The growth of multinational firms in the Great Recession*

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August 25, 2016

Abstract

We use a large firm-level dataset to study the performance of multinational firms across multiple countries during the Great Recession. We document that the foreign affiliates of multinational firms grew faster than local firms both before and after the crisis, but that this rapid growth was interrupted in the crisis. We disentangle the mechanisms accounting for this decline in multinational activity. Much of the slowdown can be explained by industry and size differences between domestic and foreign-owned firms. We show, however, that multinational firms from different source countries had different experiences during the crisis. Building on these results, we use a quantitative model of multinational production to assess the role of multinational firms in the global recession. Had multinationals' performance relative to domestic firms remained unchanged during the crisis, the median country's aggregate growth would have been 0.12% higher. The impact is heterogeneous across countries, ranging from -0.13 to 0.5%.

Keywords: Great Recession, multinational firms

JEL Codes: F23, F44

*We are grateful our discussant Kim Ruhl, and to workshop participants at the 2016 Carnegie-Rochester-NYU Conference on Public Policy, Michigan State, and 2016 SED for helpful suggestions. We thank Sam Haltenhof for excellent research assistance. This research is supported by the Michigan Institute for Teaching and Research in Economics (MITRE). Email: vanessa.alviarez@sauder.ubc.ca, jcravino@umich.edu, alev@umich.edu.

1 Introduction

Between 1980 and 2007, the global economy witnessed an unprecedented period of economic integration. While international trade in goods and services grew from 20% to 30% of world GDP, the growth of foreign direct investment was even more spectacular, with sales of foreign multinational affiliates growing from less than 20% of world GDP in the 1980s to nearly 50% today. This pace of economic integration appears to have halted during the recent Great Recession. While a large literature has focused on the collapse in trade and its role in the cross-border transmission of the crisis, little is known about the behavior of foreign multinational firms during this period. This paper uses novel firm-level data for a broad set of countries to shed light on two questions. First, was the growth of foreign multinationals relative to domestic firms affected by the Great Recession? Second, how did foreign multinationals contribute to the recession?

We first document that during the Great Recession there was a "Multinationals Sales Collapse" that was similar in magnitude to the much-studied "Trade Collapse." In particular, we use aggregate OECD statistics to show that manufacturing sales of foreign multinational affiliates fell by nearly as much as imports of goods in many OECD countries between 2008 and 2009. We then use a large firm-level database covering 8 million firms in 34 countries over the 2004-2014 period to better understand this aggregate phenomenon. The firm-level data also show a slowdown in foreign affiliates' sales relative to domestic firms' sales during the recession. While the combined sales of foreign affiliates grew faster than domestic firms before the crisis (2004-2008), they shrunk relative to domestic firms during the crisis (2008-2009). This pattern is pervasive across the developed and developing countries in our data, and across destination countries with different multinational presence. Foreign affiliates' growth was on average about 2 percentage points higher than the growth of domestic firms outside of the crisis, but 1 percentage point *lower* during the crisis.

We provide an account of the collapse in multinational firms' sales by focusing on the role of observable differences between foreign affiliates and domestically-owned firms. In particular, we exploit the firm-level nature of our data to show that the fall in multinational sales is largely explained by the sectoral composition and by differences in size across firms. Controlling for sectoral composition differences between foreign and domestic firms (by means of destination-industry-year fixed effects) reduces the crisis growth differential between foreign and domestic firms from -1 to zero percentage points. Further controlling for firm size implies that foreign affiliates actually grew faster during the crisis than domestic firms of comparable size, erasing any difference in relative per-

formance of multinationals in the crisis compared to the pre-crisis period. Finally, we implement a propensity score matching (PSM) estimator that matches each foreign multinational affiliate with a control group of domestically-owned firms within each sector and country based on observable firm characteristics such as size, age, and multi-product status. Refining the control group in this way produces essentially the same results. We conclude that the pronounced difference in performance between multinationals and domestic firms during the crisis is accounted for by observable differences between foreign affiliates and domestic firms. We show, however, that multinational firms are far from being a homogeneous group: the impact of the crisis varied substantially across foreign affiliates from different source countries. For instance, according to the PSM estimates French foreign affiliates actually grew 1% faster than domestic firms during the crisis compared to the pre-crisis years, whereas the Swedish foreign affiliates grew 2.3% slower.

A natural implication of the heterogeneity in multinational firms' performance is that their impact on aggregate growth should be different across destination countries that host different multinationals. We evaluate this implication in a quantitative multi-country model of multinational production that we calibrate to match observed bilateral multinational production shares. We interpret our empirical estimates of the differential growth by multinational firms through the lens of the model, which allows us to recover the shocks affecting multinationals from different source countries. We use these estimated shocks to conduct a counterfactual exercise that asks: how much would aggregate output change in the Great Recession had multinationals' relative performance remained the same as in normal times?

Our results show that output growth would have been 0.12 percentage points higher in the median country had multinationals' relative performance not been affected by the crisis. Among the 10 countries with the largest multinational presence (about the top third of our country sample), the counterfactual growth rate is 0.18 percentage points higher. Differences in the overall multinational presence and the fact that different countries host multinationals from different sources induce substantial differences in counterfactual growth rates across destination countries. The differences between counterfactual vs. actual growth rates in the full sample range from -0.13 to 0.5 percentage points. Relative to the overall output declines observed in these countries over 2008-2009, the incremental contribution of the shock to multinationals was thus modest.

This paper contributes to the literature on the international dimension of the Great Recession, and in particular its effect on cross-border linkages. A number of papers analyze the determinants of cross-country differences in the severity of the Great Recession, including openness to trade and capital flows (Blanchard et al., 2010; Lane and Milesi-

Ferretti, 2011; Berkmen et al., 2012). An extensive literature, surveyed by Bems et al. (2013), studies the Great Trade Collapse, and the transmission of country shocks through trade linkages (see, e.g. Bems et al., 2010; Levchenko et al., 2010). To our knowledge this is the first study that uses firm-level data spanning the crisis and its aftermath to study the performance of multinational firms during this period. Alfaro and Chen (2012) use a dataset similar to ours to argue that affiliates of foreign multinationals that had vertical production linkages to the parent or were in more financially dependent sectors did better during the crisis than local firms. The difference between our analysis and Alfaro and Chen (2012) is that while their data end in 2008, we observe the worst part of the Great Recession and its aftermath. While Alfaro and Chen (2012) analyze growth rates over 2007-2008, we show that the multinational collapse did not occur until the following year (2008-2009). Our paper also reveals that there is no single impact of multinational status on firm performance, as it varies in a first-order way across source countries. In addition, we explore the aggregate implications of the slowdown of foreign affiliate sales.

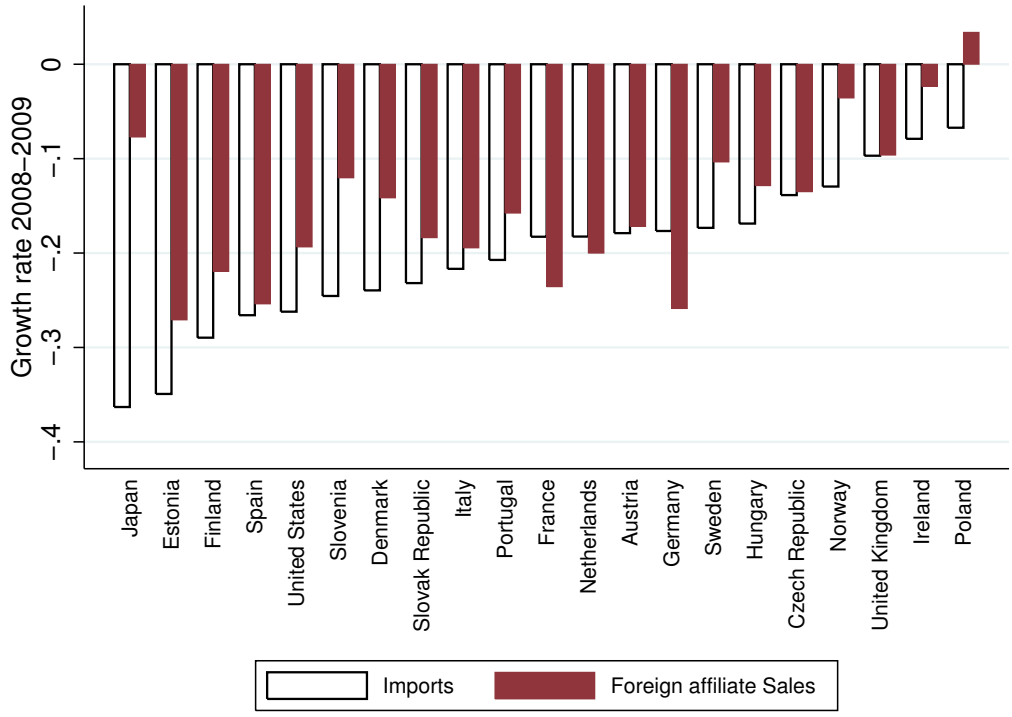
The rest of the paper is organized as follows. Section 2 presents the first evidence on a multinational sales collapse using publicly-available aggregate data. Section 3 presents the main empirical results using firm-level data. Section 4 lays out the theoretical framework and performs counterfactual experiments. Section 5 concludes.

2 Multinational sales collapse in aggregate data

This section documents that there was a collapse in the sales of foreign multinational affiliates coinciding with the collapse in trade of 2008-2009. We use publicly-available data on aggregate multinational sales and imports from the OECD Statistics database. Figure 1 compares the decline in foreign affiliate sales operating in the manufacturing sector to the decline of goods imports across 21 OECD countries between 2008 and 2009. The white bars depict the well-known collapse in goods imports in 2009 that motivated the Great Trade Collapse literature. The dark bars show that the collapse in trade coincided with a large decline in sales by the affiliates of foreign multinational firms. In fact, affiliate sales fell by more than imports in Germany, France, and the UK, and by nearly as much as imports in many of the other countries, including the US, where imports dropped by 26%, while foreign affiliate sales declined by 20%. Understanding the causes and consequences of this decline in foreign affiliate sales is the main goal of this paper.

