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Financial crisis, bank diversification, and financial stability: OECD countries

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ABSTRACT

Using a sample of commercial banks based in OECD countries, we investigate the effect of bank diversification on financial stability and find a significantly nonlinear (i.e., inverted U-shaped) relationship. These findings suggest that a moderate degree of bank diversification increases bank stability, but excessive diversification has an adverse effect. Furthermore, we find that this relationship has a temporal dimension. For example, bank diversification decreased the variance of bank stability prior to the financial crisis but increased its variance during the crisis. Thus, during crisis periods, it is better for banks to concentrate on traditional intermediation functions (i.e., deposits and loans) rather than diversifying their activities and investments. Further, the results suggest that although most regulators worldwide encourage diversification to reduce bank risk, bank diversification may exacerbate bank financial instability or increase the risk of financial market collapse when idiosyncratic events, such as financial crises occur.

1. Introduction

With increasing financial liberalization and innovation prior to the global financial crisis, banks eagerly pursued operational diversification. Policymakers and regulators in many countries have deregulated the scope of bank diversification and lowered barriers among commercial and investment banks and security and insurance companies to increase competitiveness in the banking industry. Thus, banks have tended to rely less on traditional interest income and have expanded their business ranges to include other financial sectors. However, the recent global financial crisis raises questions about the benefits of such diversification. The financial community is now arguing for a serious reassessment of the advantages and disadvantages of bank diversification. Regulators and market practitioners claim that excessive bank diversification accelerates the propagation of financial risk, leading to financial crises, and they suggest that policies and laws are needed to regulate excessive bank diversification (Acharya, Hasan, & Saunders, 2006; DeYoung & Roland, 2001). For example, in 2009, the Bank of England considered requiring banks to split their retail and investment banking sectors to reduce and diversify risks.[1] In Asia, the Korean government recently imposed sanctions on banks to limit their over-the-counter investments in financial derivatives. Tsai, Lin, and Chen (2015) also argue that in Taiwan, the diversification of banks is not beneficial during a recession.

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[1] For additional details, see "Bank of England Governor Mervyn King weighs case for forcing banks to split their operations," available at: http://cbonds.com/news/item/429314.

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Academic research reflects these changes from a market perspective. Earlier studies predominantly claim that bank diversification provides economic benefits. For example, Baele, De Jonghe, and Vander Vennet (2007) argue that bank diversification reduces operating costs (especially fixed costs) and improves loan origination and credit risk management owing to economies of scope and information. Kroszner and Rajan (1994), Puri (1994, 1996), Gande, Puri, Saunders, and Walter (1997), and Hebb and Fraser (2002) also claim that bank diversification is beneficial, citing synergistic effects. Kwan (1998) and Cornett, Ors, and Tehranian (2002) argue that commercial banks can reduce risk through diversification because of the low correlation of returns among securities and bank subsidiaries. Although arguments supporting bank diversification dominated before the global financial crisis, the aftermath of this crisis necessitated a reassessment of the practice.

However, only a handful of existing studies rigorously consider the effect of the financial crisis on bank diversification (Elsas, Hackethal, & Holzhäuser, 2010). Not only do these previous studies have inconclusive findings, but the empirical evidences and findings in the bank diversification literature are primarily based on the US banking industry, with much less focus on global financial markets. These limitations motivate us to conduct a global study of bank diversification. We analyze the different effects of diversification on banks' financial stability before, during, and after the financial crisis. To accomplish this aim, we use data from 34 OECD countries because of their influential economic power and representativeness. Moreover, unlike previous studies that assume a linear relationship between bank diversification and financial stability, this study allows for the existence of a non-linear relationship and considers the possibility that the relationship may vary depending on the market state or economic condition.

An analysis of bank-year observations from 34 OECD countries during the period 2002 to 2012 reveals that bank diversification and financial stability have an inverted U-shaped relationship. The findings indicate that financial stability increases with bank diversification until bank diversification reaches its optimal level, but it then begins to decrease once bank diversification increases beyond this optimum. Our findings also show that the effects of bank diversification on financial stability differ between before and during the global financial crisis. Specifically, the variance in bank financial stability increases during the financial crisis even though diversification reduces this variance before the financial crisis. This evidence implies that although the majority of past studies endorse diversification as a method of hedging risk, concentrating on traditional functions (i.e., deposits and loans) can be more effective for banks during a crisis. In addition, because bank diversification may exacerbate financial instability or increase the risk of financial system collapse when idiosyncratic events occur, the results indicate the need to reduce the variance in bank financial stability by limiting relatively high-risk businesses in the event of an economic crisis.

We contribute to the existing literature in the following three ways. First, previous studies generally concentrate on the US or European nations, and OECD countries are largely ignored (Baele et al., 2007; Stiroh & Rumble, 2006). Thus, this study is necessary and timely given the tremendous impact of OECD countries on today's global economy. Our study therefore fills this gap in the existing literature on the effects of bank diversification and financial stability by presenting and discussing evidence using a dataset that includes the banking markets of all 34 OECD countries. Second, unlike previous studies, which observe a linear relationship between diversification and stability, we find a nonlinear relationship between the two. Thus, this study suggests that appropriate levels of bank diversification may positively affect stability but that excessive levels have a negative effect. Third, the existing literature on bank diversification primarily analyzes the period before the 2008 financial crisis. This study, however, also includes the periods during and after the financial crisis. Thus, we can provide evidence that the effects of bank diversification on financial stability vary across periods before, during, and after the financial crisis in the context of a non-linear relationship between bank diversification and financial stability. In this regard, this study not only provides practical implications for bank managers in the 34 OECD countries but also offers a vital perspective on financial regulations for policymakers worldwide.

