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Global Banks and the Transmission of Shocks across Borders

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Abstract

In this study, we explore the impact of solvency and wholesale funding shocks on the lending behavior of 84 OECD parent banks and their 375 foreign subsidiaries. Our findings indicate that solvency shocks play a more significant role than wholesale funding shocks in influencing subsidiary lending. Moreover, we observe that solvency shocks have a heightened impact on larger subsidiary banks operating in mature markets with limited growth opportunities. These results carry substantial theoretical and policy implications, contributing to a deeper understanding of how solvency and wholesale shocks traverse borders and affect the lending dynamics of global banking entities.

JEL classification: G01, G21, G28
Keywords: Commercial banks, global banks, wholesale shocks, solvency shocks, transmission, internal capital markets

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1 Introduction

The surge in financial integration has sparked heightened interest in understanding how multinational banks impact global credit supply and economic growth, particularly during crises. However, the knowledge gap regarding the determinants of cross-border lending decisions by global banks, acting as conduits for international shocks, remains. This study addresses the critical issues of measuring negative shocks to parent banks, their impact on the lending behavior of foreign subsidiaries, and the regions most affected by such transmission, offering insights for policymakers.

The role of internal capital markets in shock transmission is well-documented (Cetorelli & Goldberg 2012a,b). While previous studies often focused on global or macroeconomic shocks, our research, spanning 1997 to 2012, delves into the impact of adverse idiosyncratic shocks on 84 OECD parent banks and their 375 subsidiaries globally. Specifically, we examine solvency and wholesale funding shocks, defining them as significant and unexpected deviations from their targets. This approach stems from insights gathered through discussions with industry representatives, highlighting how global banks respond differently to shocks based on their nature and business strategy.

Our findings underscore the prominence of solvency shocks over wholesale shocks in influencing cross-border lending. Larger subsidiary banks with limited growth prospects in mature markets are notably affected. This aligns with the behavior of parents treating high-growth markets as investment targets, thereby avoiding contraction in subsidiary lending in non-OECD countries. Symmetry testing reveals that positive equity shocks to parents don't translate into higher subsidiary lending growth, while positive wholesale shocks do, especially in foreign markets with sluggish past lending growth. Overall, our results suggest that parents safeguard investment markets and redirect excess liquidity to enhance lending growth in lagging markets.

This study contributes to the evolving literature on the bank lending channel, particularly the paths of transmission of lending supply shocks. In the context of internal capital markets within multinational banks, it aligns with prior works (Houston & James 1998; De Haas & van Lelyveld 2003, 2010; Holod & Peek 2010; Cetorelli & Goldberg 2012a,b; Radev 2021a,b). Insights from Gambacorta & Mistrulli (2004) and Mora & Logan (2012) on the causal effect of bank capital on shock propagation and the impact of regulatory capital constraints are incorporated. Our study adds value by simultaneously investigating solvency and wholesale shocks to parents, a rarity in empirical studies. Notably, it diverges from the common focus on U.S. banks, presenting a global perspective. Lastly, our findings shed light on parents' inclination to safeguard investments in high-growth markets, with shocks predominantly affecting low-growth, mature markets.

This remainder of this paper is organized as follows. Section 2 presents our major hypotheses, empirical baseline model and discusses the data. Section 3 reports the baseline empirical results and further findings and robustness checks. Section 4 concludes.

2 Empirical Model and Data

2.1 Theoretical Predictions

Several theoretical studies posit that solvency shocks to parent banks significantly impact the lending activities of their subsidiaries, especially in foreign markets. Bruno & Shin (2015) put forth a model of the international banking system, illustrating that leverage serves as a transmission channel for shocks through capital flows within the banking sector. Their findings hold true regardless of whether the local bank is independently owned or part of the same banking organization as the global bank. Complementarily, Devereux & Yetman (2010) present a straightforward two-country model wherein highly-leveraged financial institutions, constrained by capital limitations, hold interconnected portfolios. The intertwining of portfolios and capital constraints results in a negative shock in the host country affecting the balance sheets of financial institutions in the home country, triggering a global episode of balance sheet contractions and disinvestment. Therefore, we formulate our first hypothesis as:

Hypothesis 1. Shocks to the *solvency* of parents lead to a reduction in subsidiary lending.

Khwaja & Mian (2008) introduce a model for the transmission of liquidity shocks to the lending of domestic banks. We argue that through the internal capital markets within international conglomerates, these shocks can also transmit across borders. To test for this effect in our global sample, we introduce our second hypothesis:

Hypothesis 2. Shocks to the *wholesale funding* of parents lead to a reduction in subsidiary lending.

With our next hypothesis, we provide a direct test of the "organizational vs locational pecking order" streams of literature, described by Cetorelli & Goldberg (2012*b*). Under the former theory, banks manage their liquidity on a global level and therefore a shock to a parent should be directly felt by its subsidiaries and be negatively correlated with lending (see, e.g., Bruno & Shin 2015 and Devereux & Yetman 2010). The latter theory postulates that the transmission may depend on the level of development of the host market (Cetorelli & Goldberg 2012*b*). To analyze these contradicting theories, we formulate our fifth hypothesis as:

Hypothesis 3. The transmission of shocks depends on the financial and economic development of the host market.

To summarize, we expect that: negative (i) solvency and (ii) wholesale shocks to parents lead to a reduction in the lending of their subsidiaries. In addition, we test whether the effect is different between mature, low-growth markets and emerging, high-growth destinations.

2.2 Empirical Model

In this paper, we investigate the transmission of idiosyncratic shocks to the solvency and wholesale funding status of a parent bank on the lending of its foreign subsidiaries.