Figure 2 displays the evolution of foreign affiliate sales in the manufacturing sector and imports normalized by the overall level of economic activity as proxied by GDP. The series are index numbers set to 1 in 2008. In many of the largest OECD countries, both for-

Figure 1: Collapse in imports and foreign affiliate sales, 2008-2009



Notes: This figure reports the growth rates of goods imports and of foreign affiliate sales between 2008-2009. Source: Authors' calculations based on OECD Statistics database. We use goods imports, and inward turnover by the foreign affiliates of multinational firms in the manufacturing sector in domestic currency.

eign affiliate sales and goods imports fell faster than GDP in 2009, and the multinational sales collapse was as pronounced as the collapse in imports.[1]

The aggregate data underlying Figures 1 and 2 have a number of limitations when it comes to understanding the decline in multinational activity. First, industrial production indices incorporate production that is done by affiliates of foreign multinational firms. This is problematic for isolating the relative performance of foreign affiliates, since they account for about 25 percent of sales in the median OECD country, and for more than 50 percent in the countries with the largest multinational presence. Second, as shown below, multinational firms operate in different industries than domestic firms, even within the manufacturing sector. There is growing consensus that much of the collapse in trade can be accounted for by differences in the sectoral composition of output vs. imports (see, e.g. Levchenko et al., 2010; Eaton et al., 2016), and the same feature may be important for the multinational collapse as well. Finally, aggregate sales data mask the different characteristics of domestic and foreign affiliate firms even within narrowly-defined sectors. An ideal comparison of the performance of the foreign affiliates and domestic firms thus requires firm-level data, to which we now turn.

3 Firm-level evidence

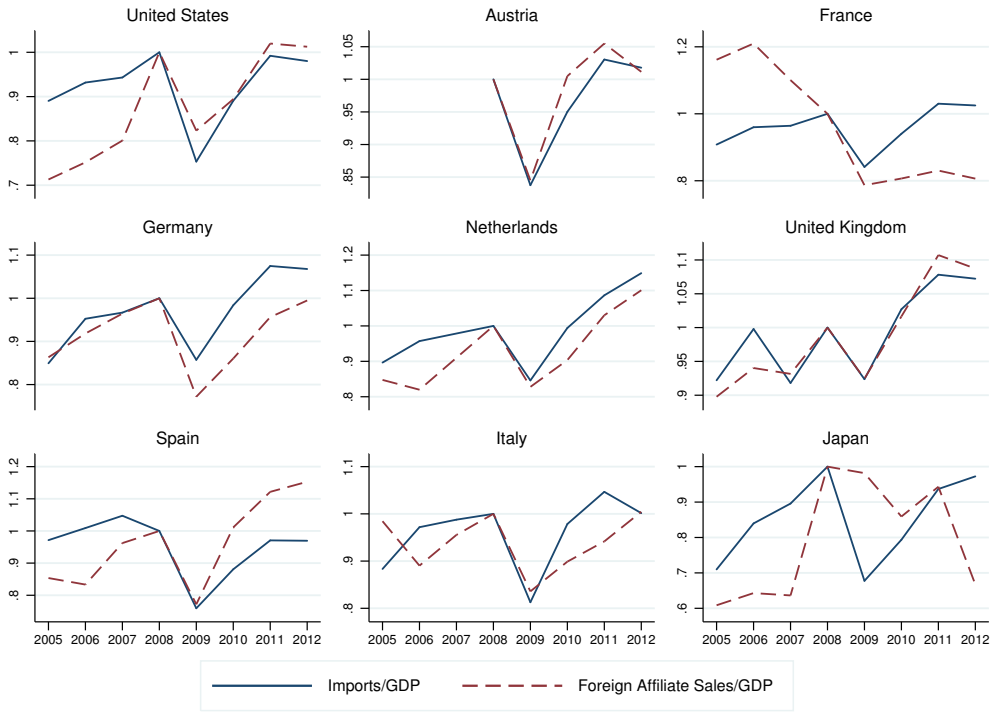
3.1 Data and summary statistics

The analysis is based on ORBIS, the firm-level, multi-country database made available by Bureau Van Dijk. This database collects information from business registries and annual reports, and thus contains both listed and unlisted firms. Importantly, ORBIS provides information on the ownership structure of firms, identifying the "global ultimate owner" of many of the firms. This information permits identifying firms that are affiliates of a foreign parent, as well as the country of the parent. The main variable used in the analysis is turnover (sales).

While firm-level data are available for more than 100 countries, the coverage is very uneven across countries. We follow the cleaning steps and the criteria described in detail in Cravino and Levchenko (2016) to settle on a sample of 34 countries with relatively good

[1] To establish that the patterns in Figure 2 are not driven entirely by differences between manufacturing and the other sectors that comprise the GDP, Appendix Figure A1 normalizes multinational sales and imports by industrial production instead. Appendix Figure A2 plots the evolution of foreign affiliate sales in all sectors, manufacturing and non-manufacturing. These data are only available starting in 2008. Both of these alternative exercises reveal once again a pronounced fall in multinational activity relative to overall economic activity.

Figure 2: Imports and affiliate sales relative to GDP



Notes: This figure reports the evolution of goods imports relative to GDP and manufacturing foreign affiliate sales ("inward turnover by the foreign affiliates of multinational firms") relative to industrial production, normalized to 1 in 2008. Source: Authors' calculations based on OECD Statistics database.

coverage and properties of the ORBIS data.[2] Appendix Table A1 lists the countries in the sample, along with the number of firms and the number of foreign multinational affiliates in each country. Appendix Figure A3 plots the multinational production shares in our data against the shares from other sources, such as the OECD and Eurostat compiled by Alviarez (2013), along with a 45-degree line. In both cases, the shares are averaged over the period 2005-2012. There is a very close correspondence between the multinational production shares in the two datasets, with a correlation coefficient of over 0.9.[3]

We describe three dimensions of heterogeneity that will guide the analysis below. First, multinationals operate in different sectors than domestic firms. Figure 3 shows the share of manufacturing in total foreign affiliate sales for each country, and compares it to the share of manufacturing in total domestic firms' sales. It is clear that multinationals operate disproportionately in the manufacturing sector in the majority of countries.[4] Figure 4 presents the sector-country level scatterplot of the sectoral shares of multinationals and domestic firms at the 2-digit NAICS level, along with the 45-degree line. The graph shows that multinational and domestic shares are very different from each other in many of the country-sectors. The Trade Collapse literature has highlighted differences in the sectoral compositions of output and imports as the key to understanding the collapse in trade relative to production. The next section investigates whether sectoral composition differences between domestic firms and foreign affiliates can account for the multinationals' sales collapse as well.

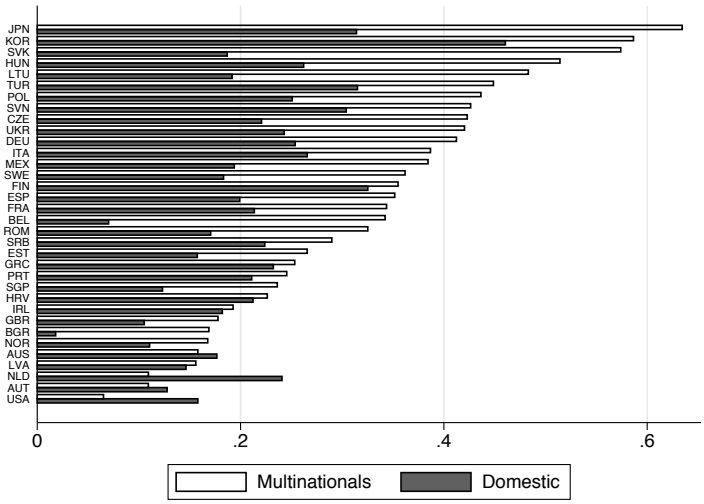
The second important difference, emphasized by the cross-sectional literature on multinational firms, is that multinational parents and their affiliates are much larger than domestic firms. This is illustrated in Table 1, which shows that the shares of foreign multinational affiliates in aggregate sales in each country are much larger than the fraction of firms that are foreign multinational affiliates. While multinational affiliates are responsible for nearly 30% of aggregate output on average, they comprise less than 7% of the firms. For the average country in our sample, revenues are 12 times larger for the me-

[2]We update the sample of firms used by Cravino and Levchenko (2016) in two dimensions. First, our sample has benefited from updates in ORBIS since the first version of Cravino and Levchenko (2016) in 2013, and also includes the most recent revenue information available for the years 2013 and 2014. Second, this paper uses information for firms classified by ORBIS as "Limited Financial", for which ORBIS does not have complete financial statements but for which revenue data are available.

[3]We acknowledge that some countries with the largest foreign multinational presence, such as Ireland and the Netherlands, are believed to be tax havens, and thus their inward MP shares might exaggerate the real multinational production taking place in these countries. As we document above, the collapse in multinational activity is pervasive across countries, including those not identified as tax havens.

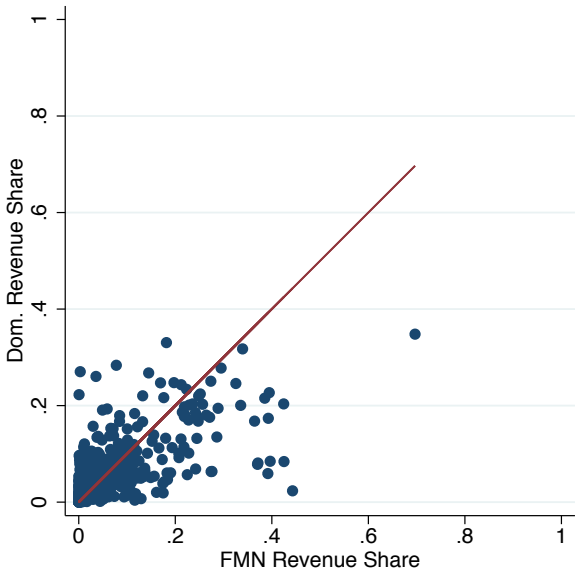
[4]It is notable that, while relative to domestic firms' sales MP sales are skewed towards manufacturing, in absolute terms the majority of MP sales occur outside of manufacturing, with the exception of a few countries.

Figure 3: Shares of multinational affiliates and domestic firms in manufacturing



Notes: This figure reports, for each country, the share of manufacturing sales in total sales by foreign affiliates (white bars), and the share of manufacturing in total sales by domestically-owned firms (dark bars).

Figure 4: Sectoral shares of multinationals and domestic firms



Notes: This figure reports the scatterplot of the share of sectoral sales in total sales by foreign affiliates for each country and sector against the share of sectoral in total sales by domestically-owned firms in the same country and sector.

Table 1: Aggregate multinational shares

	Mean	St. Dev	Min.	Max
Share of output	0.287	0.138	0.015	0.668
Share of firms	0.067	0.068	0.001	0.298

Notes: This table reports the summary statistics of the shares of foreign multinational affiliates in total output, and in the total number of firms, averaged over the period 2005-2012.

dian multinational firm than for the median domestic firm. There is wide variation in the relative revenues of multinationals vs domestic firms in our sample, the ratio of median multinational to median domestic revenues in 2010 was 6 in Germany, 13 in the UK, and 23 in Belgium.

