of the coefficients on the interaction terms between *FI* and *Y*.

We include an array of time-variant bank- and country-level factors to avoid that we confound financial innovation with other important factors driving bank growth. Specifically, we control for the tier 1 capital-asset ratio, the loan-asset ratio, the share of non-lending earning assets in total assets, the bank's market share in the country and period, and a too-big-to-fail dummy variable that takes the value one if the bank's deposit share in a country and period exceeds 10%. We also control for the market structure in a country's banking system by including the Herfindahl index of market shares computed using deposit data and the share of total assets by foreign-owned banks, as well as the regulatory framework, by including indicators of restrictions on banks' activities beyond the traditional intermediation business, requirements on banks' entry to capture contestability, official supervisory power, tightness of capital requirements and transparency of financial statements. Many of these indicators have been shown by previous work to be associated with bank growth and stability.[14] In addition, we control for (but do not report) log(GDP), log(GDP per capita) and GDP growth volatility, defined as the standard deviation of GDP annual growth rates.

The regressions in Panel A of Table 2 show that banks in countries with higher levels of financial innovation grow faster, consistent with the hypothesis that financial innovation allows more rapid expansion of banks. Columns (1) through (4) show the main results across the four different indicators of financial innovation and growth in bank assets as dependent variable, while columns (5) through (8) show regressions that gauge the differential effect of financial innovation across countries with different financial market characteristics, degrees of integration into international capital markets, and different regulatory frameworks; we will discuss the specific variables below. Columns (9) and (10) show the robustness of our main findings to the use of two alternative dependent variables.

The results in column (1) show that banks in countries with higher levels of *Financial R&D Intensity (Value Added)* experience higher asset growth. The result is not only statistically significant (at the 1% level), but also economically. One standard deviation in Financial R&D Intensity (0.56) increases annual bank asset growth by 3%, which constitutes 20% of its standard deviation and compares to an average growth rate of 11.7%. Our results also suggest that banks that (i) have lower capitalization, (ii) have fewer non-loan earning assets, (iii) smaller market shares, and (iv) lower loan-asset ratios grow faster, while the too-big-to-fail status (market share of above 10%) is not significantly associated with asset growth. We also find that banks in countries with higher entry requirements grow more slowly, while other country factors do not enter significantly. This lack of finding significant associations between country factors and bank growth might reflect both (i) a differential relationship of these factors with banks of different characteristics in the country and (ii) the limited variation of these factors within countries over time.

The results in columns (2)–(4) confirm the positive relationship between financial innovation and bank growth for three alternative indicators of financial innovation. Specifically, column (2) shows a significant (5% level) and positive relationship between *Financial R&D Intensity (Costs)* and bank growth, of a similar economic significance as the findings in column (1).[15] The results in column (3) show a positive and statistically significant (10% level) between the *Securitization/GDP* and bank growth. The results in column (4) show a positive and statistically significant (10%) relationship between the importance of a bank's off-balance sheet items relative to total assets and bank growth. Unlike the other three measures, this one is measured on the bank- rather than country-level. One standard deviation in the importance of off-balance sheet items explains a growth difference of 0.9% across banks. In unreported regressions, we also include three of the financial innovation measures in the same regression and find that while *Financial R&D Intensity (Value Added)* and *Off-Balance Sheet to Assets* continue to enter positively and significantly, with even higher coefficient estimates, *Securitization/GDP* loses significance.[16] That suggests that higher innovative activity by banks and the expansion of off-balance sheet items is associated with faster on-balance bank growth, independently of each other, while there is no independent effect from a stronger capacity to securitize assets in an economy.

The regressions in columns (5)–(8) gauge cross-country variation of the relationship between financial innovation and bank growth by including additional interaction terms of our primary measure of financial innovation (*Financial R&D Intensity (Value Added)*). First, we gauge whether diffusion across borders and integration into international capital markets dampens or strengthens the positive relationship between financial innovation and bank growth. Specifically, we use the Abiad et al. (2010) indicator of financial liberalization which captures seven different dimensions of financial reform, especially openness of the banking system, and the Bekaert et al. (2011) indicator of market segmentation of equity market (data for 2001–2005). The regression in columns (5) and (6) show no variation of the relationship between financial innovation and bank growth across countries with different degrees of financial openness (column 5), but a stronger association between financial innovation and bank growth in countries with higher level of market integration (column 6). So there is some evidence that the diffusion across borders and integration into international capital markets strengthens the positive effect of financial innovation on bank growth. Second, we gauge whether more developed securities markets in a country enable a stronger relationship between financial innovation and bank growth; to do so, we introduce a dummy variable that indicates whether the ratio of equity and bond market capitalization to GDP is above the sample median. The results in column (7) show that a stronger relationship between financial innovation and bank growth in countries with deeper capital markets, consistent with theories that point to the use of capital markets for purposes of financial innovation, such as credit derivatives and new forms of securitization to

[13] All variables are defined in Table A1 and descriptive statistics presented in Table 1 Panel B. For conciseness, we do not discuss these here.

[14] While the coefficient is significantly lower, the standard deviation of Financial R&D Intensity (Cost) is almost four times as high as Financial R&D Intensity (Value Added).

[15] Since Financial R&D Intensity and the other two measures are not significantly correlated with each other, we can include them in the same regression.

[16] 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. For brevity, we use the label "*Z*-score" in referring to the logged *Z*-score in the remainder of the paper.

better manage risks and expand credit. Third, we gauge whether the regulatory framework has a conditioning effect on the relationship between financial innovation and bank growth. The results in column (8) show that the relationship between financial innovation and bank growth is stronger in countries with tighter capital regulation and higher activity restrictions, while there is no significant interaction with financial statement transparency. This can be interpreted as regulatory restrictions providing impetus for financially innovative activities ("regulatory arbitrage") to expand banks' balance sheets.

The results in columns (9) and (10), finally, show the robustness of our findings to using alternative indicators of bank growth. *Financial R&D Intensity (Value Added)* enters positively and significantly at the 1% level in the regressions of both bank loan growth (column 9) and bank profit growth (column 10). In unreported regressions, we also confirm our findings with these two dependent variables and alternative indicators of financial innovation, used in columns (2)–(4).

3.2. Financial innovation and bank fragility

To gauge the relationship between financial innovation and bank fragility, we run the same regressions as in the previous section, but using a measure of banks' distance to default as dependent variable. Specifically, we run the following regression

$$Z_{i,k,t} = \alpha X_{k,t-1} + \beta Y_{i,t-1} + \gamma FI_{i,t-1} + \delta FI_{i,t-1} Y_{i,t-1} + \nu_i + \tau_t + \varepsilon_{i,k,t}, \quad (2)$$

where Z is the log of the z-score of bank k in country i in period t. 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., 2010; 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.[17]

The regression results in Panel B of Table 2 show a negative relationship between financial innovation on the country- and bank-level and bank stability, as measured by the z-score, though with important cross-country variation. Specifically, all four indicators of financial innovation enter negatively and significantly at least at the 5% level (columns 1–4). The relationship is not only statistically but also economically significant. Using *Financial R&D Intensity (Value Added)*, we find that one standard deviation variation in financial innovation results in 0.32 difference in log(z-score), around 30% of one standard deviation. In unreported regressions, we find (similar to the case of bank growth), that when including three of the financial innovation measures together in the regression, *Financial R&D Intensity (Value Added)* and off-balance sheet items/total assets continue to enter negatively and significantly, while securitization/GDP loses significance.

In unreported regressions, we also explore which of the three components of the z-score drives the relationship between financial innovation and fragility. While we do not find significant relationships between financial innovation and profitability or capitalization, we find a positive and significant relationship between the volatility of ROA (i.e. the denominator of the z-score) and financial innovation. This suggests that financial innovation increases bank fragility through a higher volatility of their profitability.

The results in columns (5)–(8) show important cross-country variation in the relationship between financial innovation and bank stability. As in the case of bank growth, we interact our main measure of financial innovation with indicators of international capital market integration, securities market development and the regulatory framework. First, the results in columns (5) and (6) show that the relationship between financial innovation and bank fragility is less strong in countries that are less integrated in international capital markets. Specifically, for countries with market segmentation above 2.7%, the relationship between Financial R&D Intensity (Value Added) and the z-score turns positive. Nine out of the 32 countries have market segmentation above this value. The interaction between financial liberalization and *Financial R&D Intensity (Value Added)* enters negatively, but not significantly. Together, the findings provide suggestive but not conclusive evidence that stronger integration in international capital markets exacerbates the relationship between financial innovation and bank fragility. Second, the results in column (7) show that the relationship between financial innovation and bank fragility is stronger in countries with deeper security markets. Finally, the results in column (8) show that this relationship is stronger in countries where banks' activities are more restricted, while the relationship is mitigated by more transparent bank statements. There is thus some evidence that regulatory restrictions strengthen the relationship between financial innovation and bank fragility, while a higher degree of transparency weakens it.

