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

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August 2022

Abstract

This paper empirically examines the effects of financial crises on multinational firms' performance and the international organization of production. We use a panel of multinational networks spanning 25 European countries between 2006 and 2015. Our financial shock is the increase in countries' risk premium between August 2007 (BNP freezing funds) and July 2012 (whatever-it-takes speech). We document three sets of results. First, parents located in more financially-hit countries experience a growth reduction in sales, size (employment) and number of affiliates (specially those affiliates located in the periphery). All these effects are exacerbated among more initially leveraged parents. Second, affiliates are more likely to exit if the parent is both leveraged and located in a financially hit country. Third, parents in more financially hit networks (taking into account the initial location of affiliates) experience a decline in both sales and size growth. In addition, they reduce the relative number of affiliates, in particular, vertical relationships (no significant effect on horizontal ones). We interpret this evidence as suggesting that financial crises have long-run effects, since they change the global supply chain and shift production even in those countries not directly hit.

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

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

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Basco acknowledges financial support from Catalan Agency for Management of University and Research Grants (2017SGR1301) and Spanish Ministry of Science, Innovation and Universities (PID2019-104723RB-I00)

1 Introduction

Financial crises 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, for example, Schularick and Taylor, 2012 or Jordà et al., 2013). Within a country, the losses do not need to be equally shared. For example, firms owning affiliates in financially hit countries may decide to reorganize their supply chain, which could affect their short- and long-run performance. Similarly, firms being owned by a parent located in a financially hit country may be more adversely affected.[1] The goal of this paper is to provide a comprehensive analysis of how financial shocks propagate to different countries through multinational networks.[2]

The most recent financial crisis had a global spread. However, it was particularly severe within the Eurozone. A poster child of this financial disruption is illustrated in Figure 1. It shows the monthly evolution of the 10-year government bonds yields of Germany and Spain in the last two decades. We define the difference in the yields of a country with respect to Germany as the risk premium. As it can be seen, 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).

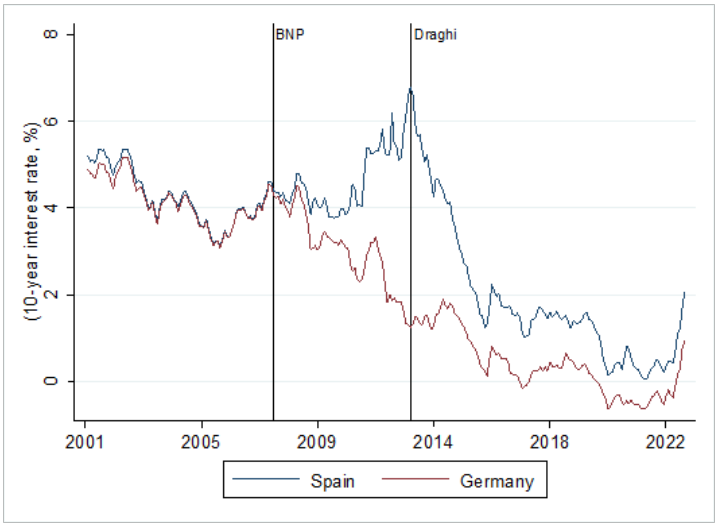
In this paper, we examine how the increase in risk premia between the two events (our financial shock) affected multinational activity in European multinational networks. We proceed in three steps. First, we consider the effect of an increase in the risk premium in the country of the parent on parent's outcomes. Second, we analyze how the affiliate performance is affected by the financial shock in both countries. Finally, we examine the dynamic adjustment of the parent to the network shock (taking into account the initial location of affiliates). In particular, we focus on ouctomes such as sales, employment, and changes in the location and number of affiliates.

[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 the domestic counterpart. One main difference is that we will be comparing across 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 a related literature (see, for example, Gopinath et al., 2017 or Basco et al., 2021). The focus of this paper is in 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

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 parent and affiliates taken from Amadeus (see Merlevede et al., 2015). The dataset covers 25 European countries, and it accounts for between 50 and 60 percent of aggregate multinational activity 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. 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 a very protracted recession period.[5] The dataset has two main advantages. First, it contains information on the network of affiliates of parents in different countries. This allows us to compare multinational firms in the same country with a different set of affiliates. Second, it is a long panel. As emphasized in the trade literature (see, for example, the seminal contribution of Autor et al., 2014), the effects of shocks build slowly over time and if we only used a short-run panel, we could wrongly conclude that there were small or no effects.

Before describing the results, we take advantage of our dataset to uncover some facts on

[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 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 (see, 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 quite mild and short-term recession, GDP in Spain did not recover pre-recession boom until 2016 (according to World Economic Outlook Data).

multinationals. First, multinational activity is very 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 is substantially heterogeneous. Most networks are small (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 seems important (roughly 90 percent of affiliates are either domestic or in European countries). Fifth, most affiliates are fully owned (over 70 percent).

We first analyze the effect of the financial shock in the country of the parent on parent's activity. The dependent variables compare the outcomes in 2006 and 2015. We document that parents located in countries hit by a larger financial shock experience both a relative decline in sales and size (employment) growth. This negative effect is exacerbated among more leveraged parents. We also show that these more leveraged parents choose to shrink their network of affiliates and move away from the periphery.[6] This exacerbation result underlines the financial nature of the shock. It is also reminiscent of the findings of Jordà et al. (2013) for sluggish GDP recovery after financial shocks for countries with excess credit growth and the investment results documented in Kalemli-Ozcan et al. (2018) for leveraged European firms during the last financial crisis.

Next, we examine how the financial shock in both countries affects the survival of affiliates. The dependent variable is a dummy equal to one if the affiliate exits before 2015. First, we show that affiliates are more likely to exit when they are located in a financially hit country. This result is complementary to Alfaro and Chen (2012) that find that foreign multinational firms cope better with the shock that domestic ones. We also find that affiliates are more likely to exit when the parent is located in a financially hit country. More interestingly, this effect is exacerbated in leveraged parents. The importance of the parent as a credit provider was discussed in, for example, Antràs and Yeaple (2014). However, we are not aware of a paper empirically showing this result for a financial crisis.

In our third set of results, we investigate how exposure to affiliates located in hard-hit countries affects the parent. To do that, we create a multinational-specific "network shock" measure, which is a weighted average of the increase in risk premium in the countries of the affiliates (belonging to a given multinational network) and the country of the parent. In this case, our dependent variables are (normalized) cumulative outcomes between 2006 and 2015 to track the parents' adjustment.[7] We find that parents in a more financially hit network experience a reduction in sales and size (employment) growth. They are also forced to reduce leverage.

[6]The periphery refers to Portugal, Ireland, Italy, Greece and Spain. These countries, also labelled as PIGS, were at the center of the financial disruption in the Eurozone.

[7]This is a standard measure to compute long-run adjustment to shocks. See, for example, Autor et al. (2014) for an application to China shock.

These parents also re-organize their supply chain. We document a reduction in the relative number of affiliates. Interestingly, this effect is driven by vertical relationships. Indeed, we do not find a significant effect on horizontal ones. This result is consistent with affiliates in vertical relationships being located in the lowest cost countries and being more dependent on credit from the parent.[8] Lastly, we attempt to disentangle the network shock by decomposing the shock coming from the risk of the parent, domestic affiliates and foreign affiliates. The picture that emerges is nuanced. It seems that different components of the shock affect different outcomes. For example, the shock arising from foreign affiliates explains the results on size and number of affiliates. By contrast, the parent shock seems to drive the results on sales and assets. A plausible explanation of this latter result is that the parent shock is larger in multinationals where affiliates account for a small fraction of total production and, thus, they are the most affected because its production is not diversified.

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-Ozcan et al. (2018) that emphasize the role of the leverage of firms for investment during the Eurzone (EZ) financial crisis. One main difference is that we focus on multinational firms and our goal is on understanding how the shock propagates to and from the country of affiliates.

The trade literature has emphasized the importance of multinational activity and its determinants. We refer to the survey of Antràs and Yeaple (2014). 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. This paper would be comparable to our first set of results. 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 related to our second set of results 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

[8] See, for example, Basco (2013) for similar theoretical interpretations of the product cycle.