To test the hypotheses outlined above, we estimate variations of the following model:

$$\begin{aligned} growth\ (Loans)_{i,j,k,t} = {} & \alpha_0 + \alpha_1 \cdot \text{SolvencyShock}_{j,t-1} \\ & + \alpha_2 \cdot \text{WholesaleShock}_{j,t-1} \\ & + \alpha_3 \cdot \text{Interactions}_{j,t-1} \\ & + \alpha_4 \cdot \text{BankControls}_{i,j,k,t-1} \\ & + \alpha_5 \cdot \text{MacroVariables}_{i,j,k,t} \\ & + \beta_t + \gamma_i + \epsilon_{i,j,k,t} \end{aligned} \tag{1}$$

where $growth(Loans)_{i,j,k,t}$ is the loan growth of subsidiary *i* of parent *j* in host country *k* at time *t*; $SolvencyShock_{j,t-1}$ and $WholesaleShock_{j,t-1}$ are solvency and wholesale funding shocks on parent *j* at time *t-1*, respectively; $Interactions_{j,t-1}$ is a vector of interaction terms discussed later; $BankControls_{i,j,k,t}$ is a vector of individual bank-related indicators of subsidiary *i* of parent *j* in country *k* at time *t-1*; $MacroControls_{k,t}$ is a vector of macroeconomic variables, pertaining to host country *k* at time *t*; β_t is a time fixed effect for period *t*; γ_i is an entity fixed effect for subsidiary *i*.[3] We define the solvency and liquidity shocks, respectively, as a large and unexpected decline in the capital of the parent bank (solvency shock), or a sudden dry-up in its wholesale funding (liquidity shock). We discuss the definition of shocks in more detail in Section 2.4.

The bank variables control for individual bank idiosyncratic characteristics, related to the size, sources of funding, performance and financial health of the subsidiary. The variables that we use are: *size*, defined as the logarithm of the subsidiary's total assets; *profitability*, proxied by the subsidiary's profit to total earning assets; *riskiness*, represented by the bank's loan loss provisions to total loans; *liquidity*, defined as liquid assets to total assets; *capitalization*, being the ratio of the bank's equity to total assets. The last variable, *internally generated funds*, defined by the ratio of net income at time *t* to total loans at time *t-1*, is an important indicator for the financial independence of the subsidiary from its parent, and is introduced by Jeon et al. (2013).[4] In our estimations, we lag the bank controls by one

[3] Table 2 defines all variables and the sources of the data.

[4] In contrast to the remaining bank variables, which are stock variables, the internally generated funds is a flow variable.

period. To control for the local demand for credit, we also introduce macroeconomic variables. These include *GDP growth*, *change in unemployment rate (*Δ *unemployment rate)* and annual inflation. Throughout the paper, we cluster the standard errors at the parent level.

2.3 Data

2.3.1 Dataset Construction

For our primary dataset, we utilized annual bank-level data from Bureau van Dijk's Bankscope. Aligning with prevailing literature practices (e.g., Deléchat et al., 2012; Cornett et al., 2011; Bonner et al., 2014), our focus was specifically on commercial banks to mitigate biases stemming from diverse business models, such as those of investment banks. Initially, we compiled a roster of the top 500 global commercial banks based on total assets. Through manual scrutiny, we identified first-level subsidiaries of these banks, selecting global subsidiaries of OECD parents with a minimum ownership share of 50%, a first-level subsidiary status, and a Bureau van Dijk top-10,000 ranking in total assets. This initial selection yielded 114 parents and 602 subsidiaries for the 1997–2012 period. Subsequently, during the data matching process, instances emerged where data for parent or subsidiary for a given year were missing. Domestic subsidiaries were excluded from the analysis. Ultimately, our dataset consisted of 84 parents and 375 subsidiaries. The Online Appendix's Table A1 lists parent commercial banks along with the number of their foreign subsidiaries.[5] The parent banks represent 27 OECD countries, with subsidiaries located in 98 countries (combining OECD and non-OECD). Geographical distribution is illustrated in Online Appendix Figures A1 (subsidiaries) and A2 (parents). Both parents and subsidiaries' unconsolidated data were used, comprising 2791 subsidiary-year observations and 870 parent-year observations. To ensure result interpretability, balance sheet data unit measurements were uniformly transformed to millions, and original country-specific currencies were converted to U.S. Dollars

2.3.2 Descriptive Statistics

Table 1 presents the descriptive statistics of some of the main variables in our regression analysis. In terms of loan growth, we notice that the average rate in the subsidiary sample is more than 4 percentage points higher than the average loan growth rate in the parent sample. However, the volatility in loan growth is twice higher in the former sample. Overall, subsidiaries are smaller than parents, but are more profitable, better capitalized and possess more liquid asset relative to total assets. Also, foreign subsidiaries allot more than 50% more funds than parents to provisions against bad loans. We notice a similar pattern when we consider internally generated funds: foreign subsidiaries tend to generate twice higher net income to total loans than their parents. The full set of regression variables and their descriptions is provided in Table 2.

[5] The full list of subsidiaries is available upon request.

Table 1: Descriptive Statistics. This table presents the descriptive statistics of the dependent variable and the bank control variables in our regression analysis. The sample comprises 375 foreign subsidiaries of 84 OECD parent banks in the period 1997-2012.
Note: Not all data for parents are available, therefore the number of observations for some of the variables below is lower than 870. These variables are not used in the regression analysis, as it is at the subsidiary level, and the averages are presented for the sake of approximate comparison only.