Third, as illustrated by Tables 1 and 2, countries differ greatly in both the overall foreign multinational presence, and in the composition of source countries that own its foreign affiliates. Foreign multinational shares account for less than 2% of total output in Japan, but can be over 50% in countries such as Singapore, Belgium, and the Czech Republic. Table 2 reports the multinational shares in the top 10 destination countries for the top 5 source countries. The table reveals substantial heterogeneity across countries in where foreign multinationals come from. UK and US multinationals are the most important presence in Singapore, whereas Germany and France have a negligible presence there. By contrast, in Central European countries – Czech Republic, Slovak Republic, and Austria especially – Germany is the largest source country. Yet another set of countries exhibits a fairly diffuse pattern of multinational presence. In Romania, Estonia, and Poland, the top multinational shares are spread more evenly across the major sources. This heterogeneity can be potentially important if multinationals from different source countries fared differently in the Great Recession.

Throughout the firm-level analysis below, we use growth rates and shares in the form suggested by Davis et al. (1996): for any variable x_j and time periods t and $t-1$, the growth rate is defined as $\gamma_{j,t} \equiv 2\left(\frac{x_{j,t}-x_{j,t-1}}{x_{j,t}+x_{j,t-1}}\right)$. That is, the denominator is the average of the beginning and end period levels, rather than the beginning period level. Davis et al. (1996) recommend using this growth rate because it has a number of attractive properties: it is bounded between -2 and 2, is symmetric around zero, and lends itself to aggregation. If $x_t = \sum_j x_{j,t}$, the aggregate growth of x_t, γ_t, can be written as the weighted sum of the disaggregated growth rates, $\gamma_t = \sum \omega_{j,t}\gamma_{j,t}$, with weights that are defined as $\omega_{j,t} = \frac{x_{j,t}+x_{j,t-1}}{\sum_j (x_{j,t}+x_{j,t-1})}$. All of the firm-level and aggregate growth rates between years $t-1$ and t are computed using only firms present in ORBIS in both $t-1$ and t, and thus capture

Table 2: Selected multinational shares

Source → *Dest* ↓	France	Germany	Japan	United Kingdom	United States
Austria	0.012	0.122	0.048	0.046	0.036
Belgium	0.133	0.053	0.062	0.025	0.113
Czech Republic	0.031	0.168	0.021	0.03	0.039
Estonia	0.01	0.025	0.007	0.013	0.018
Ireland	0.021	0.019	0.012	0.111	0.189
Netherlands	0.011	0.02	0.026	0.047	0.115
Poland	0.048	0.078	0.012	0.032	0.045
Romania	0.047	0.055	0.009	0.027	0.029
Singapore	0.006	0.011	0.096	0.172	0.117
Slovak Rep.	0.038	0.129	0.008	0.026	0.052

Notes: This table reports the shares of each source in the total sales in each destination, averaged over the period 2005-2012.

intensive margin growth rates.[5]

3.2 Empirical results

This section documents three empirical patterns about the relative performance of multinational firms during the Great Recession. First, there was a pronounced contraction in multinational firms' sales growth relative to domestic firms' sales growth in the Great Recession. Second, this slowdown in the performance of multinationals is largely accounted for by differences in observable characteristics – such as the firms' sector and size – between foreign affiliates and domestically-owned firms. Third, there is large heterogeneity across source countries, with affiliates from certain countries performing considerably worse than affiliates from other source countries.

3.2.1 The performance of multinationals relative to domestic firms

This section establishes the decline of foreign affiliate sales during the crisis using the firm-level data. An advantage of firm-level data relative to the aggregate OECD statis-

[5]Because ORBIS does not cover the universe of firms in each country, it cannot be used to measure entry and exit, since for newly observed firms we cannot distinguish between genuine entry and entry into the ORBIS data collection. Using a Census of French firms in which entry and exit can be measured more accurately, di Giovanni et al. (2014) show that the extensive margin of entry and exit of firms is not important in accounting for aggregate fluctuations. A potential concern with the micro-level specifications below is that they are estimated on surviving firms, and thus ignore the possibility that domestic firms and multinationals may have a different propensity to enter or exit. It is reassuring that the micro-level estimates obtained from ORBIS are consistent with the patterns seen in aggregate data.

Table 3: Growth of foreign affiliates relative to domestic firms

	2004-08	2008-09	2009-14
World	0.009	-0.020	0.002
Developed Europe	0.007	-0.036	-0.002
Emerging Europe	0.013	-0.015	0.007
Developed ROW	0.011	-0.031	-0.001

Notes: This table reports the growth rate of multinational affiliates relative to the growth rate of domestic firms in the three time periods and for different country groups.

tics is that foreign affiliates and domestic firms are observed simultaneously in the same dataset for many countries. We can thus compare the growth of the affiliates of foreign multinationals to the growth of domestically-owned firms in the countries in our sample. Table 3 reports the difference in aggregate growth rates across these groups of firms over three periods: pre-crisis (2004-2008), crisis (2008-2009), and post-crisis (2009-2014).[6] Sales of foreign multinational affiliates grew modestly faster than sales of domestically-owned firms until the crisis. However, they had a lower growth rate during the crisis, both in the whole sample, and within each of the groups of countries we consider: developed Europe, emerging Europe, and developed rest of the world. After the crisis, the disparities in growth rates between domestic and foreign aggregates of firms narrow to nearly zero.

We now make full use of firm-level information to study more formally the relative performance of foreign multinationals outside and during the crisis using the following specification:

$$\gamma_{in,t}(f) = \alpha \times \mathbb{I}_{\{f \in FMN\}} + \beta \times \mathbb{I}_{\{f \in FMN\}} \times \mathbb{I}_{\{t=2009\}} + \delta_{n,t} + \epsilon_{in,t}(f), \tag{1}$$

where $\gamma_{in,t}(f)$ is the sales growth rate of firm f from source country i operating in destination country n. $\mathbb{I}_{\{f \in FMN\}}$ is an indicator variable that takes the value of 1 if firm f is an affiliate of a foreign firm, and $\mathbb{I}_{\{t=2009\}}$ is an indicator variable that takes the value of 1 if the year is 2009. The coefficient α picks up any differential in the growth rate between foreign affiliates and domestically-owned firms in a typical year, whereas β captures whether foreign affiliates had a growth differential different from normal in the Great Recession. δ_{nt} denotes different sets of fixed effects described in detail below.[7]

Table 4 presents the results. The first column contains the unconditional compari-

[6] That is, for the group of firms that we observe continuously between any two years, we compute the the growth rates of multinationals minus the growth rates of domestic firms.

[7] To account for the fact that revenue growth is less volatile for larger firms, we implement a 2-step FGLS procedure that accounts for the cross-firm differences in volatility. In the first step, we run an unweighted

Table 4: Firm-level growth rates

	(1)	(2)	(3)	(4)
Dep. Var.: $\gamma_{in,t}(f)$				
$\mathbb{I}_{\{f \in FMN\}}$	0.0207	0.0184	0.0177	0.0205
	(0.0042)	(0.0009)	(0.0009)	(0.0010)
$\mathbb{I}_{\{f \in FMN\}} \times \mathbb{I}_{\{t=2009\}}$	-0.0326	-0.0297	-0.0177	-0.0012
	(0.0093)	(0.0023)	(0.0020)	(0.0017)
Number of Observations	31,521,858	31,521,858	31,302,684	31,302,216
Number of Firms	6,639,262	6,639,262	6,563,480	6,563,408
Number of Multinationals	214,851	214,851	212,988	212,981
R^2	0.0110	0.0240	0.0333	0.0422
Year	Yes	No	No	No
Destination×Year	No	Yes	No	No
Destination×Sector×Year	No	No	Yes	No
Destination×Sector×Quartile×Year	No	No	No	Yes

Notes: Standard errors clustered at the source-destination level in parentheses. This table reports the results of estimating equation (1).

son of growth rates between foreign and domestic firms, controlling for year fixed effects. The second column adds destination×year effects, effectively comparing foreign multinationals to domestically-owned firms within the same country and same year. The results are very similar across these two specifications. Outside of the crisis, foreign multinational affiliates grew about 2 percentage points faster than domestic firms over this period. In 2009, however, foreign multinationals grew 1 percentage point slower than domestic firms. The difference in growth rates across the groups of firms is strongly statistically significant. The following observation summarizes these findings:

Observation 1: *The affiliates of foreign multinationals grew faster than domestically-owned firms outside of the crisis, and slower during the 2008-2009 crisis.*

regression, and estimate how log squared residuals from that regression relate to log firm size:

$$\widehat{log\epsilon_{in,t}(f)}^2 = a + b \times log\omega_{n,t-1}(f) + \eta_{in,t}(f),$$

where $\omega_{n,t-1}(f)$ is the share of firm f in total sales in destination n. We then weight by the inverse of the predicted firm variance, $exp\left(\widehat{log\epsilon_{in,t}(f)}^2\right)$. In practice, because firm volatility falls only slowly in size (Stanley et al., 1996; Sutton, 2002), the results are quite similar to running unweighted OLS.

3.2.2 Understanding the collapse in multinational sales

Observation 1 establishes that sales of foreign affiliates declined relative to sales by domestic firms, and that these differences persist after controlling for country-specific trends. This section evaluates whether the observable differences between foreign and domestic firms documented in Section 3.1 can account for the pattern reported in Observation 1.

Column 3 of Table 4 reports the results of estimating equation (1) with destination×sector×year effects to account for the different sectoral composition of domestic vs. foreign multinationals firms. The inclusion of sectoral fixed effects does not appreciably affect the difference in performance across the groups of firms outside of the crisis, whereas the difference in growth rates of foreign multinationals and domestic firms in 2009 drops to zero.

The last column of the Table controls for size differences between foreign affiliates and domestic firms, by including destination×sector×size quartile×year fixed effects, where the size quartile is defined using firm-level sales for each year within each sector and destination country. This specification thus compares foreign affiliates to their domestic counterparts in the same sector and same size quartile within each destination country. There is no significant difference between the relative performance of multinationals in 2009, and the point estimate drops to a negligible -0.1%.

Controlling for compositional differences using matching methods The above results were obtained controlling for destination×sector×size quartile×year effects, and thus amounted to comparing foreign multinational affiliates to firms of similar size in the same sector in each market and each year. To find an even closer comparison group for the multinational affiliates, we implement a propensity score matching (PSM) estimator, following Alfaro and Chen (2012). Within each destination-sector pair and in each year, we match foreign affiliates with local firms that are most comparable based on their propensity score. The propensity score is the estimated probability of being foreign-owned based on observable characteristics. The details of the PSM procedure are described in Appendix A.