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 third exercise, we allow each multinational firm to be differently affected as a function of the composition of its 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. Last, but not least, while most of the related literature focuses on sales, we also examine the effect on the international organization of production.[9]

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.

2 A New Database on Multinational Networks

We use the Amadeus database by Bureau van Dijk (BvDEP) to construct a panel of European multinational networks.[10] For each firm, Amadeus contains information on whether or not the firm has any affiliates. For firms with affiliates, a list of affiliates is available, but information on the affiliate is limited. The share held by the parent is known and we retain affiliates where the parent holds more than 10 percent of the shares in the affiliate. Affiliates that are available as separate entries in Amadeus are identified by a unique ID number. For these affiliates, we are thus able to 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.[11] 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 (no agriculture nor non-market services). We include all networks, those for which consolidated accounts for the parent or one of the affiliate only are available and those for which unconsolidated accounts are available (see Kalemli-Ozcan et al., 2022 for the importance of including both). Our sample is a panel in the affiliates-year dimension with full information on the parent side attached to each affiliate-year entry, as such

[9] 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.

[10] Amadeus can be thought of as the Orbis database 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.

[11] 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.

duplicating parent-year information when the parent has multiple affiliates.

Our parent-affiliate-year panel contains data for 25 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 the years. In terms of representativeness, 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. There are 18,223 multinational networks in 2006, of which 12,087 are still active as networks in 2015 (Table 1 in Online Appendix).[13]

A geographical concentration of both parents and affiliates emerges in our sample of European multinational networks. 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 documented. 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.

We also document some facts on the characteristics of multinational networks. As shown in Online Appendix, Table 5, 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). Given that we have a sample of multinational networks, in the case of the 43.7% of networks with only one affiliate, this affiliate is foreign. However, this disproportion of foreign-based affiliates is extensive. Almost 70 percent of networks have, at most, one domestic affiliate. This is reported in Table 6 in Online Appendix, where no clear correlation between the number of domestic and foreign affiliates emerges. Most multinational networks are located close to the parent (Table 7 in Online Appendix). 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 Extra-Europe affiliates increases (from 5.2% to 18.7%). As for the percentage of European affiliates we see a decreasing dynamics starting

[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.

in 2006. Most multinational networks in our sample remain stable over time. Table 8 in Online Appendix shows that between 2007 and 2015 about 64% of the networks neither added or dropped any affiliate. However, there exists more than 10 percent of networks with at least one affiliate added. 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 (dropped). In our empirical analysis, we will examine whether these changes in the network are correlated with financial shocks. Finally, Table 9 in Online Appendix shows that most affiliates (71%) are fully owned.

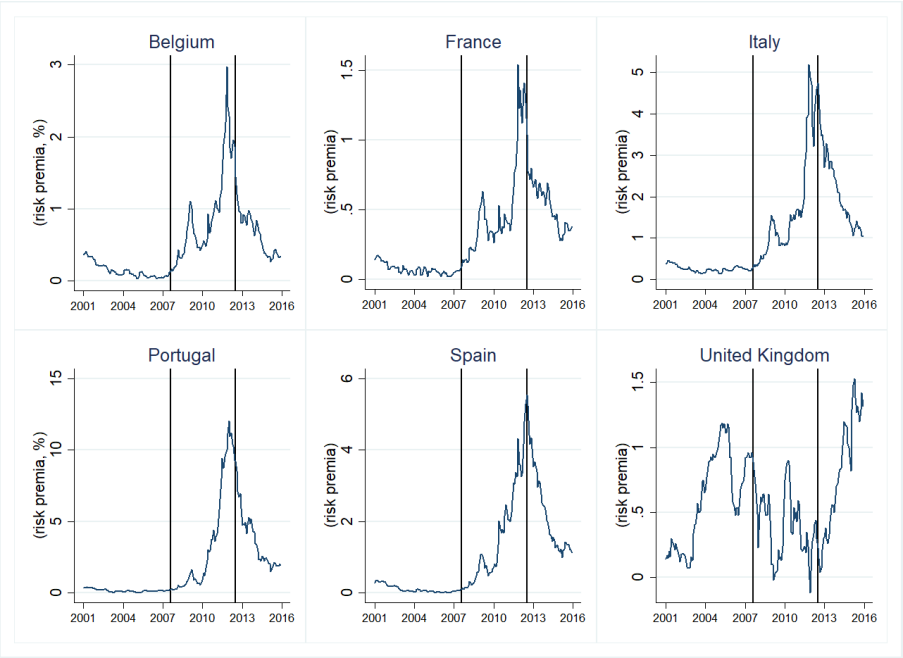
3 Macroeconomic Financial Disruption in Eurozone

In our empirically analysis, we use three measures of financial shocks. As we detail later, we have (i) a parent shock, (ii) affiliate shock, and (iii) network shock. To give empirical content to these measure of financial shocks, we will use the increase in risk premia of the countries during the Great Recession. In this section, we show the evolution of risk premia during the last decade and explain why we can interpret the increase during August 2007 and July 2012 as a financial shock. Then, we describe how we compute each of the three measures of financial shocks.

One of the defining features of the Great Recession was the increased financial risk in some countries within the Eurozone. We will exploit the heterogeneous increase in financial risk to capture how the worsening of financial conditions affects the performance of parents and affiliates. This increased financial risk can be seen by analyzing the evolution of the so-called "risk premia" across countries. Figure 2 reports the monthly evolution of the risk premia for a selected group of 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 with respect to the 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. 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 "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. These countries illustrate the heterogenous financial disruption within the Eurozone. In contrast, the risk premium in the United Kingdom even declined, reflecting the fact that the perceived risk

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

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

in the United Kingdom was somewhat lower than in Germany.[15]

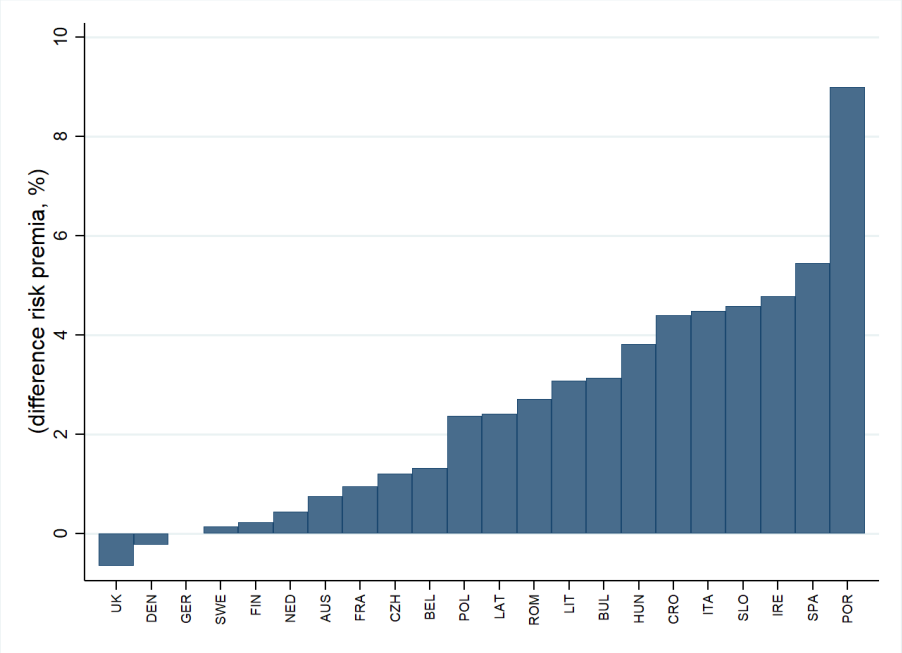
Parent Shock In our first exercise, we will be interested in the effect of the financial shock in the parent country on parent's outcome. Thus, we define the *parent shock* as

$$ParentShock_p = \Delta Risk_{p,c}, \tag{1}$$

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. Note that this variable is country specific. Thus, a potential drawback is that it can proxy for other country shocks. In our preferred specification we will interact this variable with the leverage of the firm. This specification has two main advantages. First, it speaks more directly to the financial channel. Second, it allow us to compare firms within the

[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: Difference Risk Premia



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. For ease of exposition, we do not include Greece in the figure. The difference in risk premia was 24.6 percentual points. Long-term interest rates obtained from ECB Statistical Data Warehouse.https://sdw.ecb.europa.eu/browse.do?node=9691124

same country and control for country specific shocks by introducing country fixed effects.

