Financial Crises and the Global Supply Chain: Evidence from Multinational Networks

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Abstract

This paper empirically examines the effects of financial crises on multinational firms' performance and organization of production. We use a panel of multinational networks spanning twenty-nine European countries between 2003 and 2015 and thirty-nine countries in total. We use as a financial shock the increase in countries' risk premium between August 2007 (BNP freezing funds) and July 2012 (Draghi's whatever-it-takes speech). We construct a multinational-specific exposure measure to the financial shock based on the network structure of each multinational prior to the shock. We document that multinationals more exposed to the financial shock experienced a reduction in their revenue, employment, and in their number of affiliates. We also show that the effect of the financial shock built up slowly over time. The reduction in the number of affiliates operates through a reduction in the number of domestic and foreign affiliates, and it is concentrated in affiliates that are in a vertical relationship with the parent. We also show that all these effects are exacerbated among more initially leveraged parents and that more leveraged multinationals tend to reduce more the number of foreign relative to domestic affiliates.

Keywords: International Organization of Production, Global Financial Crisis, Network of Affiliates, Vertical Integration.

JEL Codes: F14, F23, F44, L22, L23.

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1 Introduction

Financial crisis have large, negative, and persistent effects on economic activity. Compared to normal recessions, they have been shown to generate larger declines in output, credit, and employment in the affected countries (see, among others, Schularick and Taylor, 2012 or Jordà et al., 2013). Within a country, the burden of a financial crisis is not shared equally across its different economic actors. For example, firms owning affiliates in financially hard-hit countries may decide to reorganize their supply chain, which in addition to affect their organization, could also affect their short- and long-run performance. Similarly, firms being owned by a parent located in a financially hard-hit country may be more adversely affected than a comparable firm that is not part of a multinational network.[1] The goal of this paper is to analyze how financial shocks affect multinationals' performance and organization in the context of the last financial crisis.[2]

The most recent financial crisis had a global spread. However, it was particularly severe within the Eurozone. An archetypical example of this financial disruption in the Eurozone is illustrated in Figure 1. This figure shows the monthly evolution of the 10-year government bond yields of Germany and Spain between 2001 and 2023. Both countries had almost identical borrowing costs during the 2000s.[3] This pattern dramatically changed in August 2007 when BNP decided to suspend subprime-related funds. At that moment, the risk premium started to rise and it was not until the "whatever it takes" speech of the ECB president (Mario Draghi) in July 2012 that the borrowing costs stop diverging and started to converge. Similar figures are obtained for other members of the so-called periphery (Portugal, Italy, Ireland, and Greece). In contrast, the changes in risk premia are much milder for the so-called core countries (e.g, France or Belgium). Motivated by these patterns, we take the difference in the yields of a country relative to Germany as our measure of the risk premium of a given country.

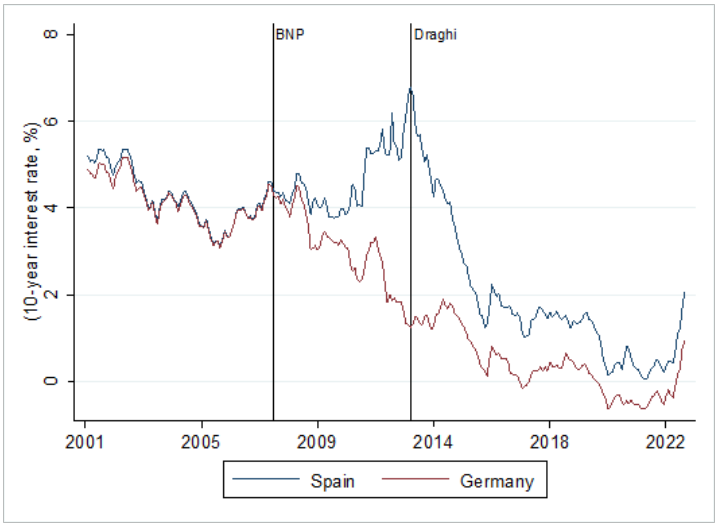
In this paper, we examine how the increase in risk premia between these two events—our financial shock—affected European multinationals and their networks of affiliates. To identify the effect of the financial shock on European MultiNational Enterprises (MNEs), we use the differential exposure of MNEs within a country and sector arising from their idiosyncratic exposure to the financial shock determined by their pre-shock network of affiliates (measured

[1] Related questions have been analyzed in the literature. For example, Alviarez et al. (2017) find that multinational firms actually grew slower than domestic ones between 2008 and 2009 (the onset of the Great Recession). In a related contribution, Alfaro and Chen (2012) show that affiliates of foreign multinationals cope better with the initial shock (their study finished in 2008) than their domestic counterpart. One main difference is that we will be comparing MNE's located in different countries and with different networks of affiliates. Moreover, we are more interested in the potential reshuffling of the supply chain and its long-run effects.

[2] Cravino and Levchenko (2017) show that the network of foreign affiliates helps to propagate business cycle shocks to the parent domestic firm. One main difference is that we consider a specific financial shock and emphasize the endogenous structure of the network.

[3] The consequences of this seemingly zero risk and the boom in Spain and other southern countries have been studied in the related literature (see, for example, Gopinath et al., 2017 or Basco et al., 2021). This paper focuses on the effect of the ensuing financial crisis on the global supply chain.

Figure 1: The Financial Shock in the Eurozone: Poster Child



Notes: The two vertical lines are August 2007 and July 2012. The first corresponds to the announcement of BNP Paribas of freezing subprime related funds. The second corresponds to the "whatever it takes" announcement of Mario Draghi.Long-term interest rates obtained from ECB Statistical Data Warehouse.https://sdw.ecb.europa.eu/browse.do?node=9691124

in 2006). We document that more exposed MNEs according to our network shock measure experience a negative effect on MNEs performance measures (revenue, employment), and a shrinkage of their MNE network that builds slowly over time. We also show that most of the effect is accounted for by MNEs that were more leveraged pre-shock (in 2006).

To empirically perform this exercise, we need a long-run panel covering the network structure of multinational firms. We construct this panel with information on parents and affiliates taken from Merlevede and Theodorakopoulos (2023), extending the work of Merlevede et al., 2015. The dataset covers twenty-nine European countries and thirty-nine countries in total. It accounts for between 50 and 60 percent of aggregate multinational activity in Europe as reported in FATS.[4] To the best of our knowledge, this is the most comprehensive panel on multinational activity and network of affiliates studied in the literature. We select the period 2006-2015 for our analysis (while doing pre-trend analysis starting in 2003 when possible). The initial period is selected to allow for observations before the onset of the Great Recession, while 2015 is chosen to allow for the possibility of tracking protracted effects of the recession.[5] The dataset has two main advantages. First, it contains information on the network of affiliates

[4]Given that our goal is to compare multinational firms located in different countries and exposed to different shocks (both domestically and through the affiliates), we choose to ignore firms with only domestic networks. Focusing on multinational firms, we mitigate the concern that these firms are different from domestic ones. Needless to say, one drawback of this choice is that we cannot compare multinational vs domestic firms. However, this type of exercise has already been done in, for example, Alfaro and Chen, 2012 or Alviarez et al. (2017).

[5]It is well-known that the European recession were very uneven. While Germany suffered a mild and short-term recession, GDP in Spain did not recover pre-recession boom outcomes until 2016 according to World Economic Outlook Data.

of parents in different countries. This allows us to compare multinational firms in the same country and industry but with a different set of affiliates. Second, it is a long panel. As already emphasized in the trade literature in other contexts (e.g., Autor et al., 2014 and Dix-Carneiro and Kovak, 2017), we document that the effect of the financial shock builds slowly over time. If we only used a short-run panel, we could wrongly conclude that there were small or no effects.

Before performing our empirical analysis, we begin the paper by taking advantage of the novelty of our dataset to uncover some facts about multinationals. First, multinational activity is highly heterogeneous across countries and concentrated in a few of them (the top-5 countries concentrate more than half of the parents and affiliates). Second, the distribution of the network size also exhibits substantial heterogeneity. Most networks are small (around 50% have only one or two affiliates), but there is a significant fraction of middle-sized ones (around 10 percent have between 6 and 10 affiliates). There is also a non-negligible amount of networks with more than 50 affiliates (around 2 percent). Third, roughly half of multinational networks do not have domestic affiliates. Fourth, geographical proximity to the parent is important (roughly 90 percent of affiliates are either domestic or in European countries). Fifth, most affiliates (over 70 percent) are fully owned.

After having documented these facts, we turn to our main empirical exercise. We analyze the effect of the financial shock on European MNEs. Our dependent variables compare the cumulative outcomes from 2007 through 2015 relative to the same outcomes in 2006. As an explanatory variable, we use the pre-existing MNE-specific network to construct MNE-specific exposure to the financial shock based on the location of the parent and affiliates in 2006. Intuitively, this allows us to compare, for example, two MNEs located in the same industry in Germany but with different affiliate networks that experienced the financial crisis with different intensity (e.g, one MNE with affiliates in Spain and Greece relative to another MNE with affiliates in Switzerland and Sweden). In our regression, we also control for MNE characteristics such as total assets, age, and initial number of affiliates, in addition to country and two-digit NACE industry fixed effects.

