ONLINE APPENDIX

Financial Linkages and the Global Business Cycle

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1. Additional Literature

Empirical studies have shown that business cycles are more correlated for country pairs that trade more (Frankel and Rose, 1998), including those with more trade between multinational affiliates.[1]

We are motivated by recent empirical evidence that documents how the US plays a pivotal role as a provider of funds to the rest of the world (Gourinchas et al., 2010; Farhi and Maggiori, 2018). Recent empirical evidence has identified the US as the key driver of a Global Financial Cycle (Monnet and Puy, 2019; Miranda-Agrippino and Rey, 2020) in which a tightening of US financial conditions leads to a fall in cross-border capital flows (Bruno and Shin, 2015; Passari and Rey, 2015) and a decline in foreign economic activity (Dedola et al., 2017; Iacoviello and Navarro, 2019; Erik et al., 2019, 2020).

There is a large literature on how internal capital markets of multi-establishment firms, and multinationals more specifically, shape the ability of production units to access funds and choose the location and scale of their operations (e.g. Antras et al., 2009). Foley and Manova (2015) provides a review on the corporate finance of multinationals. Recent papers that build on this literature include Desbordes and Wei (2017), Fan and Luo (2019), Bilir et al. (2019), and Erel et al. (2020). There is also ample empirical evidence that economic activity of foreign affiliates depends on the financial position of the multinational's headquarters or parent company, including by Desai et al. (2008), Kalemli-Ozcan et al. (2016) and Biermann and Huber (2019). From firm-level data, it is well known that comovement of economic activity between foreign affiliates and their parent firm positively impacts the correlations of countries' business cycles (Kleinert et al., 2015; Cravino and Levchenko, 2017; Di Giovanni et al., 2018).

Our reduced form approach is similar to that of Matvos and Seru (2014), Giroud and Mueller (2019) and Loualiche et al. (2019), who study how within-firm financial networks affect the reallocation of resources within multi-establishment firms when one of the establishment is hit by a shock that tightens the firm's internal budget constraint. Other studies on resource allocation through internal capital markets of multi-establishment firms include Lamont (1997), Shin and Stulz (1998), Rajan et al. (2000), Gopalan et al. (2007),

[1]Additional evidence is provided by Clark and Van Wincoop (2001), Baxter and Kouparitsas (2005), Kose and Yi (2006), Calderon et al. (2007), Ng (2010) and Di Giovanni and Levchenko (2012). For papers documenting the trade comovement puzzle, see Backus et al. (1993), Kose and Yi (2001), Kose and Yi (2006) and Johnson (2014).

Yan et al. (2010) Boutin et al. (2013), Seru (2014), Almeida et al. (2015), Giroud and Mueller (2015), and Santioni et al. (2019).

There is a rich literature on the role that banks play in transmitting financial crises between countries (e.g. Acharya and Schnabl, 2010; Cetorelli and Goldberg, 2011; Giannetti and Laeven, 2012; De Haas and Van Horen, 2013; Presbitero et al., 2014; Buch and Goldberg, 2015; Ivashina et al., 2015; Ongena et al., 2015). These studies do not examine the role of non-financial firms in transmitting financial shocks. Moreover, Kalemli-Ozcan et al. (2013) and Bräuning and Sheremirov (2020) find evidence that suggests that financial integration through banks does not always lead to greater business cycle correlations.

Other empirical papers on multinational affiliates examine their performance during the 2008-09 crisis (Alfaro and Chen, 2012; Alviarez et al., 2017; Deloof and Montalto, 2017), their role in driving productivity spillovers to domestic firms (e.g. Javorcik, 2004; Keller and Yeaple, 2009; Alfaro and Chen, 2018; Alfaro-Urena et al., 2019) and cross-country income differences (Alviarez et al., 2019). Quantitative studies that examine how multinationals affect welfare and the gains from openness include Helpman (1984), Rodriguez-Clare (1996), Helpman et al. (2004), Ramondo and Rodríguez-Clare (2013), Ramondo (2014), Tintelnot (2017), Lind and Ramondo (2018), Alviarez (2019) and Bilir and Morales (2020).

Recent papers have advanced the literature on production networks by studying the interactions between production networks and distortions (Bigio and La'O, 2016), entry and exit (Baqaee, 2018), monetary policy (La'O and Tahbaz-Salehi, 2019; Rubbo, 2020), stock markets (di Giovanni and Hale, 2020), industrial policy (Liu, 2019), fiscal policy (Devereux et al., 2019) and credit linkages (Luo, 2019; Altinoglu, 2020).

Besides Benmelech et al. (2019), other papers that document how financial shocks affect firm performance include Benmelech et al. (2011), Berton et al. (2018), Benmelech et al. (2019), with papers focusing on the 2008-09 financial crisis such as Duchin et al. (2010), Almeida et al. (2012), Chodorow-Reich (2014), Giroud and Mueller (2017), Bentolila et al. (2018), Huber (2018), Duval et al. (2020). Besides Barrot and Sauvagnat (2016), other empirical papers studying firm-to-firm linkages include Barrot and Sauvagnat (2016), Carvalho et al. (2016), Costello (2017), Ozdagli and Weber (2017), Demir et al. (2019), Boehm et al. (2019), and Alfaro et al. (2019).