While we cannot interpret our regression results in a causal sense, the results in Table 2 suggest a trade-off between financial innovations allowing banks to expand their balance sheets more rapidly but also being associated with higher levels of fragility. These findings are consistent across different measures of financial innovation and show important differential effects across countries with different financial structures, regulatory frameworks and degree of integration into international capital markets. Specifically, the size of securities markets has an important role in allowing banks to use financial innovations to grow their balance sheets but also expose them to higher profit volatility and thus higher fragility. We find that international capital market integration strengthens the positive relationship between financial innovation and bank growth but also between financial innovation and bank fragility, consistent with evidence from the recent crisis where international capital market integration might have been one of several contagion channels (e.g. Devereux and Yu, 2014).

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

The estimations so far rely on panel regressions relating financial innovation (mostly measured on the country-level) to bank-level growth and stability over longer time periods. In the following, we focus on bank performance around the Global Financial Crisis, using book- and market-based indicators. In the first test, we regress the difference in ROA between 2008 and 2006 on financial innovation in 2006 to assess whether banks in countries with higher pre-crisis levels of financial innovation in the banking sector showed stronger performance reductions during the first year of the global financial crisis. Specifically, we run the following regression:

$$\Delta R_{i,k} = \alpha X_k + \beta Y_{i,} + \gamma FI_i + \varepsilon_{i,k,} \quad (3)$$

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. We include the same bank- and country-level control

[17] Their sample is smaller as they are focusing only on a sample of large banks, with total assets larger than $50bn.

variables as in regressions (1) and (2). When using off-balance sheet items/total assets as bank-level indicator of financial innovation, we include country fixed effects. We cluster standard errors at the country-level to take into account possible correlation in banks' performance during the crisis not captured by any of the explanatory variables.

We use a bank-level sample to assess the relationship between pre-crisis financial innovation and changes in banks' profitability between 2006 and 2008. Descriptive statistics for this sample of 1536 banks across 32 countries are reported in Panel C of Table 2. On average, banks' ROA dropped by 1.2% between 2006 and 2008.

The results in Table 3 Panel A suggest that higher pre-crisis financial innovation is associated with higher drops in profitability between 2006 and 2008. All four indicators of financial innovation enter negatively in the regressions of changes in ROA and significantly at least at the 10% level. The economic effect of this relationship is also large. Taking the column (1) estimate, for example, it suggests that a one standard deviation in *Financial R&D Intensity (Value Added)* is associated with a 0.3 percentage point drop in ROA, compared to an average drop of 1.2 percentage point in ROA. It is important to note that even when using the bank-level indicator of financial innovation (off-balance sheet items/total assets) and thus considering within-country relationships between financial innovation and bank performance, we find a negative relationship. Our results also suggest that banks with higher loan-asset ratios and higher tier 1 capital-asset ratio as well as banks in countries with more transparent standard for financial statements performed better during the crisis.

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), but use a larger sample.[18] 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 3 Panel B suggest that banks in countries with a higher level of financial innovation pre-crisis had lower buy-and-hold returns during the crisis. All four 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.

In a final test on 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.

[18] 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).

The results in Appendix Table A4 show that Financial R&D Intensity does not proxy for general innovative attitude in the economy. Here, we replicate the regressions of the bank growth and *Z*-score in Table 2 and the regressions of change in ROA in Table 3. R&D intensity in manufacturing enters positively and insignificantly across all three regressions. In the case of the *z*-score and the ROA change, it thus has also the wrong sign in addition to being insignificant. Overall, these findings provide additional evidence that the relationship between financial innovation and bank growth and fragility is not driven by a spurious correlation.

In summary, the results in this section provide evidence for both the innovation-growth and innovation-fragility hypotheses. Banks grow faster in countries with higher levels of financial innovation, but also experience higher fragility, due to higher volatility of their profits. Financial innovation thus seems to be a double-sided sword, contributing to financial deepening and to instability. This raises the question on the relationship of financial innovation with real economy outcomes. Does financial innovation support economic growth by supporting financial deepening or does it undermine economic growth by resulting in oversized and fragile financial systems? We will turn to this question in the next section.

4. Financial innovation and the real economy

The results in the previous section suggest a trade-off in the effects of financial innovation o banks' growth and stability. But what are the real sector implications of financial innovation? The finance and growth literature suggests positive real sector implications of more efficient banking systems; do these findings expand to financial innovation that helps countries deepen their financial systems? Alternatively, and consistent with the innovation-fragility hypothesis, does financial innovation lead to an overexpansion of the financial sector, with higher fragility ultimately undermining the growth of the real economy? In this section, we study the relationship between financial innovation and economic growth.

To address endogeneity concerns and explore the channels through which financial innovation might affect the real economy, we focus on exogenous growth opportunities. Theory suggests that financial intermediaries are critical in choosing projects and entrepreneurs with the highest growth opportunities (King and Levine, 1993a), as well as in monitoring them (Blackburn and Hung, 1998). Similarly, by offering risk diversification opportunities, well-developed financial intermediaries allow investment in high risk but high return projects (Greenwood and Jovanovic, 1990). The innovation-growth hypothesis suggests that financial innovation helps financial intermediaries and markets improve screening, monitoring and risk management capacities and thus support and fund growth opportunities in the real economy. The innovation-fragility hypothesis would predict no such effect or, at a minimum no long-term sustainable growth effect, as financial innovations mainly serve regulatory arbitrage purposes and undermine stable financial intermediaries with negative repercussions for the real economy. In this section, we will employ different panel data sets (i) across countries and over time and (ii) across countries and across industries, exploring whether financial innovation helps countries and industries with higher growth opportunities grow faster. In each case, we will first explain the methodology, then describe data and finally discuss the results.

One important concern that we want to address before presenting regressions of real sector outcomes of financial innovation is that of endogeneity – in faster growing economies or economies with higher growth opportunities there might be higher demand for innovative financial products. In addition, relating country-level factors such as financial development or innovation always raises

concerns of simultaneity bias, where omitted factors drive both the explanatory variable of interest and the dependent variable. In the following, we will therefore first present regressions exploring factors explaining cross-country and over-time variation in financial innovation, including growth opportunities, since our subsequent regression analysis will exploit cross-country and cross-industry variation in growth opportunities.

4.1. What explains cross-country variation in financial innovation?

We first explore factors explaining cross-country and over-time variation in financial innovation. We would like to stress that this is far from being a full-fledged analysis of the drivers of financial innovation, an analysis beyond the objective of this paper and which we leave for future research. Table 4 thus presents exploratory OLS regressions, relating country-year variation in financial innovation to an array of country characteristics, including indicators of financial market structure and the regulatory framework of countries. Specifically, we use the following regression set-up:

$$FI_{i,t} = \alpha X_{i,t} + Year_t + \varepsilon_{i,t,} \quad (4)$$

where i stands for country and t for year. We include year-fixed effects to control for the time trends documented earlier. While we exploit variation in financial innovation both across countries and over time, not all our explanatory variables, most notably the regulatory indicators, vary over time. To control for this and the correlation of the intensity of financial innovation within countries over time but also across countries within given years, we double-cluster our standard errors at the country- and year-level.

One of our main variables of interest is growth opportunities, which in the following regressions (as well as in the subsequent section) we measure on the country-year level. 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. 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.[19] 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 0.078 across countries and over time, with a standard deviation of 0.419 (Table 1, Panel D).

The regressions in Table 4 show that cross-country and over time variation in financial innovation is associated with different features of the regulatory framework, the ownership structure and the importance of capital markets. Most notably, however, we find no significant relationship between a country's growth opportunities and financial innovation by its banks. Columns (1)–(6) use *Financial R&D Intensity (Value Added)* as dependent variable, while columns (7)–(9) use the three alternative indicators of financial innovation. The results suggest higher levels of financial innovation in countries with higher restrictions on banks' activities, with less powerful supervisors, but higher capital stringency and less transparent accounting standards. Overall, this provides some evidence for the regulatory arbitrage hypothesis of financial innovation, especially in countries with higher activities restrictions 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. In addition, countries with above median securities market depth (comprising equity and debt markets) have higher levels of financial innovation. We also find some evidence that financial innovation is lower in larger countries. Important for our subsequent regression analysis, we cannot find any significant relationship of financial innovation with growth opportunities. The results also show no significant relationship between the level of economic development or business cycles and financial innovation. The fact 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.

4.2. Does financial innovation help countries exploit growth opportunities?

Our first test of the effect of financial innovation on the real economy builds on previous work by Bekaert et al. (2005, 2007) who show that exogenous growth opportunities predict subsequent GDP growth and more so in countries with liberalized capital accounts, banking systems and equity markets. Here, we gauge the relationship between financial innovation, growth opportunities and GDP per capita growth in the following regression model:

$$Growth_{i,t} = \beta_1 GGO\_MA_{i,t} + \beta_2 FI_{i,t} + \beta_3 GGO\_MA_{i,t}{}^{*} FI_{i,t} + \gamma X_{i,t} + \sum_i \delta_i Country_i + \varepsilon_{i,t}, \quad (5)$$

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; X contains an array of time-variant country-level control variables and *Country* is an array of country dummies. Our sample period is 1997–2010 and, 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 in financial liberalization index in a specific 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. As we include country dummies, our coefficient estimates pick up economic relationships relative to country averages.