Figure 3 reports the change in the risk premium between July 2012 and August 2007 for all the countries in our sample.[16] As it can be seen, countries like 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. In contrast, periphery countries like Portugal or Spain had much higher increase in the risk premia (9.0 and 5.5 percent, respectively), reflecting higher financial risk in those countries. These changes in risk premium reflect the financial conditions of banks in these countries. We expect that firms located in countries with larger increases in risk premium to have more difficulties to access to 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 is plausible to have affected the capacity of firms to fund themselves or provide credit to affiliates. For ease of exposition, Greece is excluded from this figure because the difference in risk premia was 24.6 percentual points. We include Greece in our regressions. Our results do not depend on this choice.

Affiliate Shock In our second exercise, we will analyze exit rate of affiliates. To perform

[16] We are unable to compute risk premium for all countries with multinational activity due to data availability.

this exercise, we will also include the financial shock in the country of the affiliate. Analogously to the parent shock, we define the *affiliate shock* as

$$AffiliateShock_a = \Delta Risk_{a,c}, \tag{2}$$

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. Note that this is the same variable as the parent shock. The only difference is that it takes into account the country of the affiliate. Thus, Figure 3 can also be used to observe the location of affiliates more financially hit.

Network Shock In our third exercise, we will be interested in the shock to the whole network. In this case, we define the *network shock* as

$$NetworkShock_p = \sum_i \Delta Risk_{i,c} \alpha_i^{06}, \tag{3}$$

where i denotes all the affiliates of the parent 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 (assets) weight of affiliate/parent i for parent p in 2006. Note that this variable is parent specific since it depends on the network of the parent. According to this definition, the network shock is larger if the parent has most of its assets in a financial hit country. In a final step, we will decompose the network shock in three components: (i) parent shock, (ii) domestic affiliates and (iii) foreign affiliates.

4 Empirical strategy

This section describes the empirical specifications we choose to conduct each of the three exercises described above. We focus on well-established multinational firms with at least two affiliates at the start of the period to examine how the shock affects the structure of multinational networks. The number of countries covered in the estimation sample reduces due to the non-availability of risk premia for some countries (Estonia, Serbia, Ukraine). The number of observations further varies due to the fact that financial variables are not available for all parents or affiliates.

In our first exercise, we examine the effect of the financial shock in the country of the parent on parent's outcome. We consider the following model,

$$Y_p = \beta_0 + \beta_1 * ParentShock_p + \beta_2 X_p + \delta_i + \varepsilon_p, \tag{4}$$

where p denotes parent. $ParentShock_p$ is the parent shock defined in section 3, X_p is a set of control variables and δ_i is a set of parents' industry fixed effects, and Y_p is the outcome

variable change between 2006 and 2015. Our parent control variables are total assets, age and number of affiliates. All measured at the initial year.

We consider two sets of outcome variables. On the one hand, parent's performance. In particular, changes in sales and employment. We use three measures of changes: (i)a dummy equal to one if the outcome increases and zero otherwise, (ii) the growth rate, and (iii) the winsorized growth rate). On the other hand, we examine how the network changes. We start introducing three alternatives dichotomous indicators: (i) exit, (ii) exit or shrink, and (iii) expand. Then, we consider changes in the number of affiliates (both as change relative to the initial number and in absolute terms), and finally seven dummy variables capturing along which line the network is shrinking: domestic affiliates, foreign affiliates (absolute number and share), affiliates located in the PIGS (absolute number and share).

One concern with this specification is that the shock could capture any other time invariant characteristic of the country where the parent is located. In addition, the financial channel goes untested. To address these concerns, we consider the role of the leverage of the parent in affecting the relationship between the shock and the outcome variable. To this aim we include the interaction between the parent shock and the leverage of the parent.[17] In this part of the analysis we also include parents' country fixed effects. According to our narrative, we expect that the effects of the shock are exacerbated among leveraged firms.

In our second exercise, we investigate the effect of the financial shock in both the affiliate's and parent's country on the affiliate probability of exit. We consider the following linear probability model,

$$Y_a = \beta_0 + \beta_1 * AffiliateShock_a + \beta_2 * ParentShock_p + \beta_3 X_a + \delta_i + \delta_j + \varepsilon_a, \tag{5}$$

where a is the affiliate's subscript. $AffiliateShock_a$ is the affiliate shock, analogous to the $ParentShock_p$ described above. Y_a is a dummy variable taking value one if the affiliate exited before 2015 and zero otherwise. X_a denotes a set of affiliate specific control variables, δ_i and δ_j are parent's industry and affiliates' industry fixed effects, respectively. We also estimate other models differing from the baseline in the combination of fixed effects. In particular, one specification taking into account affiliate's country fixed effects and one specification with parent fixed effects.

The control variables included differs across specifications. We consider total assets, the size of the network the affiliates belongs to in the initial year, a dummy variable taking value one if the affiliate is cross-border, a dummy variable taking value one if the affiliate is majority-owned and the direct input requirement by the parent from the affiliate capturing the extent of vertical integration.[18] These last three variables are also interacted with the parent shock.

[17] We compute leverage as the ratio $(longtermdebt + loans)/(shareholderfunds + longtermdebt + loans)$.

[18] We follow Acemoglu et al. (2009) and Alfaro and Charlton (2009) and combine the parent's and affiliate's industry classification with information on industry level input-output relationships between these industries. We use Input-Output Accounts data from EU-wide input-output tables.

In this exercise, we also consider the role of the leverage of both parent and affiliate in affecting how the shock impact on the probability of exit of the affiliate. We interact the parents' shock variable, $ParentShock_p$, with the leverage of the parent and the affiliates' shock variable, $AffiliateShock_a$. Leverage is computed as explained above. As a robustness, we also consider a dummy equal to one if the leverage of the affiliate/parent is above the industry median.

Finally, in the third part, we are interested in the effect of the shock to the network on parent's performance and structure of the network. We consider the following model,

$$Y_p = \beta_0 + \beta_1 * NetworkShock_p + \beta_2 X_p + \delta_{c,i} + \varepsilon_p, \tag{6}$$

where the $NetworkShock_p$ was defined in Equation 3. X_p denotes parent control variables, and $\delta_{c,i}$ are parent country-industry fixed effects. Y_p is the parent's normalised cumulative outcome in the period 2006-2015.[19]

We are interested in two sets of outcome variables. First, we analyze the effect on parent's performance. In particular, employment, sales, operating revenue, leverage, assets, and return on assets. Then, we analyse how the network of the parent changes. We consider the number of affiliates (total, foreign and domestic), number of affiliates located in PIGS countries, and differentiating between horizontal and vertical relationships.[20]

The parent level control variables are analogous to our first specification- IN particular, we 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 taken in the initial year (2006).

As discussed above, this $NetworkShock$ is parent specific, which allow us to include parent's country fixed effects and, thus, better identify the shock. The use of this shock comes at a cost, since we need information on all affiliates of the parent to compute it and we lose a sizeable amount of observations. Thus, we view these results as complementary to the previous ones.

We conclude our empirical exercise with an attempt to disentangle the effects of the network shock. In particular, we decompose it in three: (i) parent shock, (ii) domestic affiliates and (iii) foreign affiliates. By construction, the sum of these three shocks adds up to the network shock. Thus, we run equation 6 by including separately the three components of the $NetworkShock$.

5 Results

This section present the main results of the paper. First, we analyze how multinational firms are affected by experiencing a financial crises in its location. Second, we examine how the

[19] $Y_{p,T} = \frac{\sum_{t=0}^{T} y_{p,t}}{y_{p,t=0}}$ denotes cumulative outcome variable y between 0 and T normalized by initial outcome variable y.

[20] Affiliates are classified as horizontal or vertical based on their industrial classification. Horizontal2 (4) is set to one if both parent and affiliate operate in the same NACE 2(4)-digit industry and vertical otherwise.

survival of affiliates depends on both the financial crises at home and in the country of the parent. Lastly, we investigate how a shock to the network affects multinational activity and supply chain.