The literature on business cycle co-movement documents that standard international business cycle models cannot match the positive growth correlation for countries with deeper trade ties (Backus et al., 1993; Kose and Yi, 2001, 2006; Burstein et al., 2008; Arko-

lakis and Ramanarayanan, 2009; Johnson, 2014). It is well known from microdata that the growth of multinational parents and affiliates is correlated across countries (Desai and Foley, 2004; Cravino and Levchenko, 2017; Di Giovanni et al., 2018; Bena et al., 2019). It is clear that this comovement is not primarily driven by intra-firm trade. Kleinert et al. (2015) documents that comovement is not stronger for subsidiary-parent pairs that engage in more intra-firm trade, while Cravino and Levchenko (2017) and Bena et al. (2019) find that comovement is pervasive across multinationals in different sectors, including services. Ramondo et al. (2016) show that US multinational affiliates abroad sell mostly in the local market, with the median affiliate having no shipments to the parent. More generally, Atalay et al. (2014) show that most vertical ownership links are not primarily motivated by input trade within the firm, and Ding (2020) documents that within multi-industry U.S. firms, intra-firm trade accounts for only about one percent of all sales.

Most papers interpret the growth correlation between multinationals subsidiaries and their parent company (or headquarters) as driven by technology transfer (e.g. Menno, 2014; Zlate, 2016; Cravino and Levchenko, 2017; Alviarez et al., 2019), even though utilization-adjusted TFP shocks are virtually uncorrelated across countries Huo et al. (2019). Moreover, there is consensus in the literature that the 2008-09 crisis was driven by credit, not productivity shocks. Hall (2010) and Ohanian (2010) both argue that the crisis was caused by an increase in financial frictions. More generally, there is little evidence that movements in TFP drive GDP fluctuations (Basu et al., 2006; Angeletos et al., 2018). In fact, Ohanian (2010) shows that a large increase in the labor wedge during the crisis - hours worked during the recession were much too low relative to the marginal product of labor - is consistent with a credit shock. Although total factor productivity drops by more than 2 percent during the average postwar U.S. recession, there was almost no total factor productivity deviation during the 2008-09 crisis. With respect to trade flows, Eaton et al. (2016) estimate that trade frictions, productivity shocks and demand shocks played minor roles in accounting for the collapse in trade during the crisis, which was mainly accounted for by an increase in the cost of investment.

Huo et al. (2019) use a wedge accounting exercise to show that most GDP comovement is driven by a common shock that can be viewed as a generalization of the labor wedge (e.g. Chari et al., 2007). One of the potential microfoundations of the labor wedge is the working capital constraint used in this paper (e.g. Neumeyer and Perri, 2005; Bigio and La'O, 2016). The primary transmission mechanism in this paper -international financial

linkages between firms- is thus consistent with their findings.

2. Data

2.1 Details on Data Selection and Cleaning

Compustat

Selection and cleaning. We use a subsets of Compustat, Fundamentals Annual. We consider the consolidated balance sheet data of all active US based firms. We only consider firms with positive sales and a positive number of employees.

Orbis

Selection and cleaning. We follow Kalemli-Ozcan et al. (2015) in cleaning Orbis. First, we remove duplicates, prioritizing unconsolidated balance sheets over consolidated ones, annual reports over local registry filings, and reports published in December over the rest of the year. Second, we clean firms with suspicious or incomplete information. We drop firms that have negative total assets, employees, sales, fixed assets, tangible fixed assets, or materials. We also drop firms that do not report information on the industry in which they operate. Third, we fill missing information on components of the balance sheet using accounting identities. For example, we fill tangible fixed assets as the difference between total fixed assets and the sum of intangible fixed assets and other fixed assets.

Merge with Compustat. There is no formal identifier to link firms in the two data sets. Instead, we leverage information on company names and tickers in both Compustat and Orbis. We start with 10,017 unique companies in Compustat that had positive sales and employment between 2000 and 2016. For Orbis, we limit ourselves to the 12,629 U.S. entities that were the ultimate owner of at least one European subsidiary in 2008. First, we merge companies with entities that have a perfect match on name and ticker. We then merge on name only. As a last step, we apply a fuzzy matching algorithm on the names from both data sets. We manually check and match every pair with a similarity score above a certain threshold.

We match 577 companies on name and ticker, and an additional 93 companies on name only. With the fuzzy matching algorithm, we merge an additional 998 entities in Orbis to a company in Compustat.