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

[19] We cannot use our fourth indicator – securitization/GDP, given limited country and time-series coverage. When including both Financial R&D Intensity (Value Added) and off-balance sheet items/total assets, only the latter enters significantly.

Table 1
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), 1996–2009	0.399	0.560	0	3.140	32	411
Financial R&D Intensity (Cost), 1996–2009	1.057	2.066	0	11.528	32	403
Securitization/GDP, 1999–2009	6.214	9.653	2.1E−04	34.844	20	161
Off-Balance-Sheet Items/Total Assets, 1996–2009	14.082	10.741	1.328	40.362	32	346

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 B. Bank risk taking analysis 1996–2010

Variable	Mean	Standard deviation	Min	Max	No. of countries	No. of obs. (bank-time)
Bank Level Data						
Bank Asset Growth	0.117	0.152	−0.329	1	32	6030
Bank Loan Growth	0.013	0.096	−0.501	1	32	6033
Bank Profit Growth	0.033	0.377	−1	1	32	5885
Log *Z*-score	3.618	1.051	1.228	6.152	32	6030
Bank Market Share	0.011	0.049	7.820E−06	0.392	32	6030
Loan to Asset Ratio	0.644	0.141	0.044	0.925	32	6030
Tier 1 Capital Ratio	0.086	0.035	0.026	0.289	32	6030
Other Earning Assets	0.246	0.133	0.004	0.764	32	6030
Too-big-to-fail	0.036	0.177	0	1	32	6030
Country Level Data						
Overall Activities Restrictions	8.054	1.047	3	10	32	6030
Official Supervisory Power	7.630	0.541	6	8	32	6030
Entry into Banking Requirements	12.918	1.671	6	14.5	32	6030
Tight Capital Regulation	0.040	0.195	0	1	32	6030
Financial Statement Transparency	4.987	0.359	3	6	32	6030
HHI	0.071	0.111	0.028	0.646	32	6030
Foreign Bank Ownership	0.137	0.101	0.000	0.858	32	6030
Log GDP Per Capita	10.413	0.416	7.879	10.824	32	6030
Log GDP	29.542	1.108	24.945	30.211	32	6030
GDP Growth Volatility	0.030	0.043	0.012	0.248	32	6030
Financial Liberalization	0.236	0.425	0	1	32	6030
Market Segmentation	0.019	0.013	0.012	0.088	32	5904
Market Segmentation 2001–2005	0.012	0.010	0.007	0.068	32	5904
R&D Intensity in Manufacturing Industry (Placebo Test)	0.082	0.020	0.005	0.132	32	5853

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 C. 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	1536
Change in ROE (ROE_{2008}–ROE_{2006})	−0.118	0.228	−1.240	0.454	32	1533
Buy-and-Hold Stock Returns July 2007–December 2008	−0.420	0.289	−0.975	0.528	20	487
Tier 1 Capital Ratio	0.121	0.124	−0.137	2.414	32	1537
Too-big-to-fail	0.056	0.230	0	1	32	1537
Bank Market Share	0.018	0.050	0	0.531	32	1537
Loan to Asset Ratio	0.604	0.227	−0.004	0.990	32	1537
Country Level Data						
Overall Activities Restrictions	6.881	1.769	3.273	9.727	32	1537
Official Supervisory Power	11.119	2.338	6.364	14.136	32	1537
Entry into Banking Requirements	7.494	0.675	4.091	8.000	32	1537
Capital Regulatory Index	6.641	1.191	3.273	9.636	32	1537
Financial Statement Transparency	4.984	0.571	3.636	6	32	1537
HHI	0.098	0.063	0.045	0.275	32	1537
Log GDP Per Capita	10.071	0.726	7.758	10.697	32	1537
Log GDP	28.100	1.593	24.667	29.946	32	1537
Foreign Bank Ownership	0.143	0.105	0	0.888	32	1537
R&D Intensity in Manufacturing Industry (Placebo Test)	28.100	1.593	24.667	29.946	32	1196

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.

(*continued on next page*)

Table 1 (*continued*)

Panel D. Exogenous growth opportunity analysis 1997–2010

Variable	Mean	Standard deviation	Min	Max	No. of countries	No. of obs.
Annual Real GDP Growth (5-year horizon)	0.015	0.020	−0.027	0.084	31	359
GGO_MA	0.078	0.419	−0.557	2.646	31	359
Private Credit	4.397	0.741	2.272	5.408	32	359
Stock Market Cap	0.796	0.597	0.010	3.034	31	359
Recession	0.188	0.392	0	1	31	359
Financial Liberalization	0.174	0.380	0	1	32	264

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 E. Industrial growth and volatility analysis 1996–2009

Variable	Mean	Standard deviation	Min	Max	No. of countries	No. of obs.
Average Growth Rate in Real Value Added	2.647%	11.842%	−40.104%	57.398%	28	704
GO	0.351	0.390	−0.450	1.490	28	709
Private Credit	4.170	0.693	2.551	4.934	28	723
Stock Market Cap	0.586	0.414	0.071	1.724	28	723
Financial Liberalization	0.194	0.155	0.000	0.600	28	723
HHI	0.390	0.222	0.121	0.878	28	723
Entry into Banking Requirements	7.368	0.951	4.091	8.000	28	723
Industry's Initial Share of Total Manufacturing VA	0.023	0.024	0.000	0.110	28	723

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.

predictions by Laeven et al. (2015), 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 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 1.5%, ranging from −2.8% in Israel in 2004–2008 to 8.4% in Russia in 2002–2006, with a standard deviation of 2.0%.

The results in Table 5 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 across different specifications and regressions with different sets of control variables. Similarly, our two alternative indicators of financial innovation – Financial R&D Intensity (Cost) and Off-Balance Sheet Items/Total Assets – enter positively and significantly (columns 3 and 4).[20] The level of financial innovation, on the other hand, does not enter consistently across the different specifications of Table 5, which suggests that it is not financial innovation per se that is associated with faster economic 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.[21] 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 (Rioja and Valev, 2004; Aghion et al., 2005; Arcand et al., 2015).

The effect is not only statistically, but also economically significant. At the mean of financial innovation (0.40%), a move from a country and period with growth opportunities at the mean of 0.08 to a country and period with growth opportunities of one standard deviation above the mean (0.42) predicts an increase in annual real per capita GDP growth by 0.9 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 1.2 percentage points.[22] Given that the mean annual growth rate in our sample is 1.2%, this difference of 0.3 percentage points is economically meaningful. In summary, the evidence presented in Table 5 is consistent with the innovation-growth hypothesis.

4.3. Does financial innovation help industries with higher growth opportunities?

In additionto cross-country estimations, we follow work by Rajan and Zingales (1998) and Fisman and Love (2007) to test the effect of financial innovation on the growth of industries with different growth opportunities. 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, while Fisman and Love (2004, 2007) use the same methodology to show that industries with higher growth opportunities grow faster in countries with higher levels of financial development. 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.[23] Specifically, we estimate the

[20] 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.

[21] To compute these economic effects, we add up the level and the interaction effects of financial innovation.

[22] See, e.g., Cetorelli and Gambera (2001), Beck and Levine (2002), Raddatz (2006), Kroszner et al. (2007).

[23] This indicator is from the Barth et al. (2001, 2006, 2008) database and measures the regulatory requirements to obtain a banking license. See Appendix Table A1 for details.

Table 2
Financial innovation, bank growth and bank risk taking: OLS regressions.