2. Bank diversification, financial stability, and financial crisis

Presenting diversification in a positive light, Demirgüç-Kunt and Huizinga (2010) argue that activities that generate non-interest income can improve bank performance and help diffuse risk. Elsas et al. (2010) and Chronopoulos, Girardone, and Nankervis (2011) show that bank diversification increases profitability by producing higher non-interest margins and lower cost-income ratios, enhancing a bank's market valuation. Filson and Olfati (2014) also indicate that, under the Gramm–Leach–Bliley Act, the diversification of US bank holding companies via expansions into investment banking, securities brokerages, and insurance businesses increases their value. Similarly, Edirisuriya, Gunasekarage, and Dempsey (2015) find that stock markets in South Asia positively respond to bank diversification, increasing market-to-book ratios. They also show that diversification can improve bank solvency. Lin, Chung, Hsieh, and Wu (2012) argue that diversifying banks' income sources reduces the sensitivity of net interest margins to risk fluctuations. Fang and van Lelyveld (2014) indicate that geographic diversification decreases banks' credit risk by 1.1% on average, although the effects differ across multinational banking groups. Doumpos, Gaganis, and Pasiouras (2016) show that income diversification improves banks' financial strength, especially in less developed countries. Gurbuz, Yanik, and Ayturk (2013), Sawada (2013), and Lee, Hsieh, and Yang (2014) also argue that diversification positively affects banks' performance or market value.

In contrast, bank diversification increases the likelihood that lendable funds are linked to speculative funds (Bhargava & Fraser, 1998; Boyd, Graham, & Hewitt, 1993; Boyd & Graham, 1986; Demsetz & Strahan, 1997; Kwan, 1998; Kwast, 1989; Lepetit, Nys, Rous, & Tarazi, 2008; Wall, Reichert, & Mohanty, 1993), and such funds can increase bank management's risk contagion (Brunnermeier, Dong, & Palia, 2012). Wagner (2010) argues that diversification can cause systemic crises, which increase the threats to a bank's payment and settlement system. Arinaminpathy, Kapadia, and May (2012) also argue that exposure can be increased through diversification, which exacerbates asset contagion in financial system collapse. Engle, Moshirian, Sahgal, and Zhang (2014) show that the US, Germany, and the UK tend to have high levels of non-interest income (i.e., diversification) and that, in these countries, non-interest income is positively related with systemic risk and does not reduce the volatility of profitability. Köhler (2015) argues that income diversification reduces

stability and increases the risk for investment banks, whereas it improves stability and profitability for savings and cooperative banks. Similarly, Tsai et al. (2015) show that portfolio diversification of Taiwanese banks increases systematic risk during a recession and that this increase far exceeds the benefit of lowering individual risk. Using Chinese data, Zhou (2014) argues that the diversification of commercial banks is not significantly related to bank risk.

Although some studies examine the effects of bank diversification, these studies find both benefits and drawbacks to diversification with no consensus thus far. Furthermore, empirical analyses of bank diversification mostly assume a linear relationship between bank diversification and financial stability and primarily concentrate on the US banking market, leaving this issue largely unexamined in other banking markets. Thus, we try to fill this gap in the banking literature using a dataset of 34 OECD countries. We also explore the evidence of a non-linear relationship between bank diversification and financial stability because different degrees of diversification may affect a bank's financial stability differently. Like Berger, Hasan, and Zhou (2010) and Gambacorta, Scatigna, and Yang (2014), who use bank data to investigate the non-linearity of the effects of bank diversification on profitability, we predict that a low degree of bank diversification increases bank financial stability but that an excessive level of diversification adversely affects this stability. Thus, we expect to find a significantly nonlinear (i.e., inverted U-shaped) relationship between bank diversification and bank financial stability.

Prior to the financial crisis, nontraditional activities, such as proprietary trading and hedge funds, had relatively low insolvency rates and could be seen as presenting no significant threat. However, during the financial crisis, the insolvency rates of such investments escalated, seriously tarnishing the stability of the banks engaged in these activities. DeYoung and Torna (2013) argue that during the financial crisis, the asset-based diversification of US banks aggravated their probability of failure. Bank diversification also involves allocations of limited resources, limiting the ability of more diversified banks to focus their resources on specific businesses during a crisis. As a result, diversification could reduce stability during a crisis period, such as the 2008 financial crisis. Thus, we hypothesize that the slope of the inverted U-shape that describes the association between bank diversification and financial stability differs across the pre-financial, financial, and post-financial crisis periods. The results provide evidence that bank diversification differently affects financial stability during the financial crisis from how it does during non-financial crisis period; specifically, the slope of the inverted U-shape is steady in the non-financial crisis period but steeper in the financial crisis period.