Dealscan

Selection and cleaning. We start with all observations in the facility and lender files. The first year with more than 1,000 facility-lender observations is 1986. We drop facilities with non-positive loan values. Up until 2018, the data set contains 1,034,978 facility-lender observations. In the case of missing values, we impute bank allocation shares with equal shares. We follow Ivashina (2009) and assign the lead agent title to the lender with the role 'Agent', 'Arranger', 'Book runner', 'Lead Arranger', 'Lead Bank', or 'Lead Manager'.

Merge with Compustat. We use the public linking file from Chava and Roberts (2008). We match 1,383 companies in Compustat with their main lenders in Dealscan.

FitchConnect

Selection and cleaning. We start with the annual data files from 2005 to 2018, which contain balance sheet information on global bank subsidiaries. We restrict ourselves to subsidiaries that can be matched to banks in Bankscope, and keep only statements issued in December covering the entire year. In the case of duplicates in terms of total assets and total equity, we restrict ourselves to balance sheets with regulatory accounting standards and consolidated balance sheets. We drop subsidiaries that are not based in the United States, and only keep subsidiaries with entries for commercial loans, impaired loans, total assets, short-term funding, total equity, and net income. Our final sample is a panel of 4,658 subsidiaries from 2005 to 2012.

Activities of Multinational Enterprises (AMNE)

Selection and cleaning. We consider the Analytical AMNE database (Cadestin et al., 2018), which contains a full matrix of the output of foreign subsidiaries in 59 countries plus the rest of the world. It also contains input-output tables by host country and industry over the period 2005-2016. We collapse these data to the following countries: Austria, Belgium, Brazil, Canada, Switzerland, Chili, China, Germany, Denmark, Spain, Finland, France, United Kingdom, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, Sweden, United States and South Africa. Our final data set also covers Taiwan, PoC, and a Rest of the World that reflects all other countries.

2.2 Variable Definitions

Compustat[2]

Sales. Represents "gross sales (the amount of actual billings to customers for regular sales completed during the period) reduced by cash discounts, trade discounts, and returned sales and allowances for which credit is given to customers."

Employment. Represents "the number of company workers as reported to shareholders. This figure is reported by some firms as an average number of employees and by some as the number of employees at year-end. No attempt has been made to differentiate between these bases of reporting. If both are given, the year-end figure is used."

Orbis

Sales. Represents "net sales." These do not include sales to other subsidiaries within same company.

Employment. Represents "total number of employees included in the company's payroll."

Global ultimate owner. Orbis contains information on each company's equity ownership structure: the names of owners, their ownership shares, whether their ownership is direct or ultimate cross-ownership, and their countries of origin. We consider an entity to be the global ultimate owner of a company in Orbis if its ownership share exceeds 50 %.

Dealscan

Facility (start) (end) (amount). Represent "the date at which the facility was issued (closed), and "the actual amount of the facility commited by the facility's lender pool."

Lender Role. Represents the role of the lender in the syndicate.

Bank Allocation. Represents "the percentage a particular lender has committed to the given facility."

FitchConnect

Corporate and Commercial Loans. Represents "loans and leases to corporate and commercial enterprises."

[2]Information taken from Compustat Manuals - Chapter 5 - Data Definitions.

Total Deposits, Money Market and Short-Term Funding. Represents the sum of "Customer Deposits (Current)", "Customer Deposits (Savings)", "Customer Deposits (Term)", "Deposits from Banks", "Repos and Cash Collateral", and "Other Deposits and Short-term Borrowings".

Customer Deposits (Current). Represents "customer deposit accounts, which can be withdrawn on demand or short notice. Where customer deposits by type are not disclosed, the amount will be included here."

Customer Deposits (Savings). Represents "customer deposit accounts with limitations as to the timing or number of withdrawals per period, which has no set maturity date."

Customer Deposits (Term). Represents "customer deposit accounts, which mature after a fixed period."

Deposits from Banks. Represents "deposits made by banking institutions."

Repos and Cash Collateral. Represents "securities that are designated for repurchase or cash received as collateral as part of securities lending."

Other Deposits and Short-term Borrowings. Represents "deposits, which do not fall into any other category, including money market instruments, other short term borrowing instruments and long term debt instruments with less than year until maturity."

3. Model Details

3.1 Equivalence of financing in general model and application - microfoundations

Here we show how the micro-foundations of the application generate an economywide unit cost function used in the framework of section 2 in the main text.