Table 5 reports how foreign ownership affects firms' growth by comparing the average growth of foreign multinationals to the average growth of their domestically-owned matches. The foreign affiliates of multinational firms grew faster on average than the control group. The Average Treatment Effect on the Treated (ATT) is positive and highly statistically significant in every year. In the crisis year, the estimated growth advantage for multinationals is estimated to be around 2%, similar to the estimates with destination×sector×size quartile×year in column 4 of Table 4. This is essentially the same as the average growth differential across all the non-crisis years, and 0.27 percentage points lower than the av-

erage growth differential in the pre-crisis years (2.37%). Thus, the relative difference between multinationals and domestic firms in the crisis compared to normal times is similarly negligible according to this alternative estimation technique.

Table 5 contrasts these results with the unconditional comparison of mean growth rates between foreign affiliates and domestic firms, reported under Unconditional Mean Difference (UMD). These results parallel closely the differences in growth rates between multinationals and domestic firms when not conditioning on sector and size (columns 1-2 of Table 4). Just as in the regression estimates, the UMD results imply that foreign affiliates grew 1 percentage point slower in 2009 than domestic firms.

The results are broadly similar if we use employment (Appendix Table A2), or if we use conventional growth rates instead of DHS ones (Appendix Table A3). An advantage of using employment data is that it is less subject to concerns about transfer pricing and holding companies in tax haven countries that can arise with affiliate sales. The disadvantage of using employment is that this variable is available for much fewer firms compared to sales/turnover, so the sample size drops substantially.

Figure 5 plots the unconditional growth differentials (UMD) and the conditional ones obtained through PSM (ATT) for each year. The Figure shows that after recovering to pre-crisis levels in 2010-2011, the multinational-domestic growth differential fell in every year until the end of our data. While pre-crisis the growth differential between multinationals and local firms was around 2.4%, in the post-crisis period it decreased monotonically from around 1.4% in 2011 to 0.5% in 2014, according to the PSM estimates. This may be a parallel to the slowdown in global trade that started to become apparent over the same time period (Hoekman, ed, 2015; Aslam et al., 2016).

While the literature on the current trade slowdown has not yet matured, early findings suggest that compositional effects are largely responsible for the trade slowdown (Aslam et al., 2016). To illustrate whether differences in sectoral composition, size, and other observables between multinational and domestic firms can account for the post-2011 "multinational slowdown," we can compare the UMD and the ATT growth differentials plotted in Figure 5. While the ATT growth differentials are closer to zero throughout, both the unconditional and conditional growth differentials exhibit a marked slowdown, and indeed in the last year the two are essentially the same. Thus, in contrast to the findings regarding trade, compositional forces cannot account for the post-crisis multinational slowdown. Observation 2 summarizes these findings.

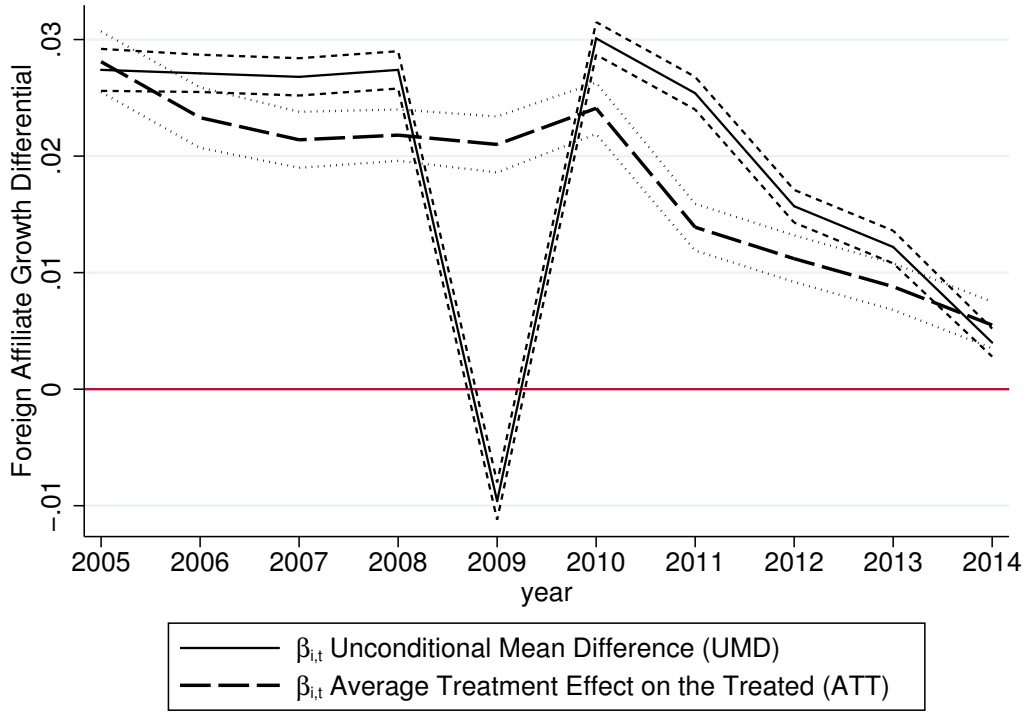
Observation 2: *Within sectors, the foreign affiliates of multinational firms grew faster than similarly-sized domestically firms in every year between 2004-2014. Much of the aggregate rela-*

Table 5: Propensity score matching results

Dep. Var.: $\gamma_{in,t}(f)$	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ATT (treatment)	0.0398	0.0646	0.0570	0.0160	-0.0598	0.0359	0.0329	0.0035	-0.0042	0.0160
ATT (control)	0.0117	0.0413	0.0357	-0.0058	-0.0808	0.0118	0.0189	-0.0078	-0.0130	0.0105
ATT (diff)	0.0281	0.0233	0.0214	0.0218	0.0210	0.0241	0.0139	0.0112	0.0088	0.0055
SE ATT (diff)	0.0013	0.0013	0.0012	0.0011	0.0012	0.0011	0.0010	0.0010	0.0010	0.0010
t-stat ATT (diff)	20.9400	18.6000	18.1800	19.1900	17.9400	22.4100	13.6400	11.0100	8.7000	5.4600
ATE (diff)	0.0317	0.0318	0.0242	0.0358	0.0306	0.0329	0.0212	0.0192	0.0231	0.0171
UMD (treatment)	0.0403	0.0650	0.0568	0.0160	-0.0608	0.0363	0.0329	0.0034	-0.0043	0.0162
UMD(control)	0.0129	0.0379	0.0301	-0.0114	-0.0512	0.0063	0.0075	-0.0124	-0.0166	0.0121
UMD(diff)	0.0274	0.0271	0.0268	0.0274	-0.0096	0.0301	0.0254	0.0157	0.0122	0.0040
SE UMD (diff)	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007	0.0007	0.0007	0.0006
t-stat UMD (diff)	30.7800	32.9300	34.6000	36.4000	-12.6200	42.7000	37.4800	23.3000	18.3100	6.3200
Untreated/Off support	73,285	66,893	59,879	66,181	71,428	71,576	73,121	81,423	71,120	68,068
Untreated/On support	2,145,210	2,301,485	2,544,820	2,753,726	2,839,872	2,999,686	3,077,301	3,052,708	2,868,961	2,128,798
Treated/Off support	3,919	4,210	4,475	4,755	5,052	5,456	5,481	5,447	5,526	5,561
Treated/On support	74,102	83,744	94,556	105,107	110,941	120,400	125,726	125,870	123,874	110,057
Total Number of firms	2,296,516	2,456,332	2,703,730	2,929,769	3,027,293	3,197,118	3,281,629	3,265,448	3,069,481	2,312,484
Standardized Bias, %										
Log sales	2	1.7	1.5	1.3	1.2	1.5	1.1	0.8	0.5	0.5
Age	-0.7	-1.7	-1.6	-2.7	-1.7	-2	-1.9	-2.3	-1.3	-2.3
Multi-sector	-0.4	-0.4	-0.5	-0.5	-0.1	-0.4	-0.2	-0.4	-0.3	-0.7

Notes: This table reports the Unconditional Mean Difference (UMD) and the Average Treatment Effect on the Treated (ATT) in each year. The dependent variable is the annual sales growth rate. In every year we assume common support, ties and a caliper of 0.005. The propensity scores were estimated using a probit model with log sales, age and multi-product status as explanatory variables.

Figure 5: Estimated ATT and UMD



Notes: This figure plots the estimates of the Unconditional Mean Difference (UMD) and the Average Treatment Effect on the Treated (ATT) in each year, along with a 2-standard error band.

tive slowdown of multinational firms in 2008-2009 is accounted for by observable differences in firm size and by differences in the sectors in which multinational firms operate.

Differences across industries Appendix Figure A4 plots the UMD and ATT coefficients in each year in manufacturing and services. In order to do this, the PSM model is re-estimated for those two sectors separately. While the UMD shows a clear drop in relative growth rates during the crisis for both segments of the economy, the ATT results differ: the service sector exhibits a dip in 2008-2009, slightly more pronounced than the overall economy. By contrast, the ATT results show no dip at all in manufacturing.

Differences in firm size and cyclicality Both the regression estimates in Table 4 and the matching estimates in Table 5 reveal that multinationals did slow down relative to the *average* domestic firm in 2009; but that their performance relative to domestic firms within their size quartile remained largely unchanged in the crisis. Given that multinationals are larger than domestic firms, this implies that large firms performed especially badly during the crisis. We provide evidence on this in more detail in Appendix Table A4. The Table shows that, conditioning on survival, there is a negative relation between firm size (measured by sales) and sales growth. The Table also shows that this relation became even more negative in 2009. That is, large firms performed particularly poorly during the crisis. Since foreign affiliates are larger than domestic firms, this accounts for much of the slowdown in foreign affiliate sales in the crisis.

This pattern is in line with the findings of Moscarini and Postel-Vinay (2012), who show that large firms respond disproportionally to business cycles.[8] In a related paper, Fort et al. (2013) argue that accounting for age differences across firms is crucial, and that in fact small young businesses were affected the most in the recession. Unfortunately, the coverage of small young firms in ORBIS is not broad enough to shed light on this dichotomy. Note that the ATT estimates in Table 5 control for firm age.