Using this empirical specification, we first document that parents with a more financially-hit network of affiliates (our measured is constructed using the MNE affiliates' network in 2006) experience a reduction in their performance measures (revenue and employment) over the 2007-2015 period. The effects are substantial. Over the period 2007-2015, a MNE with a financial shock to its network equal to one standard deviation of the financial shock experiences a reduction of 10.8 and 14.4 percent of revenue and employment relative to its 2006 level. Note that this effect is identified through comparing MNEs with networks that are deferentially exposed to the financial shock, and it is not driven by the direct financial shock to the country in which a parent is located (since the country fixed effects absorbs it).

We then investigate how the MNE network is re-shaped due to the financial shock. We first show that MNEs whose network experiences a larger financial shock react by reducing its

number of affiliates. The effect of a shock of magnitude equal to one-standard deviation of our MNE-specific network shock is to reduce by 5.4 percent the number of affiliates relative to the pre-shock year (2006). We find that the reduction on the number of affiliates occurs roughly equally for both foreign and domestic MNE affiliates. By contrast, MNEs carry all adjustment in the number of affiliates through reducing the number of vertically related affiliates, while we do not find any significant adjustment for horizontally-related affiliates.

We also investigate how the effect of the financial shock builds up over time. We use the local projection method of Jordà (2005) to compute the effect of the financial shock at different time horizons. We find that for both MNE network adjustment and parents' performance the effect of the financial shock builds up slowly over time. This finding underlies the importance of using a long panel to study the effects of the financial crisis on MNE activity.

After having documented the effect of the financial crisis operating through the MNE network, we provide evidence consistent with a financial-frictions mechanism being at play in shaping MNE adjustment. Using the richness of our data, we construct a MNE-specific measure of leverage pre-shock (2006), following the work of Kalemli-Özcan et al. (2022). We interact our MNE-specific leverage measure with our MNE-specific network financial shock. We find that relatively more leveraged MNEs are those more severely affected by the network shock. Both their performance measures (operating revenue and employment) and the shrinkage of the MNE network operate through MNEs whose parents are more leveraged and experience a more severe financial network hit. By contrast, the direct effect of the financial shock disappears once we control for its interaction with MNE leverage. This finding is consistent with the interpretation of the results being driven financial frictions.

We also observe that the pattern of adjustment of the MNE network to the financial shock is broadly similar to the one we uncovered—but concentrated in initially leveraged MNEs. In particular, we observe that the adjustment in MNE network is concentrated in vertically-related affiliates, and that the reduction of affiliates operates both through domestic and foreign affiliates. A noteworthy difference is that the estimated effect on foreign affiliates is substantially larger relative to domestic affiliates, suggesting that leveraged MNEs tend to adjust more on the foreign affiliates margin. In contrast to the interaction results, we find again that the direct contribution of the network shock have no effect on MNE network adjustment. This suggests that, perhaps not surprisingly, the firm leverage mechanism plays a substantial role in adjustment to the financial network shock.[6] The dependence of the survival of the affiliate on the leverage of the parent is consistent with a mechanism in which the parent offers credit to the affiliate, i.e., internal trade credit within MNEs (Antràs and Yeaple, 2014).

[6]This finding is also similar to Giroud and Mueller (2016), who following a similar approach to ours, find that after interacting their network shock (housing prices in their case) with leverage, all the variation is absorbed by the interaction and the effect of the shock by itself disappears.

Related Literature This paper relates to different strands of the literature. First, it contributes to the large and expanding literature on the long-run economic effects of financial crises. In this sense, it is related to, for example, the works of Schularick and Taylor (2012) or Jordà et al. (2013). The latter documents that financial crises are different from normal recessions and shows how the recovery from financial crises depends on the credit accumulated prior to the crises. Similar to this paper, we also document that financial shocks have significant and long-lasting effects. Moreover, even though we look at firms instead of countries, we also emphasize that the leverage of the firm at the onset of the financial crises shapes its effects. The literature on financial constraints and firms performance is rich and vibrant. We refer the reader to, for example, the survey in Buera et al. (2015). A close paper is Kalemli-Özcan et al. (2022) that emphasize the role of the leverage of firms for investment during the Eurzone (EZ) financial crisis. Two main difference with this paper is that we focus on multinational firms and that we study how the financial shock propagates to and from affiliates' countries.

The trade literature has emphasized the importance of multinational activity and its determinants, see the survey by Antràs and Yeaple (2014) and the references therein. Our paper belongs to the subset of the literature interested in the effects of economic crises. In a related contribution, Alviarez et al. (2017) compares the performance of multinational versus domestic firms during the Great Recession. They document that multinationals' sales grew slower between 2008 and 2009. There are two main differences. First, we compare multinationals located in different countries. Second, we are also interested in how parents change their global supply chain. An important contribution in this field is Alfaro and Chen (2012). They showed that foreign owned firms cope better with the recent financial crises than domestic firms. One main difference is that we compare affiliates owned by firms in different countries. Another difference is that we underscore the importance of leverage of the parent to understand the effects on the affiliate. Lastly, in our empirical exercise we allow each multinational firm to be differently affected as a function of the composition of its affiliates' network. This exercise is related to Cravino and Levchenko (2017), which emphasize that business cycle shocks to foreign countries may affect parents performance. The main departure from this paper is that we consider a specific shock and compare multinationals within an industry and country, also allowing the MNE network to change as a reaction to the shock. Last, but not least, while most of the related literature focuses on sales, we also examine the effect on the international organization of production and other performance outcomes (employment).[7]

The rest of the paper is organized as follows. Section 2 introduces the database and presents some facts on multinational activity. Section 3 briefly explains the financial disruption in the Eurozone and how we build our proxies for the financial shock. Section 4 describes the empirical strategy. Section 5 reports the results. Lastly, section 6 concludes.

[7] Blanchard et al. (2010) explores how the Great Recession may effect emerging economies, through trade and finance shock. Even though the topic is similar, we focus on the micro transmission through the network of affiliates.

2 A New Database on Multinational Networks

In this section, we discuss the construction of our data set. It consists of a panel of firms spanning from 2006 through 2015. Our data contains information on the parent-affiliate relationship of each firm, in addition to information on firm characteristics and performance (e.g., employment, profits, etc.).

We use the Amadeus database by Bureau van Dijk (BvDEP), which provides comprehensive firm-level information for European firms, to construct a panel of multinationals networks.[8] Key for our purposes, in addition to standard firm characteristics and performance measures,[9] Amadeus contains information on whether or not each firm appearing in the database has any affiliates. For firms with affiliates, it also provides a list of its affiliates, and some limited information on each of the affiliates. In particular, it includes the location of the affiliates, which allows us to construct the entire network of a multinational including affiliates that are located outside Europe. Moreover, it also includes the share held by the parent of each affiliate. To construct our measure of a MNE network, we retain affiliates where the parent holds more than 10 percent of the affiliate's share.

Affiliates that are available as separate entries in Amadeus are identified by a unique ID number. These essentially correspond to affiliates located in European countries. For these affiliates, we can retrieve full information (balance sheet, profit and loss account, location, industry classification,...) from their own entry in the Amadeus database rather than being limited to the information provided through the parent's entry.

We use annual versions of the Amadeus database and extract parent-affiliate combinations to construct a time series of parent-affiliate links.[10] In this parent-affiliate-year data set, we then fill out the financial and other relevant information for parent and affiliate from their own entry in the database. We focus on parents and affiliates active in the business economy (and thus exclude agriculture and non-market services from our analysis).[11] We include all networks that we observe in our data set. That is, we include both networks 1) for which consolidated accounts for the parent (or only one of the affiliates) are available and 2) for which unconsolidated accounts are available (see Kalemli-Ozcan et al., 2022 for the importance of including both). In practice, this implies that one can think of our data set as consisting of a panel in the affiliates-year dimension with full information on the parent side attached to each affiliate-year entry.

[8] Amadeus can be thought of as the eqivalent to the Orbis database but limited to European countries. Merlevede et al. (2015) describe the construction and representativeness of an earlier version of the dataset at length. The dataset used in this paper is an update with more recent data that have meanwhile become available.

[9] These include, among others, operating revenue, total assets, employees, sales, financial revenues and expenses. See https://www.bvdinfo.com/en-gb/our-products/data/international/amadeus.

[10] Occasionally, a link is not reported in the year t issue of the database, while it is reported in the $t-1$ and $t+1$ issues. In these cases, we assume that the link existed in t as well.

[11] Both agriculture and non-market services are heavily regulated in Europe and it is unclear that the market forces we study in this paper apply to these sectors as well.