Variable		Parents	Subsidiaries
Loan Growth Rate	Mean	14.33%	18.72%
	Standard Deviation	24.25%	44.99%
	Observations	870	2791
Size	Mean	11.77	7.70
	Standard Deviation	1.49	1.89
	Observations	870	2791
Profitability (Profit/Total Earning Assets)	Mean	0.91%	1.56%
	Standard Deviation	1.27%	2.51%
	Observations	860	2791
Riskiness (LLP/Loans)	Mean	0.89%	1.31%
	Standard Deviation	1.11%	2.45%
	Observations	843	2791
Capitalization (Equity/Total Assets)	Mean	6.36%	12.62%
	Standard Deviation	3.03%	9.74%
	Observations	870	2791
Liquidity (Liquid Assets/Total Assets)	Mean	22.10%	27.86%
	Standard Deviation	12.96%	20.68%
	Observations	870	2791
Internally Generated Funds (Net Income$_t$)/Loans$_{t-1}$)	Mean	1.80%	3.50%
	Standard Deviation	3.37%	7.51%
	Observations	860	2791

Table 2: Regression Variables. This table presents a description of the regression variables and data sources. All relevant balance sheet variables are converted to U.S. dollars for an easier interpretation of the results.

Variable name	Description	Data source
Loan Growth Rate$_i$	Growth of total subsidiary loans	Bankscope
Size$_i$	Natural logarithm of total subsidiary assets	Bankscope
Profitability$_i$	Ratio of subsidiary profits to total earning assets	Bankscope
Riskiness$_i$	Ratio of subsidiary loan-loss provisions to total loans	Bankscope
Capitalization$_i$	Ratio of subsidiary equity to total assets	Bankscope
Liquidity$_i$	Ratio of subsidiary liquid assets (cash, trading securities and interbank lending of maturities less than three months) to total assets	Bankscope
Internally Generated Funds$_i$	Ratio of subsidiary net income at time t to total loans at time t-1	Bankscope
Parent Capitalization$_j$	Ratio of parent equity to total assets	Bankscope
Parent Wholesale Funding$_j$	Total parent liabilities minus equity and deposits	Bankscope
Parent Reliance on Wholesale Funding$_j$	Dummy variable that takes the value of 1 if the wholesale funding to total liabilities of the parent bank is: 1) below 10% or 2) above 90% , and 0 otherwise	Bankscope
Subsidiary Importance as a Funding Source	Ratio of total liabilities minus total customer deposits to total liabilities	Bankscope
Subsidiary Importance as an Investment Income Source	Ratio of net loans to total assets	Bankscope
Gross Domestic Product Growth$_k$	Annual GDP growth in subsidiary country	Datastream, World Bank's World Development Indicators
Inflation$_k$	Annual inflation in subsidiary country	Datastream, World Bank's World Development Indicators
Unemployment$_k$	End-of-year unemployment in subsidiary country	Datastream, World Bank's World Development Indicators

3 Results

In this section, we present the results from our empirical analysis. We start with our baseline model and estimate the effects of solvency and wholesale funding shocks to parents on the full sample of subsidiaries. Subsequently, we run several additional analyses to understand the drivers of our results: Subsidiary size, past growth or host country development.

3.1 Solvency vs. Wholesale Shocks: Which are More Important?

Table 4 presents the results from the estimation of our baseline Equation 1 for the overall sample of subsidiaries, without interactions. Model (1) is a simple pooled ordinary least squares model that involves only dummy variables for the solvency and wholesale shocks and no control variables. At this stage, we notice a considerable disparity in the effects of the two types of shocks. A solvency shock to the parents leads to a substantial reduction of the loan growth of their subsidiaries, while the effect of a wholesale funding shock is not statistically significant. Model (2) adds bank variables to control for the subsidiary situation. The magnitude of the effects remains largely unaffected and the bank control variables exhibit the expected signs. Bigger (hence, more mature) and more profitable subsidiaries tend to expand their lending at a slower rate. Also, the better capitalized the subsidiary and the more liquid funds it has at its disposal, the higher the lending growth. Furthermore, an increase in internally generated funds leads to a rise in loan growth. In Model (3), we introduce host country fixed effects to account for unobservable local demand factors in the host country. The results for the main variables of interest remain qualitatively the same. In Model (4), we introduce subsidiary fixed effects. At this stage, the effect of parent wholesale shocks disappears, while the effect of solvency shocks remains highly significant. Including time fixed effects and controlling for *dynamic* loan demand factors at the host country level using macroeconomic controls (Model (5)) reduces the magnitude of the effect of solvency shocks, but it remains statistically significant. Since Model (5) controls for unobserved heterogeneity at the narrowest level, we choose it as our workhorse model in the next section. It is worth noting that the results for the effects of the *continuous* bank control variables for capitalization and liquidity remain relatively robust (at least in terms of magnitude) throughout all model specifications. Therefore, while the starting level of capitalization and liquidity of the subsidiaries at *t-1* may matter for their lending decisions, only solvency shocks affect credit supply at time *t*.