3. Research design

3.1. Sample construction

To examine the relationship between bank diversification and financial stability, we use two databases: *i*) *Bankscope*, which provides an annual dataset including bank balance sheets and income statements, and *ii*) *World Bank and Trading Economics*, which offers data regarding GDP *per capita* and interbank lending rates for each country. Table 1 provides detailed explanations of the variables used in our univariate and multivariate analyses. The unbalanced panel data used in our study comprise bank-year observations from 34 OECD member countries over the period from 2002 to 2012. Our sample therefore covers a ten-year time span that includes the pre-financial crisis, financial crisis, and post-financial crisis periods, allowing us to compare the effects of bank diversification on financial stability in each subperiod.

Table 2 presents summary statistics. We use two financial stability measures: the standard deviation of the return on assets (ROA) and the distance to default. In Table 2, the mean (median) value of *Standard ROA (*2-yr) is 0.408 (0.199), and the mean (median) value of

Table 1
Explanations and data sources of variables.

	Explanation	Source
Panel A. Dependent variables		
*Standard ROA (*2-yr*)*	*Standard ROA (*2-yr*)* denotes the standard deviation of the ROA over a two-year period.	Bankscope
Distance-to-default	Distance-to-default is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009).	Bankscope
Panel B. Independent variables		
Lag non-interest income/TOR	*TOR* denotes a bank's total operating revenue. *Lag non-interest income/TOR* is a proxy for bank diversification (Baele et al., 2007).	Bankscope
Lag SQ non-interest income/TOR	*Lag SQ non-interest income* denotes the square of lagged non-interest income, and *TOR* denotes a bank's total operating revenue.	Bankscope
Pre-financial crisis	*Pre-financial crisis* is a dummy variable that takes the one for years 2002–2007.	Authors' calculations
Financial crisis	*Financial crisis* is a dummy variable that takes the one for years 2008 and 2009, which are classified as crises periods, following Lins et al. (2013).	Authors' calculations
Post-financial crisis	*Post-financial crisis* is a dummy variable that takes the one for years 2010–2012.	Authors' calculations
Lag three LB share	*Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks.	Bankscope
Lag gross loan/equity	*Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity.	Bankscope
Lag log *(total assets)*	*Lag* log *(total assets)* denotes the lagged logarithm of total assets and is used as a proxy for bank size.	Bankscope
Lag ROA	*Lag ROA* denotes the lagged ROA ratio.	Bankscope
Log *(GDP per capita)*	Log *(GDP per capita)* denotes the logarithm of GDP *per capita*.	World Bank
Interbank lending rates	*Interbank lending rates* denote the interbank lending rates taken from the World Bank and Trading Economics.	World Bank and Trading Economics

Notes: This table provides detailed explanations of the variables used in the regression analyses and identifies the sources of the data (Bankscope). The GDP *per capita* and interbank lending rate data are available online at www.worldbank.org and www.tradingeconomics.com.

Table 2
Descriptive statistics for firm characteristics.

	Mean	Median	SD	P25	P75
Standard ROA (2-yr)	0.408	0.199	0.603	0.095	0.435
Distance-to-default	4.235	4.296	1.192	3.499	5.017
Lag non-interest income/TOR	0.204	0.159	0.181	0.104	0.238
Lag three LB share	0.334	0.322	0.137	0.221	0.351
Lag gross loan/equity	0.605	0.641	0.193	0.512	0.740
Lag log *(total assets)*	5.320	4.977	1.799	4.143	6.043
Lag ROA	0.795	0.890	1.311	0.420	1.320
Log *(GDP per capita)*	10.674	10.746	0.245	10.589	10.786
Interbank lending rates	4.865	4.340	1.811	3.250	6.189

Notes: This table presents the distribution of the full sample, which includes observations for 34 OECD member countries over the period from 2002 to 2012. *Standard ROA (2-yr)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Lag non-interest income/TOR* is a proxy for bank diversification. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics.

Distance-to-default is 4.235 (4.296). The ratio of lagged non-interest income to total operating revenue (*lag non-interest income/TOR*) is used as a measure of bank diversification, and its mean (median) value is 0.204 (0.159).

3.2. Empirical models and variable definitions

In this study, we examine whether diversified banks are more financially stable than non-diversified banks are. Because previous empirical studies present inconclusive results, we hypothesize that the effect of bank diversification on financial stability is non-linear and varies depending on the degree of diversification. To test this hypothesis, we include the squared ratio of lagged non-interest income to total operating revenue (*Lag SQ non-interest income/TOR*) in our regression equations. We also analyze the effect of bank diversification on financial stability by considering the influence of the recent financial crisis, which previous studies have overlooked. Specifically, we estimate Equations (1) and (2):

$$\text{Financial stability} = \beta_0 + \beta_1 \textit{ Lag non-interest income/TOR} + \beta_2 \textit{ Lag SQ non-interest income/TOR} + \beta_3 \textit{ Lag three LB share} + \beta_4 \textit{ Lag gross loans/equity} + \beta_5 \textit{ Lag} \log \textit{(total assets)} + \beta_6 \textit{ Lag ROA} + \beta_7 \log \textit{(GDP per capita)} + \beta_8 \textit{ Interbank lending rates} + \textit{Year and country fixed effects} + \varepsilon, \quad (1)$$