Our parent-affiliate-year panel contains data for twenty-nine European countries between 2006 and 2015. The dataset captures on average 44.6% of cross-border affiliates and 62.0% and 64.3% of employees and turnover that is reported in the Foreign AffiliaTes Statistics (FATS).[12] These numbers are stable over time and draw consistently from different industries and source-destination pairs. For example, when considering source-destination-industry-year cells correlations amount to 0.72 (68,511 cells) for the number of firms, 0.67 for the number of employees (26,633 cells), and 0.39 (45,583 cells) for turnover. In our sample, there are 18,223 multinational networks in 2006, of which 12,087 are still active as networks in 2015 (see Table 1 in the Online Appendix).[13]

Parents and affiliates are geographical concentrated in our database. The majority of parents are located in a few countries (see Table 2 in Online Appendix). For example, in 2006, 62% of parents are located in the top-5 countries (Germany, Netherlands, UK, Belgium, and Italy). Similarly, affiliates are mostly located in a few mature EU economies. Indeed, roughly half of them were also located in the top-5 countries (Germany, UK, France, Netherlands and Italy). Proximity to the parent is also a prominent feature of MNEs networks. Indeed, the vast majority of affiliates are located in Europe, while the US is the first non-European destination with the 5% of affiliates (Tables 3 and 4 in Online Appendix). This geographical distribution of parents and subsidiaries is in line with the findings of Altomonte et al. (2021) for a cross-section of worldwide business groups in 2015.

Novel Facts about MNEs Networks Given the novelty of the data set, we briefly document some facts on the characteristics of multinational networks that can be of independent interest. As shown in Table 5 in the Online Appendix, most multinational networks are small. In 2006, 43.7% of the networks had only one affiliate and 71% less than three. From 2006 to 2015, the percentage of networks with only one affiliate decreases by about 13 percentage points to the benefit of larger networks (in particular, those with more than six affiliates). Next we turn to discussing the share of foreign affiliates in MNEs networks, which we report in Table 6 of the Online Appendix. Given that we are analyzing MNEs, MNEs with only one affiliate have, by construction, a foreign affiliate. Networks with only one affiliate represent 43.7% of the total number of networks in our sample. This disproportion of foreign-based affiliates is extensive even when we look at larger networks. Almost 70 percent of networks have, at most, one domestic affiliate. Finally, we also note that Table 6 shows that there is no clear correlation between the number of domestic and foreign affiliates.

[12]The Regulation (EC) No 716/2007 on the structure and activity of foreign affiliates as the regulatory framework for the provision of foreign affiliates statistics was adopted in 2007. The main objective of Regulation (EC) No 716/2007 is to establish a common framework and statistical quality standards for the systematic production of comparable statistics on foreign affiliates. Inward FATS-statistics describe the activity of foreign affiliates resident in the compiling economy, outward FATS-statistics describe the activity of foreign affiliates abroad controlled by the compiling economy.

[13]We identify a multinational network as having at least one cross-border affiliate in 2006.

Most multinational networks are located close to the parent. Table 7 in the Online Appendix shows that, in 2006, almost 95 percent of affiliates were either domestic or European (54% and 40.8%, respectively). Over the whole period (2006-2015), the percentage of domestic affiliates decreases (from 54% to 46%) while that of affiliates outside of Europe increases (from 5.2% to 18.7%). As for the percentage of European affiliates we see a decreasing dynamics starting at 40.8% in 2006 to 35.4% in 2015. Most multinational networks in our sample remain stable over time. Table 8 in Online Appendix shows that between 2007 and 2015 about 64 percent of the networks neither added or dropped any affiliate. By contrast, around 12 percent of MNEs networks added at least one affiliate between 2007 and 2015. Similarly, more than 15 percent have at least one affiliate dropped. There is also a non-negligible 3 percent of networks with more than 5 affiliates added or dropped. In our empirical analysis, we will examine whether these changes in the network are correlated with financial shocks. Finally, Table 9 in the Online Appendix shows that most affiliates (71%) are fully owned, whereas only 0.4% have an ownership below ten percent.

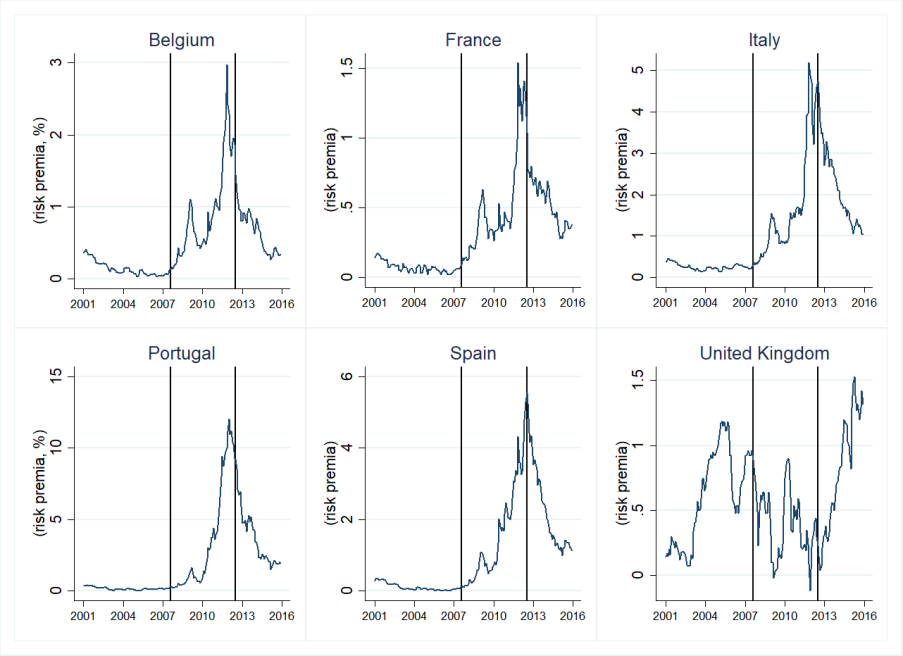
3 Financial Shock: The Eurozone Financial Disruption 07-12

We use the differential increase in countries' risk premia relative to Germany during the Great Recession as our measure of financial shock. In this section, we discuss the evolution of risk premia during the last two decades and explain why we can interpret the increase between August 2007 and July 2012 as a financial shock. Then, we describe how we compute our measure of financial shocks.

One of the defining features of the Great Recession was the differential increase in financial risk across countries within the Europe. We exploit this heterogeneous increase in financial risk across countries as an exogenous financial shock to firms to investigate how the worsening of financial conditions affects the performance of parents and affiliates. This increased financial risk is readily seen by analyzing the evolution of the "risk premia" across countries.

Figure 2 reports the monthly evolution of the risk premia for a selected group of six European countries, and illustrates the heterogenous financial disruption across European countries. As it is common in the literature, we define the risk premia of a country as the difference between the interest rate of the long-term government bonds issued by a given a country relative to comparable bonds issued by the German government. If the risk premia of a country increases, it means that borrowers require a higher interest rate to hold the government debt of that country, which translates into worsening financial conditions of the country. In particular, we consider the yields of 10-year government bonds to construct our measure of risk premia. The two vertical lines in the figure represent the origin and end of the financial crises: August 2007 (the announcement of BNP Paribas, which froze subprime related funds) and July 2012 (the

Figure 2: Evolution of Risk Premia - Selected Countries



Notes: Long-term interest rates differential with Germany. The two vertical lines are August 2007 and July 2012. The first corresponds to the announcement of BNP Paribas of freezing subprime related funds. The second corresponds to the "whatever it takes" announcement of Mario Draghi. Long-term interest rates are obtained from ECB Statsitictial Data Warehouse. They relate to interest rates for long-term government bonds denominated in Euro for euro area Member States and in national currencies for Member States that have not adopted the Euro at the time of publication. The long-term interest rate statistics are released monthly on the 8th working day of the month. 10 year maturity. https://sdw.ecb.europa.eu/browse.do?node=9691124

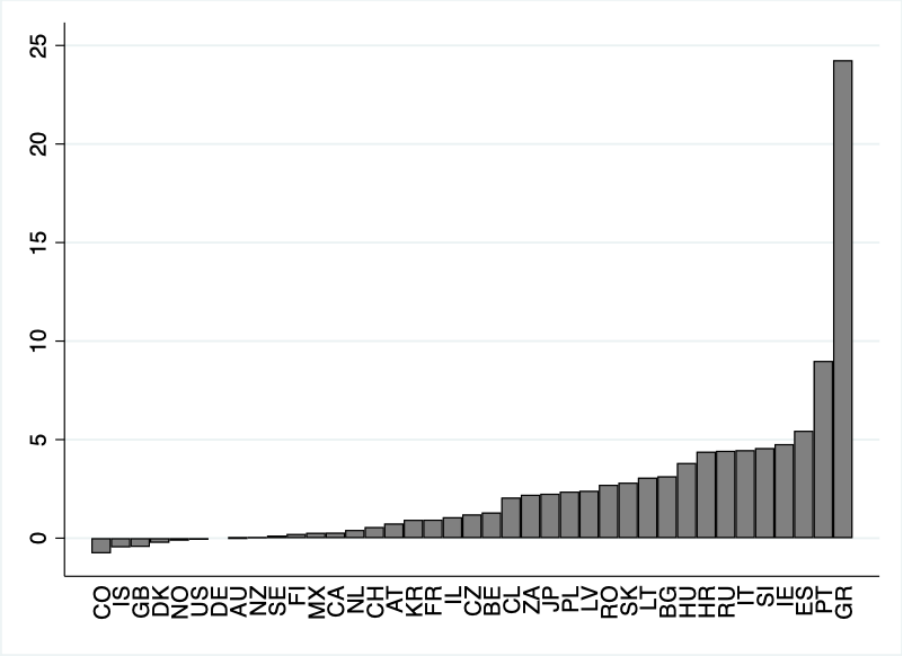
"whatever it takes" speech of Mario Draghi, president of the ECB at the time.)[14] As it can be seen in the figure, these two dates perfectly fit the remarkable increase in the risk premia of the periphery countries (Italy, Portugal and Spain). Note that for core countries (Belgium and France) the qualitative pattern is the same but the scale is much smaller. In contrast, the risk premium in the United Kingdom even declined, reflecting the fact that the perceived risk in the United Kingdom was somewhat lower than in Germany.[15]

In practice, we have data on long-term ten-year bonds for thirty-nine countries spanning the Europe and its major trade partners (e.g., the US, China, etc). Figure 3 reports the change in the risk premium between July 2012 and August 2007 for all the countries in our sample. Table A.1 in the appendix reports the actual numbers used in the figure. As it can be seen, countries like

[14]The importance of the BNP shock has been emphasized before (see, e.g., Basco, 2018).