We abstract from international trade in goods, collapse to a common factor that is paid the wage w_n, and assume away international technology transfer, i.e. $d_{ih}^k = +\infty$ and $\delta_{ih}^{kj} = +\infty$ if $i \neq h$. In this case, the price index becomes

$$P_x = const \cdot (T_h)^{-1/\theta} w_x^{\alpha_L} (P^x)^{\alpha_x} [\sum_{o=1}^{N} (u_{ox})^{-\theta}]^{-1/\theta}$$

where u_o takes the CES form

$$u_{ox} = [\zeta r_x^{1-\phi} + (1-\zeta) r_o^{1-\phi}]^{1/(1-\phi)}$$

It suffices to show that $[\sum_{o=1}^{N} (u_{ox})^{-\theta}]^{-1/\theta}$ takes the general CES form with more than two sources of funding. Combining the two gives

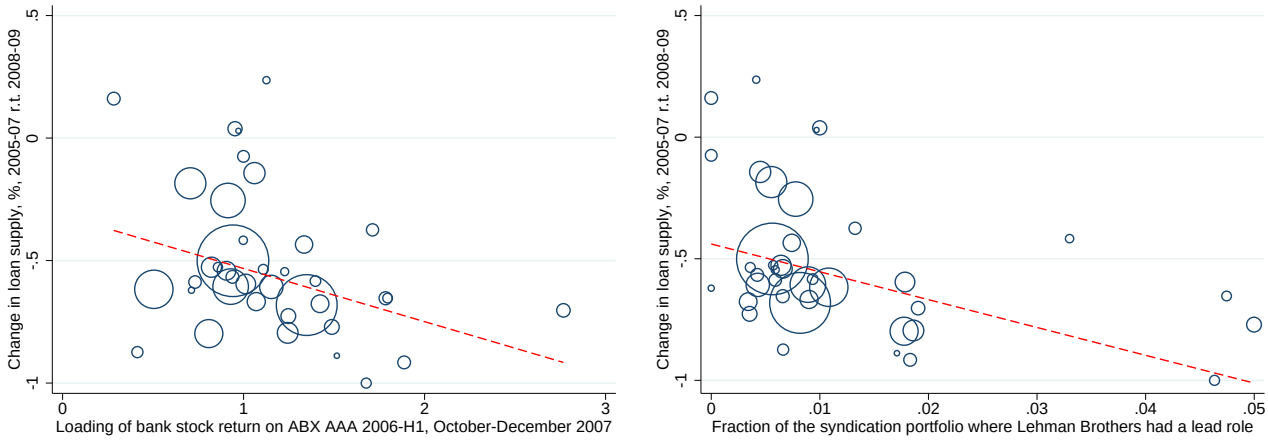
$$[\sum_{o=1}^{N} (u_{ox})^{-\theta}]^{-1/\theta} = [\sum_{o=1}^{N} [\zeta r_x^{1-\phi} + (1-\zeta) r_o^{1-\phi}]^{-\theta/(1-\phi)}]^{-1/\theta}$$

Under the restriction that the elasticity of substitution between funding sources (ϕ) equal the elasticity of substitution between producer groups from different countries/sectors ($1+\theta$), this collapses to

$$[\sum_{o=1}^{N} (u_{ox})^{-\theta}]^{-1/\theta} = [\sum_{o=1}^{N} \bar{\zeta}_o r_o^{1-\phi}]^{1/(1-\phi)}$$

where we define $\bar{\zeta} = \frac{N\zeta+1-\zeta}{N}$ such that $\bar{\zeta}_o = \bar{\zeta}$ if $o = x$ and $\bar{\zeta}_o = 1 - \frac{\bar{\zeta}}{N-1}$ if $o \neq x$.

Figure 1 Replication of Results in Chodorow-Reich (2014) - Exposure to Housing Market and Lehman Brothers



Notes: 'Change in loan supply' measures the annual percentage change in the value of loans supplied to the syndicated loan market between the sum of October 2005 and June 2006 and October 2006 and June 2007 relative to October 2008 and June 2009. Criteria for loans are slightly more restrictive in Chodorow-Reich (2014). Results are restricted to 39 banks out of the top 43 lenders in this period. Bubble size is proportional to pre-crisis lending share of bank.

4. Estimation

4.1 Identification

In this section, we replicate some of the results in Chodorow-Reich (2014). We collect data on 39 of top 43 US lenders during the crisis, generously provided by Gabriel Chodorow-Reich. We then test to what extent the change in loan supply of these lenders is explained by exposure to the mortgage market, exposure to Lehman Brothers, and the extent to which banks were dependent on short-term or customer deposits for funding their loans. Table 1 shows this test in a regression framework. Among these 39 banks, those of which the stock price loaded stronger onto a measure of mortgage market distress cut their loan supply significantly more during the crisis (Column (1)). Similarly, those banks with a higher fraction of syndicated loans in which Lehman Brothers had a lead role also cut their loan supply significantly more (Column (2)). Finally, banks with more customer deposits relative to assets pre-crisis cut their loan supply by significantly *less* than other banks (Column (3)). We visualize these patterns in panels in Figure 1 and Figure 2.