3.2.3 Differences in country of origin

The previous two sections establish that the relatively fast growth of multinational firms decelerated during the crisis, and that much of this reduction in relative growth can be accounted for by the differences in sectoral composition and size between foreign affiliates and domestically-owned firms. Multinational firms, however, differ along another

[8] In earlier work, Gertler and Gilchrist (1994) show that small firms respond more to monetary shocks than large firms, though the period in the paper does not cover the Great Recession.

important dimension, namely their country of origin. In this section, we study the relative performance of multinational affiliates from different source countries during the crisis.

With this objective in mind, we expand our specification in equation (1) to allow for heterogenous growth differentials across foreign affiliates from different source countries:

$$\gamma_{in,t}(f) = \sum_i \beta_{i,t} \times \mathbb{I}_{\{f \in FMN_i\}} + \delta_{n,t} + \epsilon_{in,t}(f), \tag{2}$$

and estimate this equation year by year. In this specification, $\mathbb{I}_{\{f \in FMN_i\}}$ is an indicator for whether firm f is an affiliate of a parent from country i, and the coefficient $\beta_{i,t}$ is source country-and-year-specific. The estimate of $\widehat{\beta}_{i,t}$ for each source country and year is interpreted as the differential growth in the foreign affiliates from country i in year t within the comparison group specified by the fixed effects $\delta_{n,t}$. We also re-estimate the PSM procedure, but for each source country and year separately, yielding estimates of ATT that are source-country-specific.

Table 6 reports the estimates of $\widehat{\beta}_{i,t}$ for the 10 largest source countries during the crisis (2008-2009 growth rates). Columns 1-3 present the results controlling for destination×sector×size quartile×year effects, and 4-6 using propensity score matching for multinationals from each individual source country separately. There is pronounced heterogeneity in how foreign affiliates from different source countries did during the crisis, relative to domestic firms. Among the top 10 source countries, with destination×sector×size quartile×year effects the growth differentials range from 1.1% for France to -2.5% for Japan. Columns 3 and 6 report the differences between the estimated crisis $\widehat{\beta}_{i,t}$ and the average pre-crisis $\widehat{\beta}_{i,t}$ for the same country. There is a 3 percentage point range in these values, from 0.4%(1%) for France to -2.7%(-2.3%) for Sweden according to the destination×sector×size quartile× year effects (PSM procedure).

Figures 6 and 7 plot the country-specific UMD and ATT estimated by the PSM procedure for the 10 source countries with the largest multinational presence in foreign countries in each year, along with 2-standard error bands. The solid line reports UMD, whereas the thick dashed line reports the ATT. The figures show that multinationals from all of these sources grew faster than domestic firms before and after the crisis. In those "normal" times, the point estimates according to the simple UMD and using to the propensity-score-matched control group are quite similar. During the crisis, two things happen. First, firms from these 10 source countries do worse relative to the normal times. Second, as was also evident in Table 6, during the crisis it matters for the results whether one looks at the unconditional growth differential (UMD), or or a growth differential relative to propensity-score-matched firms (ATT). The ATT estimates are higher than UMD, imply-

Table 6: Source effects for the top 10 source countries, 2008-2009

	(1)	(2)	(3)	(4)	(5)	(6)
Controls:	Destination×sector ×size quartile×year effects			PSM		
	$\widehat{\beta}_{i,2009}$	s.e.($\widehat{\beta}_{i,2009}$)	$\widehat{\beta}_{i,2009} - \widehat{\beta}_{i,pre-crisis}$	$\widehat{\beta}_{i,2009}$	s.e.($\widehat{\beta}_{i,2009}$)	$\widehat{\beta}_{i,2009} - \widehat{\beta}_{i,pre-crisis}$
France	0.032	0.006	0.004	0.033	0.004	0.010
Netherlands	0.027	0.008	-0.005	0.026	0.004	-0.003
Austria	0.021	0.008	-0.013	0.020	0.005	-0.007
United Kingdom	0.018	0.006	-0.010	0.020	0.004	-0.006
Italy	0.023	0.011	0.002	0.023	0.005	0.007
Switzerland	0.013	0.005	-0.018	0.017	0.004	-0.009
United States	0.018	0.006	-0.006	0.019	0.003	-0.002
Germany	0.017	0.008	-0.014	0.016	0.003	-0.012
Sweden	0.004	0.006	-0.027	0.003	0.005	-0.023
Japan	0.002	0.009	-0.013	0.001	0.006	-0.009

Notes: This table reports the estimated source effects for the top 10 largest source countries for the crisis period.

ing that finding a better control group reduces the differential between firms from these source countries and domestically-owned firms. Estimates based on equation (2) yield very similar results (available upon request).

The following observation summarizes these findings:

Observation 3: *Multinationals from different source countries fared differently in the crisis.*

4 Conceptual Framework

This section describes a model of multinational production used to quantitatively evaluate the role of multinational firms in the propagation of the Great Recession.

Preliminaries Consider a world economy consisting of multiple countries indexed by i and n. Households in each country consume an homogeneous final good that can be freely traded across countries.[9] The final good can be produced in each country by aggregating the output of differentiated intermediate good producers. The differentiated producers can be owned by firms from different source countries, and we assume that their output cannot be traded across countries. The final good is the numeraire of the world economy and its price is set to one. We focus on the model's predictions for productivity and aggregate output. As discussed below, these assumptions coupled with a standard functional form for agent preferences imply that production allocations are independent of the international asset market structure.

Technologies and market structure The production function of the final good in each country n is given by:

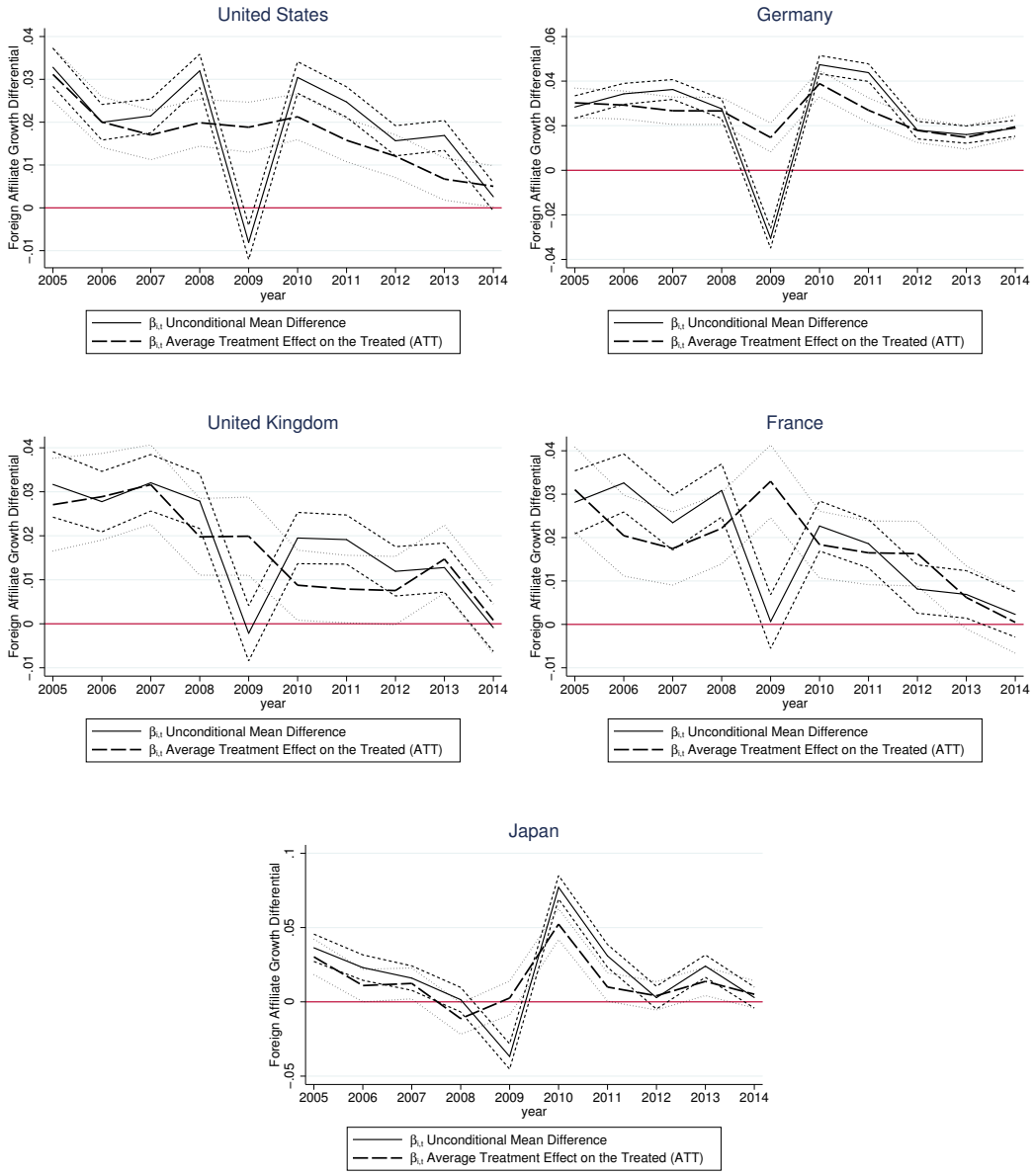
$$Q_{n,t} = \left[\sum_i \sum_{f\in\Omega_i} Q_{in,t}(f)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{3}$$

where Ω_i is the set of firms from country i and $Q_{in,t}(f)$ is the output of firm f from country i in the destination country n. The demand for firm's f product is given by:

$$Q_{in,t}(f) = \frac{P_{in,t}^{-\rho}(f)}{P_{n,t}^{-\rho}} Q_{n,t}, \tag{4}$$

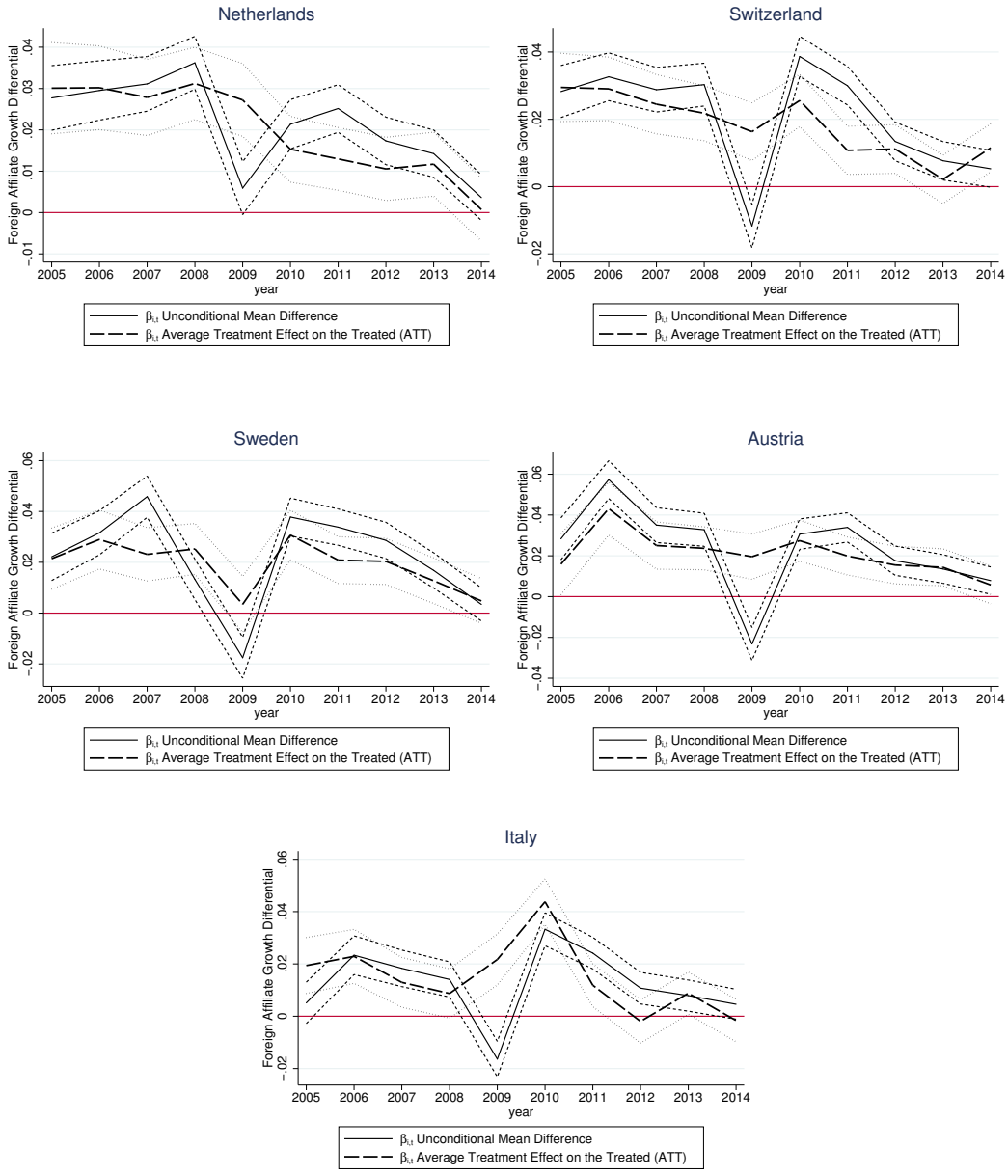
[9]The assumption that the final good is homogeneous is not crucial for the results that follow. Cravino and Levchenko (2016) derive the equations under the assumption that country-specific goods are imperfect substitutes, so that there are terms of trade movements in response to productivity shocks.

Figure 6: Estimated ATT and the UMD by country and year, top 5 source countries



Notes: This figure plots estimates of the Unconditional Mean Difference (UMD) and Average Treatment Effect on the Treated (ATT) estimated year-by-year for the top 5 source countries. The short-dashed lines report 2-standard error bands for the UMD, and the dotted lines report 2-standard error bands for the ATT.

Figure 7: Estimated ATT and the UMD by country and year, source countries 6-10



Notes: This figure plots estimates of the Unconditional Mean Difference (UMD) and Average Treatment Effect on the Treated (ATT) estimated year-by-year for the 6-10 source countries. The short-dashed lines report 2-standard error bands for the UMD, and the dotted lines report 2-standard error bands for the ATT.

where

$$P_{n,t} = \left[\sum_i \sum_{f\in\Omega_i} P_{in,t}^{1-\rho}(f)\right]^{\frac{1}{1-\rho}} = 1 \tag{5}$$

is the aggregate price index in country n. The second equality follows from the choice of the numeraire.

Firms are monopolistically competitive and heterogeneous in their productivity. Labor is the only factor of production. Output of firm f owned by country i operating in country n is given by

$$Q_{in,t}(f) = \widetilde{Z}_{in,t}(f) L_{in,t}(f), \tag{6}$$

where $L_{in,t}(f)$ is the firm-specific labor input, and $\widetilde{Z}_{in,t}(f)$ is a firm-source-destination specific productivity component. Finally, profit maximization implies a constant markup over marginal cost:

$$P_{in,t}(f) = \frac{\rho}{\rho-1}\frac{W_{n,t}}{\widetilde{Z}_{in,t}(f)}, \tag{7}$$

where $W_{n,t}$ is the wage in country n.

Equilibrium and aggregate output Combining equations (5) and (7) we can write the real wage as:

$$W_{n,t} = \frac{\rho-1}{\rho}\left[\sum_i \sum_{f\in\Omega_i} \widetilde{Z}_{in,t}(f)^{\rho-1}\right]^{\frac{1}{\rho-1}}. \tag{8}$$

We assume that the labor supply in each country is independent of the level of consumption and is given by

$$L_{n,t} = W_{n,t}^{\frac{1}{\psi-1}}. \tag{9}$$

This labor supply schedule can be micro-funded by the assumption that households have GHH preferences over consumption of the final good and leisure (Greenwood et al., 1988). We exploit this property to derive predictions for output that are independent of the international asset market structure. To solve for aggregate output, note that profit maximization implies that aggregate revenues are proportional to total labor payments:

$$\sum_i P_{in,t}Q_{in,t} = Q_{n,t} = \frac{\rho}{\rho-1}W_{n,t}L_{n,t}. \tag{10}$$

Combining equations (9) and (10), aggregate output can be written as:

$$Q_{n,t} = \frac{\rho}{\rho-1} W_{n,t}^{\psi} = \left(\frac{\rho-1}{\rho}\right)^{\psi-1} \left[\sum_i \sum_{f\in\Omega_i} \widetilde{Z}_{in,t}(f)^{\rho-1}\right]^{\frac{\psi}{\rho-1}}, \tag{11}$$

where $\psi \equiv \frac{\bar{\psi}}{\bar{\psi}-1} > 1$. Aggregate growth in country n is then given by:

$$\gamma_{n,t} = \psi \sum_i \sum_{f\in\Omega_i} \omega_{in,t-1}(f)\, \widetilde{z}_{in,t}(f), \tag{12}$$

where lower-case variables denote growth rates, and $\omega_{in,t}(f) \equiv \frac{P_{in,t}(f)Q_{in,t}(f)}{P_{n,t}Q_{n,t}}$ is the share of country $n's$ aggregate sales generated by firm f from source country i.

Equation (12) states that the aggregate growth rate of country n is proportional to the weighted average of the productivity changes of all the firms operating in the country, with weights corresponding to the sales shares of firms. Note that these shares can be written as $\omega_{in,t}(f) = \frac{\widetilde{Z}_{in,t}(f)^{\rho-1}}{\sum_i \sum_{f\in\Omega_i} \widetilde{Z}_{in,t}(f)^{\rho-1}}$, so that the model rationalizes the heterogeneity in multinational shares across country pairs through (potentially source-destination specific) differences in firm productivity. This approach is in the spirit of quantitative models of multinational production with frictional technology transfer, for instance Ramondo (2014), Ramondo and Rodríguez-Clare (2013), or Alvarez (2013). More broadly, Cravino and Levchenko (2016) show that the framework above can be thought of as isomorphic to one in which differences in multinational shares across country pairs are driven by demand. The elasticity ψ summarizes how firm productivity shocks translate into output growth under a non-constant labor supply.

4.1 The role of multinational firms in propagating the crisis

To evaluate the role of multinational firms in propagating the crisis, we need to specify how productivity evolves over time for domestic vs. foreign-owned firms. With this in mind, we allow for a flexible process for the growth of firm productivity given by:

$$\widetilde{z}_{in,t}(f) = z_{in,t}(f) + x_{i,t} I_{i\neq n}. \tag{13}$$

Guided by the estimates in Section 3.2, equation (13) explicitly allows for the possibility that there is a common component $x_{i,t}$ to the growth of all the foreign affiliates from

country i. From equations (12) and (13) we can then write the growth rate of country n as:

$$\gamma_{n,t} = \psi \sum_{i} \sum_{f \in \Omega_i} \omega_{in,t-1}(f) z_{in,t}(f) + \psi \sum_{i \neq n} \omega_{in,t-1} x_{i,t}, \tag{14}$$

where $\omega_{in,t-1}$ is now the combined share of all multinationals owned by i operating in n.

Equation (14) shows that to the extent that there are common shocks affecting foreign multinational firms, these will affect the growth rates of host countries through the term $\psi \sum_{i \neq n} \omega_{in,t-1} x_{i,t}$. Whether these common components are quantitatively important is of course an empirical question. We now show how the empirical estimates from the previous section can be used to recover these common shocks affecting multinational firms, and evaluate the role of multinational firms in propagating the crisis to host countries.

Estimating foreign affiliates' shocks

To estimate the shocks that are common to all foreign affiliates from a given source country, we start by writing firm-level sales as:

$$P_{in,t}(f) Q_{in,t}(f) = \widetilde{Z}_{in,t}(f)^{\rho-1} \left(\frac{\rho}{\rho - 1} W_{n,t} \right)^{1-\rho} \frac{Q_{n,t}}{P_{n,t}^{-\rho}}. \tag{15}$$

Sales growth is then given by:

$$\gamma_{in,t}(f) = (\rho - 1) x_{i,t} \mathbb{I}_{i \neq n} + \widetilde{d}_{n,t} + (\rho - 1) z_{in,t}(f), \tag{16}$$

where $\widetilde{d}_{n,t}$ is the growth rate of the term $\left(\frac{\rho}{\rho-1} W_{n,t} \right)^{1-\rho} \frac{Q_{n,t}}{P_{n,t}^{-\rho}}$, which only varies by destination. The common shocks to multinational firms can then be estimated using the following specification:

$$\gamma_{in,t}(f) = \beta_{i,t} \times \mathbb{I}_{\{f \in FMN_i\}} + d_{n,t} + \mathbf{X}_t + \epsilon_{in,t}(f), \tag{17}$$

which coincides with estimating equation (2) when pooled across countries. The coefficient of interest in this equation is $\beta_{i,t}$, which captures the differential growth in the sales of multinationals firms from country i in year t. The derivation above shows that this empirical estimate corresponds to $(\rho - 1) x_{i,t}$ in the model. The destination fixed effects $d_{n,t}$ control for all aggregate shocks in the destinations, $\tilde{d}_{n,t}$, and for the component of the firm-level productivity that is common to all firms operating in a destination. $\mathbf{X}_t$ controls for other covariates that can be affecting the firm-level productivity $z_{in,t}(f)$ that may be correlated with foreign multinational status, such as sector, firm size, country of origin,

or interactions of those. Table 4 in Section 3.2 reports our estimates of $\hat{\beta}$ for 2009 when restricting it to be the same across i, under different assumptions for the firm-level productivity process. Table 6 and Figures 6-7 give a sense of how estimated $\widehat{\beta}_{i,t}$ vary across sources. The following section applies these estimates to equation (14) to evaluate how host countries were impacted by the slowdown of multinational firms.