$$\text{Financial stability} = \beta_0 + \beta_1 \textit{ Lag non-interest income/TOR} + \beta_2 \textit{ Lag SQ non-interest income/TOR} + \beta_3 \textit{ Pre-financial crisis (Financial crisis or Post-financial crisis)} \times \textit{Lag non-interest income/TOR} + \beta_4 \textit{ Pre-financial crisis (Financial crisis or Post-financial crisis)} \times \textit{Lag SQ non-interest income/TOR} + \beta_5 \textit{ Pre-financial crisis (Financial crisis or Post-financial crisis)} + \beta_6 \textit{ Lag three LB share} + \beta_7 \textit{ Lag gross loans/equity} + \beta_8 \textit{ Lag} \log \textit{(total assets)} + \beta_9 \textit{ Lag ROA} + \beta_{10} \log \textit{(GDP per capita)} + \beta_{11} \textit{ Interbank lending rates} + \textit{Country fixed effects} + \varepsilon, \quad (2)$$

In Equations (1) and (2), the dependent variable is financial stability. *Standard ROA* (Return On Assets) and *Distance-to-default* are used to measure financial stability. *Standard ROA (2-yr)* is defined as the standard deviation of the ROA over a two-year period. *Distance-to-default* is a proxy for the probability of bankruptcy and is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA following Laeven and Levine (2009) and Kim, Park, and Song (2016), and we take the natural log of this ratio.[2] A higher value of *Distance-to-default* indicates a lower probability of bank insolvency. We use one-year lags for the explanatory and control variables to alleviate any endogeneity issues (Baele et al., 2007). Many studies use a non-interest income ratio to proxy for bank diversification. For example, Baele et al. (2007) measure bank diversification using the ratio of non-interest income to operating income and argue that this ratio is an effective proxy for diversification. DeYoung and Rice (2004), Stiroh (2006), Laeven and Levine (2007), Lin et al. (2012), Gambacorta et al. (2014), and Williams (2016) also use the ratio of non-interest income to various quantities to proxy for diversification.[3] Following these studies, we use *lag non-interest income/TOR*, which is the lagged ratio of non-interest income to the bank's total operating revenue. *Lag SQ non-interest income/TOR*, the square term of the ratio of lagged non-interest income to total operating revenue, captures the potential non-linear relationship between bank diversification and financial stability. We include the squared term because we believe an adequate level of diversification can be beneficial for bank financial stability, especially up to an optimal diversification threshold.

In Equation (2), *Pre-financial crisis* period is a dummy variable that takes one for the years 2002–2007. *Financial crisis* period is represented by a dummy variable that takes one for the years 2008 and 2009. We follow the definition of the 2008–2009 financial crisis

[2] Kim et al. (2016) also use a *Distance-to-default* ratio to examine the effect of size structure on financial stability using bank data from Asian countries.

[3] DeYoung and Rice (2004) use the ratio of non-interest income to assets to proxy for bank diversification, whereas Stiroh (2006), Lin et al. (2012), Gambacorta et al. (2014), and Williams (2016) use the ratio of non-interest income to total operating income (or total revenue or total income). Laeven and Levine (2007) measure diversification as one minus the interest income ratio.

Table 3
Financial stability and bank diversification.

	Standard ROA (2-yr)		Distance-to-default	
	(1)	(2)	(3)	(4)
Lag non-interest income/TOR	−0.919***	−0.919***	0.572***	0.571***
	(-12.59)	(-12.62)	(10.10)	(10.07)
Lag SQ non-interest income/TOR	2.255***	2.255***	−2.490***	−2.490***
	(8.60)	(8.61)	(-27.54)	(-27.32)
Lag three LB share	0.641***	0.655**	−2.358**	−2.374**
	(2.76)	(2.39)	(-2.64)	(-2.43)
Lag gross loan/equity	0.241***	0.241***	−1.979***	−1.979***
	(3.50)	(3.50)	(-24.47)	(-24.46)
Lag log *(total assets)*	−0.012	−0.012	−0.023***	−0.023***
	(-0.95)	(-0.95)	(-5.19)	(-5.16)
Lag ROA	−0.180***	−0.180***	0.367***	0.367***
	(-8.58)	(-8.59)	(25.31)	(25.35)
Log *(GDP per capita)*		0.028		−0.058
		(0.18)		(-0.13)
Interbank lending rates		−0.001		−0.002
		(-0.18)		(-0.14)
Constant term	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Clusters by country	Yes	Yes	Yes	Yes
Observations	84,150	84,150	77,919	77,919
Adj. *R*-squared	0.226	0.226	0.293	0.293

Notes: This table presents the results of regressing financial stability measures on the lagged ratio of non-interest income to TOR, the lagged second-order (quadratic) term of the ratio of non-interest income to TOR, and controls. *Standard ROA (*2-yr*)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Lag non-interest income/TOR* is a proxy for bank diversification. *Lag SQ non-interest income* denotes the square of lagged non-interest income, and *TOR* denotes a bank's total operating revenue. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics. *t*-statistics are given in brackets, and *** and ** indicate statistical significance at the 1% and 5% levels, respectively.

used by Lins, Volpin, and Wagner (2013), who examine the effects of family control on valuation and corporate decisions during that time.[4] *Post-financial crisis* period is indicated using a dummy variable that takes one for the years 2010–2012. To examine the different impacts of bank diversification on financial stability before, during, and after the financial crisis, we include interaction terms between the financial crisis dummy variables (i.e., *Pre-financial crisis, Financial crisis*, or *Post-financial crisis*) and the diversification measures in our analyses. Using these interaction terms, we examine the different relationships between bank diversification and financial stability during the financial crisis and non-crisis periods.