Table 4: Baseline Regressions. This table reports the results from the estimation of Equation 1 without interactions at the subsidiary bank level. The sample comprises 375 foreign subsidiaries of 84 OECD parent banks in the period 1997-2012. The dependent variable is the growth rate of subsidiary loans. "Solvency Shock$_j$" and "Wholesale Shock$_j$" are dummy variables that take the value of 1 if a parent bank *j* is hit by a solvency and wholesale shock, respectively, and 0 otherwise. The bank controls ("Size", "Profitability", "Riskiness", "Capitalization", "Liquidity" and "Internal") are at the subsidiary *i* level. They are lagged with one period. The variable "Internal" stands for "Internally Generated Funds". The "Macro Controls" vector of variables contain Gross Domestic Product growth, inflation and unemployment in the host country *k* of the respective subsidiary. All variables are defined in Table 2 and in the main text. The country fixed effects are at the host country level. The bank fixed effects are at the subsidiary level. The numbers in parentheses are standard errors. All standard errors are clustered at the parent level. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, **, and *, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Solvency Shock$_{j,t-1}$	-0.1057***	-0.1037***	-0.1208***	-0.0892***	-0.0571**
	(0.025)	(0.026)	(0.027)	(0.028)	(0.026)
Wholesale Shock$_{j,t-1}$	-0.0363	-0.0456**	-0.0513**	-0.0178	0.0226
	(0.022)	(0.021)	(0.022)	(0.022)	(0.028)
Size$_{i,j,t-1}$		-0.0340***	-0.0451***	-0.1466***	-0.2078***
		(0.006)	(0.007)	(0.015)	(0.033)
Profitability$_{i,j,t-1}$		-1.6205**	-1.3119	-1.9739**	-1.9333**
		(0.770)	(0.930)	(0.898)	(0.850)
Riskiness$_{i,j,t-1}$		-1.0891***	-1.5893***	-2.6558***	-1.7250**
		(0.396)	(0.441)	(0.625)	(0.673)
Capitalization$_{i,j,t-1}$		0.3719*	0.2503	0.4875	0.3770
		(0.188)	(0.179)	(0.316)	(0.308)
Liquidity$_{i,j,t-1}$		0.2924***	0.4260***	0.7946***	0.7178***
		(0.056)	(0.069)	(0.124)	(0.131)
Internally Generated Funds$_{i,j,t-1}$		0.6244***	0.5707**	0.8367***	0.8454***
		(0.227)	(0.234)	(0.285)	(0.286)
Host Country Fixed Effects	No	No	Yes	No	No
Subsidiary Fixed Effects	No	No	No	Yes	Yes
Time Fixed Effects	No	No	No	No	Yes
Macro Controls	No	No	No	No	Yes
Observations	2791	2791	2791	2791	2791
R-squared	0.007	0.076	0.127	0.145	0.235
Adjusted R-squared	0.006	0.073	0.093	0.143	0.228

3.2 Subsidiary Size, Past Growth and Country Development

In this subsection, we extend our analysis by slicing the subsidiary sample across several dimensions. If parent banks do not discriminate between subsidiaries in distributing the shock, bigger subsidiaries should be able to weather shocks better than smaller subsidiaries (see, e.g., Cetorelli & Goldberg (2012*b*)). To test this, in Models (1) and (2) in Table 5, we split the subsidiary sample into below and above median bank size and find that lending is reduced primarily by large foreign subsidiaries. In Models (3) and (4), we test how the shock is transmitted depending on the past lending growth of foreign subsidiaries and find that the highest drop is for the subsidiaries with already sluggish lending growth. This is in line with the results from Models (5) and (6), where we split the sample into non-OECD and OECD subsidiaries, respectively: solvency shocks are transmitted to the mature OECD markets, which typically exhibit slower growth.[6]

Table 5: Subsidiary Size, Growth and Country Development. This table reports the results at the subsidiary bank level, with the subsidiaries split according to their size (Models (1) and (2)), past growth (Models (3) and (4)) and host country development (Models (5) and (6)). The full sample comprises 375 foreign subsidiaries of 84 OECD parent banks in the period 1997-2012. The dependent variable is the growth rate of subsidiary loans. "Solvency Shock$_j$" and "Wholesale Shock$_j$" are dummy variables that take the value of 1 if a parent bank *j* is hit by a solvency and wholesale shock, respectively, and 0 otherwise. The bank controls include: Size, Profitability, Riskiness, Capitalization,, Liquidity and Internally Generated Funds and are at the subsidiary *i* level. They are lagged with one period. The "Macro Controls" vector of variables contain Gross Domestic Product growth, inflation and unemployment in the host country *k* of the respective subsidiary. All variables are defined in Table 2 and in the main text. The bank fixed effects are at the subsidiary level. The numbers in parentheses are standard errors. All standard errors are clustered at the parent level. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, **, and *, respectively.

	Subsidiary Size		**Past Subsidiary Growth**		**Subsidiary Country Development**	
	Below Median	**Above Median**	**Below Median**	**Above Median**	**Non-OECD**	**OECD**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Solvency Shock$j,t-1$	-0.0434	-0.0774***	-0.0870**	0.0048	-0.0151	-0.0882**
	(0.037)	(0.022)	(0.037)	(0.045)	(0.033)	(0.037)
Wholesale Shock$j,t-1$	0.0335	0.0071	0.0755**	-0.0114	0.0249	0.0162
	(0.037)	(0.030)	(0.038)	(0.043)	(0.025)	(0.048)
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Subsidiary Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1378	1413	1381	1381	1360	1431
R-squared	0.256	0.287	0.201	0.283	0.391	0.130
Adjusted R-squared	0.242	0.274	0.187	0.270	0.379	0.115

[6] In unreported regressions, we find that shock to subsidiaries is the highest for low loan-growth OECD banks.

Overall, the results provide support for Hypothesis 3: Shocks affect bigger subsidiary banks with low growth opportunities in mature markets. This is consistent with parents treating high-growth markets as investment targets and therefore avoiding subsidiary lending contraction in these particular host countries. These results are in line with the notion of "locational pecking order" introduced by Cetorelli & Goldberg (2012*b*): Global banks tend to treat certain foreign markets as investment targets, while other markets are treated as funding sources. Typically, banks can attract cheaper funding from mature, slow-growth markets, which can then be used either to support parents during distress or be invested in high-growth ("investment") markets. In Cetorelli & Goldberg (2012*b*), "locational pecking order" is juxtaposed to "organizational pecking order", where the headquarters of global banks extract funds through their foreign subsidiaries irrespective of their location and place in the parent bank's investment strategy. We do not find support for the latter hypothesis in our global sample, which is in line with the findings of Cetorelli & Goldberg (2012*b*) for their limited sample of US parent banks. Therefore, we find that locational pecking order is the prevalent *modus operandi* in the global banking system.

4 Conclusion

The links between parents and subsidiaries within international bank conglomerates lead to a reduction of information asymmetries and provide a liquidity source in cases when outside funding is scarce or unavailable. They, however, could also be channels for transmission of adverse shocks. In this paper, we analyze the transmission channels of negative shocks from parent banks to their foreign subsidiaries and try to find an explanation of why a negative shock transmission occurs in certain cases and not in others.