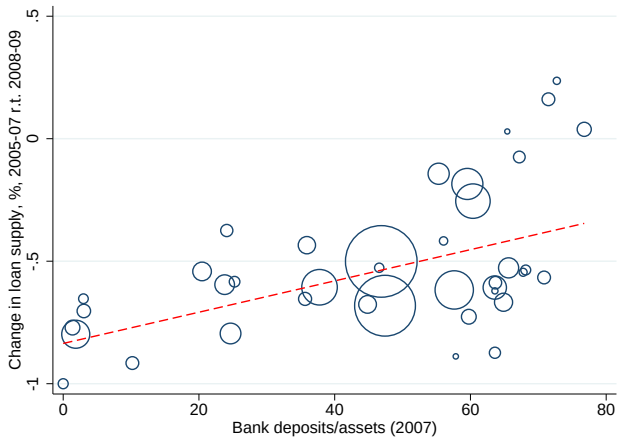
Table 1 Replication of Results in Chodorow-Reich (2014) - Regressions

	(1)	(2)	(3)	(4)
	Change in loan supply, %, 2005-07 r.t. 2008-09			
Stock loading on mortgage market	-0.338**			-0.164
	(0.166)			(0.186)
Exposure to Lehman Brothers		-0.481***		-0.108
		(0.144)		(0.177)
Bank Deposits/Assets			0.515***	0.388**
			(0.116)	(0.166)
Observations	39	39	39	39
R-squared	0.135	0.167	0.287	0.320

Robust standard errors in parentheses.

Notes: Table replicates findings in Chodorow-Reich (2014). All variables are standardized, so coefficients reflect marginal changes in standard deviations. 'Change in loan supply' measures the annual percentage change in the value of loans supplied to the syndicated loan market between the sum of October 2005 and June 2006 and October 2006 and June 2007 relative to October 2008 and June 2009. Criteria for loans are slightly more restrictive in Chodorow-Reich (2014). Results are restricted to 39 banks out of the top 43 lenders in this period. Four banks have missing values for one of the explanatory variables. We weigh regressions by the pre-crisis lending share of each bank. The results are robust to using unweighted regressions. 'Stock loading on mortgage market' equals the loading of the bank's stock return on the ABX AAA 2006-H1 index between October 2007 and December 2007. The variable 'Exposure to Lehman Brothers' equals the fraction of the bank's syndication portfolio where Lehman Brothers had a lead role in the loan deal. 'Bank Deposits/Assets' is the ratio of the bank's customer deposits to total assets at the end of 2007.

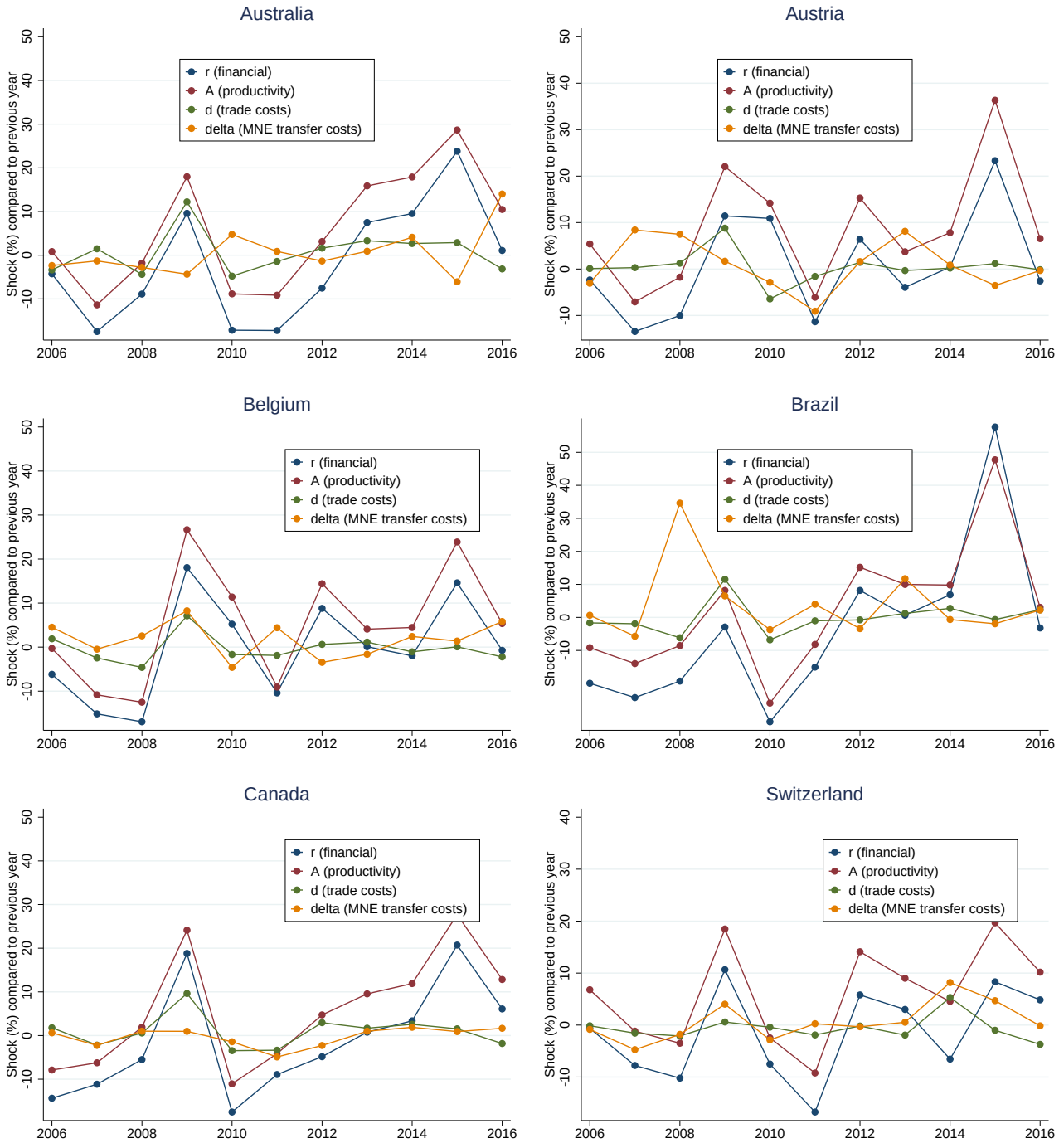
Figure 2 Replication of Results in Chodorow-Reich (2014) - Reliance on Bank Deposits