Panel A. Financial innovation and bank growth

	Bank Asset Growth								Bank Loan Growth	Bank Profit Growth
	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)	0.054***				0.133**	0.175***	0.053***	0.073**	0.041***	0.153***
	[0.015]				[0.056]	[0.051]	[0.019]	[0.031]	[0.011]	[0.056]
Financial R&D Intensity (Cost)		0.013**								
		[0.007]								
Securitization/GDP			0.003*							
			[0.002]							
Off-Balance-Sheet Items/Total Assets				0.006*						
				[0.003]						
Financial Liberalization × Financial R&D Intensity (Value Added)					−0.093					
					[0.154]					
Market Segmentation × Financial R&D Intensity (Value Added)						−0.058**				
						[0.023]				
Financial R&D Intensity (Value Added) × High Security Market Depth							0.041***			
							[0.009]			
Financial R&D Intensity (Value Added) × Overall Activities Restrictions								0.040*		
								[0.024]		
Financial R&D Intensity (Value Added) × Tight Capital Regulation								−0.025**		
								[0.012]		
Financial R&D Intensity (Value Added) × Financial Statement Transparency								−0.049		
								[0.033]		
High Security Market Depth							0.027*			
							[0.015]			
Overall Activities Restrictions	−0.013	−0.007	−0.014*	−0.004	−0.002	−0.008	0.021*	−0.000	−0.004	−0.002
	[0.008]	[0.007]	[0.008]	[0.012]	[0.011]	[0.007]	[0.011]	[0.005]	[0.005]	[0.023]
Entry into Banking Requirements	−0.034**	−0.017	−0.015	0.046***	−0.055**	−0.026	−0.069***	−0.007	0.012	0.037
	[0.016]	[0.018]	[0.018]	[0.015]	[0.026]	[0.016]	[0.021]	[0.010]	[0.011]	[0.054]
Official Supervisory Power	−0.003	−0.000	−0.002	−0.021***	0.003	0.001	0.022**	−0.000	−0.005	−0.035
	[0.006]	[0.006]	[0.007]	[0.007]	[0.009]	[0.006]	[0.010]	[0.005]	[0.004]	[0.022]
Tight Capital Regulation	−0.004	−0.030	−0.023	−0.025**	−0.003	0.005	−0.016	−0.032	−0.050***	0.154***
	[0.017]	[0.022]	[0.022]	[0.012]	[0.020]	[0.017]	[0.021]	[0.021]	[0.016]	[0.056]
Financial Statement Transparency	0.022	0.032**	0.038**	0.061***	0.003	0.027*	−0.026	0.019*	0.015	0.101**
	[0.015]	[0.016]	[0.016]	[0.017]	[0.026]	[0.016]	[0.020]	[0.011]	[0.009]	[0.042]
Tier 1 Capital Ratio	−0.211**	−0.211**	−0.252***	0.132	−0.270***	−0.198**	−0.275***	−0.179*	0.131	−0.215
	[0.087]	[0.086]	[0.090]	[0.112]	[0.081]	[0.088]	[0.081]	[0.095]	[0.099]	[0.179]
Other Earning Assets	−0.208***	−0.205***	−0.184***	0.030	−0.214***	−0.209***	−0.216***	−0.194***	0.011	0.020
	[0.037]	[0.037]	[0.037]	[0.026]	[0.039]	[0.037]	[0.039]	[0.039]	[0.028]	[0.105]
Bank Market Share	−0.434***	−0.464***	−0.577***	0.130	−0.500***	−0.426***	−0.484***	−0.389***	0.067	−0.179
	[0.134]	[0.132]	[0.146]	[0.119]	[0.183]	[0.135]	[0.181]	[0.136]	[0.098]	[0.419]
Loan to Asset Ratio	−0.092**	−0.090**	−0.055	−0.024	−0.090**	−0.091**	−0.094**	−0.092***	−0.044	0.272**
	[0.037]	[0.037]	[0.043]	[0.036]	[0.040]	[0.036]	[0.039]	[0.035]	[0.038]	[0.123]
Too-big-to-fail	0.028	0.037	0.044*	−0.039*	0.061*	0.032	0.059*	0.016	−0.019	0.064
	[0.026]	[0.025]	[0.024]	[0.023]	[0.034]	[0.027]	[0.033]	[0.024]	[0.018]	[0.084]
HHI	1.053	0.851	1.176	−0.168	1.354	0.917	0.529	0.781	0.317	−0.878
	[0.717]	[0.662]	[0.718]	[0.449]	[0.901]	[0.675]	[0.806]	[0.564]	[0.443]	[1.860]
Foreign Bank Ownership	−0.141	−0.061	0.022	−0.234***	−0.380*	−0.167	−0.652***	−0.109	−0.108	−0.211
	[0.142]	[0.140]	[0.145]	[0.060]	[0.209]	[0.139]	[0.151]	[0.100]	[0.066]	[0.353]
Other Country Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5918	6030	4637	5605	5657	5904	5657	5914	6033	5885
Adjusted R^2	0.179	0.193	0.243	0.086	0.177	0.179	0.183	0.163	0.085	0.157

(*continued on next page*)

Table 2 (*continued*)

Panel B. Financial innovation and bank risk taking								
	Log *Z*-score							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Financial R&D Intensity (Value Added)	−0.563**				−1.120*	−1.736***	−0.777***	−1.188***
	[0.265]				[0.584]	[0.437]	[0.289]	[0.409]
Financial R&D Intensity (Cost)		−0.139***						
		[0.040]						
Securitization/GDP			−0.060***					
			[0.023]					
Off-Balance-Sheet Items/Total Assets				−1.443***				
				[0.379]				
Financial Liberalization × Financial R&D Intensity (Value Added)					−0.312			
					[1.299]			
Market Segmentation × Financial R&D Intensity (Value Added)						0.520***		
						[0.174]		
Financial R&D Intensity (Value Added) × High Security Market Depth							−2.477***	
							[0.540]	
Financial R&D Intensity (Value Added) × Overall Activities Restrictions								−0.803*
								[0.447]
Financial R&D Intensity (Value Added) × Tight Capital Regulation								0.314
								[0.215]
Financial R&D Intensity (Value Added) × Financial Statement Transparency								0.522*
								[0.284]
High Security Market Depth							0.832	
							[0.776]	
Overall Activities Restrictions	0.011	−0.041	−0.031	−0.114	−0.098	0.016	−0.089	0.018
	[0.035]	[0.026]	[0.058]	[0.111]	[0.073]	[0.037]	[0.056]	[0.034]
Entry into Banking Requirements	0.208**	0.112*	0.095	0.100	0.209	0.152*	0.056	0.093
	[0.088]	[0.059]	[0.145]	[0.196]	[0.152]	[0.088]	[0.112]	[0.082]
Official Supervisory Power	0.068*	0.030	0.023	0.033	0.114*	0.079**	0.162***	0.065*
	[0.035]	[0.020]	[0.048]	[0.154]	[0.063]	[0.034]	[0.055]	[0.035]
Tight Capital Regulation	0.022	0.109	0.276**	0.011	−0.328	−0.075	−0.204*	0.005
	[0.180]	[0.088]	[0.136]	[0.196]	[0.263]	[0.181]	[0.107]	[0.128]
Financial Statement Transparency	−0.053	−0.078	−0.069	0.018	0.055	−0.075	0.054	−0.152
	[0.101]	[0.058]	[0.089]	[0.225]	[0.163]	[0.097]	[0.128]	[0.178]
Tier 1 Capital Ratio	4.650***	4.753***	3.373**	5.454***	5.399***	4.617***	5.362***	4.665***
	[1.075]	[1.269]	[1.508]	[0.838]	[0.934]	[1.091]	[0.943]	[1.078]
Other Earning Assets	2.433***	2.452***	2.209***	2.563***	2.559***	2.425***	2.558***	2.437***
	[0.259]	[0.336]	[0.256]	[0.335]	[0.228]	[0.265]	[0.227]	[0.257]
Bank Market Share	1.346**	1.205	1.771**	1.722	1.616**	1.267**	1.418*	1.170*
	[0.602]	[0.831]	[0.789]	[1.508]	[0.786]	[0.608]	[0.808]	[0.601]
Loan to Asset Ratio	0.810***	0.799***	0.507**	0.910**	0.915***	0.803***	0.906***	0.809***
	[0.226]	[0.274]	[0.250]	[0.359]	[0.217]	[0.230]	[0.215]	[0.226]
Too-big-to-fail	−0.223	−0.204	−0.099	−0.356	−0.329	−0.205	−0.303	−0.196
	[0.168]	[0.156]	[0.181]	[0.308]	[0.224]	[0.171]	[0.232]	[0.170]
HHI	−2.299***	−1.962***	0.235	−1.953	−2.181**	−2.014***	−1.632*	−1.988***
	[0.512]	[0.179]	[0.366]	[1.880]	[1.046]	[0.514]	[0.918]	[0.499]
Foreign Bank Ownership	0.716	0.273	0.638	2.285*	1.199*	0.525	0.875	0.739*
	[0.453]	[0.394]	[0.577]	[1.274]	[0.698]	[0.399]	[0.585]	[0.446]
Other Country Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5746	5884	4689	5491	5523	5740	5527	5746
Adjusted R^2	0.168	0.171	0.153	0.166	0.166	0.168	0.168	0.168

The sample period is from 1996 to 2010, which has a total of 15 years and provides three five-year non-overlapping sub-periods. The dependent variable is bank asset growth, loan growth, or profit growth in Panel A, and log *z*-score or Sharpe ratio in Panel B. *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 five-year window. Higher *z*-score implies more stability and less bank risk taking. Securitization measures the securitization capacity of a country, proxied by the summation of the outstanding value of all the securitization assets, including Asset-Backed Securities (ABS) (including auto, consumer, credit cards, leases, and others), CDO, Mortgage-Backed Securities (MBS) (including CMBS, mixed, and RMBS), Small and Medium Enterprises (SME), and Whole Business Securitization (WBS). The data is available from 1999 to 2009 for about 20 countries in our sample. The data comes from European Securitization database, prepared by the Securities Industry and Financial Markets Association (SIFMA) in partnership with the Association for Financial Markets in Europe (AFME). Bank market share is the share of each bank's deposits to total deposits within a given country. 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, and GDP growth volatility. GDP growth volatility is the standard deviation of GDP growth in the previous five years. Detailed variable definitions and descriptions can be found in Appendix Table A1. This table reports the impacts of financial R&D intensity on bank growth and risk taking across around 6000 bank-time observations in 32 countries. Four 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 (double clustering) are reported in brackets. *significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3
Financial innovation and bank performance change in the recent financial crisis.