Our results have important theoretical and policy implications and add to our understanding of the transmission of solvency and wholesale shocks across borders. In our analysis, we recognize that not only the negative shocks are important as such, but also is their type, because banks use different approaches to address different types of shocks. We use this observation to analyze whether solvency and wholesale shocks to parent banks are systematically related to a reduction in subsidiary lending. Our findings suggest that solvency shocks to parents generally have larger effect on subsidiary lending than wholesale shocks. We also find that solvency shocks have higher impact on big subsidiary banks with low growth opportunities in mature markets, which further reinforces the "locational pecking order" hypothesis (see Cetorelli & Goldberg 2012*b*), as the latter markets may be used as sources of funding for investments in high-growth developing markets.

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A. Online Appendix

A.1 Estimation of Solvency and Wholesale Shocks (Radev, 2021*b*)

In estimating the solvency and wholesale funding shocks to parents, we adopt and extend the methodology by DeYoung et al. (2017). To this end, we use a partial capital adjustment model to estimate the banks' internal capital ratio targets in order to identify the parent solvency shocks. Following this model, every bank has a target capital ratio that is a function of observable characteristics:

$$K_{i,t}^{*} = \beta \cdot X_{i,t-1}, \tag{1}$$

with $K_{i,t}^{*}$ being the bank *i*'s capital ratio in period *t*, while $X_{i,t-1}$ is a vector of observable determinants of the capital ratio, such as parent size, average return on assets, whether the bank is public and whether it is a global systemically important bank. β is a vector of coefficients.

In extreme situations, banks may deviate from their target capital ratios, which results in costly capital adjustments. During this adjustment process, banks close a constant proportion λ of the gap between their actual capital *K* and $K*$ in each time period:

$$K_{i,t} - K_{i,t-1} = \lambda \cdot \left(K_{i,t}^{*} - K_{i,t-1}\right) + \epsilon_{i,t}, \tag{2}$$

where λ is the aforementioned adjustment speed. A value of $0 < \lambda < 1$ reflects the partial adjustment towards *K** between *t-1* and *t*. Substituting for the respective values in both equations and rearranging leads to:

$$K_{i,t} - K_{i,t-1} = \lambda \cdot \left(K_{i,t}^{*} - K_{i,t-1}\right) + \epsilon_{i,t}, \tag{3}$$

where λ is the aforementioned adjustment speed. A value of $0 < \lambda < 1$ reflects the partial adjustment towards $K*$ between *t-1* and *t*. Substituting for the respective values in both equations and rearranging leads to:

$$K_{i,t} = \lambda\beta \cdot X_{i,t-1} + (1-\lambda) \cdot K_{i,t-1} + \epsilon_{i,t}. \tag{4}$$

Recovering $\hat{\lambda}$ from $\left(\widehat{1-\lambda}\right)$ and subsequently $\hat{\beta}$ from $\left(\widehat{\lambda\beta}\right)$, we calculate the target ratio $K_{i,t}^{*}$ for bank *i* in period *t*. Since the equation contains a lagged dependent variable, DeYoung et al. (2017) suggest using the dynamic generalized method of moments by Blundell and Bond (1998).

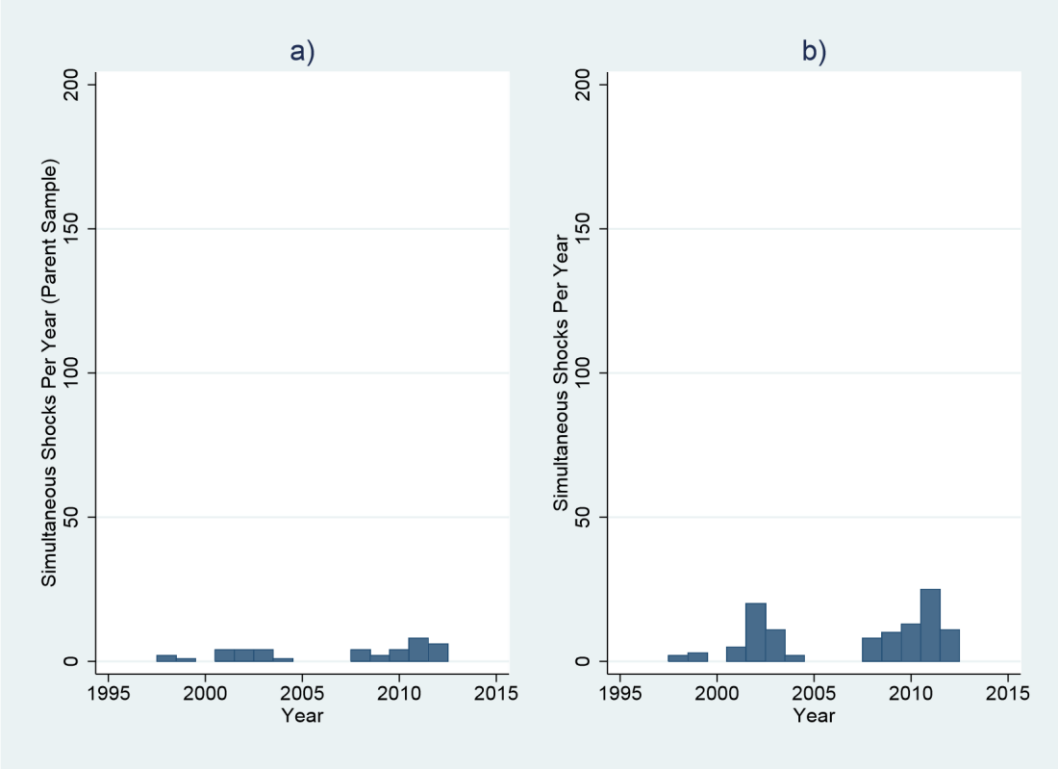
To identify exogenous shocks, we follow DeYoung et al. (2017) and set a number of conditions, such as a decrease in the equity capital ratio $\left(\Delta K_{i,t-1}\right)$ of a bank that is already below its target capital ratio $GAPCAP_{i,t-2} = K_{i,t-2}^{*} - K_{i,t-2} > 0$ that leads to an *unexpected* even larger deviation from its internal target (assuming that the goal of the bank is to return to its target ratio as soon as possible – already in the subsequent period). We also require a drop in equity by at least 5%. As banks usually expect profits in the next year in their annual forecasts, a year-on-year drop in equity in the unconsolidated parent reports by 5% represents a substantial undershooting of these forecasts.