Notes: 'Change in loan supply' measures the annual percentage change in the value of loans supplied to the syndicated loan market between the sum of October 2005 and June 2006 and October 2006 and June 2007 relative to October 2008 and June 2009. Criteria for loans are slightly more restrictive in Chodorow-Reich (2014). Results are restricted to 39 banks out of the top 43 lenders in this period. 'Bank Deposits/Assets' is the ratio of the bank's customer deposits to total assets at the end of 2007. Bubble size is proportional to pre-crisis lending share of bank.

5. Additional Figures and Tables

Figure 3 Calibrated Shocks by Country



Notes: Figures plot calibrated shocks by country, as the percentage change relative to previous year. Shocks include financial shocks ($\bar{r}_{n,t}$), productivity shocks ($\hat{A}_{n,t}$), trade cost shocks ($\hat{d}_{xi,t}$, we plot the country mean), and multinational technology transfer cost shocks ($\hat{\delta}_{ox,t}$, we plot the country mean).

Figure 4 Calibrated Shocks by Country (2)

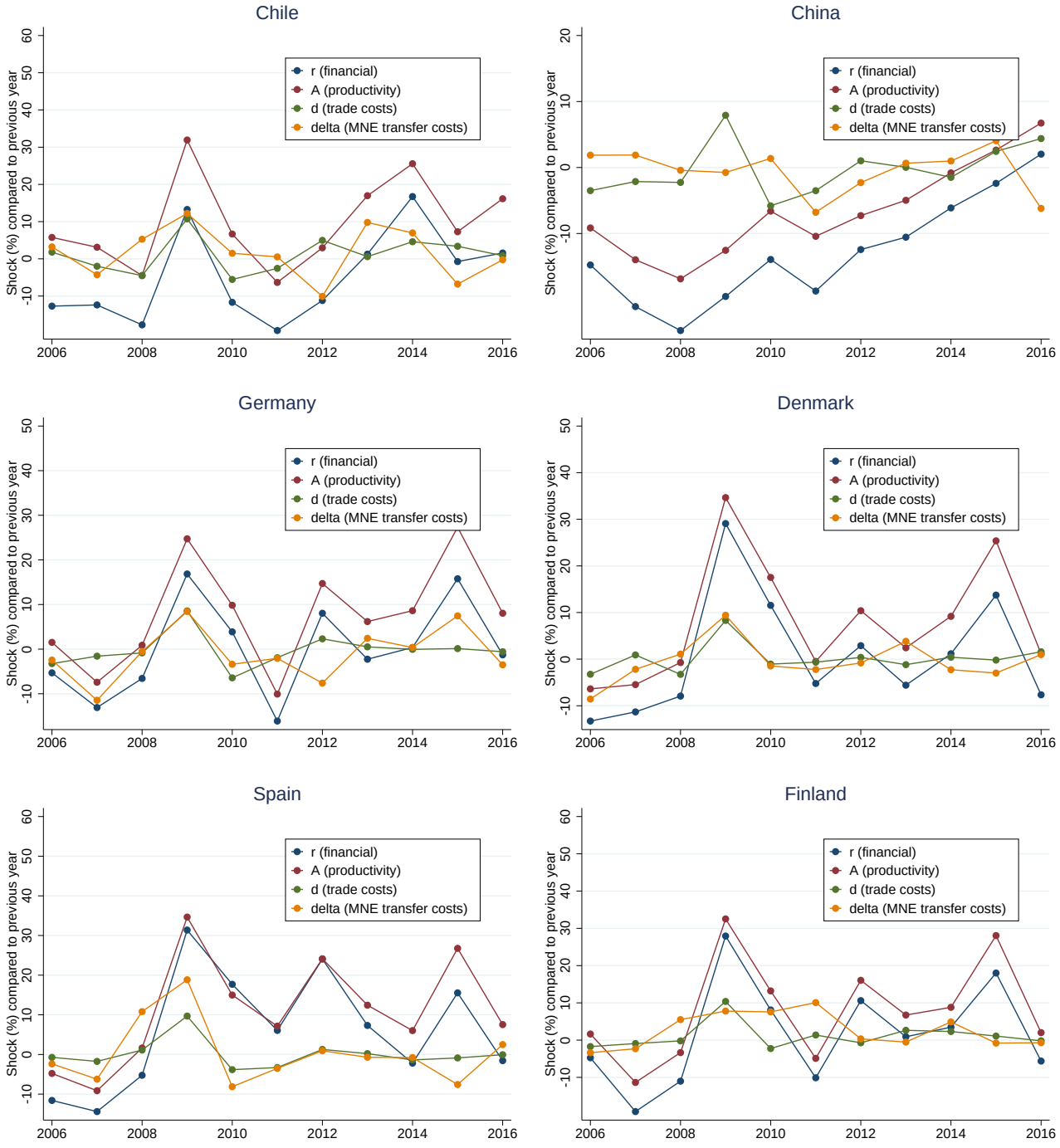


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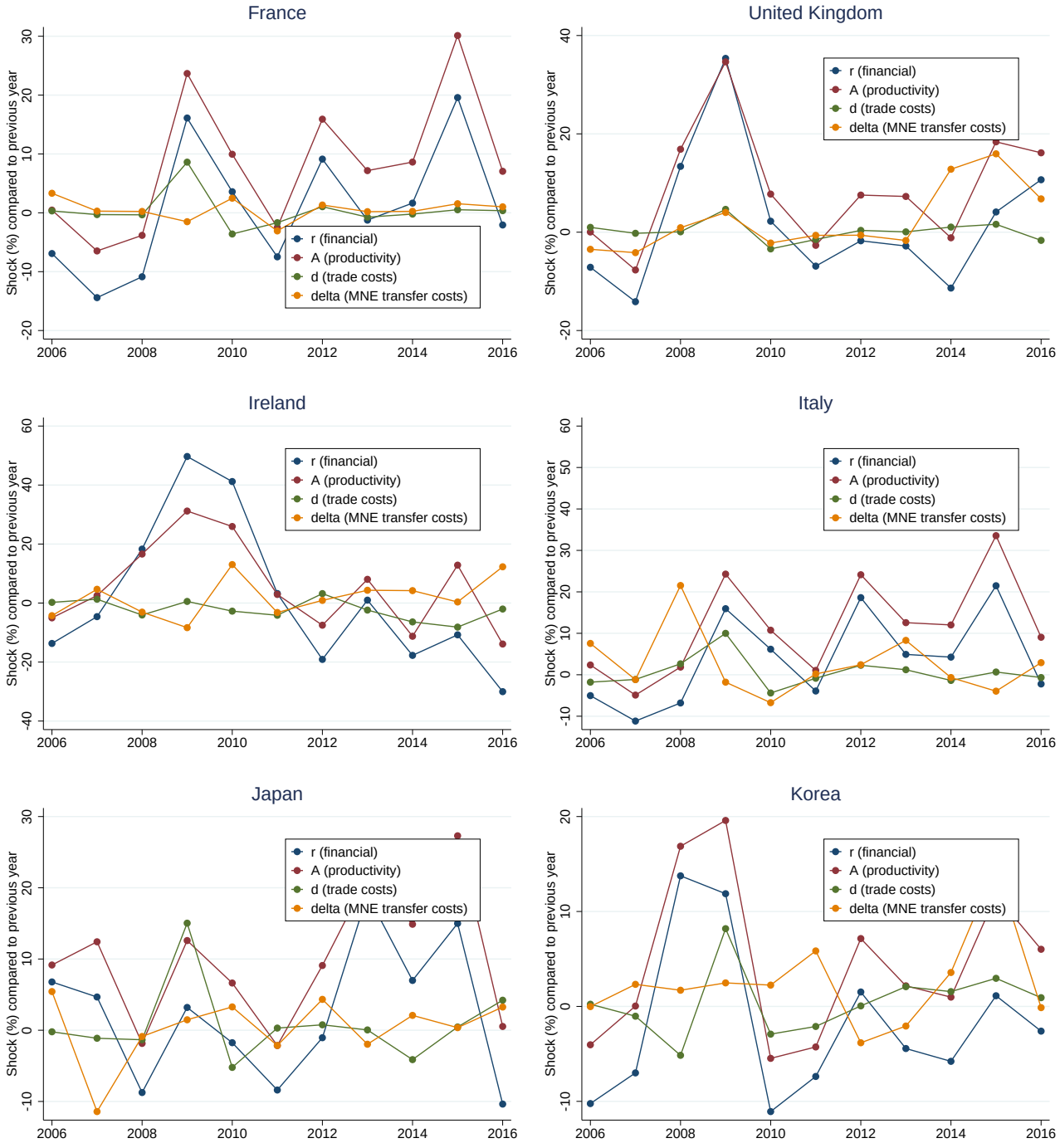
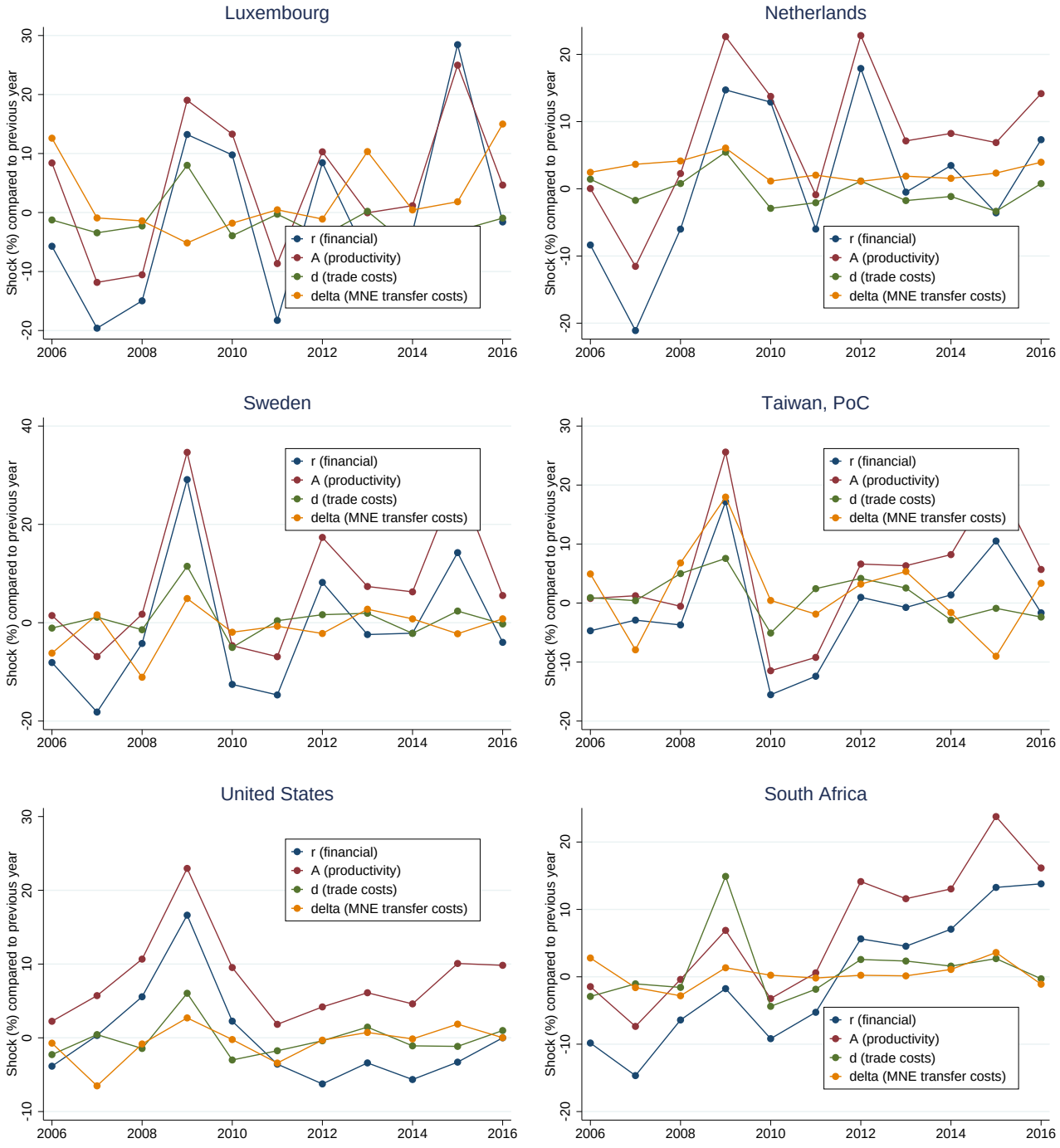
Figure 5 Calibrated Shocks by Country (3)



Notes: Figures plot calibrated shocks by country, as the percentage change relative to previous year. Shocks include financial shocks ($\bar{r}_{n,t}$), productivity shocks ($\hat{A}_{n,t}$), trade cost shocks ($\hat{d}_{xi,t}$, we plot the country mean), and multinational technology transfer cost shocks ($\hat{\delta}_{ox,t}$, we plot the country mean).

Figure 6 Calibrated Shocks by Country (3)



Notes: Figures plot calibrated shocks by country, as the percentage change relative to previous year. Shocks include financial shocks ($\bar{r}_{n,t}$), productivity shocks ($\hat{A}_{n,t}$), trade cost shocks ($\hat{d}_{xi,t}$, we plot the country mean), and multinational technology transfer cost shocks ($\hat{\delta}_{ox,t}$, we plot the country mean).

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