5.1 Parent Shock

We start our analysis with the effect of domestic financial shock on parent's outcome. Table 1 reports the results for sales and employment. The variable of interest is the change in risk premium in the country of the parent. Columns 1 to 3 refer to changes in sales between 2006 and 2015. All coefficient of the variable of interest are negative and statistically significant. Column 1 implies that parents located in more financially hit countries are more likely to experience a decline in sales. A ten percentage point higher risk premium is associated with an almost 15 percent higher probability of declining sales or exiting. Also for surviving parents, the effects are substantial. A one percentage point increase in risk premium is associated with a 5 percent lower sales growth (column 2). The result is robust to winsorizing the dependent variable (column 3). Columns 4 to 6 repeat the same exercise for employment, which is a common proxy for size. The qualitative results are the same. Quantitatively, a one percent increase in the risk premium represents a 1.8 percent decline in employment growth at surviving parents. These results are not directly comparable with the related literature since we compare multinationals located in different countries. However, it seems consistent with the findings of Alviarez et al. (2017) which document that multinationals grew slower than domestic firms between 2008 and 2009. An important difference is that, in our case, it seems that the negative effect did not just last one year but it had a longer-run effect.

Next, we turn to the effect of the parent shock on the network. Table 2 reports the results. The overall picture that emerges is that the size of the network diminishes. Different columns explore different changes in the structure of the network. For example, parents in financially hit country are more likely to shrink or exit (columns 1 and 2) and less likely to expand (column 3). The number of affiliates diminishes (column 4 and 5) and this decline seems to come from dropping domestic affiliates (column 6).

A potential concern with these findings is that these effects could be unrelated to financial conditions. To address this concern, we interact the parent shock with the initial leverage of the firm. If the shock is financial, we would expect that the effects were exacerbated in more leveraged parents. Tables 3 and 4 reproduce the previous two tables with this interaction term. We are now able to include country fixed effects in addition to the industry fixed effects. Thus, the country-specific parent shock drops from the regression. However, in this regression, the variable of interest is the interaction term as we are interested in leverage as a potential mechanism. As expected, the negative effect of the country shock is exacerbated among leveraged parents. This is true for both sales and employment (Table 3) as for the shortening of the supply chain (Table 4). Interestingly, more leverage hit parents drop foreign affiliates located

in the PIGS. These changes in the organization of production had not been, to the best of our knowledge, documented before. The importance of leverage of European firms during the financial crises was also documented in Kalemli-Ozcan et al. (2018). The results are not comparable since they focus on investment and do not target multinational activity. However, both sets of results indicate that initial leverage is a key predictor of the effects of financial crises.

5.2 Affiliate Shock

We now turn our attention to the effect of shocks to the affiliates. In this case, we postulate that affiliates can be shocked both for their location and the location of the parent. For affiliates, we are interested in survival. Thus, our dependent variable is a dummy equal to one if the affiliate exits before 2015.

Table 5 reproduces the results. The coefficients of both affiliate and parent country shock are positive and statistically significant. Quantitatively. it seems that the shock in the country of the parent is more important than the shock in the country of the affiliate. For example, according to our most demanding specification (column 4), one percent increase in risk premium in the country of the parent increases the probability of exit for 0.95 percent. In comparison, the shock in the country of the affiliate translates into an increase of 0.25 percent. It is also noteworthy that when we include affiliate country fixed effects (column 5), the coefficient of parent shock remains positive. These results are complementary to the findings of Alfaro and Chen (2012), which show that foreign owned firms coped better with the crises than domestic firms. Our results emphasize that if it is also relevant the country where the owner is located.

In the same table we also explore potential heterogeneous effects of the financial shock across networks. For example, in column 7, we document that the effect of the parent shock is reduced in cross-border relationships. In columns 9 and 6, we show that the effect increases if the affiliate is majority owned or has higher input requirement, respectively. The latter result speaks to the differential effects between horizontal and vertical relationships. Ceteris paribus, higher input requirement (a measure vertical relationship) is negatively correlated with exit (columns 1 to 9). This results is consistent with affiliates providing relationship specific inputs to the parent (Antràs (2014). The positive coefficient of the interaction suggests that affiliates in vertical relationship may depend more on credit from the parent and, thus, they are more likely to exit if the parent is financially hit. In the next section, we will explore in more detail which type of affiliates are more likely to be dropped when the network is hit.

Following up on this later result, we explore the effect of leverage of both affiliate and parent. Table 6 reports different specifications when we include these interactions. One first result is that the interaction with the leverage of the affiliate is not statistically significant. This is true both for the actual initial leverage as for a dummy equal to one if the leverage is above the industry median. In contrast, we find that the leverage of the parent exacerbated the impact of the shock. This results is robust to the different specifications and definitions of leverages.

The interpretation is that the probability that an affiliates exist is larger when it is owned by a leverage parent located in financially hit country. 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 in multinational activity has been discussed before (Antràs and Yeaple, 2014).

5.3 The Network Shock

In this last section, we examine the effect of the network shock on parent's outcome and organization of production. As explained in Section 3, the network shock is an (assets) weighted average of the financial shock. In this shock, we include both the shock in the country of the parent and the shock in the country of the affiliate. The main advantage of this specification is that this is a parent specific shock. Different parents, within the same country and industry, will most likely have a different set of affiliates. The main drawback of this specification is that we need information on the affiliates to compute it and, thus, we lose a sizeable amount of observations. Another difference is that in this section our dependent variables are (normalized) cumulative changes between 2006 and 2015. This is a standard measure to track long-run effects of shocks (see, for example, the trade shock literature following the seminal paper of Autor et al. (2014)). It allow us, for example, to explore how the effects build up over time. In addition, by normalizing by initial outcomes, it facilitates the interpretation of the results.

Panel A of Table 7 reports the effects of the network shock in parent's outcome. All regressions include parent country-industry fixed effects. Parents in more financially hit networks experience a decline in both size (column 1) and sales (column 2) growth. Quantitatively, the effects are very similar, a one percent increase in network shock reduces normalized cumulative size (employees) and sales by 0.26 percent and 0.23 percent of initial values. These magnitudes may seem small compared to the parent shock. However, notice that in this specification we are including country-industry fixed effects which absorbs all the country specific shocks. 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.

Panel A of Table 8 reports the effects on the structure of the network. We find that parents in more financially hit networks have a relatively lower number of affiliates (column 1). This effect seems to happen in both domestic and foreign affiliates, even though the significance is larger for domestic. More interesting, when we consider horizontal vs. vertical relationships (columns 4/5 vs. 6/7), we see that the relative shrinkage of the network is mostly driven by affiliates in vertical relationships. When we use a less stringent definition of vertical, we find a mild (10 percent significant) effect also on horizontal relationships (column 5).

Lastly, in Panel B of both tables, we decompose the network shock in three. First, the

parent network, which is the increase in risk premium in the country of the parent times its assets weight in the network. Analogously, the *domestic network* and the *foreign network* are the assets weighted of the increases in financial risk in the domestic and foreign affiliates, respectively. Note that the parent network shock is different from the parent shock discussed above. The latter was country specific, this new one is parent specific since it is multiplied by the importance of the asset of the parent in the network. When considering parent's outcomes (Table 7), it seems that the location of foreign affiliates drives the results on size. Indeed, according to column 1, a one percent increase in the foreign network shock translates into 0.3 percent lower (normalized) cumulative size. In contrast, the effect on sales comes from the parent shock. A one percent increase in the parent shock, represents a decline in 1.1 percent in (normalized) cumulative sales. Since we include country fixed effects, it means that the lower is the diversification of the parent, the higher is the sales loss. We conclude the analysis by decomposing the effect on the structure of the network (Panel B of Table 8). The shock coming from foreign affiliates seems the overall most important. For example, the most significant determinant on the effect on the number of affiliates is the affiliates being located in more financially hit countries (column 1). It is also the most important determinant of the effect on vertical relationships. A plausible explanation is that affiliates located in more financially hit countries, specially those vertically integrated, need trade credit from the parent and are the most likely to be dropped. This is also consistent with the findings on affiliates' exit described above. Maybe interestingly, the parent network shock does not seem relevant to explain the changing organization of production. In other words, given the shock in the country of the parent, being more or less diversified, does not significantly affect how they change the structure of the network.

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), the literature has largely ignored the effects on the global supply. 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 25 European countries between 2006 and 2015 to examine the effect of the financial disruption on multinational activity and network structure.