Panel A. Change in ROA				
	Change in ROA			
	Model 1	Model 2	Model 3	Model 4
Financial R&D Intensity (Value Added)	−0.011***			
	[0.003]			
Financial R&D Intensity (Cost)		−0.001**		
		[0.000]		
Securitization/GDP			−0.009*	
			[0.005]	
Off-Balance-Sheet Items/Total Assets				−0.005***
				[0.001]
Overall Activities Restrictions	−0.000	−0.000	−0.000	
	[0.001]	[0.001]	[0.001]	
Entry into Banking Requirements	0.001	0.000	0.002	
	[0.001]	[0.001]	[0.001]	
Official Supervisory Power	−0.000	0.000	−0.000	
	[0.001]	[0.001]	[0.001]	
Capital Regulatory Index	−0.000	−0.002	−0.002	
	[0.002]	[0.002]	[0.003]	
Financial Statement Transparency	0.002**	0.002*	0.003**	
	[0.001]	[0.001]	[0.001]	
Tier 1 Capital Ratio	0.076***	0.077***	0.068***	0.079***
	[0.020]	[0.020]	[0.021]	[0.021]
Bank Market Share	0.005	0.009	0.005	0.009
	[0.021]	[0.021]	[0.025]	[0.021]
Loan to Asset Ratio	0.014***	0.014***	0.015***	0.015***
	[0.004]	[0.004]	[0.004]	[0.004]
Too-big-to-fail	0.002	0.001	0.001	0.001
	[0.003]	[0.003]	[0.005]	[0.003]
HHI	−0.025	−0.045	−0.088**	
	[0.024]	[0.030]	[0.042]	
Foreign Bank Ownership	−0.000	−0.000	−0.012	
	[0.003]	[0.003]	[0.012]	
Other Country Controls	Yes	Yes	Yes	No
Country Fixed Effects	No	No	No	Yes
Observations	1536	1536	1337	1536
Adjusted R^2	0.114	0.111	0.090	0.121
Panel B. Buy-and-hold stock returns July 2007–December 2008				
	Buy-and-hold stock returns July 2007–December 2008			
	Model 1	Model 2	Model 3	Model 4
Financial R&D Intensity (Value Added)	−0.201*			
	[0.113]			
Financial R&D Intensity (Cost)		−0.033**		
		[0.015]		
Securitization/GDP			−1.663***	
			[0.243]	
Off-Balance-Sheet Items/Total Assets				−0.029***
				[0.005]
Tangible Equity	0.974	1.061	2.075**	2.205**
	[0.691]	[0.698]	[0.935]	[0.868]
Deposits	0.577***	0.586***	0.658***	0.628***
	[0.112]	[0.107]	[0.087]	[0.083]
Funding Fragility	0.152*	0.135*	0.109	0.100
	[0.076]	[0.078]	[0.101]	[0.100]
Loan to Asset Ratio	−0.325***	−0.322***	−0.230**	−0.182
	[0.095]	[0.090]	[0.103]	[0.118]
Log Assets	−0.006	−0.006	−0.008	−0.017*
	[0.006]	[0.006]	[0.008]	[0.010]
Log Z-score	0.077***	0.078***	0.076***	0.076***
	[0.006]	[0.006]	[0.005]	[0.006]
Non-interest	−0.426***	−0.435***	−0.155	−0.266*
	[0.096]	[0.102]	[0.123]	[0.142]
Income Diversity	0.420***	0.422***	0.286***	0.361***
	[0.060]	[0.061]	[0.060]	[0.072]
Other Earning Assets	0.321***	0.325***	0.419***	0.439***
	[0.105]	[0.105]	[0.126]	[0.135]
Tier 1 Capital Ratio	−1.284**	−1.436**	−3.032***	−3.046***
	[0.561]	[0.561]	[0.900]	[0.840]
2006 Return	0.047*	0.044*	0.055*	0.041
	[0.024]	[0.024]	[0.029]	[0.025]
Overall Activities Restrictions	0.018	0.011	−0.042	
	[0.018]	[0.022]	[0.032]	

(*continued on next page*)

Table 3 (*continued*)

Panel B. Buy-and-hold stock returns July 2007–December 2008				
	Buy-and-hold stock returns July 2007–December 2008			
	Model 1	Model 2	Model 3	Model 4
Entry into Banking Requirements	0.121***	0.115***	0.620***	
	[0.024]	[0.030]	[0.091]	
Official Supervisory Power	0.044**	0.052**	−0.000	
	[0.019]	[0.020]	[0.019]	
Capital Regulatory Index	−0.070***	−0.072***	−0.131***	
	[0.020]	[0.018]	[0.040]	
Financial Statement Transparency	0.265***	0.293***	−0.072**	
	[0.051]	[0.046]	[0.029]	
HHI	0.398	0.325	−0.987***	
	[0.313]	[0.267]	[0.122]	
Foreign Bank Ownership	−0.291	−0.384	−3.152***	
	[0.354]	[0.380]	[0.532]	
Other Country Controls	Yes	Yes	Yes	No
Country Fixed Effects	No	No	No	Yes
Observations	486	486	463	487
Adjusted R^2	0.210	0.211	0.215	0.215

The table presents the results of financial innovation and bank performance in the recent financial crisis period. In Panel A., the dependent variable is the performance change (ROA) between 2008 and 2006 for each bank, calculated as the difference of ROA value between 2008 and 2006. ROA refers to return on asset. In Panel B, the dependent variable is buy-and-hold stock for each bank over the period returns July 2007-December 2008. The sample includes 1536 banks in BankScope in Panel A, and 487 banks in BankScope in Panel B 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. Four measures of financial innovation are applied. Financial R&D intensity (value added), financial R&D intensity (cost), and Off-Balance-Sheet Items/Total Assets are averaged from 1996 to 2006, Securitization/GDP is averaged from 1999 to 2006. Securitization measures the securitization capacity of a country, proxied by the summation of the outstanding value of all the securitization assets, including Asset-Backed Securities (ABS) (including auto, consumer, credit cards, leases, and others), CDO, Mortgage-Backed Securities (MBS) (including CMBS, mixed, and RMBS), Small and Medium Enterprises (SME), and Whole Business Securitization (WBS). The data is available from 1999 to 2009 for about 20 countries in our sample. The data comes from European Securitization database, prepared by the Securities Industry and Financial Markets Association (SIFMA) in partnership with the Association for Financial Markets in Europe (AFME). Bank market share is the share of each bank's deposits to total deposits within a given country. 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. We also control for beta and real estate beta as in Beltratti and Stulz (2012) in Panel B. Beta is defined as the slope of the regression of weekly excess stock returns on the MSCI World excess return for the period 2004–2006 and real estate beta is 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. Detailed variable definitions and descriptions of other variables can be found in Appendix Table A1. Heteroskedasticity-consistent standard errors clustered at the country level are reported in brackets.*, **, *** represent statistical significance at the 10%, 5% and 1% level, respectively.

following model:

$$Growth_{i,k} = \sum_j \alpha_j Country_j + \sum_l \beta_l Industry_l + \gamma Share_{i,k} + \delta_1 (GO_k{}^* FI_i) + \delta_2 (GO_k{}^* FD_i) + \varepsilon_{i,k}, \quad (6)$$

where $Growth_{i,k}$ is the average annual growth rate of value added in industry k and country i, over the period 1996–2009. *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 growth opportunities (GO) of an industry with both (a) a measure of overall financial development (*FD*) and (b) an indicator of financial innovation (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 GO and financial development/innovation has on industry growth rates relative to country and industry means. We include several additional interaction terms of growth opportunities with country characteristics, including stock market capitalization to GDP, financial liberalization, the Herfindahl index of bank concentration and an indicator of entry into banking requirements to thus control for market structure[24] 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.

A positive and statistically significant δ_1 in regression (6) would be evidence for the innovation-growth hypothesis, as it would not only suggest a positive impact of financial innovation on industries with higher growth opportunities, but such effect would be in addition to the positive effect of financial depth, gauged by δ_2, an effect shown by Fisman and Love (2007) and confirmed by other authors (e.g. Beck et al., 2008).

Following Fisman and Love (2007), we calculate the average growth rate in real value added for 1996–2009 for each industry in each country (*Average Growth Rate in Real Value Added*). The industry level data on growth opportunities are from Fisman and Love (2007) and are computed as the real annual growth in net sales of U.S. firms over the period 1980–1989 using data from Compustat. This industry-specific measure relies on the assumption of worldwide, industry-specific shocks to growth opportunities; if firms in the United States respond perfectly to these shocks, then the actual growth of firms in the U.S. should be a proxy for these growth opportunities.