Counterfactual results

In this section we ask how the slowdown of multinational firms' growth during 2009 affected aggregate growth rates across different host countries. To answer this question, we use equation (14) in combination with our estimates for $\beta_{i,t}$ from Section 3.2 to compute the aggregate growth rate for each country in a counterfactual scenario in which foreign multinational firms' performance relative to domestic firms is the same during the crisis as in normal times. In particular, we compute counterfactual growth rates for each country, $\gamma_{n,2009}^{counter}$, using the estimates of $\hat{\beta}_{i,pre-Crisis}$ and $\hat{\beta}_{i,Crisis}$ and equation (14):

$$\gamma_{n,2009}^{counter} - \gamma_{n,2009} = \frac{\psi}{\rho - 1} \sum_{i \neq n} \omega_{in} \left(\hat{\beta}_{i,pre-Crisis} - \hat{\beta}_{i,Crisis} \right). \tag{18}$$

The equation gives the difference between the counterfactual and actual growth rates for each country n as a function of multinational revenue shares $\omega_{in,t-1}$, the estimated differential growth of multinational firms before and during the crisis $\hat{\beta}_{i,t}$, and the composite parameter $\frac{\psi}{\rho-1}$ that captures general equilibrium effects.

We measure the multinational revenue shares for each country pair directly from the ORBIS data. In our baseline calibration, we set the composite parameter $\frac{\psi}{\rho-1}$ equal to 1.[10] The advantage of our approach is that the role of general equilibrium effects is transparent and captured by multiplying the summation in (18) by the composite parameter. This makes it easy to to scale the counterfactual outcomes up or down according alternative values of ψ and ρ. We compute counterfactuals using $\hat{\beta}_{i,t}$ coming from the source-country-specific PSM estimates such as those reported in Figures 6-7.

Table 7 reports the summary statistics. Because many countries do not have a large multinational presence, we also present the results for the top 10 destination countries with the largest multinational production shares. The incremental contribution of the reduction in multinational output to the severity of the Great Recession is modest. Growth rates would have been 0.12 percentage points higher for the mean country in the sample,

[10] This value is consistent with a labor supply elasticity of 0.5 as estimated by Chetty et al. (2013) ($\psi = 1.5$) and an elasticity of substitution across varieties ρ of 2.5 (close to the average of the Broda and Weinstein, 2006, estimates).

and 0.18 percentage points on average in the top 10 destination countries. There is a range of effects, from -0.13% to 0.5%. These numbers are small relative to the overall reduction in output in these countries over the same period.

To better illuminate the results, we can decompose the difference between the counterfactual and observed growth rates as follows:[11]

$$\begin{aligned} \gamma_{n,2009}^{counter} - \gamma_{n,2009} &= \frac{\psi}{\rho - 1} \underbrace{(1 - \omega_{nn}) \left(\overline{\hat{\beta}}_{pre-Crisis} - \overline{\hat{\beta}}_{Crisis} \right)}_{"Average\ Effect"}. \\ &+ \frac{\psi}{\rho - 1} \underbrace{\sum_{i \neq n} \omega_{in} \left[\left(\hat{\beta}_{i,pre-Crisis} - \hat{\beta}_{i,Crisis} \right) - \left(\overline{\hat{\beta}}_{pre-Crisis} - \overline{\hat{\beta}}_{Crisis} \right) \right]}_{"Covariance\ Effect"}, \end{aligned} \tag{19}$$

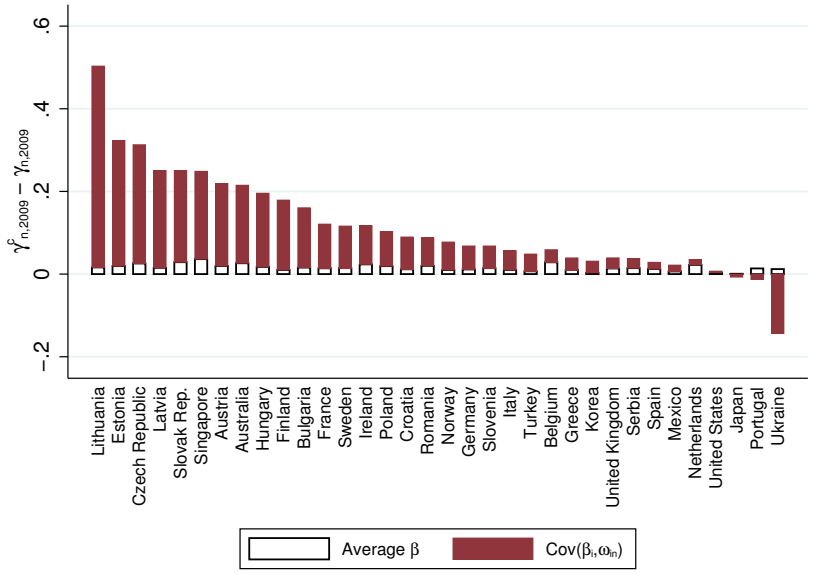
where $\overline{\hat{\beta}}_{pre-Crisis}$ and $\overline{\hat{\beta}}_{Crisis}$ are unweighted averages of the pre-crisis and crisis FMN coefficient across all i, respectively. Equation (19) writes the total effect of foreign multinationals on output as the sum of an "Average" and a "Covariance" term. The average term captures the performance of multinationals from the average source country, scaled by the overall multinational presence in the destination country, $1 - \omega_{nn}$. The second term captures whether the mix of multinationals that operate in destination country n did relatively well or poorly in the crisis. The bottom two rows of Table 7 report the decomposition. It turns out that the unweighted average $\overline{\hat{\beta}}_{pre-Crisis} - \overline{\hat{\beta}}_{Crisis}$ is close to zero, and thus the average term is small. This is not surprising given our finding that multinationals from the average country did not perform significantly differently than similarly sized local firms. Most of the overall effect is accounted for by the "Covariance" term, described below

Figure 8 presents the results graphically. The white bars report the average effect, and the red bars the "Covariance" term. Essentially both the overall level of the impact, and the variation across countries are all absorbed by the covariance term. There are two things to note about this result. First, the covariance term is positive for virtually all countries. This implies that in almost all countries, multinational shares ω_{in} were higher for source countries i with greater falls in $\beta_{i,t}$ during the crisis. This suggests that affiliates from larger source countries suffered more during the crisis.

Second, there is a great deal of dispersion in the Covariance term, indicating that differences across countries in the country of origin of foreign multinationals had aggregate implications during the crisis. For instance, multinationals contributed 0.5 percentage points to the reduction in output in Lithuania. The largest single source of foreign multi-

[11] We thank our discussant, Kim Ruhl, for suggesting this decomposition.

Figure 8: Counterfactual changes in aggregate output, %, 2008-2009



Notes: This figure plots the results from evaluating equation (19) for each country.

nationals in Lithuania is Poland, whose foreign affiliates did quite poorly in the crisis, with the growth differential of -4.3% relative to the pre-crisis times. Estonia and Latvia were also among the countries most negatively affected. Looking closer, this is because Sweden and Finland are the largest sources of foreign affiliates in these countries, and multinationals from Sweden and Finland did especially poorly in the crisis (see Table 6, Figure 7).

Table 7: Counterfactual differences in growth rates, %, 2008-2009

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
	All countries (N = 34)				Top 10 destinations			
Total effect	0.117	0.121	-0.131	0.503	0.176	0.107	0.035	0.323
Average	0.015	0.008	0.001	0.036	0.024	0.006	0.019	0.036
Covariance	0.101	0.118	-0.144	0.487	0.151	0.106	0.013	0.303

Notes: This table the summary statistics for the change in aggregate output in the counterfactual described by equations (18) and (19).

5 Conclusion

The international dimension of the Great Recession has been the subject of an active and exciting research program, and indeed led to a renewed interest in the macroeconomic impact of international linkages more broadly (Bems et al., 2013). In contrast to the voluminous micro and macro literatures on the Great Trade Collapse, our understanding of the behavior of multinational firms during the recent crisis is much more limited. This paper uses a multi-country firm-level database covering millions of multinational and non-multinational firms to examine how multinationals fared in the Great Recession.

It turns out that, in parallel to the collapse in trade, there was a similarly-sized collapse in foreign multinational sales during the crisis. Having established this fact, we explore it in two dimensions. First, we show that much of relative differential between foreign affiliates and domestically-owned firms in the crisis compared to normal times is accounted for by compositional differences in sector, size, and other observables such as firm age. Second, we show that an important dimension of heterogeneity, namely across source countries, nonetheless remains after controlling for these observables. We conclude the analysis by developing a quantitative framework of multinational production and deriving a simple analytical formula for the counterfactual change in aggregate output had multinationals' growth rates during the crisis been different. Our main result is that multinational presence had a modest impact on both the level and the cross-section of growth rates in our sample of countries during the crisis.

Finally, we document that in the post-crisis years, there has been a slowdown in the relative growth of foreign multinationals that coincided with the slowdown in goods trade. Our preliminary analysis suggests that differences in the composition of activity between multinationals and domestic firms cannot account for this slowdown. Better understanding the deceleration in the growth of multinational production in the years after 2011 remains a fruitful avenue for future research.

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Appendix A Propensity Score Matching

The PSM estimator compares the growth rate of multinational affiliates to the growth rate of a control group. The control group is obtained by matching foreign affiliates to domestically-owned firms based on their propensity score. The propensity score is the estimated probability of being foreign-owned based on observable characteristics. The observable characteristics we use are size (log sales), firm age, and multi-product status. The age variable is measured by the year of incorporation of the firm reported in ORBIS. The multi-product variable takes the value of 1 if the firm operates in only one NAICS sector at 6-digits level of disaggregation, 2 if it operates in two sectors, and 3 if the firm operates in three or more sectors.[12]

The propensity score is obtained by running probit regressions of multinational status on log sales, age, and multi-product status in each sector in each destination country. When estimating the probability of being foreign-owned and for the subsequent matches, we exclude headquarters of multinationals from the potential comparison group. To avoid country-sectors that do not have a sufficient sample size, we also exclude country-sector pairs with less than 30 observations, dropping a total of 164 country-sector pairs (2.7%). As expected, there is a significant and positive relationship between foreign ownership status and establishment size for most country-sector pairs. In contrast, age and multi-sector status often imply a lower probability of being a foreign affiliate. In the case of multi-sector status, for example, this may be due to the fact that even though multinational corporations as a whole are often multi-product, individual foreign affiliates may actually be more specialized in a single activity.