We obtained three set of results. First, parents located in financially hit countries experience a growth reduction in sales and size. In addition, they are also more likely to reduce the size of their networks and move their affiliates away from the periphery. All these effects are exacerbated among more leveraged parents. Second, affiliates owned by parents located in financially hit countries are more likely to exit. This effect increases with the leverage of parent.

Finally, when we take into account the shock to the entire network, we document that parents in more financially hit networks experience a decline in sales and size growth. In addition, they also have lower increase in the number of affiliates, mostly driven by vertical relationships.

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 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. According to our evidence, these results may need to be qualified given that the network itself also changes. We leave a quantitative analysis of the financial shock for future research.

References

Acemoglu, D., S. Johnson, and T. Mitton (2009): "Determinants of Vertical Integration: Financial Development and Contracting Costs," *Journal of Finance*, 64, 1251–1290.

Alfaro, L. and A. Charlton (2009): "Intra-industry Foreign Direct Investment," *American Economic Review*, 99, 2096–2119.

Alfaro, L. and M. X. Chen (2012): "Surviving the Global Financial Crisis: Foreign Ownership and Establishment Performance," *American Economic Journal: Economic Policy*, 4, 30–55.

Altomonte, C., G. I. Ottaviano, A. Rungi, and T. Sonno (2021): "Business groups as knowledge-based hierarchies of firms," CEPR Discussion Paper 16677, Centre for Economic Policy Research.

Alviarez, V., J. Cravino, and A. A. Levchenko (2017): "The growth of multinational firms in the Great Recession," *Journal of Monetary Economics*, 85, 50–64.

Antràs, P. (2014): "Grossman–Hart (1986) Goes Global: Incomplete Contracts, Property Rights, and the International Organization of Production," *Journal of Law, Economics, and Organization*, 30, 118–175.

Antràs, P. and S. R. Yeaple (2014): "Multinational Firms and the Structure of International Trade," in *Handbook of International Economics*, ed. by G. Gopinath, . Helpman, and K. Rogoff, Elsevier, vol. 4 of *Handbook of International Economics*, chap. 0, 55–130.

Autor, D. H., D. Dorn, G. H. Hanson, and J. Song (2014): "Trade Adjustment: Worker-Level Evidence," *The Quarterly Journal of Economics*, 129, 1799–1860.

Basco, S. (2013): "Financial development and the product cycle," *Journal of Economic Behavior & Organization*, 94, 295–313.

——— (2018): *Housing Bubbles*, no. 978-3-030-00587-0, Palgrave Macmillan. Springer Books.

Basco, S., D. Lopez Rodriguez, and E. Moral-Benito (2021): " House Prices and Misallocation: The Impact of the Collateral Channel on Productivity ," Bank of spain working paper no. 2135.

Blanchard, O. J., M. Das, and H. Faruqee (2010): "The Initial Impact of the Crisis on Emerging Market Countries," *Brookings Papers on Economic Activity*, 41, 263–323.

Buera, F. J., J. P. Kaboski, and Y. Shin (2015): "Entrepreneurship and Financial Frictions: A Macrodevelopment Perspective," *Annual Review of Economics*, 7, 409–436.

Cravino, J. and A. A. Levchenko (2017): "Multinational Firms and International Business Cycle Transmission," *The Quarterly Journal of Economics*, 132, 921–962.

Gopinath, G., Şebnem Kalemli-Özcan, L. Karabarbounis, and C. Villegas-Sanchez (2017): "Capital Allocation and Productivity in South Europe," *The Quarterly Journal of Economics*, 132, 1915–1967.

Jordà, O., M. Schularick, and A. M. Taylor (2013): "When Credit Bites Back," *Journal of Money, Credit and Banking*, 45, 3–28.

Kalemli-Ozcan, S., L. Laeven, and D. Moreno (2018): " Debt overhang, rollover risk, and corporate investment: Evidence from the European crisis ," CEPR Discussion Paper 12881, Centre for Economic Policy Research.

Kalemli-Ozcan, S., B. E. Sørensen, C. Villegas-Sanchez, V. Volosovych, and S. Yesiltas (2022): "How to Construct Nationally Representative Firm Level Data from the Orbis Global Database: New Facts and Aggregate Implications," NBER Working Paper 21558, National Bureau of Economic Research.

Merlevede, B., M. D. Zwaan, K. Lenaerts, and V. Purice (2015): "Multinational Networks, Domestic,and Foreign Firms in Europe," Working Papers of Faculty of Economics and Business Administration, Ghent University, Belgium 15/900.

Schularick, M. and A. M. Taylor (2012): "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008," *American Economic Review*, 102, 1029–1061.

A Tables

Table 1: Parent sales and employment performance

	(1)	(2)	(3)	(4)	(5)	(6)
		Sales			*Employment*	
	increase?	log growth	log growth (win)	increase?	log growth	log growth (win)
Parent shock	-1.478***	-5.017***	-4.575***	-1.307***	-1.757**	-1.903***
	[0.205]	[0.865]	[0.750]	[0.209]	[0.716]	[0.655]
Total assets (parent)	0.008**	-0.079***	-0.067***	0.018***	-0.063***	-0.059***
	[0.004]	[0.017]	[0.015]	[0.004]	[0.014]	[0.013]
Age (parent)	0.028***	-0.049	-0.039	0.013*	-0.089***	-0.084***
	[0.008]	[0.033]	[0.029]	[0.008]	[0.027]	[0.024]
Initial # affiliates	0.042***	0.140***	0.129***	0.022**	0.102***	0.096***
	[0.009]	[0.036]	[0.031]	[0.009]	[0.030]	[0.027]
Observations	5,848	4,682	4,682	6,035	4,848	4,848
R-squared	0.072	0.043	0.050	0.058	0.027	0.030
Parent industry FE	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is parents with networks with at least two affiliates; dependent variable is indicated in column headings. Column 1 (4) uses a dummy that is set to one when there is a strict increase in sales (employment) between 2006 and 2015, the dummy is set to zero when there is a decrease. The dummy is also set to zero for exiting networks. Columns 2 and 5 use log growth, columns 3 and 6 use log growth winsorized at the 1st and 99th percentile; only surviving networks are included in the estimation sample so growth rates refer to networks existing throughout the period 2006-15.

Table 2: Parent network evolution

	(1) exit	(2) shrink/exit	(3) expand	(4) Δ#af. (rel., win)	(5) Δ#af. (abs., win)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Does the parent reduce ...? (0/1)						
						# dom af.	# for af.	for share	# PIGS af.	PIGS sh	# PIGS af.	PIGS sh
Parent shock	0.385***	0.880***	-0.566***	-1.166***	-25.296***	1.637***	0.108	-0.029	1.592***	0.074	2.406	-1.000
	[0.145]	[0.187]	[0.176]	[0.352]	[4.559]	[0.194]	[0.185]	[0.187]	[0.238]	[0.230]	[1.962]	[1.864]
Total assets (parent)	-0.011***	-0.033***	0.040***	0.093***	0.688***	-0.025***	-0.026***	-0.013***	-0.035***	0.025***	-0.021***	0.020***
	[0.002]	[0.002]	[0.002]	[0.005]	[0.059]	[0.003]	[0.002]	[0.002]	[0.006]	[0.006]	[0.008]	[0.007]
Age (parent)	-0.034***	-0.027***	0.010	0.021*	0.152	-0.024***	-0.029***	-0.016**	-0.029**	-0.026**	-0.022	-0.006
	[0.005]	[0.006]	[0.006]	[0.012]	[0.158]	[0.007]	[0.006]	[0.006]	[0.012]	[0.012]	[0.016]	[0.016]
Initial Numb. affiliates	-0.051***	0.029***	0.036***	-0.031**	3.973***	0.094***	-0.003	-0.053***	0.082***	0.020*	0.049***	-0.008
	[0.005]	[0.007]	[0.006]	[0.013]	[0.168]	[0.007]	[0.007]	[0.007]	[0.013]	[0.012]	[0.017]	[0.016]
Observations	9,499	9,499	9,499	9,499	9,499	8,330	9,499	9,499	2,989	2,989	1,417	1,417
R-squared	0.055	0.052	0.098	0.089	0.194	0.040	0.051	0.047	0.061	0.056	0.088	0.066
Parent industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is parents with networks with at least two affiliates. Dependent variable is indicated in column headings. Columns 1 to 3 have as dependent variable a dummy set to one if the network exits (col. 1), the network exits or shrinks (col. 2), and the network expands (col. 3). Column 4 uses the percentage change in the number of affiliates in the network as dependent variable, column 5 the unit change in the number of affiliates. Columns 6 to 12 focus on whether the parent reduces the number of specific types of affiliates. Column 6, 7, and 9 use a dummy variable set one if the number of domestic, foreign, or PIGS affiliates is reduced respectively. Columns 8 and 10 use set the dummy variable to 1 if the share of foreign or PIGS affiliates has decreased. The sample in columns 6 to 12 is networks that contain at least one of the specific types of affiliates indicated in the column heading, columns 11 and 12 that repeat the setting of columns 9 and 10 additionally exclude parents that are located in PIGS themselves.