Lag three LB share is the proportion of lagged deposits with the three largest banks in each country and year. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity. *Lag* log *(total assets)* is the lagged logarithm of total assets, and *Lag ROA* is the lagged ROA. Following Keim and Stambaugh (1986), Lamont, Polk, and Saa-Requejo (2001), and Chan, Covrig, and Ng (2005), we also control for macro variables, such as log *(GDP per capita)* and *Interbank lending rates*. Finally, we control for year and country fixed effects.[5]

4. Empirical results

We design our empirical analyses as follows. First, we perform multivariate regression analyses by regressing the financial stability variables on the diversification measures, the interaction terms between the diversification measures and the financial crisis period dummies, and the control variables. We include the square of the diversification measure (*Lag SQ non-interest income/TOR*) in the regression equations to capture the possible non-linear relationship between bank diversification and financial stability. Second, to mitigate possible endogeneity problems, we also use 2SLS method. Additionally, we perform other robustness tests to confirm our primary results.

[4] Although, in this study, we define the 2008–2009 financial crisis following Lins et al. (2013), different studies, such as those of Bhimjee, Ramos, and Dias (2016) and Degl'Innocenti, Grant, Šević, and Tzeremes (2018), use different definitions.

[5] Some of the explanatory and dependent variables are winsorized to remove outliers. In Table 4, we do not include year fixed effects in our regressions because they could be perfectly correlated with the dummies representing the pre-financial crisis, financial crisis, and post-financial crisis periods in Equation (2).

4.1. Multivariate analysis

To examine the association between financial stability and bank diversification, we regress the financial stability variables on *Lag non-interest income/TOR*, its squared term, and other control variables. In Table 3, we find a significantly negative relationship between *Standard ROA (2-yr)* and *Lag non-interest income/TOR,* and we find a significantly positive relationship between *Standard ROA (2-yr)* and *Lag SQ non-interest income/TOR*. The results for Models (3) and (4) in Table 3 indicate that the effect of *Lag non-interest income/TOR* on *Distance-to-default* is positive and that of *Lag SQ non-interest income/TOR* on *Distance-to-default* is negative. These effects are jointly

Table 4
Financial stability and bank diversification: Crisis effects.

	Pre-financial crisis period		Financial crisis period (2008–2009)		Post-financial crisis period	
	(1) *Standard ROA (2-yr)*	(2) *Distance-to-default*	(3) *Standard ROA (2-yr)*	(4) *Distance-to-default*	(5) *Standard ROA (2-yr)*	(6) *Distance-to-default*
Lag non-interest income/TOR	−1.100***	1.050***	−0.870***	0.400***	−0.864***	0.332***
	(-20.94)	(12.74)	(-14.57)	(5.92)	(-8.92)	(4.51)
Lag SQ non-interest income/TOR	2.434***	−2.834***	2.184***	−2.330***	2.242***	−2.401***
	(10.46)	(-26.03)	(8.68)	(-26.55)	(7.76)	(-24.44)
Pre-financial crisis × *Lag non-interest income/TOR*	0.410***	−1.215***				
	(3.99)	(-9.46)				
Pre-financial crisis × *Lag SQ non-interest income/TOR*	−0.394***	0.911***				
	(-3.05)	(5.41)				
Pre-financial crisis	−0.247***	0.543***				
	(-9.99)	(8.22)				
Financial crisis × *Lag non-interest income/TOR*			−0.223**	0.653***		
			(-2.61)	(6.10)		
Financial crisis × *Lag SQ non-interest income/TOR*			0.393**	−0.744***		
			(2.44)	(-5.44)		
Financial crisis			0.139***	−0.253***		
			(14.71)	(-9.48)		
Post-financial crisis × *Lag non-interest income/TOR*					−0.189	0.634***
					(-1.47)	(6.68)
Post-financial crisis × *Lag SQ non-interest income/TOR*					0.080	−0.243
					(0.52)	(-1.67)
Post-financial crisis					−0.091***	0.066*
					(-3.01)	(1.95)
Lag three LB share	0.396**	−2.242***	0.608***	−2.676***	1.004***	−3.483***
	(2.38)	(-5.43)	(4.33)	(-4.42)	(8.22)	(-7.26)
Lag gross loan/equity	0.257***	−2.004***	0.249***	−1.999***	0.254***	−2.012***
	(3.78)	(-25.61)	(3.59)	(-24.26)	(3.64)	(-25.05)
Lag log *(total assets)*	−0.013	−0.020***	−0.012	−0.022***	−0.011	−0.022***
	(-1.05)	(-4.49)	(-0.98)	(-5.25)	(-0.97)	(-5.33)
Lag ROA	−0.179***	0.367***	−0.182***	0.373***	−0.183***	0.374***
	(-8.39)	(25.14)	(-8.83)	(26.56)	(-9.00)	(26.88)
Log *(GDP per capita)*	−0.387*	−0.188	0.098*	−1.242***	0.402***	−1.539***
	(-1.88)	(-1.20)	(1.76)	(-3.12)	(4.44)	(-3.54)
Interbank lending rates	0.017**	−0.043***	−0.012***	0.015***	−0.032***	0.043***
	(2.43)	(-4.29)	(-5.29)	(11.88)	(-16.73)	(8.70)
Constant term	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clusters by country	Yes	Yes	Yes	Yes	Yes	Yes
Observations	84,150	77,919	84,150	77,919	84,150	77,919
Adj. *R*-squared	0.223	0.287	0.225	0.286	0.222	0.286