[15]Beyond these selected countries, there exists a consensus that these two dates marked the start and end of financial turbulence in the European Union. The 9th of August of 2007 BNP Paribas decided to froze funds related to US subprime mortgages, thereby initiating a broad liquidity crises. The 26th of July of 2012, Mario Draghi, the then president of the European Central Bank, gave the famous "whatever it takes" speech, which had an immediate effect on government debt of countries at-risk.

Figure 3: The Financial Shock: Differences in Risk Premia Relative to Germany



Notes: Each bar corresponds to the difference in risk premia between July 2012 and August 2007. Risk premia is defined as the long-term interest rates differential with Germany.

United Kingdom or Denmark were perceived as less riskier than Germany. Indeed, the change in risk premium in the United Kingdom was -0.7 percent. By contrast, periphery countries like Portugal or Spain experience a substantial increase in their risk premia (9.0 and 5.5 percent, respectively), reflecting higher financial risk in those countries. Our identifying assumption is that firms did not anticipate the financial crises in 2006 and that the increase in risk premia is a good proxy for the financial shock experienced by different countries. We expect that changes in the risk premia captures well how the financial conditions of banks evolved during the crisis, so that firms located in countries with larger increases in risk premium would have more difficulties to access liquidity. It is well know that European firms are more dependent on loans from banks as source of liquidity than their US counterparts. Thus, this shock plausibly affected the capacity of firms to fund themselves or provide credit to affiliates—we will explore this channel and provide evidence consistent with it playing a substantial role. However, and needless to say, the financial crisis operated through multiple channels that affected firms in a number of ways, e.g., through changes in demand to consumers, in addition to a tightening of the borrowing constraints.

Our empirical strategy proceeds in two steps. First, we study the reduced-form effect of the financial shock on MNEs outcomes. Second, we provide evidence with financial constraints playing an important role in shaping the adjustment to the financial shock. We proxy the financial shock to a country with the change in the risk premia of this country relative to

Germany. Using country-specific measures of risk premia to assess their effect on MNEs is intuitively appealing. However, country-specific shocks do not take into account the network structure of MNEs, that is, the potential interdependence across business units in their choices. By contrast, our proposed measure of exposure of a MNE to the financial shock accounts for the network structure of MNEs. This allows us to compare MNEs within the same industry and country that have networks with differential exposure to the financial shock.

Network Shock We define the *network shock* of MNE with parent p as

$$NetworkShock_p = \sum_{i \in \mathcal{S}_p} \alpha_i^{06} \cdot \Delta Risk_{i,c}, \tag{1}$$

where $\mathcal{S}_p$ denotes the set of all affiliates of a given MNE and the parent itself. $\Delta Risk_{i,c}$ is the change in risk premium in the country c of the affiliate/parent i between July 2012 and August 2007 and α_i is the weight of affiliate/parent i for parent p in 2006 (i.e., the weight is taken prior to the shock to alleviate anticipation concerns). Note that this variable is MNE specific since it depends on the network of the MNE. According to this definition, the network shock is larger if a MNE has most of its network in financially hit countries. These types of measures have been used in other contexts in order to assess how firm networks shape the adjustment of different firm outcomes to location-specific shocks, see, for example, Giroud and Mueller (2016) in the context of US firms and housing prices.

As our baseline weights for the network shock, α_i^{06}, we choose to attach equal weights to all countries present in the MNE network in 2006. Even though this may introduce some noise in our measure since we are weighting equally without using any information on the importance of the country nodes of the network, this strategy has the advantage of maximizing the amount of observations in our sample. The reason is that this weighting scheme requires a minimal amount of information on the MNEs network. We find that the average and standard deviation of our the network shock in our sample are 1.39 and 1.97, respectively.[16] As a robustness, we also compute the same network shock using the value of assets in a country in 2006 as a weight for the network shock. This comes at the cost of reducing the sample size. Reassuringly, we find similar results when using this alternative weighting scheme.

Firm Leverage The empirical strategy that we proposed so far can only capture the overall effect of the financial shock on the MNE outcomes of interest. However, it is not informative on the mechanisms driving the results. To make progress in this direction, we propose to augment our empirical strategy by making use of the financial records of the firms in Amadeus. We propose to create a measure of firm leverage along the lines of Kalemli-Ozcan et al. (2022) and use it to investigate whether firms with higher leverage, which we would expect to be more

[16] The interquartile range is 1.90, the tenth percentile, −.15, the median, 0.76, and ninetieth, 3.49.

affected by the financial crisis, are driving the reduced-form results we find when we regress outcomes of interest on the financial shock.

In particular, we calculate firm leverage as the ratio of the sum of long-term debt, loans, trade credit, and other current liabilities (total liabilities) to total assets. We find that the average and median values are 0.50 and 0.48, respectively. The standard deviation of our leverage measure is 0.42. Note that we compute a firm-specific measure of firm leverage. This allows us to investigate the role of leverage of parent and affiliates separately. Our empirical strategy is to interact the leverage variable with our measure of the financial shock in our regressions of interest. While this strategy does not uncover the effect of firm leverage, it allows us to compute a correlation in the data which is identified by comparing outcomes of firms with different levels of leverage. We indeed show that more leveraged firms tend to adjust more to financial shocks, suggesting that the financial channel is at play.

4 Empirical strategy

This section describes the empirical specifications we choose to conduct our investigation of the effect of financial shocks on MNE activity. Before discussing our empirical specifications, we discuss some sample restrictions that we apply to our data.

Sample Restrictions First, in order to have meaningful variation in the MNE networks, we focus on MNEs that have at least two affiliates at the start of the period (2006) and do not have a disproportionately large network of domestic affiliates. For the latter, we trim networks above the 95th percentile of the number of domestic affiliates in 2006.[17] Second, to ensure that our results are not driven by outliers, we windsorize outcomes at the 1st and 99th percentile. We also note that the number of countries covered in the estimation sample reduces due to the non-availability of risk premia for some countries (Estonia, Serbia, and Ukraine).[18]

Effect of the Financial Shock Our first empirical exercise is to examine the effect of the financial shock on MNE outcomes. Our main specification investigates the effect of the financial network shock on the structure of the MNE network and parents' performance. We consider the following empirical model to assess the effect of the network shock on outcome Y_p,

$$Y_p = \beta_0 + \beta_1 * NetworkShock_p + \beta_2 X_p + \delta_{c,i} + \varepsilon_p, \tag{2}$$

where $NetworkShock_p$ is the network shock defined in Equation (1). X_p denotes parent control variables, and $\delta_{c,i}$ are parent country and industry fixed effects, and ε_p denotes an error term.

[17] This is a cutoff of 16 domestic affiliates. Results carry through without the cutoff or with cutoffs of 10 or 20.

[18] The number of observations further varies due to the fact that financial variables are not available for all parents or affiliates.

Y_p is the parent's normalized outcome over the period 2006-2015, which we discuss in more detail below.

We are interested in two sets of outcome variables. First, we analyze the effect on parent's performance. In particular, we analyze employment and operating revenue for which we have the largest number of observations. Then, we analyze how the network of affiliates associated to a parent adjusts after the financial shock. We consider the total number of affiliates, and also study separately the effect to foreign and domestic affiliates, and to affiliates that are in vertical and horizontal relationships with the parent firm.[19] The parent-level control variables include the following variables: total assets, age of the parent, size of the network (number of affiliates) and the share in total assets of domestic affiliates. All these controls are taken in the initial year (2006). As discussed above, this $NetworkShock$ is parent specific. This allows us to include parent's country and industry fixed effects and, thus, better identify the shock since the variation we use is within country and industry, by comparing firms with different network exposure to the financial shock.