Table 3: Parent sales and employment performance - initial leverage interaction

	(1)	(2)	(3)	(4)	(5)	(6)
		sales			*employment*	
	increase?	log growth	log growth (win)	increase?	log growth	log growth (win)
Parent shock × leverage	-1.765*	-17.351***	-16.087***	-2.095**	-9.236***	-9.134***
	[1.054]	[5.012]	[4.659]	[1.020]	[3.338]	[3.246]
Leverage (parent)	-0.073**	-0.018	-0.033	-0.038	-0.123	-0.119
	[0.036]	[0.154]	[0.143]	[0.032]	[0.091]	[0.088]
Total assets (parent)	0.019***	-0.039	-0.038	0.022***	-0.054***	-0.051***
	[0.006]	[0.027]	[0.025]	[0.006]	[0.017]	[0.017]
Age (parent)	0.011	-0.132***	-0.123***	0.000	-0.192***	-0.184***
	[0.013]	[0.048]	[0.045]	[0.012]	[0.032]	[0.031]
Initial # affiliates	0.039**	0.150**	0.144**	0.012	0.094**	0.087**
	[0.016]	[0.061]	[0.057]	[0.016]	[0.041]	[0.040]
Observations	2,902	2,131	2,131	2,941	2,221	2,221
R-squared	0.090	0.099	0.106	0.094	0.097	0.098
Parent industry FE	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is parents with networks with at least two affiliates; dependent variable is indicated in column headings. Column 1 (4) uses a dummy that is set to one when there is a strict increase in sales (employment) between 2006 and 2015, the dummy is set to zero when there is a decrease. The dummy is also set to zero for exiting networks. Columns 2 and 5 use log growth, columns 3 and 6 use log growth winsorized at the 1st and 99th percentile; only surviving networks are included in the estimation sample so growth rates refer to networks existing throughout the period 2006-15.

Table 4: Parent network evolution - initial leverage interaction

	(1) exit	(2) shrink/exit	(3) expand	(4) Δ#af. (rel., win)	(5) Δ#af. (abs., win)	(6) Does the parent reduce ...? (0/1) dom af.	(7) for af.	(8) share for	(9) PIGS af.	(10) PIGS sh
Parent Shock × leverage	1.553**	1.265*	-1.830***	-3.169**	-17.338*	1.530*	0.968	0.669	3.647***	2.777**
	[0.622]	[0.736]	[0.674]	[1.295]	[9.501]	[0.781]	[0.746]	[0.753]	[1.269]	[1.272]
Leverage parent	-0.024	-0.004	0.004	-0.012	-0.058	0.027	-0.010	-0.030	-0.058	-0.080
	[0.020]	[0.023]	[0.021]	[0.041]	[0.301]	[0.026]	[0.024]	[0.024]	[0.058]	[0.059]
Total assets (parent)	-0.013***	-0.045***	0.047***	0.097***	0.198***	-0.023***	-0.026***	-0.013***	-0.043***	0.010
	[0.004]	[0.004]	[0.004]	[0.008]	[0.056]	[0.005]	[0.004]	[0.004]	[0.010]	[0.010]
Age (parent)	-0.039***	-0.026***	0.007	0.023	0.483***	-0.025**	-0.037***	-0.022**	-0.013	-0.043**
	[0.008]	[0.010]	[0.009]	[0.017]	[0.125]	[0.010]	[0.010]	[0.010]	[0.018]	[0.018]
Initial Numb. affiliates	-0.064***	0.073***	0.013	-0.111***	-0.108	0.135***	-0.002	-0.037***	0.129***	0.072***
	[0.011]	[0.013]	[0.012]	[0.023]	[0.169]	[0.014]	[0.013]	[0.013]	[0.022]	[0.022]
Observations	4,823	4,823	4,823	4,823	4,823	4,096	4,823	4,823	1,528	1,528
R-squared	0.071	0.095	0.114	0.115	0.067	0.094	0.069	0.055	0.118	0.089
Parent industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Parent country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is parents with networks with at least two affiliates. Dependent variable is indicated in column headings. Columns 1 to 3 have as dependent variable a dummy set to one if the network exits (col. 1), the network exits or shrinks (col. 2), and the network expands (col. 3). Column 4 uses the percentage change in the number of affiliates in the network as dependent variable, column 5 the unit change in the number of affiliates. Columns 6 to 12 focus on whether the parent reduces the number of specific types of affiliates. Column 6, 7, and 9 use a dummy variable set one if the number of domestic, foreign, or PIGS affiliates is reduced respectively. Columns 8 and 10 use set the dummy variable to 1 if the share of foreign or PIGS affiliates has decreased. The sample in columns 6 to 10 is networks that contain at least one of the specific types of affiliates indicated in the column heading, columns 9 and 10 additionally exclude parents that are located in PIGS themselves.

Table 5: Affiliate exit - cross-section, linear probability model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Affiliate Shock	0.302***	0.237***	0.408***	0.250***		0.163**	-0.136	0.253***	0.276***
	[0.082]	[0.084]	[0.091]	[0.084]		[0.081]	[0.098]	[0.084]	[0.084]
Parent Shock	1.186***	0.833***	0.770***	0.953***	1.042***		1.630***	0.839***	0.522***
	[0.087]	[0.091]	[0.100]	[0.092]	[0.092]		[0.129]	[0.105]	[0.152]
cross-border		0.037***	0.042***	0.044***	0.073***	0.023***	0.060***	0.043***	0.043***
		[0.003]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Input requirm.		-0.374***	-0.330***	-0.229***	-0.228***	-0.316***	-0.224***	-0.258***	-0.229***
		[0.025]	[0.028]	[0.031]	[0.031]	[0.031]	[0.031]	[0.034]	[0.031]
Majority-owned		-0.103***	-0.095***	-0.099***	-0.100***	-0.076***	-0.099***	-0.099***	-0.109***
		[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]
Log network size		-0.006***	0.006***	0.005***	0.007***		0.005***	0.005***	0.005***
		[0.001]	[0.001]	[0.001]	[0.001]		[0.001]	[0.001]	[0.001]
Log af. size			-0.017***						
			[0.001]						
Parent shock interactions with									
Cross-border							-1.286***		
							[0.172]		
Input requirm.								1.938**	
								[0.878]	
Majority-owned									0.557***
									[0.156]
Observations	92,510	84,537	65,307	84,537	84,537	84,128	84,537	84,537	84,537
R-squared	0.005	0.014	0.024	0.034	0.059	0.365	0.035	0.034	0.034
Aff. industry FE	-	-	-	Y	Y	Y	Y	Y	Y
Aff. country FE	-	-	-	-	Y	-	-	-	-
Parent industry FE	-	-	-	Y	Y	-	Y	Y	Y
Parent FE	-	-	-	-	-	Y	-	-	-

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is affiliates existing in 2006 from networks with at least two affiliates; dependent variable is set to one if affiliate exits before 2015 and zero otherwise.