Notes: This table presents the estimation results for financial crisis and non-financial crisis periods. *Standard ROA (2-yr)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Lag non-interest income/TOR* is a proxy for bank diversification. *Lag SQ non-interest income* denotes the square of lagged non-interest income, and *TOR* denotes a bank's total operating revenue. *Pre-financial crisis* is a dummy variable that takes the one for the years 2002–2007. *Financial crisis* is a dummy variable that takes the one for 2008 and 2009, following Lins et al. (2013). *Post-financial crisis* is a dummy variable that takes the one from 2010 to 2012. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics. *t*-statistics are given in brackets, and ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

significant at the 1% level. Our results consistently support a non-linear relationship between financial stability and bank diversification. In addition, these results indicate that bank financial stability increases with bank diversification up to an optimal level but decreases as bank diversification continues to increase beyond the optimal point.

The results for the effects before, during, and after the financial crisis are presented in Table 4. We estimate the crisis effects using the interactions between bank diversification and financial crisis period dummies. In Models (1) through (6) in Table 4, the estimated coefficients of *Lag non-interest income/TOR* indicate that increasing diversification enhances bank financial stability. Once banks are overly dependent on diversification, however, their financial stability decreases as diversification increases. In Model (1) of Table 4, when *Standard ROA (2-yr)* is used to measure financial stability, the coefficient of the interaction between *Pre-financial crisis* and *Lag non-interest income/TOR* is significant and positive, whereas that of the interaction between *Pre-financial crisis* and *Lag SQ non-interest income/TOR* is significant and negative. When *Distance-to-default* is used as the stability measure in Model (2), we find that the interaction term between *Pre-financial crisis* and *Lag non-interest income/TOR* has a significantly negative coefficient and that the interaction term between *Pre-financial crisis* and *Lag SQ non-interest income/TOR* has a significantly positive coefficient.

In contrast, for Model (3) in Table 4, we find that the estimated coefficient of the interaction between *Financial crisis* and *Lag non-interest income/TOR* is significantly negative, whereas the coefficient of the interaction between *Financial crisis* and *Lag SQ non-interest income/TOR* is significantly positive. The estimated results for Model (4) also show that when *Distance-to-default* is used to measure stability, the estimated coefficient of the interaction between *Financial crisis* and *Lag non-interest income/TOR* is significantly positive, whereas the coefficient of the interaction between *Financial crisis* and *Lag SQ non-interest income/TOR* is significantly negative. However, most of the estimated coefficients are insignificant when we examine the relationship between financial stability and the interaction between the post-financial crisis dummy and bank diversification (and its square), as shown by Models (5) and (6) in Table 4. Overall, the findings provide evidence that the slope of the inverted U-shape is steady in the pre-financial crisis period but becomes steep in the financial crisis period. Thus, bank diversification increases the variance of bank financial stability during the financial crisis and decreases it in the pre-financial crisis period. These results imply that bank diversification helps banks manage financial stability in non-financial crisis periods but not during crises.

4.2. Robustness tests

Next, we perform a rich set of robustness tests to confirm the results. Table 5 through 8 show the results of estimating pooled OLS and random effects models and considering robust standard errors clustered at the year and country (or year and bank) levels, sample composition adjustments, and endogeneity. Overall, our results support the argument that when bank diversification is low, increasing it

Table 5
Robustness tests: Pooled OLS and random effects models.

	Pooled OLS		Random effects model	
	(1) *Standard ROA (2-yr)*	(2) *Distance-to-default*	(3) *Standard ROA (2-yr)*	(4) *Distance-to-default*
Lag non-interest income/TOR	−0.968***	0.757***	−0.562***	0.452***
	(-32.36)	(12.04)	(-11.15)	(6.63)
Lag SQ non-interest income/TOR	2.231***	−2.560***	1.487***	−1.541***
	(64.52)	(-33.03)	(5.76)	(-8.54)
Lag three LB share	0.138***	−1.673***	0.114	−0.109
	(8.34)	(-37.69)	(0.64)	(-0.23)
Lag gross loan/equity	0.283***	−2.058***	0.116	−1.281***
	(25.64)	(-88.05)	(1.59)	(-18.83)
Lag log *(total assets)*	−0.021***	−0.001	−0.029	−0.02
	(-17.44)	(-0.38)	(-1.58)	(-0.76)
Lag ROA	−0.181***	0.376***	−0.171***	0.288***
	(-113.96)	(110.46)	(-9.09)	(22.21)
Log *(GDP per capita)*	−0.071***	−0.405***	−0.114**	0.108
	(-8.13)	(-19.50)	(-2.22)	(0.80)
Interbank lending rates	−0.010***	0.014***	0.007	−0.018**
	(-9.60)	(6.83)	(1.08)	(-1.96)
Constant term	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes
Clusters by country	No	No	Yes	Yes
Observations	84,150	77,919	84,150	77,919
Adj. *R*-squared	0.198	0.249	0.211	0.275

Notes: This table presents the results of pooled OLS and random effects estimations. *Standard ROA (2-yr)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Lag non-interest income/TOR* is a proxy for bank diversification. *Lag SQ non-interest income* denotes the square of lagged non-interest income, and *TOR* denotes a bank's total operating revenue. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics. *t*-statistics are given in brackets, and *** and ** indicate statistical significance at the 1% and 5% levels, respectively.