Role of Leverage The second exercise that we perform is to investigate one channel through which adjustment to the financial shock is likely to operate: financial frictions. In particular, we investigate whether part of the MNE adjustment to the financial shock can be accounted for by differences across MNEs in their pre-shock leverage levels. To this end, we use our measure of leverage discussed in the previous section. We interact firm leverage with our shock measure in our empirical specification, Equation (2), to obtain

$$\begin{aligned} Y_p =& \beta_0 + \beta_S * NetworkShock_p + \beta_{SL} * NetworkShock_p * FirmLeverage_p \\ &+ \beta_L * FirmLeverage_p + \beta_2 X_p + \delta_{c,i} + \varepsilon_p, \end{aligned} \tag{3}$$

where $FirmLeverage_p$ denotes our leverage measure of parent p. As in our baseline baseline model, X_p denotes parent and network controls, $\delta_{c,i}$ denotex country and industry fixed effects and ε_p, the error term. Note that the coefficient on the interaction term β_{SL} is identified by comparing firms in the same country, industry and network shock, but different levels of leverage.

Dynamics of Adjustment to the Financial Shock Finally, in addition to estimating the overall effect of the financial shock between the initial and final period in our sample, we are also interested in studying the peace at which the effects of the financial shock build up over time. In order to estimate the dynamics of firm responses to the financial shock, we use the local projections method developed by Jordà (2005). For a given outcome variable of interest

[19] Affiliates are classified as horizontal or vertical based on their industrial four-digit NACE classification.

Y_p, we estimate the following local projections

$$\Delta^{t_0,t_0+j} Y_p = \beta_{0j} + \beta_{1j} * NetworkShock_p + \beta_{2j} X_{pt_0} + \delta_{cj,ij} + \varepsilon_{pj}, \tag{4}$$

with t_0 being the base year, in our case 2006, and j running from 2003 to 2015 (2006 excluded) for different outcomes Y_p. In this regression, the coefficient β_{1j} captures the effect of the network shock after j periods from 2006. Finally, X_{pt_0} denotes firm-specific controls from the base year and $\delta_{cj,ij}$ denote dyads of parent country-time and parent industry-time fixed effects.

5 Results

This section presents the main results of the paper. We begin by presenting our main results, which document the effect of a financial shock on multinational activity and its organization. Then, we also provide evidence consistent with the view that, within a country and an industry, holding the MNE network constant, more leveraged MNEs suffered larger adjustments to the financial shock.

5.1 The Network Shock

In this section, we examine the effect of the network shock on the organization of MNE production and also a variety of parents' outcomes.

As we discussed in Section 3, the network shock is a weighted average of the financial shock across all locations in wich a MNE is present. Thus, the network shocks include both the shock in the country of the parent and the shocks in the countries where the MNE has affiliates. An appealing feature of this specification is that it features a parent-specific shock. This allows us to compare outcomes of different MNE networks and parents within the same country and industry. Our baseline weighting scheme in the construction of the MNE network shock, α_i^{06} in Equation (1), is a uniform weighting across all countries in which the MNE is present. As a robustness check we use the asset value of a firm in 2006 to construct the weights α_i^{06} in our network shock measure, Equation (1). We show that our results are robust to this alternative weighting scheme.[20]

Since we are interested in both 1) the overall 2007-2015, "long-difference" effect of the shock and 2) how the effect builds up over time, we construct our outcome measures in a way that it is easy to explore both effects with comparable outcome variables. Our dependent variables are normalized cumulative changes between 2006 and 2015. For outcome Y_p, we compute $Y_p^{06,t} = Y_{p,t}/Y_{p,2006}$. It allows us to explore how the effects build up over time by considering $Y_{p,t}$ at different horizons t as well as the "long-difference outcome" which would correspond to

[20] The main drawback of this choice of weights is that we need detailed information on the affiliates, and thus, we loose a sizeable amount of observations especially for affiliates outside of Europe.

Table 1: Parent and network outcomes and average network shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			number of ... affiliates				
	Revenue	Empl't	Total	Foreign	Domestic	Horizontal	Vertical
Network shock	-0.054**	-0.072***	-0.027**	-0.033*	-0.041***	-0.008	-0.034***
	[0.026]	[0.024]	[0.012]	[0.017]	[0.012]	[0.009]	[0.012]
Total assets (parent)	-0.083***	-0.053***	0.100***	0.141***	0.055***	0.039***	0.078***
	[0.022]	[0.018]	[0.008]	[0.010]	[0.007]	[0.005]	[0.008]
Age (parent)	-0.068*	-0.091***	0.002	-0.020	0.033*	0.027*	0.006
	[0.038]	[0.032]	[0.017]	[0.026]	[0.017]	[0.014]	[0.019]
Initial # affiliates	0.130***	0.124***	-0.055**	0.202***	0.023	0.169***	-0.011
	[0.045]	[0.042]	[0.022]	[0.033]	[0.023]	[0.021]	[0.027]
Observations	3,716	3,942	8,258	8,258	8,258	5,708	5,708
R-squared	0.090	0.061	0.108	0.113	0.086	0.130	0.095
Parent industry FE	Y	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y	Y

Notes: Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1. Column headings indicate parent and network outcomes. Columns 1 and 2 use log changes between 2006 and 2015 as dependent variable. Columns 3 and 7 use the ratio of 2015 tot 2006 as dependent variable. In columns 7 and 8 only networks for which we are able to calculate the shock and for which we have a 4-digit activity code for the parent and all of its affiliates are retained. Outcomes are winsorized at the first and 99th percentile.

$t = 2015$. By normalizing by initial outcomes, it facilitates the interpretation of the results as multiples of the initial levels. All our regressions include as controls the initial (2006) number of affiliates, total parent assets, parent age and country and industry fixed effects. Since financial networks are firm-specific, we choose as baseline to report robust standard errors.[21]

Columns (1) and (2) of Table 1 report the effects of the network shock on parents' operating revenues and employment. We find that parents in more financially hit networks experience a decline in both revenue and employment. Quantitatively, a one percent increase in the network shock reduces the normalized revenue and sales by 0.06 percent and 0.07 percent of its initial values.[22] According to our estimates, a MNE experiencing a financial shock of magnitude equal to one standard deviation of the financial shock, when compared to than another MNE not experiencing a financial shock, would experience a 10.8 and a 14.4 percent decline in its level of revenue and employment in 2015 relative to its 2006 baseline when compared to the MNE not experiencing the shock.

Columns (3) through (7) of Table 1 report the effect of the financial network shock on the re-organization of the MNE network. Columnn (3) reports the effect of the network shock

[21] We have verified that our results remain significant when clustering by parent country.

[22] In addition to sales and size, we also observe that these parents have lower leverage and assets growth. The reduction in leverage is almost three times as large as the one documented by sales. This large effect on leverage is consistent with our financial interpretation of the shock. Parents in more financially hit networks were forced to decrease leverage.

on the total number of affiliates. We find that, within an industry and country, parents in more financially-hit networks tend to reduce their number of affiliates. We find a negative and significant coefficient on the network shock, implying that a one percent increase in the risk premia associated with the network shock reduces the number of affiliates by -0.027 relative to its 2006 level. Comparing again two MNE experiencing two shocks that differ in magnitude one standard deviation of the network shock, our estimates imply that the harder-hit MNE would experience a 5.4% decline in its number of affiliates relative to the other MNE.

Columns (4) and (5) break down the total number of affiliates into foreign and domestic. We find that the reduction in number of affiliates happens in both domestic and foreign affiliates. We find an estimate of roughly the same magnitude for both domestic and foreign affiliates. A one percent increase in the risk premium associated with the network shock, implies a decline of 0.033 and 0.041 percent of the number of affiliates in 2006. The effect of a financial shock of one standard deviation of magnitude is to reduce the number of foreign and domestic affiliates by 6.6 and 8.2 percent, respectively.

Finally in columns (6) and (7) we break down the total number of affiliates into whether they are horizontally or vertically related to the parent firm. We classify an affiliate as horizontally related to the parent if they share the same 4-digit activity code, and vertical otherwise. We find that the relative shrinkage of the network is mostly driven by affiliates in a vertical relationship with the parent. Quantitatively, we find that comparing a MNE not exposed to a financial shock to one MNE experiencing a shock of magnitude equal to one standard deviation of the financial shock, our estimates predict that the harder hit MNE would experience a 6.8 percent decline in the number of vertically-related affiliates relative to the MNE not experiencing the shock.

Table A.2 in the appendix reports the same regression, except that we use a network shock measure in which the weights α_i^{06} are computed using the total asset value of affiliates/parent in a given country. This alternative way of constructing our network shock is more demanding on the data and our sample size is reduced almost by a half. Reassuringly, we still find that the sign and significance of the coefficients are unaltered relative to Table 1, while the magnitudes of the coefficients remain comparable. Suggesting that the extensive margin of the network (i.e., the countries in which a MNE is present) may be more important than the intensive margin for analyzing the outcomes that we consider.

Dynamics of the Adjustment to the Financial Shock After having documented the adjustment of MNE networks and performance measures over the 2007 through 2015 period, we analyze how these effects build up over time. We proceed by using the local projection method described in Section 4. We use the empirical specification described in Equation (2) to all six outcomes presented in Table 1. We report the estimated coefficient on the financial shock β_{1t} at different time horizons $t \in \{2003, 2004, 2005, \ldots, 2014, 2015\}$ for each outcome variable

of interest.