$$Solvency\ Shock = \begin{cases} 1,\ if \quad K_{\{i,t-2\}} < K_{\{i,t-2\}}^{*} \quad and \quad \Delta K_{\{i,t-1\}}^{*} < 0 \\ \quad and \quad \Delta\, GAPCAP_{\{i,t-1\}} > 0 \quad and \quad g_{\{equity,t-1\}} < -0.05 \\ 0,\ otherwise \end{cases} \quad (5)$$

We extend the methodology of DeYoung et al. (2017) to applications for wholesale funding by analogously assuming that the bank targets a specific wholesale funding to total liabilities ratio *WF∗*. We substitute *WF* and *WF∗* for *K* and *K∗* in the procedure above and set the following conditions for wholesale funding shocks:

$$Wholesale\ Shock = \begin{cases} 1,\ if \quad \mathrm{WF}_{\{i,t-2\}} < \mathrm{WF}_{\{i,t-2\}}^{*} \quad and \quad \Delta\mathrm{WF}_{\{i,t-1\}}^{*} < 0 \\ \quad and \quad \Delta\, GAPWF_{\{i,t-1\}} > 0 \quad and \quad g_{\{\text{wholesale funding},t-1\}} < -0.05 \\ 0,\ otherwise \end{cases} \quad (6)$$

Figure A3: Number of Simultaneous Solvency and Wholesale Shocks Per Year. This figure presents the number of simultaneous solvency and wholesale shocks that transfer from the 84 OECD parent banks to the 375 subsidiary banks in our sample between 1997 and 2012. Panel a) presents the simultaneous shocks per year in the parent sample. In total, there are 40 simultaneous shocks in the parent dataset in the sample period. Panel b) presents the simultaneous shocks per year that are relevant for the sample of 375 subsidiaries after merging both datasets. Since a parent usually has more than one subsidiary, this results in a total of 110 simultaneous parent shocks in our merged dataset.



A.2 Figures

Figure A4: Geographical Distribution of Subsidiaries. This figure presents the geographical distribution of the 375 subsidiaries of the 84 OECD parent banks in our sample.

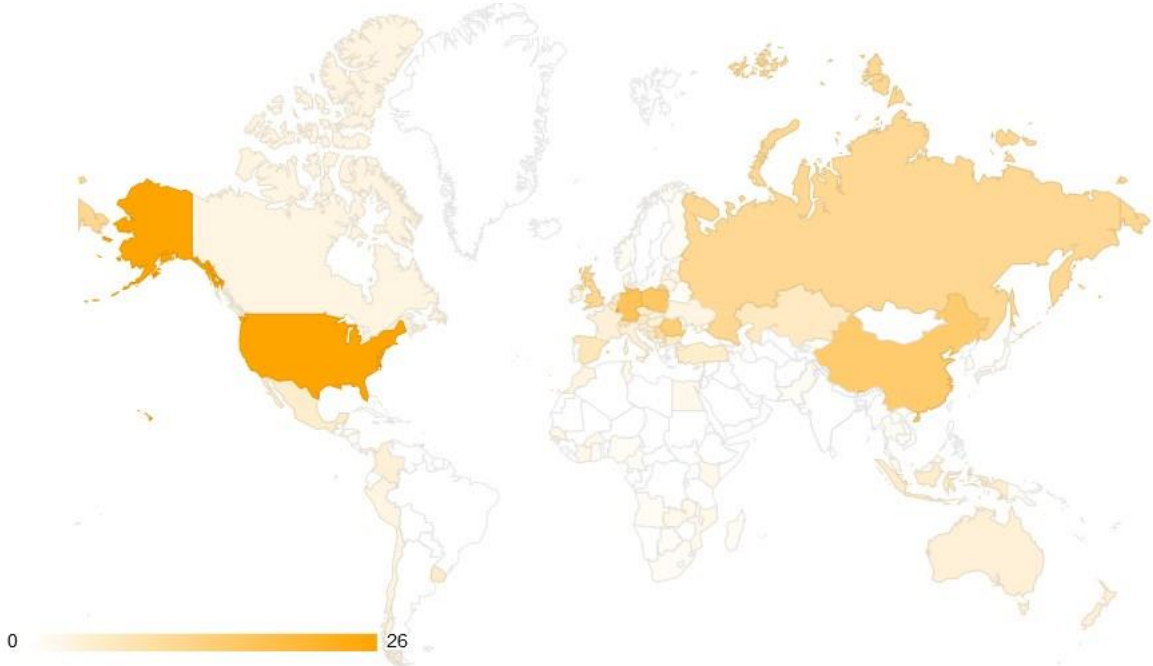
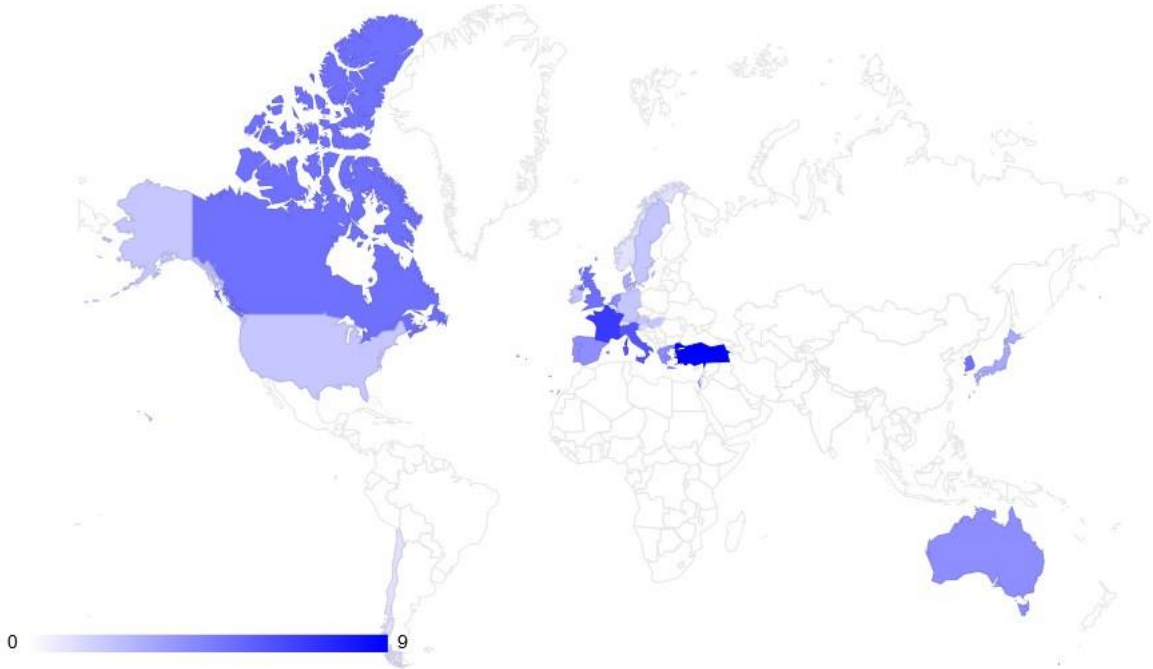