Table 6
Robustness tests: Two-way clustering analysis.

	Standard ROA (2-yr)		Distance-to-default	
	(1)	(2)	(3)	(4)
Lag non-interest income/TOR	−0.919***	−0.919***	0.571***	0.571*
	(-10.62)	(-7.41)	(4.39)	(1.73)
Lag SQ non-interest income/TOR	2.255***	2.255***	−2.490***	−2.490***
	(8.79)	(13.46)	(-17.31)	(-6.85)
Lag three LB share	0.655***	0.655***	−2.374***	−2.374***
	(3.01)	(4.72)	(-2.61)	(-4.77)
Lag gross loan/equity	0.241***	0.241***	−1.979***	−1.979***
	(3.74)	(7.89)	(-26.87)	(-25.63)
Lag log *(total assets)*	−0.012	−0.012	−0.023**	−0.023
	(-0.95)	(-1.15)	(-2.40)	(-1.03)
Lag ROA	−0.180***	−0.180***	0.367***	0.367***
	(-8.09)	(-8.34)	(21.97)	(10.70)
Log *(GDP per capita)*	0.028	0.028	−0.058	−0.058
	(0.16)	(0.19)	(-0.13)	(-0.15)
Interbank lending rates	−0.001	−0.001	−0.002	−0.002
	(-0.22)	(-0.45)	(-0.18)	(-0.25)
Constant term	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Clusters by year	Yes	Yes	Yes	Yes
Clusters by country	Yes	No	Yes	No
Clusters by firm	No	Yes	No	Yes
Observations	84,150	84,150	77,919	77,919
Adj. *R*-squared	0.226	0.226	0.293	0.293

Notes: This table presents the results of a two-way clustering analysis. *Standard ROA (*2-yr*)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Lag non-interest income/TOR* is a proxy for bank diversification. *Lag SQ non-interest income* denotes the square of lagged non-interest income, and *TOR* denotes a bank's total operating revenue. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics. *t*-statistics are given in brackets, and ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

enhances banks' financial stability but that excessive diversification adversely affects financial stability.

4.2.1. Pooled OLS, random effects, and two-way clustering analysis

To determine whether our core evidence is robust, we explore the relationship between financial stability and bank diversification by estimating pooled OLS and random effects models. The results are reported in Table 5. In Models (1) and (2), the pooled OLS results indicate that low diversification seems to increase bank stability but that too much reliance on non-interest revenue may decrease bank stability. In Models (3) and (4) in Table 5, the results for the random effects model are consistent with the previous findings because the relationship between bank stability and diversification is again non-linear. Models (1) and (3) in Table 6 present the results of regressions with robust S.E. (standard errors) clustered at the country and year levels. Models (2) and (4) in Table 6 present the results of regressions with robust S.E. clustered at the bank and year levels, following Petersen (2009). Overall, our results support our predictions that excessively high diversification adversely affects bank financial stability even though low diversification improves stability.

4.2.2. Sample composition adjustments and endogeneity

One could argue that the different bank-year observations across OECD countries can affect the estimated association between bank financial stability and diversification. Table 7 presents the results of a weighted least squares (WLS) regression following El Ghoul, Guedhami, Kwok, and Mishra (2011). We find a non-linear relationship between financial stability and bank diversification. Another concern is that our financial stability measure (i.e., *Lag non-interest income/TOR*) is endogenously determined and, thus, may bias our results. Indeed, bank diversification may affect financial stability, although the probability that it does is low because we use a one-year lagged variable to represent bank diversification. To examine this possibility, we apply a 2SLS model following Elsas et al. (2010) and El Ghoul et al. (2011), as shown in Table 8. As in El Ghoul et al. (2011), we include instruments for initial *non-interest income/TOR* in our sample. For Models (1) through (4) in Table 8, our results indicate a negative relationship between financial stability and bank diversification (*Pred. NII/TOR*) after we address these endogeneity concerns.

5. Conclusion

The recent financial crisis has raised a serious question about the effectiveness of bank diversification for achieving financial stability, which has been a prevalent strategy in global financial communities. This situation motivates us to investigate whether banks

Table 7
Robustness tests: Weighted least squares.