Figure 4 reports our results. A key finding is that the effect of the financial shock builds over time for both MNE network and performance measures. For example, consider firm employment. We see that in 2003, 2004 and 2005, the pre-shock years, there is no significant trend nor effect of the financial shock. After 2006, we see that the estimated coefficients become negative, but they do not become statistically different from zero until 2009. The downward trend continues until 2015, for which we find an estimated coefficient of -0.07 which corresponds to the total effect for 2015 relative to employment in 2006 that we already reported in Table 1. We find a very similar pattern for all other adjustment margins.

Taken together these results imply that adjustment to the financial shock is not instantaneous. Rather, it builds up over time, and even three years after the end of the financial crisis (2012), MNE firms are still adjusting their network and their performance.

5.2 Inspecting the Mechanism: The Role of Firm Leverage

We next investigate whether our previous results are related to the financial conditions of the parent firm. To do so, we interact the network shock with the initial leverage of the firm, according to the specification that we discussed in Equation (3). Given that we are analyzing the effect of a financial shock, we would expect that the effects that we find were driven by relatively more leveraged parents.

Table 2 reports our results. As expected, we find that relatively more leveraged MNEs are those more severely affected by the network shock. Both their performance measures (operating revenue and employment) and the shrinkage of the MNE network operates through MNEs whose parents are more leveraged and that experience a more severe financial network hit. We also observe that the pattern of adjustment of the MNE network to the financial shock is broadly similar to the one we uncovered in Table 1. In particular, we observe that the adjustment is concentrated in vertically-related affiliates and that it operates both through domestic and foreign affiliates. The only noteworthy difference is that the coefficient on foreign affiliates in column (3) becomes substantially larger relative to domestic affiliates reported in column (4), suggesting that leveraged MNEs tend to adjust more on the foreign affiliates margin. Comparing two MNEs at the average level of the financial shock but one standard deviation apart in their leverage, we would expect the more leveraged MNE to have reduced its initial level of foreign affiliates by a 4.3 ($= 7.3 \cdot 1.4 \cdot 0.4$) percent by 2015, while only a 1.8 percent for domestic affiliates.

In contrast to the interaction results, we find that the direct contribution of the network shock or parents' leverage have little to no effect on either MNE performance and network adjustment. This is remarkable since the correlation between the average network shock and parent leverage is virtually zero, 0.07. Thus, MNE networks with parents with high or low leverage do not face systematically different network shocks. This suggests that, perhaps not surprisingly, the firm leverage mechanism that we focus on plays a substantial role in adjustment

Figure 4: Effect of the Network Shock Over Time

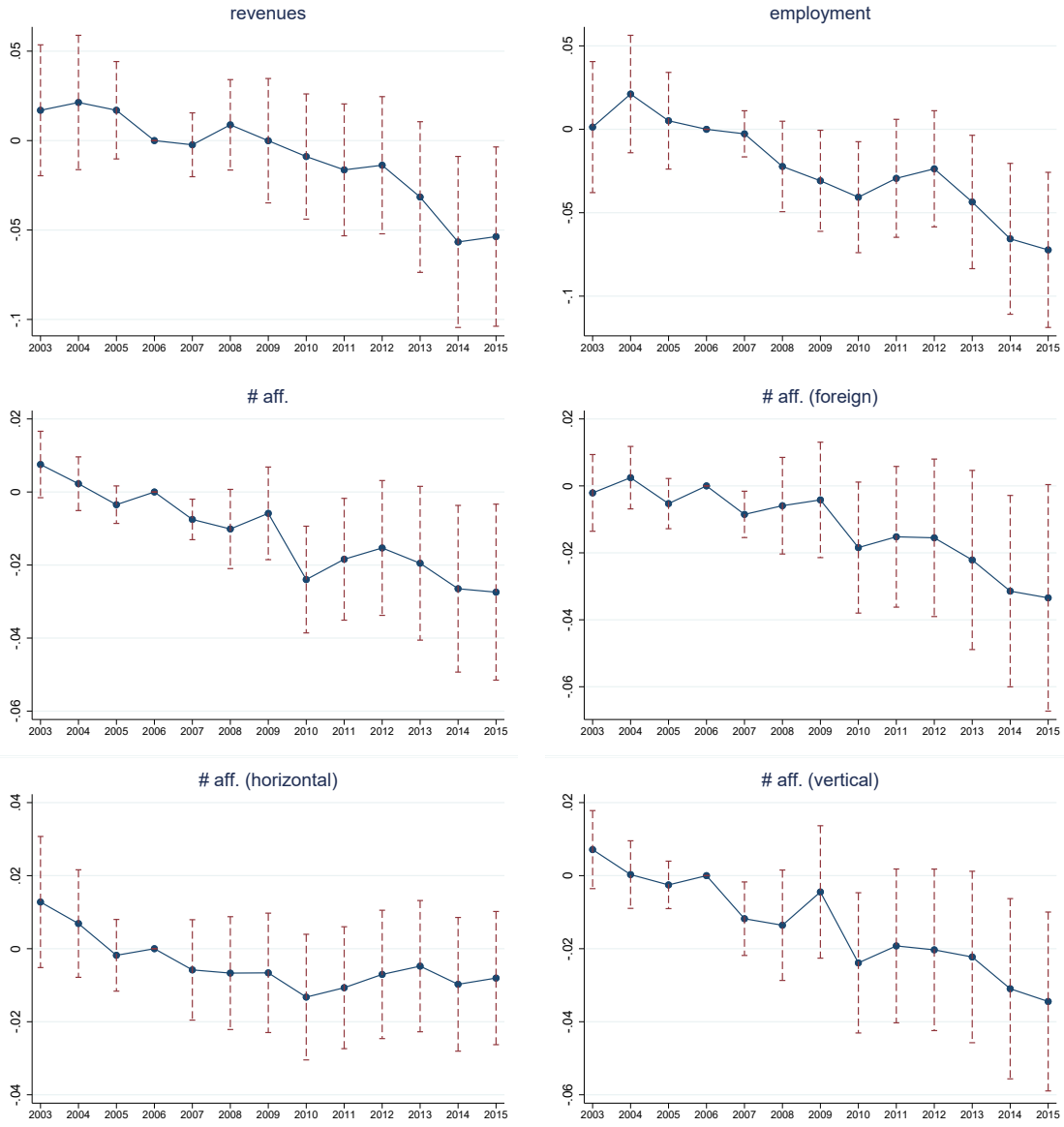


Table 2: Parent and network outcomes and average network shock interacted with leverage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			number of ... affiliates				
	Revenue	Empl't	Total	Foreign	Domestic	Horizontal	Vertical
Network shock × leverage	-0.159***	-0.076*	-0.056***	-0.073***	-0.031**	-0.020	-0.038**
	[0.054]	[0.042]	[0.016]	[0.027]	[0.015]	[0.013]	[0.019]
Network shock	0.039	-0.029	0.008	0.015	-0.017	0.007	-0.010
	[0.036]	[0.031]	[0.017]	[0.026]	[0.017]	[0.013]	[0.018]
Leverage (parent)	-0.264*	-0.131	-0.019	0.035	-0.094***	0.022	-0.037
	[0.138]	[0.106]	[0.032]	[0.046]	[0.028]	[0.024]	[0.038]
Initial # affiliates	0.114**	0.126***	-0.119***	0.136***	-0.018	0.151***	-0.031
	[0.045]	[0.042]	[0.024]	[0.035]	[0.024]	[0.022]	[0.028]
Total assets (parent)	-0.081***	-0.055***	0.135***	0.184***	0.069***	0.054***	0.093***
	[0.022]	[0.019]	[0.009]	[0.013]	[0.009]	[0.007]	[0.010]
Age (parent)	-0.079**	-0.089***	-0.002	-0.026	0.029	0.028*	0.010
	[0.038]	[0.032]	[0.017]	[0.028]	[0.018]	[0.015]	[0.020]
Observations	3,633	3,826	7,677	7,677	7,677	5,262	5,262
R-squared	0.102	0.064	0.123	0.122	0.095	0.131	0.102
Parent industry FE	Y	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1. Column headings indicate parent and network outcomes. Columns 1 and 2 use log changes between 2006 and 2015 as dependent variable. Columns 3 and 7 use the ratio of 2015 tot 2006 as dependent variable. In columns 7 and 8 only networks for which we are able to calculate the shock and for which we have a 4-digit activity code for the parent and all of its affiliates are retained. Outcomes are winsorized at the first and 99th percentile.

to the financial network shock. This finding is also similar to Giroud and Mueller (2016), who following a similar approach to ours, find that after interacting their network shock (housing prices in their case) with leverage, all the variation is absorbed by the interaction and the effect of the shock by itself disappears.

Table A.3 in the appendix reports our regression results for the number of affiliates outcome both without (panel A) and with (panel B) leverage interaction to be robust for different sample choices.

Dynamics of Adjustment across Different Leverage Levels Analogously to our previous exercise, we also investigate how adjustment of to the financial network shock builds over time using the local projections estimation described in Section 4, Equation (2). In this case, we choose three levels of leverage, corresponding to the 10th, 50th and 90th levels. Holding these levels fixed, we report the sum of the estimated coefficient of the financial shock, β_S, and the interaction term between parent leverage and the financial shock, β_{SL}, at different time horizons $t \in \{2006, 2007, \ldots, 2014, 2015\}$, multiplied by each of these three leverage levels. We repeat this exercise for each of the outcome variables reported in Table 2. The goal of this exercise is to help visualize the heterogeneous response of MNEs at different levels of leverage

and different time horizons.