The results in Table 6 Panel A show that industries with higher growth opportunities as measured by sales growth in the U.S., grow faster in countries with higher levels of financial

[24] Later in the subsample analysis we find that the interaction of Off-Balance Sheet Items/Total Assets with growth opportunities is significant in the subsample of firms with High Security Market Depth. Also we find that it turns significant when we include three measures of financial innovation in one regression.

Table 4
Determinants of financial innovation 1996–2009.

	Financial R&D Intensity (Value Added)						Financial R&D Intensity (Cost)	Securitization/ GDP	Off-Balance-Sheet Items/ Total Assets
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Growth Opportunity (GGO_MA)	−0.015	−0.015	−0.020	0.000	−0.013	−0.034	0.014	−0.037	−0.008
	[0.021]	[0.019]	[0.021]	[0.021]	[0.018]	[0.024]	[0.132]	[0.025]	[0.009]
Overall Activities Restrictions	0.042***				0.045***	0.061***	0.114*	0.001	0.003
	[0.014]				[0.012]	[0.017]	[0.060]	[0.004]	[0.003]
Official Supervisory Power		−0.018*			−0.017**	−0.006	−0.076	0.006**	−0.002
		[0.009]			[0.009]	[0.011]	[0.066]	[0.003]	[0.003]
Overall Capital Stringency			0.110*		0.040	0.096	0.820***	−0.005	0.038**
			[0.063]		[0.053]	[0.063]	[0.298]	[0.007]	[0.015]
Financial Statement Transparency				−0.053*	−0.030	−0.054*	0.065	−0.018**	−0.007
				[0.028]	[0.026]	[0.031]	[0.128]	[0.007]	[0.008]
Statutory Corporate Tax Rates	0.005	0.004	0.005	0.005	0.001	0.002	−0.001	−0.000	0.000
	[0.005]	[0.005]	[0.004]	[0.004]	[0.004]	[0.004]	[0.018]	[0.001]	[0.001]
Government Bank Ownership	−0.757***	−0.724***	−0.624***	−0.768***	−0.578***	−0.472***	−2.319***	−0.219	0.133***
	[0.133]	[0.120]	[0.122]	[0.122]	[0.121]	[0.143]	[0.746]	[0.132]	[0.048]
HHI	0.100	−0.165	0.460	−0.197	0.875*	1.162*	−3.555**	0.039	0.015
	[0.533]	[0.484]	[0.520]	[0.485]	[0.518]	[0.627]	[1.792]	[0.107]	[0.116]
HHI^2	−0.042	0.181	−0.267	0.179	−0.584	−0.807	2.034	0.007	−0.163
	[0.443]	[0.404]	[0.434]	[0.403]	[0.427]	[0.510]	[1.550]	[0.080]	[0.102]
Private Credit	0.203**	0.197**	0.215**	0.194**	0.200**	0.238**	0.065	0.008	−0.021
	[0.096]	[0.099]	[0.098]	[0.096]	[0.088]	[0.101]	[0.339]	[0.019]	[0.017]
Stock Market Cap	0.158*	0.139	0.170*	0.159*	0.218**	0.281***	1.989***	−0.048***	0.033
	[0.088]	[0.086]	[0.096]	[0.090]	[0.087]	[0.096]	[0.563]	[0.012]	[0.022]
log GDP	−0.080***	−0.080***	−0.062**	−0.091***	−0.027	−0.026	−0.238*	0.177	−0.035***
	[0.028]	[0.027]	[0.026]	[0.027]	[0.023]	[0.028]	[0.124]	[0.234]	[0.009]
log GDP Per Capita	−0.014	−0.028	−0.052	−0.031	−0.034	−0.015	−0.524	−0.147	0.047***
	[0.056]	[0.054]	[0.056]	[0.054]	[0.048]	[0.048]	[0.342]	[0.236]	[0.011]
Security Market Depth						0.090*	−0.205	0.009*	0.030**
						[0.046]	[0.204]	[0.005]	[0.015]
Recession						−0.181**	0.117	0.002	0.015
						[0.082]	[0.406]	[0.009]	[0.025]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	327	326	322	334	317	279	283	123	230
Adjusted *R*-squared	0.225	0.211	0.208	0.205	0.273	0.779	0.712	0.904	0.597

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 experiencing a recession in a particular year, which is constructed following Braun and Larrain (2005). Security market depth is measured by the summation of the value of listed shares to GDP, the private domestic debt securities issued by financial institutions and corporations as a share of GDP, and the public domestic debt securities issued by government as a share of GDP. Detailed variable definitions and descriptions can be found in Appendix Table A1. 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%.

innovation, even controlling for the interaction of growth opportunities with indicators of financial intermediary development, equity market development, financial liberalization and banking sector competition and contestability. The interactions between growth opportunities and (i) *Financial R&D Intensity (Value Added)*, (ii) *Financial R&D Intensity (Cost), (iii) Securitization/GDP* enter positively and significantly, at least at the 5% level. The interaction of Off-Balance Sheet Items/Total Assets with growth opportunities also enters positively, but not significantly at the conventional levels (column 4).[25] When entering three of the four financial innovation measures (except *Financial R&D Intensity (Cost)*), we find that the interactions of all three with growth opportunities enter positively and significantly, suggesting that these three measures capture different dimensions of financial innovation, but all with a positive net effect on economic growth. Again, the effect is not only statistically, but also economically significant. To illustrate the economic effect, we compute the growth difference between industries at the 25th and 75th percentiles of *Growth Opportunities* and countries at the 25th and 75th percentiles of financial innovation. This growth difference is 1.2%, compared to the average growth of 2.65% in our sample. While the interactions of growth opportunities with financial liberalization enter positively and significantly in three of the four regressions (with the fourth one having a substantially smaller sample), the interactions of growth opportunities with the other country-level characteristics of the financial system do not enter significantly, including the interaction with Private Credit.[26] We do not find the insignificant coefficient on the interaction of growth opportunities with 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., Aghion et al., 2005; Arcand et al., 2015). 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 drives 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 and

[25] Out of four model specifications, we only have one significant coefficient estimate of the interaction of growth opportunities with Private Credit (column 2 at 10% level).

[26] Note that here we do not perform interaction analysis as in Table 2 because it is difficult to interpret triple interaction terms.

Table 5
Exogenous growth opportunities and financial innovation in predicting growth 1997–2010.

	Annual Real Per Capita GDP Growth (5-Year Horizon)			
	Model 1	Model 2	Model 3	Model 4
GGO_MA	0.010	0.024	0.027	0.020
	[0.022]	[0.016]	[0.018]	[0.022]
GGO_MA × Financial R&D Intensity (Value Added)	0.022**	0.012*		
	[0.011]	[0.007]		
GGO_MA × Financial R&D Intensity (Cost)			0.005**	
			[0.002]	
GGO_MA × Off-Balance-Sheet Items/Total Assets				0.045***
				[0.012]
GGO_MA × Private Credit	−0.002	−0.008	−0.009*	−0.002
	[0.006]	[0.005]	[0.005]	[0.007]
GGO_MA × Stock Market Cap		0.004	−0.001	−0.007
		[0.016]	[0.016]	[0.021]
GGO_MA × Financial Liberalization		0.011*	0.011	0.006
		[0.006]	[0.008]	[0.006]
Financial R&D Intensity (Value Added)	0.009	0.007***		
	[0.006]	[0.002]		
Financial R&D Intensity (Cost)			−0.000	
			[0.002]	
Off-Balance-Sheet Items/Total Assets				−0.026
				[0.021]
Private Credit	−0.025***	−0.013***	−0.013*	−0.007
	[0.009]	[0.004]	[0.007]	[0.006]
Stock Market Cap		0.004	0.004	0.002
		[0.006]	[0.006]	[0.006]
Financial Liberalization		−0.005*	−0.004	−0.006**
		[0.003]	[0.003]	[0.003]
Country Fixed Effects	Yes	Yes	Yes	Yes
Observations	292	228	230	256
Adjusted *R*-squared	0.664	0.718	0.717	0.676

The sample includes 31 countries between 1997 and 2010. The dependent variables are either the 5-year average growth rate of real per capita gross domestic product. 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., 2010). 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 covers 91 economies. Private credit is a log of private credit divided by GDP. Detailed variable definitions and descriptions can be found in Appendix Table A1. 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%.

innovation by financial institutions. Our results are confirmed for the sample of "small" industries.

The regressions in Table 6 Panel B show that the positive relationship between financial innovation and the relative growth of industries with more growth opportunities is driven by market-based financial systems. Here we split the sample into countries whose ratio of equity and debt market capitalization to GDP is above and below the median value to gauge whether the growth benefit of financial innovation is contingent on having sufficient developed markets.[27] *Re*-running the four regressions of Panel A for the two sub-samples, we find that it is only in the subsample of countries above-median securities market depth, that our measures of financial innovation, including the ratio of off-balance sheet items to total assets, enter positively and significantly, while they enter insignificantly in the subsample of countries with low security market depth (and even negatively and significantly in the case of Securitization/GDP). We also find that in three of the four innovation measures, the estimated coefficient on the interaction between financial innovation and growth opportunities is significantly different across the two samples.