	Standard ROA (2-yr)		Distance-to-default	
	(1)	(2)	(3)	(4)
Lag non-interest income/TOR	−0.950***	−0.950***	0.559***	0.559***
	(-22.90)	(-22.90)	(8.32)	(8.31)
Lag SQ non-interest income/TOR	2.408***	2.408***	−2.492***	−2.492***
	(36.95)	(36.95)	(-26.30)	(-26.29)
Lag three LB share	0.648***	0.667***	−2.367***	−2.383***
	(4.93)	(4.67)	(-8.00)	(-7.63)
Lag gross loan/equity	0.277***	0.277***	−1.992***	−1.992***
	(21.83)	(21.83)	(-81.32)	(-81.31)
Lag log *(total assets)*	−0.006***	−0.006***	−0.023***	−0.023***
	(-3.40)	(-3.40)	(-7.84)	(-7.83)
Lag ROA	−0.191***	−0.191***	0.369***	0.369***
	(-52.00)	(-51.99)	(89.09)	(89.05)
Log *(GDP per capita)*		0.037		−0.058
		(0.43)		(-0.30)
Interbank lending rates		−0.002		−0.002
		(-0.41)		(-0.25)
Constant term	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
White SE	Yes	Yes	Yes	Yes
Observations	84,150	84,150	77,919	77,919
Adj. *R*-squared	0.242	0.242	0.294	0.294

Notes: This table presents WLS estimation results. *Standard ROA (*2-yr*)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Lag non-interest income/TOR* is a proxy for bank diversification. *Lag SQ non-interest income* denotes the square of lagged non-interest income, and *TOR* denotes a bank's total operating revenue. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by that of equity. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics. *t*-statistics are given in brackets, and *** indicates statistical significance at the 1% level.

Table 8
Robustness tests: 2SLS.

	Standard ROA (2-yr)		Distance-to-default	
	(1)	(2)	(3)	(4)
Pred. NII/TOR	1.130***	1.130***	−1.815***	−1.815***
	(62.00)	(62.00)	(-44.54)	(-44.54)
Lag three LB share	0.788***	0.812***	−2.324***	−2.362***
	(8.31)	(8.11)	(-9.00)	(-8.73)
Lag gross loan/equity	0.189***	0.189***	−1.989***	−1.989***
	(15.76)	(15.75)	(-82.62)	(-82.61)
Lag log *(total assets)*	−0.032***	−0.032***	0.002	0.002
	(-22.80)	(-22.82)	(0.61)	(0.62)
Lag ROA	−0.184***	−0.184***	0.383***	0.383***
	(-109.69)	(-109.65)	(110.54)	(110.52)
Log *(GDP per capita)*		0.048		−0.148
		(0.76)		(-0.89)
Interbank lending rates		0.002		−0.007
		(0.66)		(-0.82)
Constant term	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	83,892	83,892	77,773	77,773
Adj. *R*-squared	0.184	0.184	0.279	0.279

Notes: This table presents the results of the robustness tests using 2SLS estimation. *Standard ROA (*2-yr*)* denotes the standard deviation of the ROA over a two-year period. *Distance-to-default* is defined as the ratio of ROA plus the capital asset ratio which is divided by the standard ROA and we take the natural log of the ratio (Kim et al., 2016; Laeven & Levine, 2009). *Pred. NII/TOR* is the lagged ratio of non-interest income to TOR predicted by the instrument. *Lag three LB share* is the proportion of lagged deposits in each country and year for the three largest banks. *Lag gross loan/equity* is calculated by dividing the lagged value of gross loans by the lagged value of equity. *Lag* log *(total assets)* denotes the lagged logarithm of total assets and is a proxy for bank size. *Lag ROA* denotes the lagged ROA ratio. Log *(GDP per capita)* denotes the logarithm of GDP *per capita*. The interbank lending rates come from the World Bank and Trading Economics. *t*-statistics appear in brackets, and *** indicates statistical significance at the 1% level.

should focus on their traditional functions, such as deposits and loans, or expand their operations and provide an array of services intended to increase financial stability. Such questions regarding the impact of bank diversification on financial stability have been raised, especially after the 2008 global financial crisis.

Although a large body of prior work examines the relationship between diversification and financial stability, these studies fail to reach a consensus. Moreover, most prior studies not only conduct single-country analyses, mainly based on data from the US or other individual countries, but also lack careful consideration of the possibility of a non-linear relationship between bank diversification and financial stability. Furthermore, few studies compare the effects of bank diversification on financial stability before, during, and after the financial crisis. Thus, this study contributes empirically to the well-documented bank diversification literature by focusing on the possibility of a non-linear relationship between bank diversification and financial stability and comparing the different effects of bank diversification on financial stability before, during, and after the 2008 financial crisis using banking data from 34 OECD countries.

Our study provides evidence that bank diversification has a non-linear (i.e., inverted U-shaped) association with financial stability. Specifically, bank diversification increases bank financial stability when diversification is low, but excessive diversification adversely affects stability. Interestingly, we also find that although the slope of the inverted U-shape is steady in the pre-financial crisis period, it becomes steeper during the financial crisis. This result indicates that bank diversification decreases the variance in financial stability in the pre-financial crisis period but increases it during the financial crisis. Thus, bank diversification may exacerbate financial instability or increase the risk of a financial system collapse when idiosyncratic events, such as financial crises, occur.

This study provides the following three implications and contributions. Whereas previous studies of bank diversification focus only on the US or certain European countries, we broaden our research scope to include all OECD member countries, reflecting their tremendous global financial influence. Second, our framework allows for a non-linear relationship between bank diversification and financial stability, providing more flexibility than in previous studies, which assume a linear relationship. Third, our study is unique because it examines the periods before, during, and after the 2008 financial crisis, unlike the prior studies that only analyze bank diversification using non-financial crisis data. Thus, the results of our study shed much-needed light on the effect of the 2008 financial crisis on bank diversification arguments.

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