Figure 5 reports our results. As in our previous exercise, we see that across the board adjustment to the financial shock is slow. More importantly, we observe the large heterogeneity in responses depending on the leverage of the firm. Consider number of foreign affiliates, denoted by $\#aff.\ (foreign)$ in the figure. For firms at the 10th percentile of our leverage measure, the effect of the financial shock is hovering around zero over the entire period, with the exact point estimate fluctuating between small positive and negative numbers.[23] By contrast, a MNE at the 90th percentile of leverage, experience a sustained cumulative decline over the entire period. These patterns are similar for all other outcomes. Taken together, these figures suggest again the importance of MNE leverage in accounting for adjustment to the financial shock.

5.2.1 Zooming in on Affiliate Adjustment

To better understand how MNEs with different levels of leverage adjust to the financial shocks, we zoom in and investigate the adjustment of affiliates separately depending on their level of leverage. We analyze the role of parent's and affiliate's country shocks in affiliate's exit, and we document that parents' shocks appear to play a more central role.

We define a "parent shock" as the change in the risk premia in the country in which a parent is located,

$$ParentShock_p = \Delta Risk_{p,c}, \tag{5}$$

where $\Delta Risk_{p,c}$ is the change in risk premium in the country c of the parent p between Juny 2012 and August 2007. Analogously, we can define an "affiliate shock" as the financial shock in the country of the affiliate

$$AffiliateShock_a = \Delta Risk_{a,c}, \tag{6}$$

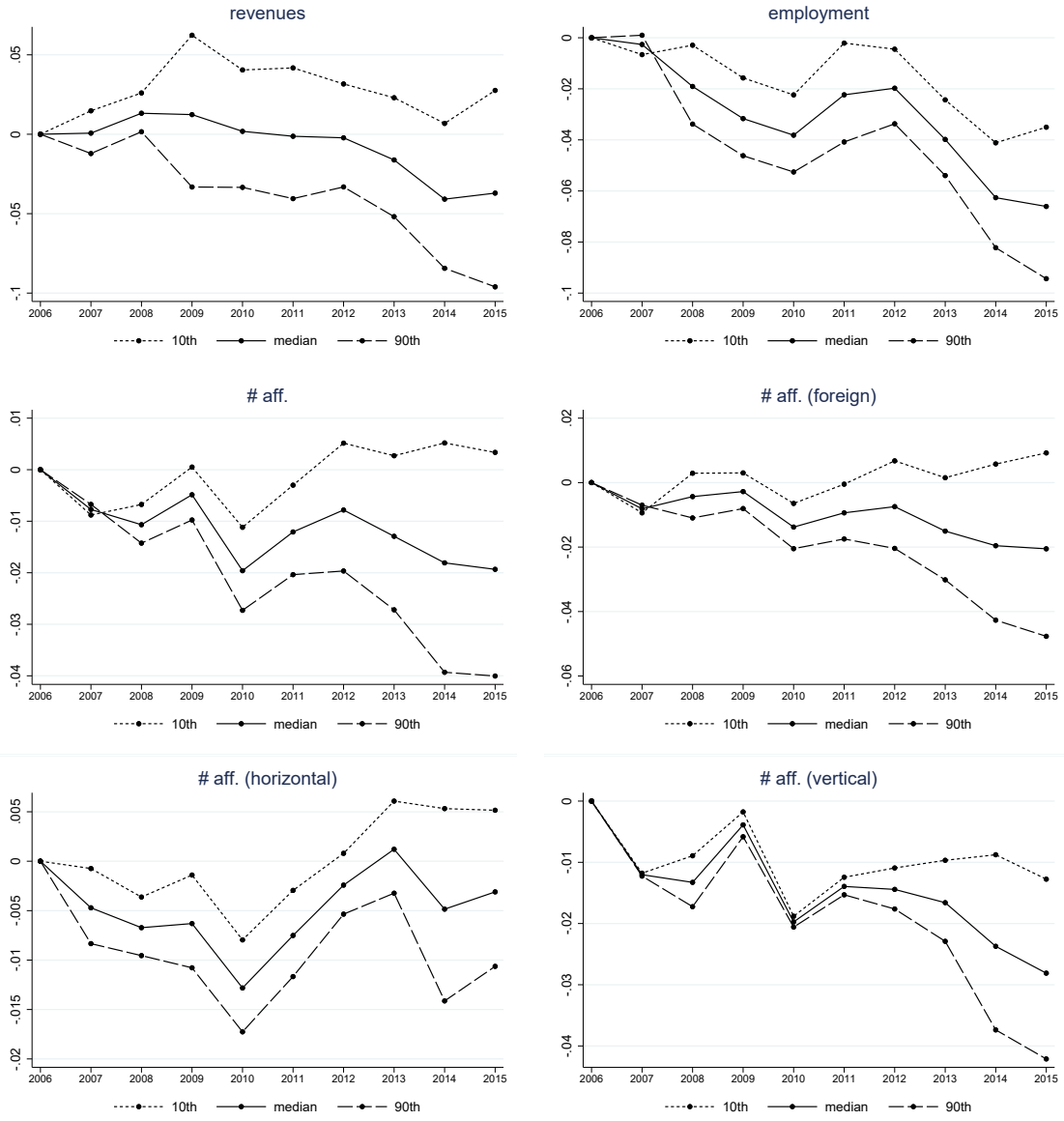
where $\Delta Risk_{a,c}$ is the change in risk premia in the country c of the affiliate a between July 2012 and August 2007.

To begin our study on the exit decision of individual affiliates, we make the remark that the probability of any given affiliate to exit our sample is increasing in the network financial shock and the parent leverage. This is to be expected, since we already showed a significant effect of the network shock on the total number of affiliates.[24] To further investigate the drivers of affiliate exit, we run a linear probability model with our dependent variable being a dummy equal to one if the affiliate exits before 2015. We include as regressors the interaction of the financial shock measure of the affiliate with the affiliate's leverage and the financial shock of the parent with the parent's leverage. We include four types of fixed effects (parent and affiliate country and industry) comparing affiliates in the same country industry with parents from the

[23] Recall that we normalize country-level shocks relative to Germany. Some countries are considered to have a less risky evolution than Germany and thus experience a "negative" shock.

[24] For example, the coefficient on the network shock is 1.4 and significant at 1 percent when clustering standard errors at the parent level.

Figure 5: Heterogeneous Effects of the Network Shock Across Three Initial Leverage Levels



same country industry. Table A.4 reports the results.[25]

In line with our previous result, we find that the parent's financial conditions and shock matter for affiliate network exit. The parent's 2006 leverage matters for the shock transmission to the affiliate as does the level of the parent's leverage. Perhaps more surprisingly, in column 1, we find that affiliate leverage and the financial shock interacted with leverage are insignificant. On the other hand, network exit is a parent decision on network optimisation and an affiliate that is important for the within-network supply chain may benefit from parent support in order not to jeopardise the entire network. This is exactly what we explore in the next columns.

In columns 2 and 3 we allow the shock interaction and the level of leverage to differ between affiliates that replicate the parent's activity and those that do not. The former type of activity is less crucial for the network that thus could be expected to be potentially more sensitive to affiliate local conditions. In practice, we use a dummy variable set to one if the parent and affiliate have the same four digit activity code.[26] We find that horizontal affiliates' exit probability is significantly affected by their local shock and financial conditions. The parent's effect is not different.

Column 3 shows that the level effect of leverage is not different. In column 4 we consider market exit. The dependent variable is now set to one if the affiliate exits the market and zero otherwise.[27] We thus compare market exit to surviving affiliates. Column 4 shows that now the affiliates own shock and leverage matter most. Parent shock and leverage are important in deciding network optimisation, not for affiliate network exit. The fact that the survival of the affiliate depends on the leverage of the parent suggests that the parent offers credit to the affiliate. The importance of trade credit with a MNE is a mechanism whose importance has been put forth and discussed see for example Antràs and Yeaple (2014).

Columns 5 and 6 add credibility to the prior reasoning by means of a placebo analysis. We use the placebo analysis to make sure results are not driven by potential country-industry patterns that may drive the parent's effects. The placebo exercise is done by replacing affiliate and parent variables (including the dependent variable) by those of matched firms. For affiliates matching is within country-industry cells in 2006. Matching is done through minimizing the Euclidean distance based on size, age, and leverage. So these "pseudo affiliates" are very similar in terms of size, age, and leverage in 2006 and belong to the same industry-country as the original affiliates. For parents, matching is done within country-industry cells in 2006. Matching is done through minimizing the Euclidean distance based on size, and age, but *not* leverage.

Reassuringly, we find in columns 5 and 6 that the coefficients involving the parent shock and leverage are not statistically different from zero. Instead, the own country shock and own

[25] Table A.4 also reports results for a specification that additionally to the reported variables includes parent and affiliate size (real total assets) and age, a dummy for majority ownership, and initial network size as control variables.