Table 6: Affiliate exit; leverage effects - cross-section, linear probability model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Affiliate variables									
Shock	0.488**	0.797**	0.542**	0.923***			0.449**		0.468**
	[0.229]	[0.338]	[0.230]	[0.339]			[0.179]		[0.211]
Leverage	-0.019*		-0.020*		-0.004				
	[0.011]		[0.011]		[0.011]				
Shock × Leverage	0.099		-0.003		-0.416				
	[0.317]		[0.315]		[0.316]				
Leverage dummy		-0.038***		-0.041***		-0.039***			
		[0.013]		[0.012]		[0.013]			
Shock × dummy		-0.418		-0.529		-0.669*			
		[0.349]		[0.347]		[0.346]			
Parent variables									
Shock	-0.369	-0.170							0.658***
	[0.306]	[0.328]							[0.237]
Leverage	-0.013		0.004		0.008		0.013	0.016	
	[0.016]		[0.017]		[0.017]		[0.013]	[0.013]	
Shock × leverage	2.687***		2.256***		2.143***		1.430***	1.337***	
	[0.521]		[0.532]		[0.529]		[0.402]	[0.400]	
Leverage dummy		-0.015		-0.013		-0.008			
		[0.011]		[0.011]		[0.011]			
Shock × dummy		1.305***		1.257***		1.197***			
		[0.353]		[0.357]		[0.355]			
Cross-border	0.003	0.001	0.004	0.002	0.010	0.009	0.019**	0.031***	0.004
	[0.009]	[0.009]	[0.009]	[0.009]	[0.011]	[0.011]	[0.007]	[0.009]	[0.009]
Input requirm.	-0.098	-0.085	-0.072	-0.059	-0.068	-0.051	-0.091	-0.090	-0.091
	[0.083]	[0.083]	[0.082]	[0.082]	[0.082]	[0.082]	[0.070]	[0.069]	[0.083]
Majority-owned	-0.064***	-0.066***	-0.061***	-0.063***	-0.064***	-0.066***	-0.073***	-0.075***	-0.064***
	[0.010]	[0.010]	[0.010]	[0.010]	[0.009]	[0.009]	[0.008]	[0.008]	[0.010]
Log network size	0.028***	0.027***	0.026***	0.025***	0.024***	0.024***	0.023***	0.023***	0.026***
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.004]	[0.004]	[0.005]
Observations	15,085	15,085	15,084	15,084	15,084	15,084	20,939	20,938	15,085
R-squared	0.041	0.040	0.061	0.061	0.076	0.077	0.057	0.069	0.038
Affiliate industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Parent industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Affiliate country FE					Y	Y		Y	
Parent country FE			Y	Y	Y	Y	Y	Y	

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is affiliates existing in 2006 from networks with at least two affiliates; dependent variable is set to one if affiliate exits before 2015 and zero otherwise. Leverage dummy is set to one if affiliate/parent is above the industry median in a given year. Last column for comparison to previous table with larger set of affiliates included in estimations

Table 7: Parent normalized cumulative outcomes and network shock; cross-section for networks with total assets in base year

	(1) employees	(2) sales	(3) op.rev.	(4) leverage	(5) assets	(6) RoA
			Panel A - Network shock			
$NetworkShock$	-0.264**	-0.229**	-0.126	-0.669***	-0.206**	0.212
	[0.123]	[0.110]	[0.108]	[0.179]	[0.081]	[2.017]
$Naffiliates^{06}$	0.258***	0.200***	0.302***	0.303*	0.166***	1.399*
	[0.083]	[0.072]	[0.074]	[0.184]	[0.050]	[0.806]
$domestic^{06}$	0.954**	0.455	1.091***	1.014	1.115***	19.483***
	[0.415]	[0.315]	[0.340]	[0.697]	[0.267]	[6.532]
$InitialSize_p$	0.301***	0.265***	0.070	0.223	-0.323***	0.831
	[0.103]	[0.102]	[0.102]	[0.190]	[0.058]	[1.032]
Age_p	-0.180	-0.579**	-0.584*	0.420	-0.132	-9.878**
	[0.239]	[0.231]	[0.348]	[0.638]	[0.262]	[3.946]
Observations	2,918	1,909	2,745	1,682	4,151	3,249
R-squared	0.124	0.190	0.145	0.212	0.121	0.095
			Panel B - Decomposed network shock			
$ParentNetworkShock$	-0.546	-1.076***	-1.111***	-1.252*	-0.919***	-4.456
	[0.397]	[0.268]	[0.311]	[0.664]	[0.241]	[4.948]
$DomesticNetworkShock$	-0.091	-0.111	-0.090	-0.105	-0.341**	0.981
	[0.185]	[0.152]	[0.174]	[0.346]	[0.143]	[3.414]
$ForeignNetworkShock$	-0.325**	-0.143	-0.011	-1.001***	-0.122	1.025
	[0.156]	[0.128]	[0.137]	[0.246]	[0.105]	[2.352]
$Naffiliates^{06}$	0.238***	0.136*	0.255***	0.223	0.140***	1.184
	[0.085]	[0.074]	[0.076]	[0.183]	[0.050]	[0.820]
$domestic^{06}$	0.831*	0.372	1.079***	0.350	1.269***	19.059***
	[0.451]	[0.345]	[0.369]	[0.795]	[0.290]	[6.845]
$InitialSize_p$	0.318***	0.342***	0.135	0.289	-0.284***	1.108
	[0.105]	[0.104]	[0.104]	[0.189]	[0.059]	[1.094]
Age_p	-0.225	-0.602***	-0.608**	0.290	-0.084	-10.226***
	[0.255]	[0.195]	[0.279]	[0.681]	[0.228]	[3.868]
Observations	2,918	1,909	2,745	1,682	4,151	3,249
R-squared	0.124	0.197	0.149	0.216	0.124	0.096
Parent country-industry FE	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is parents with networks with at least two affiliates; dependent variable is indicated in column headings.

Table 8: Network number of affiliates normalized cumulative outcomes and network shock; cross-section for networks with total assets in base year available

	(1) number	(2) foreign	(3) domestic	(4) horizontal2	(5) horizontal4	(6) vertical2	(7) vertical4
			Panel A - Network shock				
$TotalNetworkShock$	-0.210***	-0.130*	-0.298***	-0.106	-0.092*	-0.194**	-0.187***
	[0.064]	[0.077]	[0.066]	[0.065]	[0.055]	[0.075]	[0.071]
$\#affiliates^{06}$	-0.113***	0.204***	-0.168***	0.398***	0.307***	0.010	-0.043
	[0.040]	[0.057]	[0.042]	[0.045]	[0.041]	[0.046]	[0.044]
$domestic^{06}$	-0.258	0.313	7.238***	0.278	0.348*	0.201	-0.146
	[0.227]	[0.242]	[0.215]	[0.221]	[0.188]	[0.254]	[0.244]
$InitialSize_p$	0.458***	0.511***	0.281***	0.349***	0.254***	0.434***	0.445***
	[0.043]	[0.051]	[0.048]	[0.040]	[0.033]	[0.048]	[0.046]
Age_p	-0.768	-1.218***	0.028	-0.013	-0.228	-0.640*	-0.344
	[0.547]	[0.321]	[0.754]	[0.675]	[0.675]	[0.331]	[0.304]
Observations	4,151	4,151	4,151	4,151	4,151	4,151	4,151
R-squared	0.193	0.181	0.367	0.277	0.234	0.191	0.188
			Panel B - Decomposed network shock				
$ParentNetworkShock$	-0.119	-0.366	-0.124	0.219	0.214	-0.291	-0.157
	[0.197]	[0.243]	[0.210]	[0.198]	[0.163]	[0.221]	[0.216]
$DomesticNetworkShock$	-0.309**	-0.207	-0.298**	-0.158	-0.093	-0.271*	-0.252*
	[0.130]	[0.158]	[0.145]	[0.134]	[0.114]	[0.145]	[0.140]
$ForeignNetworkShock$	-0.228***	-0.106	-0.379***	-0.139	-0.135*	-0.182*	-0.202**
	[0.087]	[0.104]	[0.085]	[0.088]	[0.076]	[0.104]	[0.098]
$\#affiliates^{06}$	-0.106**	0.196***	-0.162***	0.414***	0.320***	0.008	-0.040
	[0.041]	[0.058]	[0.043]	[0.046]	[0.041]	[0.047]	[0.045]
$domestic^{06}$	-0.167	0.392	7.242***	0.319	0.346*	0.289	-0.081
	[0.240]	[0.264]	[0.227]	[0.235]	[0.201]	[0.271]	[0.260]
$InitialSize_p$	0.454***	0.524***	0.274***	0.333***	0.239***	0.440***	0.445***
	[0.044]	[0.053]	[0.049]	[0.040]	[0.034]	[0.049]	[0.047]
Age_p	-0.699	-1.182***	0.070	0.037	-0.200	-0.586*	-0.293
	[0.536]	[0.334]	[0.753]	[0.688]	[0.693]	[0.319]	[0.300]
Observations	4,151	4,151	4,151	4,151	4,151	4,151	4,151
R-squared	0.193	0.181	0.367	0.278	0.235	0.191	0.188
Parent country-industry FE	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1; sample is parents with networks with at least two affiliates; dependent variable is indicated in column headings. Affiliates are classified as horizontal or vertical based on their industrial classification. Horizontal2(4) is set to one if both parent and affiliate operate in the same NACE 2(4)-digit industry and vertical otherwise.