In summary, the analysis in this section and the results presented in Tables 5 and 6 are consistent with the innovation-growth hypothesis and inconsistent with the innovation-fragility hypothesis. Countries and industries with higher growth opportunities grow faster if banks in the country undertake more financial innovation, as proxied both by their innovative activities and the relative volume of off-balance sheet items and securitization capacity. We note, however, that this effect is contingent on having sufficiently developed securities markets in the country.

In conclusion, we would like to emphasize a methodological issue. By focusing on difference-in-differences regressions – in the case of the country-panel regressions by including country dummies and interacting financial innovation with growth opportunities and in the case of the country-industry panel by including country and industry dummies – we do not estimate (and therefore do not find) that countries or industries grow faster with higher financial innovation. Rather, we find that financial innovation helps exploit growth opportunities, with the documented positive growth effects being relative to overall industry or country growth. This approach allows us to mitigate (though

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

Table 6
Financial innovation and industry growth.

Panel A. Baseline regressions

	Growth in Real Value Added			
	Model 1	Model 2	Model 3	Model 4
GO × Financial R&D Intensity (Value Added)	1.381**			
	[0.663]			
GO × Financial R&D Intensity (Cost)		0.227***		
		[0.047]		
GO × Securitization/GDP			0.788**	
			[0.319]	
GO × Off-Balance-Sheet Items/Total Assets				0.830
				[0.808]
GO × Private Credit	0.265	0.392*	0.072	0.302
	[0.227]	[0.205]	[0.565]	[0.247]
GO × Stock Market Cap	−0.582	−1.138**	−0.847	−0.337
	[0.586]	[0.424]	[0.668]	[0.695]
GO × Financial Liberalization	0.074***	0.062***	−0.046	0.069***
	[0.019]	[0.020]	[0.081]	[0.019]
GO × HHI	−1.129	−0.227	−0.627	−0.734
	[0.685]	[0.613]	[0.898]	[0.700]
GO × Entry into Banking Requirements	−0.020	0.090	0.083	0.066
	[0.111]	[0.072]	[0.117]	[0.109]
Industry's Initial Share of Total Manufacturing VA	0.456	0.485*	0.859*	0.443
	[0.273]	[0.271]	[0.446]	[0.266]
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations	692	692	404	692
Adjusted R^2	0.251	0.255	0.264	0.246

Panel B. Subsample analysis

	Growth in Real Value Added							
	Security Market Depth		Security Market Depth		Security Market Depth		Security Market Depth	
	High	Low	High	Low	High	Low	High	Low
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
GO × Financial R&D Intensity (Value Added)	2.217***	1.037						
	[0.683]	[0.935]						
GO × Financial R&D Intensity (Cost)			2.846**	1.048				
			[1.022]	[0.779]				
GO × Off-Balance-Sheet Items/Total Assets					2.237**	2.005		
					[0.765]	[2.114]		
GO × Securitization/GDP							1.114**	-0.035**
							[0.312]	[0.010]
GO × Private Credit	−0.372	0.244	−2.390	0.239	0.538	1.058**	1.173***	0.064
	[0.806]	[0.381]	[1.948]	[0.357]	[1.078]	[0.358]	[0.277]	[1.042]
GO × Stock Market Cap	−0.678*	−0.655	0.085	−1.194	0.544	−2.852**	−3.333***	0.017
	[0.366]	[2.162]	[0.424]	[2.079]	[0.434]	[0.798]	[0.547]	[0.573]
GO × Financial Liberalization	0.000	0.086***	0.000	0.087***	0.000	−0.149**	−0.170**	0.000
	[0.000]	[0.016]	[0.000]	[0.014]	[0.000]	[0.050]	[0.053]	[0.000]
GO × HHI	−2.523**	1.183	−4.824	1.562*	−0.804	−0.960	0.073	−1.491
	[1.044]	[0.774]	[2.557]	[0.736]	[1.247]	[1.555]	[0.960]	[1.527]
GO × Entry into Banking Requirements	−0.123	0.073	−0.613	0.057	−0.151	−2.924**	−3.556***	−0.024
	[0.113]	[0.192]	[0.357]	[0.188]	[0.149]	[0.997]	[0.592]	[0.220]
Industry's Initial Share of Total Manufacturing VA	0.631***	0.358	0.722**	0.380	0.778**	0.888	0.917	0.857**
	[0.117]	[0.524]	[0.258]	[0.550]	[0.254]	[0.791]	[0.799]	[0.287]
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test "High = Low"	5.91**	2.58*	0.02	21.83***				
Observations	353	339	216	339	216	188	216	188
Adjusted R^2	0.278	0.243	0.192	0.245	0.187	0.241	0.187	0.241

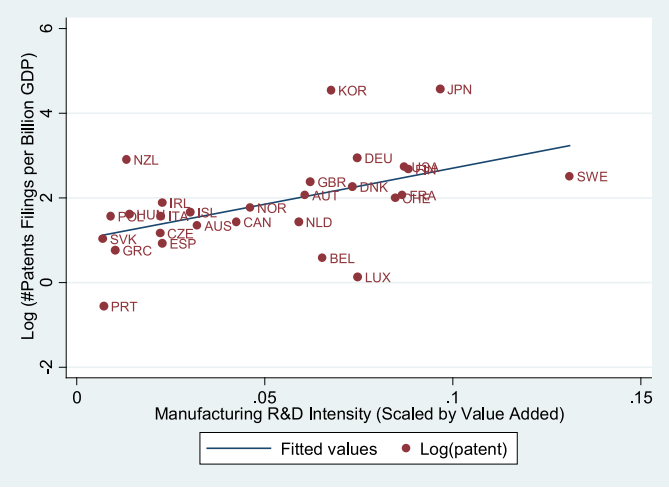
The dependent variable is the average growth rate in real value added across 1996–2009 for each ISIC industry in each country, using the data from UNIDO INDSTAT4, 2013. The sample excludes the industrial sectors in the US, which serves as the benchmark. Panel A reports the impacts of financial R&D intensity on sectoral growth, while Panel B reports the subsample analysis based on security market depth. Securitization measures the securitization capacity of a country, proxied by the summation of the outstanding value of all the securitization assets, including Asset-Backed Securities (ABS) (including auto, consumer, credit cards, leases, and others), CDO, Mortgage-Backed Securities (MBS) (including CMBS, mixed, and RMBS), Small and Medium Enterprises (SME), and Whole Business Securitization (WBS). The data is available from 1999 to 2009, and comes from European Securitization database, prepared by the Securities Industry and Financial Markets Association (SIFMA) in partnership with the Association for Financial Markets in Europe (AFME). Financial innovation is measured using the initial available value across 1996–2009 when available. Growth opportunities (GO), developed by Fisman and Love (2007), is the industry-level median of firm average growth in sales for U.S. firms, from Compustat. 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 2009. Detailed variable definitions and descriptions can be found in Appendix Table A1. 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%.

not eliminate) endogeneity concerns associated with cross-country regressions

5. Conclusions

The recent Global Financial Crisis has spurred renewed debates on the "bright" and "dark" sides of financial innovation. We find supportive evidence for both the *innovation-growth* and the *innovation-fragility* views. Overall, our results suggest that there are both "bright" and "dark" sides to financial innovation. Financial innovation is associated with more aggressive risk-taking by banks and higher bank growth, which helps provide valuable credit and risk diversification services to firms and households, which in turn enhances capital allocation efficiency and economic growth. On the downside, the "dark" side of greater risk taking is that it significantly increases the banks' profit volatility, their fragility and their losses during a banking crisis. On net, however, financial innovation allows countries to grow faster by helping them exploit exogenously given growth opportunities.

Appendix



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

Fig. A1. 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.