[26] Results also hold for two digit.

[27] Market exit obviously also implies network exit, but this is not necessarily so the other way around. In fact many affiliates are sold off, rather than defaulted on.

leverage appear to be significant and the shock interaction is about three times larger than the estimated coefficients in the actual data in column 4. These results paint a picture consistent with the view that belonging to a MNE network affords additional sources of credit to affiliates from the parent company, but at the same time exposes them to the shocks that the parent company faces.

6 Concluding Remarks

Financial crises are recurrent throughout time and usually hit several countries at the same time. Even though there exists an extensive literature on the aggregate effects (see, for example, Schularick and Taylor, 2012), their effects on the MNEs and the organization of the global supply chain have remained largely unexplored. Indeed, the literature examining the effect of economic crises on multinational activity has mostly focused on sales (see, for example, Alfaro and Chen, 2012 or Alviarez et al., 2017). One reason for this omission is data availability. In this paper, we used a parent-affiliate panel spanning twenty-nine European countries between 2006 and 2015 to examine the effect of the financial disruption on multinational activity and network structure.

We create a MNE-specific shock using the pre-existing MNE network and document that parents in more financially hit networks experience a decline in revenues and employment size. In addition, they also reduce their number of affiliates, mostly driven by vertical relationships. We also show that most of this variation is accounted for leveraged MNEs, especially for the decline in foreign affiliates. The picture that emerges from this evidence is that financial crises have long-run effects and affect the performance of both affiliates and parents. More importantly, we have shown that the global supply chain is unstable and it changes when it is shocked. This result is important not only from a policy perspective but also to understand the propagation of shocks. In an important contribution, Cravino and Levchenko (2017) quantifies how business cycles shocks to a given network of affiliates affect parents' outcomes. Building on our evidence, it would be interesting to investigate how their results may change when the MNE network itself also changes with a financial shock. We leave a quantitative analysis of the financial shock for future research.

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A Additional Tables

Table A.1: Country-level shocks

country	shock	country	shock	country	shock
Austria	0.744	France	0.941	Mexico	0.274
Australia	0.016	UK	-0.443	Netherlands	0.418
Belgium	1.304	Greece	24.254	Norway	-0.126
Bulgaria	3.140	Croatia	4.390	New Zealand	0.054
Canada	0.282	Hungary	3.814	Poland	2.364
Switzerland	0.565	Ireland	4.774	Portugal	8.994
Chile	2.062	Israel	1.064	Romania	2.710
Colombia	-0.771	Iceland	-0.466	Russia	4.434
Czech Republic	1.204	Italy	4.466	Sweden	0.134
Germany	0	Japan	2.257	Slovenia	4.571
Denmark	-0.237	South Korea	0.934	Slovakia	2.820
Spain	5.451	Lithuania	3.073	US	-0.086
Finland	0.214	Latvia	2.404	South Africa	2.204

Source: Authors' calculation based on OECD

Table A.2: Parent and network outcomes and total assets weighted network shock

	(1) op. rev.	(2) empl.	(3)	(4)	(5)	(6)	(7)
			number of ... affiliates				
			total	foreign	domestic	horizontal	vertical
Network shock	-0.040*	-0.048**	-0.038**	-0.029**	-0.060***	0.000	-0.023**
	[0.022]	[0.020]	[0.016]	[0.014]	[0.023]	[0.006]	[0.011]
Initial # affiliates	0.121	0.141**	-0.028	0.311***	0.121*	0.172***	-0.006
	[0.075]	[0.066]	[0.060]	[0.075]	[0.073]	[0.030]	[0.043]
Total assets (parent)	-0.115***	-0.056**	0.074***	0.157***	-0.010	0.025***	0.066***
	[0.031]	[0.024]	[0.023]	[0.022]	[0.036]	[0.007]	[0.020]
Age (parent)	-0.059	-0.106**	0.004	-0.071	0.058	0.042*	-0.036
	[0.054]	[0.044]	[0.044]	[0.047]	[0.059]	[0.022]	[0.028]
Observations	1,767	1,996	4,363	4,363	4,363	3,538	3,538
R-squared	0.107	0.091	0.061	0.091	0.049	0.134	0.054
Parent industry FE	Y	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1. Column headings indicate parent and network outcomes. Columns 1 and 2 use log changes between 2006 and 2015 as dependent variable. Columns 3 and 7 use the ratio of 2015 tot 2006 as dependent variable. In columns 7 and 8 only networks for which we are able to calculate the shock and for which we have a 4-digit activity code for the parent and all of its affiliates are retained.

Table A.3: Number of affiliates and robustness to sample choice

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A - Network shock							
Network shock	-0.022**	-0.019**	-0.018**	-0.016*	-0.022**	-0.021**	-0.020**	-0.019**
	[0.010]	[0.010]	[0.009]	[0.008]	[0.010]	[0.010]	[0.009]	[0.009]
Observations	8,217	8,670	14,825	15,278	6,586	6,764	13,010	13,188
R-squared	0.105	0.108	0.093	0.095	0.093	0.091	0.084	0.083
	B - Network shock and leverage							
NW shock × leverage	-0.056***	-0.052***	-0.037***	-0.035***	-0.054***	-0.051***	-0.037***	-0.036***
	[0.017]	[0.016]	[0.012]	[0.012]	[0.018]	[0.016]	[0.012]	[0.012]
Network shock	0.012	0.012	-0.004	-0.003	0.009	0.008	-0.009	-0.008
	[0.016]	[0.015]	[0.012]	[0.012]	[0.016]	[0.016]	[0.012]	[0.012]
Leverage (parent)	-0.018	-0.021	-0.018	-0.019	-0.008	-0.013	-0.005	-0.007
	[0.032]	[0.032]	[0.023]	[0.023]	[0.034]	[0.033]	[0.023]	[0.023]
Observations	7,637	8,072	13,244	13,679	6,069	6,232	11,526	11,689
R-squared	0.119	0.124	0.105	0.108	0.105	0.104	0.093	0.093
Parent industry FE	Y	Y	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y	Y	Y
Sample:								
# aff.	2	2	1	1	2	2	1	1
large domestic NW	excl	incl	excl	incl	excl	incl	excl	incl
consolidated	incl	incl	incl	incl	excl	excl	excl	excl

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; the sample used is indicated in the bottom of the table. "# aff." is the minimum number of affiliates in the network; "large domestic NW" and "consolidated" indicate whether networks with a disproportionately large domestic parts of the network or networks involving consolidated accounts are in or excluded from the sample respectively. Dependent variable is always the number of affiliates in the network in 2015 relative to 2006. The first column is our preferred sample we use for the main results.

Table A.4: Affiliate exit; leverage effects - cross-section, linear probability model

	(1)	(2)	(3)	(4)	(5)	(6)
	network exit			market	placebo	
				exit	affiliate	affiliate + parent
Affiliate variables						
Shock × Leverage	0.344	0.230	0.250	0.299**	0.873***	0.990***
	[0.223]	[0.225]	[0.226]	[0.129]	[0.259]	[0.290]
horizontal int.		1.097***	0.986**	-0.158		
		[0.354]	[0.384]	[0.146]		
Leverage (affiliate)	0.003	0.003	0.002	0.001	0.047***	0.042***
	[0.006]	[0.006]	[0.006]	[0.003]	[0.007]	[0.008]
horizontal int.			0.010	-0.003		
			[0.016]	[0.005]		
Parent variables						
Shock × Leverage	1.340***	1.362***	1.336***	-0.106	0.106	0.196
	[0.464]	[0.465]	[0.466]	[0.169]	[0.480]	[0.316]
horizontal int.		-0.537	-0.354	0.083		
		[0.496]	[0.519]	[0.187]		
Leverage (parent)	0.069***	0.070***	0.073***	0.015***	0.011	-0.000
	[0.014]	[0.014]	[0.015]	[0.005]	[0.011]	[0.012]
horizontal int.			-0.030	0.002		
			[0.032]	[0.009]		
Observations	29,856	29,856	29,856	29,856	26,860	21,846
R-squared	0.081	0.081	0.081	0.019	0.041	0.043
Controls	Y	Y	Y	Y	Y	Y
Affiliate industry FE	Y	Y	Y	Y	Y	Y
Affiliate country FE	Y	Y	Y	Y	Y	Y
Parent industry FE	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y

Clustered standard errors in brackets (parent level); *** p<0.01, ** p<0.05, * p<0.1; dependent variable is set to one if affiliate exits the network before 2015 and zero otherwise in columns 1-3; dependent variable is set to one if affiliate exits the market before 2015 and zero otherwise in column 4. The placebo exercise in columns 5 and 6 is done by replacing affiliate and/or parent variables (including the dependent variable) by those of matched domestic firms. For affiliates matching is within country-industry cells in 2006. Matching is done through minimizing the Euclidean distance based on size, age, and leverage. So pseudo affiliates are very similar in terms of size, age, and leverage in 2006 and belong to the same industry-country as the original affiliates. For parents matching is within country-industry cells in 2006 and done through minimizing the Euclidean distance based on size, and age, *not* leverage. Results are not driven by sample size/constellation.