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

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August 2022

A Additional Tables

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Table 1: Number of networks (network/parent-year observations)

	No.	%
2006	18,223	12.1
2007	17,480	11.6
2008	17,010	11.3
2009	16,057	10.7
2010	15,159	10.1
2011	14,442	9.6
2012	13,758	9.2
2013	13,390	8.9
2014	12,551	8.4
2015	12,087	8
Total	150,157	100.0

Source: ALLMNE06.dta

Table 2: Parent country location frequency (unique parents) in 2006

	No.	%
Parent home country		
DE	2,685	14.7
NL	2,475	13.6
GB	2,206	12.1
BE	2,083	11.4
IT	1,839	10.1
FR	1,426	7.8
DK	1,108	6.1
SE	1,051	5.8
ES	1,027	5.6
AT	622	3.4
IE	447	2.5
NO	350	1.9
FI	292	1.6
GR	111	0.6
PT	111	0.6
HU	77	0.4
EE	60	0.3
PL	56	0.3
CZ	51	0.3
SI	30	0.2
HR	22	0.1
UA	22	0.1
RO	18	0.1
LV	15	0.1
RU	12	0.1
LT	10	0.1
BG	7	0.0
SK	7	0.0
RS	3	0.0
Total	18,223	100.0

Source: ALLMNE06.dta

Table 3: Affiliate country location frequency (unique affiliates over period 2006-15, i.e. each affiliate counted once irrespective of the number of years and when it exists)

	No.	%
DE	36,006	14.1
GB	29,474	11.5
FR	25,117	9.8
NL	19,810	7.8
IT	17,611	6.9
ES	14,584	5.7
US	14,456	5.7
SE	11,217	4.4
BE	9,703	3.8
AT	5,380	2.1
NO	5,363	2.1
DK	5,351	2.1
IE	4,339	1.7
PL	4,317	1.7
FI	3,738	1.5
RO	2,904	1.1
CH	2,853	1.1
PT	2,661	1.0
CZ	2,418	0.9
BR	2,022	0.8
RU	2,013	0.8
CA	1,946	0.8
CN	1,908	0.7
AU	1,738	0.7
HU	1,543	0.6
LU	1,453	0.6
ZA	1,435	0.6
HK	1,380	0.5
MX	1,379	0.5
IN	1,327	0.5
GR	1,305	0.5
EE	1,013	0.4
SK	860	0.3
UA	828	0.3
AR	786	0.3
JP	738	0.3
CL	709	0.3
TR	676	0.3
SG	669	0.3
MY	636	0.2
HR	580	0.2
LV	513	0.2
... continued in next table		

Table 4: Affiliate country location frequency (unique affiliates) ... *continued*

	No.	%
... *continued*		
BG	497	0.2
TH	486	0.2
LT	476	0.2
KR	472	0.2
SI	468	0.2
RS	410	0.2
CY	401	0.2
CO	394	0.2
AE	391	0.2
MA	385	0.2
NZ	366	0.1
PE	308	0.1
TN	224	0.1
ID	222	0.1
PH	214	0.1
TW	214	0.1
PA	206	0.1
BM	195	0.1
EG	194	0.1
IL	183	0.1
MU	176	0.1
MT	154	0.1
SA	135	0.1
BA	128	0.1
CR	127	0.0
VE	125	0.0
DZ	116	0.0
NG	112	0.0
UY	100	0.0
KZ	99	0.0
ZW	96	0.0
EC	92	0.0
GT	87	0.0
PK	86	0.0
KE	81	0.0
DO	77	0.0
VN	73	0.0
AL	71	0.0
Total	255,494	100.0

Source: ALLMNE06.dta; affiliate locations with less than 70 affiliates counted in total but not represented in table

Table 5: Number of affiliates per parent (parent-year observations in 2006 and 2015)

	2006		**2015**	
	No.	%	No.	%
1	7,971	43.7	3,728	30.8
2	3,166	17.4	1,934	16.0
3	1,800	9.9	1,303	10.8
4	1,123	6.2	865	7.2
5	790	4.3	624	5.2
6 to 10	1,730	9.5	1,667	13.8
11 to 20	852	4.7	937	7.8
21 to 50	520	2.9	585	4.8
51 and more	271	1.5	444	3.7
Total	18,223	100.0	12,087	100.0

Source: ALLMNE06.dta

Table 6: Cross-tabulation of domestic and cross-border affiliates per network-year for the year 2006 (parent-year observations)

	Crossborder affiliates					
	1	**2**	**3**	**4**	**5-...**	Total
Domestic						
0	43.7	4.9	1.1	0.4	0.7	50.9
1	12.5	2.2	0.9	0.4	0.6	16.6
2	6.5	1.3	0.6	0.3	0.6	9.4
3	3.6	1.0	0.4	0.2	0.4	5.5
4	2.1	0.6	0.3	0.2	0.4	3.5
5-...	5.8	2.4	1.1	0.7	4.1	14.1
Total	74.2	12.4	4.4	2.2	6.9	100.0

Source: ALLMNE.dta for the year 2006

Table 7: Frequency of all parent-affiliate-year observations over years by *'grand'* affiliate location

	Affiliate location (observations)...							
	Domestic		**Europe**		**Extra-Europe**		**Total**	
	n	row%	n	row%	n	row%	n	col%
2006	55,621	54.0	41,983	40.8	5,330	5.2	102,934	6.6
2007	59,359	54.1	44,007	40.1	6,265	5.7	109,631	7.0
2008	63,968	54.1	46,847	39.6	7,501	6.3	118,316	7.5
2009	64,832	53.7	47,331	39.2	8,544	7.1	120,707	7.7
2010	63,596	53.6	45,872	38.7	9,165	7.7	118,633	7.6
2011	64,102	52.7	46,052	37.8	11,517	9.5	121,671	7.8
2012	62,532	51.4	45,089	37.1	13,949	11.5	121,570	7.7
2013	64,063	50.4	46,708	36.7	16,387	12.9	127,158	8.1
2014	63,339	49.4	46,056	35.9	18,734	14.6	128,129	8.2
2015	63,258	45.9	48,890	35.4	25,774	18.7	137,922	8.8

Source: ALLMNE06.dta

Table 8: Cross-tabulation of affiliates added and dropped per network-year (cells indicate share in total panel observations, network-year observations 2007-2015)

	# affiliates dropped						
	0	**1**	**2**	**3**	**4**	**5-...**	**Total**
# added							
			Panel A - All networks				
0	64.6	10.2	1.8	0.5	0.2	0.4	77.7
1	7.5	2.8	0.9	0.3	0.1	0.3	12.0
2	2.0	1.0	0.5	0.2	0.1	0.2	4.0
3	0.7	0.5	0.3	0.2	0.1	0.2	1.9
4	0.3	0.2	0.1	0.1	0.1	0.2	1.0
5-...	0.4	0.4	0.3	0.3	0.2	1.8	3.5
Total	75.5	15.0	3.9	1.6	0.9	3.0	100.0

Source: ALLMNE06.dta restricted to 2007-2015

Table 9: Distribution of ownership shares (observations)

	No.	%
fully-owned (more than 95%)	1,118,942	71.3
strictly more than 50% but not fully owned	191,904	12.2
between 10% and 50%	251,973	16.1
less than 10%	6,185	0.4
Total	1,569,004	100.0

Source: ALLMNE06.dta