Table A1
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 2009 (reported in SourceOECD Statistics 2013). 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 2009. 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 2013
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 2009. 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 2013, OECD Banking Statistics, BankScope
Securitization/GDP	Securitization measures the securitization capacity of a country, proxied by the summation of the outstanding value of all the securitization assets, including Asset-Backed Securities (ABS) (including auto, consumer, credit cards, leases, and others), CDO, Mortgage-Backed Securities (MBS) (including CMBS, mixed, and RMBS), Small and Medium Enterprises (SME), and Whole Business Securitization (WBS). The data is available from 1999 to 2009 for about 20 countries in our sample. The data comes from European Securitization database, prepared by the Securities Industry and Financial Markets Association (SIFMA) in partnership with the Association for Financial Markets in Europe (AFME).	SIFMA and AFME
Off-Balance-Sheet Items/Total Assets	The total value of off-balance-sheet items divided by total assets for all the individual banks. The measure is at bank level for bank-level analysis. For the country-level analysis, the measure is aggregated for each country.	BankScope
Bank Level Analysis Variables		
Bank Asset Growth	The growth rate of bank asset for a bank.	BankScope
Bank Loan Growth	Total loan growth rate of a bank.	BankScope

(*continued on next page*)

Table A1 (*continued*)

Variable	Definition	Original sources
Bank Profit Growth	Total revenue growth rate of a bank.	BankScope
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. σ(ROA) is standard deviation of ROA over a five-year non-overlapping window across 1996–2010. Higher z implies more stability.	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
High Security Market Depth	This measure is to capture a country's security market activities and the ability to securitize asset. Summation of the value of listed shares to GDP, the private domestic debt securities issued by financial institutions and corporations as a share of GDP, and the public domestic debt securities issued by government as a share of GDP. A country is regarded as having high security market depth if its measure is higher than the median of the sample in a year.	Beck et al. (2000a), updated in 2013
Bank Market Share	The share of each bank's deposits to total deposits within a given country.	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 1996–2009.	BankScope
Foreign Bank Ownership	The percentage of total shares held by the foreign country.	Beck et al. (2000a), updated in 2013
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 et al. (2001, 2006, 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 et al. (2001, 2006, 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 et al. (2001, 2006, 2008)
Tight Capital Regulation	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 et al. (2001, 2006, 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 et al. (2001, 2006, 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
Log GDP	Natural logarithm of the real GDP (US Dollars)	World Development Indicators (2012)

(*continued on next page*)

Table A1 (*continued*)

Variable	Definition	Original sources
Log GDP Per Capita	Natural logarithm of GDP per capita (US Dollars)	World Development Indicators (2012)
GDP Growth Volatility	Standard deviation of growth rates in real GDP in the previous five years.	World Development Indicators (2012)
Financial Liberalization	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, and then is normalized to be within (0, 1), 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. (2010). The extended version covers 91 economies.	Abiad and Mody (2005), Abiad et al. (2010)
Market Segmentation	The caculation of market segmentation follows Bekaert et al. (2011). It measures the degree of effective or de facto equity market segmentation for a country, and is computed as the value-weighted average of the absolute difference between a country's local industry earnings yields and the corresponding global industry earnings yields. We use the average value from 2001 to 2005 for each country in our analysis. A higher value indicates higher level of market segmentation and lower level of integration with the global market.	Bekaert et al. (2011), Datastream and Standard & Poor's Emerging Market Data Base.
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 2009 (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 2009. 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 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 2010.	World Development Indicators (2012)
Annual Real Investment Growth (5-year horizon)	Growth of real per capita gross fixed capital formation, which includes land improvements (fences, ditches, drains, and so on), plant, machinery, and equipment purchases, and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.	World Development Indicators (2012)
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 et al. (2000a), updated in 2013
Stock Market Cap	Value of listed shares to GDP.	Beck et al. (2000a), updated in 2013
Recession	Recession is a dummy variable indicating whether a country is experiencing a recession in a particular year, which is constructed following Braun and Larrain (2005).	Braun and Larrain (2005)
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., 2010). 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. (2010). The extended version covers 91 economies.	Abiad and Mody (2005), Abiad et al. (2010)
Industrial Level Analysis Variables		
Average Growth Rate in Real Value Added	The average growth rate in real value added for 1996–2009 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, 2013
GO	Growth opportunities (GO), developed by Fisman and Love (2007), is the industry-level median of firm average growth in sales for U.S. firms, from Compustat.	Fisman and Love (2007), 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 2009.	BankScope
Private Credit	Private Credit divided by GDP.	Beck et al. (2000a), updated in 2013
Stock Market Cap	Value of listed shares to GDP.	Beck et al. (2000a), updated in 2013
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 et al. (2001, 2006, 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, 2013

Table A2
Summary statistics for financial R&D expenditure across countries over 1996–2009.

Country	Country code	Mean	SD
Australia	AUS	590.44	528.77
Austria	AUT	31.66	13.81
Belgium	BEL	57.27	39.02
Canada	CAN	252.22	90.36
Czech Republic	CZE	22.75	38.88
Denmark	DNK	102.69	74.76
Germany	DEU	132.40	127.01
Greece	GRC	2.41	3.04
Hungary	HUN	1.19	1.00
Iceland	ISL	2.18	1.40
Ireland	IRL	8.91	8.77
Israel	ISR	9.27	11.58
Italy	ITA	173.99	84.57
Japan	JPN	16.58	5.33
Korea	KOR	2.89	4.34
Luxembourg	LUX	58.32	15.32
Mexico	MEX	61.83	46.63
Netherlands	NLD	104.37	66.80
New Zealand	NZL	3.44	2.17
Norway	NOR	48.25	28.23
Poland	POL	6.30	7.65
Portugal	PRT	98.02	107.33
Romania	ROM	0.51	0.53
Russian Federation	RUS	0.61	0.72
Singapore	SGP	40.16	42.04
South Africa	ZAF	335.38	216.95
Spain	ESP	106.23	91.30
Sweden	SWE	91.31	9.14
Switzerland	CHE	94.05	19.76
Turkey	TUR	78.59	65.70
United Kingdom	GBR	1178.37	1160.60
United States	USA	1936.38	771.69

The table reports the summary statistics for financial R&D expenditure (in Million USD) across 32 countries, over the period from 1996 to 2009.

Table A4
Placebo test.

	Bank asset growth Model 1	Log *Z*-score Model 2	ROA change Model 3
R&D Intensity in Manufacturing Industry	1.320	4.498	0.005
	[1.743]	[9.591]	[0.009]
Overall Activities Restrictions	−0.009	−0.036	0.001***
	[0.015]	[0.081]	[0.000]
Entry into Banking Requirements	−0.010	−0.033	0.003***
	[0.013]	[0.164]	[0.001]
Official Supervisory Power	0.009	−0.060	−0.001***
	[0.014]	[0.063]	[0.000]
Capital Regulatory Index	−0.041	0.025	0.001***
	[0.036]	[0.185]	[0.000]
Financial Statement Transparency	0.014	0.221	−0.004***
	[0.023]	[0.199]	[0.001]
Tier 1 Capital Ratio	−0.216***	−0.938	0.061***
	[0.059]	[1.014]	[0.024]
Other Earning Assets	−0.121**	2.142***	
	[0.058]	[0.585]	
Bank Market Share	−0.067	1.191***	0.025
	[0.082]	[0.416]	[0.017]
Loan to Asset Ratio	−0.000	0.562	0.013***
	[0.055]	[0.450]	[0.004]
Too-big-to-fail	0.018	−0.282	−0.002
	[0.039]	[0.370]	[0.004]
HHI	0.058	−0.472	−0.054***
	[0.086]	[0.323]	[0.013]
Foreign Bank Ownership	−0.298	0.302	−0.003
	[0.390]	[0.828]	[0.003]
Other Country Controls	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	No
Time Fixed Effects	Yes	Yes	No
Observations	6174	5879	1196
Adjusted R^2	0.107	0.113	0.083

This table reports the placebo test, using R&D intensity in manufacturing industry as the measure instead of Financial R&D Intensity. The dependent variables are Bank Asset Growth and Log *Z*-score as in Table 2, and ROA Change as in Table 3. Detailed variable definitions and descriptions can be found in Appendix Table A1. 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%.

Table A3
Correlation matrix.

	1	2	3	4	5	6	7	8	9
Financial R&D Intensity (Value Added)	1								
Financial R&D Intensity (Cost)	0.501***	1							
	(0.000)								
Off-Balance-Sheet Items/Total Assets	0.042	0.112**	1						
	(0.440)	(0.042)							
Securitization/GDP	-0.071	0.045	−0.111	1					
	(0.372)	(0.579)	(0.178)						
R&D Intensity in Service Industry	0.309***	0.164***	0.192***	0.347***	1				
	(0.000)	(0.007)	(0.000)	(0.000)					
R&D Intensity in Manufacturing Industry	0.314***	0.035	−0.174**	0.148	0.224***	1			
	(0.000)	(0.611)	(0.022)	(0.129)	(0.001)				
Private Credit	0.290***	0.098**	−0.081	0.551***	0.176***	0.471***	1		
	(0.000)	(0.048)	(0.132)	(0.000)	(0.004)	(0.000)			
Stock Market Cap	0.291***	0.274***	0.036	0.213***	0.211***	0.489***	0.530***	1	
	(0.000)	(0.000)	(0.507)	(0.007)	(0.000)	(0.000)	(0.000)		
Log GDP Per Capita	0.227***	−0.074	−0.067	0.247***	0.361***	0.551***	0.659***	0.366***	1
	(0.000)	(0.148)	(0.241)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	

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 2009. Detailed variable definitions and descriptions can be found in Appendix Table A1. *P*-values are reported in the parentheses below the correlation coefficients. *, **, *** represent statistical significance at the 10%, 5% and 1% level respectively.

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