Figure A5: Geographical Distribution of Parents. This figure presents the geographical distribution of the 84 OECD parent banks in our sample.



A.2 Tables

Table A1: Parents and Subsidiaries. This table presents the 84 parent commercial banks in our sample and the overall number of subsidiaries per bank.

	Parent Name	Parent Country	# Subs
1	ABN AMRO Bank NV	NETHERLANDS	2
2	Akbank T.A.S.	TURKEY	1
3	Allied Irish Banks plc	IRELAND	1
4	Alpha Bank AE	GREECE	5
5	Australia and New Zealand Banking Group	AUSTRALIA	6
6	Banca Mediolanum SpA	ITALY	1
7	Banca Monte dei Paschi di Siena SpA	ITALY	2
8	Banco Bilbao Vizcaya Argentaria SA	SPAIN	7
9	Banco Comercial Portugues, SA-Millennium bcp	PORTUGAL	3
10	Banco de Sabadell SA	SPAIN	2
11	Banco Desio - Banco di Desio e della Brianza SpA	ITALY	1
12	Banco Espirito Santo SA	SPAIN	2
13	Banco Santander SA	SPAIN	18
14	BANIF - Banco Internacional do Funchal, SA	PORTUGAL	1
15	Bank für Arbeit und Wirtschaft und Österreichische Postsparkasse Aktiengesellschaft-BAWAG PSK Group	AUSTRIA	1
16	Bank Hapoalim BM	ISRAEL	2
17	Bank Leumi Le Israel BM	ISRAEL	5
18	Bank of Montreal-Banque de Montreal	CANADA	2
19	Bank of Nova Scotia (The) - SCOTIABANK	CANADA	13
20	Bank of Tokyo - Mitsubishi UFJ Ltd (The)-Kabushiki Kaisha Mitsubishi Tokyo UFJ Ginko	JAPAN	1
21	Bankia, SA	SPAIN	1
22	Banque Fédérative du Crédit Mutuel	FRANCE	1
23	Banque Internationale à Luxembourg SA	LUXEMBOURG	1
24	Barclays Bank Plc	UNITED KINGDOM	7
25	BNP Paribas	FRANCE	25
26	Caixa Geral de Depositos	PORTUGAL	5
27	Canadian Imperial Bank of Commerce CIBC	CANADA	4
28	Citibank NA	UNITED STATES OF AMERICA	10
29	Commerzbank AG	GERMANY	6
30	Commonwealth Bank of Australia	AUSTRALIA	1
31	CorpBanca	CHILE	3
32	Credit Agricole Corporate and Investment Bank-Credit Agricole CIB	FRANCE	1
33	Credit Europe Bank N.V.	NETHERLANDS	2
34	Credito Emiliano SpA-CREDEM	ITALY	1
35	Danske Bank A/S	NORWAY	3
36	Denizbank A.S.	TURKEY	1
37	Deutsche Bank AG	GERMANY	18
38	Dexia Crédit Local SA	FRANCE	2
39	DNB Bank ASA	NORWAY	5
40	East West Bank	UNITED STATES OF AMERICA	1
41	Eurobank Ergasias SA	GREECE	3

42	First International Bank of Israel	ISRAEL	2
43	Hana Bank	REPUBLIC OF KOREA	1
44	HSBC Bank plc	UNITED KINGDOM	5
45	Industrial Bank of Korea	REPUBLIC OF KOREA	1
46	ING Bank NV	NETHERLANDS	6
47	Intesa Sanpaolo	ITALY	10
48	Investec Bank Plc	UNITED KINGDOM	1
49	Israel Discount Bank Ltd.	ISRAEL	2
50	Jyske Bank A/S	DENMARK	1
51	KB Kookmin Bank	REPUBLIC OF KOREA	2
52	KBC Bank NV	BELGIUM	5
53	Korea Exchange Bank	REPUBLIC OF KOREA	4
54	Mizuho Bank Ltd	JAPAN	6
55	MKB Bank Zrt	HUNGARY	1
56	National Australia Bank Limited	AUSTRALIA	2
57	National Bank of Greece SA	GREECE	6
58	Natixis	FRANCE	2
59	NLB dd-Nova Ljubljanska Banka d.d.	SLOVENIA	5
60	Nordea Bank Danmark Group-Nordea Bank Danmark A/S	DENMARK	1
61	OTP Bank Plc	HUNGARY	5
62	Piraeus Bank SA	GREECE	6
63	Raiffeisen Bank International AG	AUSTRIA	7
64	RCI Banque	FRANCE	1
65	Royal Bank of Canada RBC	CANADA	10
66	Royal Bank of Scotland NV (The)-RBS NV	NETHERLANDS	6
67	Shinhan Bank	REPUBLIC OF KOREA	7
68	Skandinaviska Enskilda Banken AB	SWEDEN	6
69	Société Générale	FRANCE	26
70	Standard Chartered Bank	UNITED KINGDOM	8
71	Sumitomo Mitsui Banking Corporation	JAPAN	2
72	Svenska Handelsbanken	SWEDEN	2
73	T.C. Ziraat Bankasi A.S.	TURKEY	2
74	Toronto Dominion Bank	CANADA	3
75	Turk Ekonomi Bankasi A.S.	TURKEY	1
76	Turkiye Garanti Bankasi A.S.	TURKEY	2
77	Turkiye Halk Bankasi A.S.	TURKEY	1
78	Turkiye is Bankasi A.S. - ISBANK	TURKEY	2
79	Turkiye Vakiflar Bankasi TAO	TURKEY	1
80	UBS AG	SWITZERLAND	5
81	UniCredit SpA	ITALY	24
82	Westpac Banking Corporation	AUSTRALIA	3
83	Woori Bank	REPUBLIC OF KOREA	3
84	Yapi Ve Kredi Bankasi A.S.	TURKEY	2
		Total	**375**

Table A2: Parents and Subsidiaries. This table presents the distribution of the 375 subsidiaries across countries. For a graphical representation, see Figure A1.

	Subsidiary Country	Number of Subsidiaries	OECD Member		Subsidiary Country	Number of Subsidiaries	OECD Member
1	ALBANIA	3	No	50	LATVIA	3	Yes
2	ANDORRA	1	No	51	LITHUANIA	2	Yes
3	ANGOLA	1	No	52	LUXEMBOURG	24	Yes
4	ARUBA	1	No	53	MACAO	2	No
5	AUSTRALIA	4	Yes	54	MACEDONIA (FYROM)	5	No
6	AUSTRIA	6	Yes	55	MADAGASCAR	1	No
7	BAHAMAS	3	No	56	MALAYSIA	2	No
8	BARBADOS	2	No	57	MALTA	3	No
9	BELARUS	1	No	58	MEXICO	5	Yes
10	BELGIUM	6	Yes	59	MONTENEGRO	3	No
11	BELIZE	1	No	60	MOROCCO	3	No
12	BOSNIA AND HERZEGOVINA	6	No	61	MOZAMBIQUE	2	No
13	BOTSWANA	1	No	62	NETHERLANDS	5	Yes
14	BULGARIA	5	No	63	NEW ZEALAND	4	Yes
15	BURKINA FASO	2	No	64	NICARAGUA	1	No
16	CAMBODIA	1	No	65	NIGERIA	1	No
17	CAMEROON	1	No	66	NORWAY	1	Yes
18	CANADA	3	Yes	67	PAKISTAN	1	No
19	CAPE VERDE	3	No	68	PANAMA	3	No
20	CHILE	3	Yes	69	PAPUA NEW GUINEA	1	No
21	CHINA	15	No	70	PERU	3	No
22	COLOMBIA	4	No	71	POLAND	16	Yes
23	COTE D'IVOIRE	2	No	72	PORTUGAL	1	Yes
24	CROATIA	4	No	73	REPUBLIC OF KOREA	1	Yes
25	CURACAO	1	No	74	REPUBLIC OF MOLDOVA	1	No
26	CYPRUS	3	No	75	ROMANIA	14	No
27	CZECH REPUBLIC	5	Yes	76	RUSSIAN FEDERATION	11	No
28	DENMARK	2	Yes	77	SAMOA	2	No
29	EGYPT	2	No	78	SENEGAL	2	No
30	EL SALVADOR	1	No	79	SERBIA	10	No
31	ESTONIA	1	Yes	80	SEYCHELLES	1	No
32	FINLAND	1	Yes	81	SINGAPORE	1	No
33	FRANCE	4	Yes	82	SLOVAKIA	3	Yes
34	GEORGIA	1	No	83	SLOVENIA	4	Yes
35	GERMANY	17	Yes	84	SOUTH AFRICA	1	No
36	GHANA	1	No	85	SPAIN	7	Yes
37	GRENADA	1	No	86	SWITZERLAND	9	Yes
38	HAITI	1	No	87	THAILAND	1	No
39	HONDURAS	1	No	88	TONGA	1	No
40	HONG KONG	4	No	89	TRINIDAD AND TOBAGO	4	No
41	HUNGARY	4	Yes	90	TUNISIA	2	No
42	INDONESIA	5	No	91	TURKEY	5	Yes
43	IRELAND	3	Yes	92	UKRAINE	3	No
44	ITALY	4	Yes	93	UNITED KINGDOM	11	Yes
45	JAMAICA	3	No	94	UNITED STATES OF AMERICA	26	Yes
46	JAPAN	1	Yes	95	URUGUAY	5	No
47	KAZAKHSTAN	6	No	96	VANUATU	1	No
48	KENYA	2	No	97	VIET NAM	1	No
49	KYRGYZSTAN	1	No	98	ZAMBIA	2	No
					Total:	**375**	