We match each foreign affiliate to a domestically-owned firm that operates in the same destination and sector based on the propensity score using one-to-one nearest-neighbor matching. When two or more domestic firms have an identical propensity score and are tied as "nearest neighbors," we include all the tied firms in the control group. The matching and estimation are carried out year-by-year and within each destination-sector separately.

In order to obtain good quality matches we drop firms outside the common support, that is we discard foreign affiliates whose propensity score is above the maximum or below the minimum propensity score of local firms. Additionally, we impose a tolerance on the maximum difference in propensity scores in a matched pair. Namely, each foreign multinational is matched only with local producers whose propensity score differs by no more than 0.005 percentage points.[13]

Table 5 shows the number of multinationals and local producers that are matched (on

[12]Notice that the identifying assumption in the propensity score matching is weaker than in a linear regression with destination×sector×size quartile×year fixed effects that further controls for continuous covariates such as log sales, firms age and multi-product status. The reason is that with propensity score matching the effect of the covariates on firm growth do not need to be linear.

[13]Intuitively, using narrower calipers will result in the matching of more similar firms, which should reduce the bias by reducing systematic differences between matched multinationals and local producers. However, narrowing the caliper may also result in a reduction in the number of matched pairs, thereby increasing the variance of the estimated treatment effect. Following Rosenbaum and Rubin (1985) and Lunt (2013) we chose a caliper that represents 20% of the variance of the propensity score. Indeed, we show that a stricter caliper value (0.001) and a more lax one (0.01) does not affect the significance of our results.

support) and those that are not (off support). The "treated, on support" is our group of interest. It corresponds to all multinationals for which there is a local producer that is a "good match" for it. Similarly, the "untreated, on support" group comprises of those local producers for which there is a foreign multinational that is a "good match" for it.[14]

In order to assess the quality of our matching procedure we check whether after matching the distribution of measured baseline covariates is independent of multinational status, that is, we evaluate whether the distribution of log size, age, and multiproduct status is similar between foreign affiliates and matched local producers.[15] We use the percentage bias indicator proposed by Rosenbaum and Rubin (1985), presented at the bottom of table 5. For each covariate, the standardized bias measures the difference in the sample mean for matched foreign multinationals and local producers as a percentage of the square root of the average of the sample variances in each group. Table 5 shows that the absolute value of the bias is below five percent for the three covariates in all years.[16] We also checked whether the exclusion of local multinationals (or headquarters) limits our ability to find good matches in the control group. To this end we estimate the propensity matching score while including headquarters as potential candidates to serve as matches of the foreign affiliates. The estimates as well as the balancing properties of the matches remain virtually unchanged.

[14]Notice that not all local producers on support serve as matches for foreign multinationals, but only those that are "best matches" or closer in terms of their propensity score. That is, the fact that a given foreign multinational appears as the "best match" for a local producer, does not mean that this local producer is the best matched of this foreign affiliate.

[15]Note that while the matching procedure guarantees that the matched multinationals and local producers have similar propensity scores, it is possible they can differ in the distribution of each individual covariate used to calculate the propensity score.

[16]In order to minimize the bias we run six different probit specifications, including higher order polynomials of each covariate and interaction terms, and apply several caliper levels (0.001, 0.005, 0.01, 0.3). The point estimates and significance levels across different model specifications and caliper combinations are virtually the same. In all specifications the bias of all covariates is lower than 5%.

Table A1: Sample and summary statistics

Country	Number of Firms	Number of Foreign Multinationals
Australia	8,415	1,701
Austria	51,025	5,154
Belgium	162,280	7,043
Bulgaria	122,474	2,927
Croatia	46,534	1,937
Czech Republic	104,513	12,618
Estonia	31,643	2,786
Finland	143,412	2,942
France	1,118,836	21,996
Germany	609,867	26,325
Greece	44,135	1,704
Hungary	221,822	2,086
Ireland	23,160	4,499
Italy	1,078,328	18,827
Japan	568,141	631
Korea	308,630	1,379
Latvia	48,812	3,541
Lithuania	14,531	1,155
Mexico	13,228	827
Netherlands	37,704	5,784
Norway	219,006	4,093
Poland	105,139	11,629
Portugal	259,513	5,657
Romania	292,706	19,761
Serbia	66,906	4,180
Singapore	5,189	1,544
Slovak Rep.	47,271	7,229
Slovenia	52,895	1,391
Spain	902,776	13,181
Sweden	313,415	6,035
Turkey	16,653	716
Ukraine	278,603	4,109
United Kingdom	358,540	33,558
United States	363,056	3,301
Mean	236,446	7,125
Median	113,807	4,101

Notes: This table reports the sample of countries used in the analysis. It reports the total number of firms and total number of foreign multinational affiliates in each country.

Table A2: Propensity score matching results, employment

Dep. Var.: $\gamma_{in,t}(f)$	2005	2006	2007	2008	2009	2010	2011	2012
ATT (treatment)	0.02935	0.03115	0.03484	0.02743	-0.01568	-0.00017	0.01915	0.00501
ATT (control)	0.00928	0.01423	0.02008	0.00914	-0.02671	-0.00610	0.00852	0.00153
ATT (diff)	0.02008	0.01692	0.01476	0.01829	0.01103	0.00594	0.01062	0.00348
SE ATT (diff)	0.00107	0.00100	0.00090	0.00088	0.00087	0.00076	0.00081	0.00089
t-stat ATT (diff)	18.80	17.37	16.39	21.02	12.72	7.83	13.04	3.91
ATE (diff)	0.02864	0.02502	0.02772	0.03708	0.02014	0.01759	0.00842	-0.00125
UMD (treatment)	0.02949	0.03123	0.03478	0.02715	-0.01637	-0.00025	0.01885	0.00478
UMD(control)	0.01429	0.01439	0.01526	0.00575	-0.01598	-0.00397	0.00554	-0.00443
UMD(diff)	0.01520	0.01684	0.01952	0.02140	-0.00040	0.00372	0.01331	0.00921
SE UMD (diff)	0.00075	0.00070	0.00065	0.00063	0.00062	0.00056	0.00060	0.00067
t-stat UMD (diff)	20.17	24.09	30.13	33.52	-0.62	6.69	22.33	13.85
Untreated/Off support	47,950	46,862	49,155	49,578	47,319	51,864	58,638	57,940
Untreated/On support	1,209,985	1,306,716	1,567,775	1,650,938	1,753,450	1,909,435	1,815,970	1,513,908
Treated/Off support	2,195	2,445	2,739	2,951	3,139	3,293	3,227	1,863
Treated/On support	57,644	65,230	76,057	81,222	85,591	96,747	90,896	61,090
Total Number of firms	1,317,774	1,421,253	1,695,726	1,784,689	1,889,499	2,061,339	1,968,731	1,634,801
Standardized Bias, %								
Log emp	1.2	0.5	0.5	0.0	0.3	0.2	0.2	-0.0
Age	1.2	0.8	0.1	0.2	-0.5	-0.1	-0.8	-0.2
Multi-sector	1.2	0.8	0.3	0.7	0.4	0.2	0.5	1.2

Notes: This table reports the Unconditional Mean Difference (UMD) and the Average Treatment Effect on the Treated (ATT) in each year. The dependent variable is the annual employment growth rate. In every year we assume common support, ties and a caliper of 0.005. The propensity scores were estimated using a probit model with log employment, age and multi-product status as explanatory variables.

Table A3: Propensity score matching results, conventional growth rates

Dep. Var.: $\hat{\gamma}_{in,t}(f)$	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ATT (treatment)	0.0705	0.0971	0.0891	0.0470	-0.0247	0.0703	0.0637	0.0320	0.0228	0.0403
ATT (control)	0.0394	0.0697	0.0638	0.0222	-0.0483	0.0420	0.0467	0.0180	0.0113	0.0326
ATT (diff)	0.0311	0.0275	0.0253	0.0248	0.0236	0.0283	0.0170	0.0140	0.0116	0.0077
SE ATT (diff)	0.0015	0.0014	0.0013	0.0012	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011
t-stat ATT (diff)	21.0300	19.6000	19.3800	20.2000	19.6500	24.0500	15.2800	12.9100	10.7900	7.1300
ATE (diff)	0.0439	0.0385	0.0319	0.0432	0.0360	0.0405	0.0279	0.0247	0.0298	0.0253
UMD (treatment)	0.0708	0.0973	0.0885	0.0467	-0.0259	0.0704	0.0634	0.0316	0.0223	0.0401
UMD(control)	0.0452	0.0706	0.0619	0.0200	-0.0180	0.0382	0.0385	0.0176	0.0121	0.0362
UMD(diff)	0.0256	0.0267	0.0266	0.0267	-0.0079	0.0322	0.0249	0.0140	0.0102	0.0039
SE UMD (diff)	0.0010	0.0009	0.0009	0.0008	0.0008	0.0008	0.0007	0.0007	0.0007	0.0007
t-stat UMD (diff)	26.3600	29.2100	31.1900	33.1000	-9.9900	42.1900	33.9300	19.3900	14.4300	5.6800
Untreated/Off support	73,285	66,893	59,879	66,181	71,428	71,576	73,121	81,423	71,114	68,061
Untreated/On support	2,145,210	2,301,485	2,544,820	2,753,726	2,839,872	2,999,686	3,077,301	3,052,708	2,868,939	2,128,775
Treated/Off support	3,919	4,210	4,475	4,755	5,052	5,456	5,481	5,447	5,527	5,561
Treated/On support	74,102	83,744	94,556	105,107	110,941	120,400	125,726	125,870	123,873	110,056
Total Number of firms	2,296,516	2,456,332	2,703,730	2,929,769	3,027,293	3,197,118	3,281,629	3,265,448	3,069,453	2,312,453
Standardized Bias, %										
Log sales	2	1.7	1.5	1.3	1.2	1.5	1.1	0.8	0.8	0.7
Age	-0.7	-1.7	-1.6	-2.7	-1.7	-2	-1.9	-2.3	-1.2	-2.3
Multi-sector	-0.4	-0.1	-0.5	-0.5	-0.1	-0.4	-0.2	-0.4	-0.3	-0.7

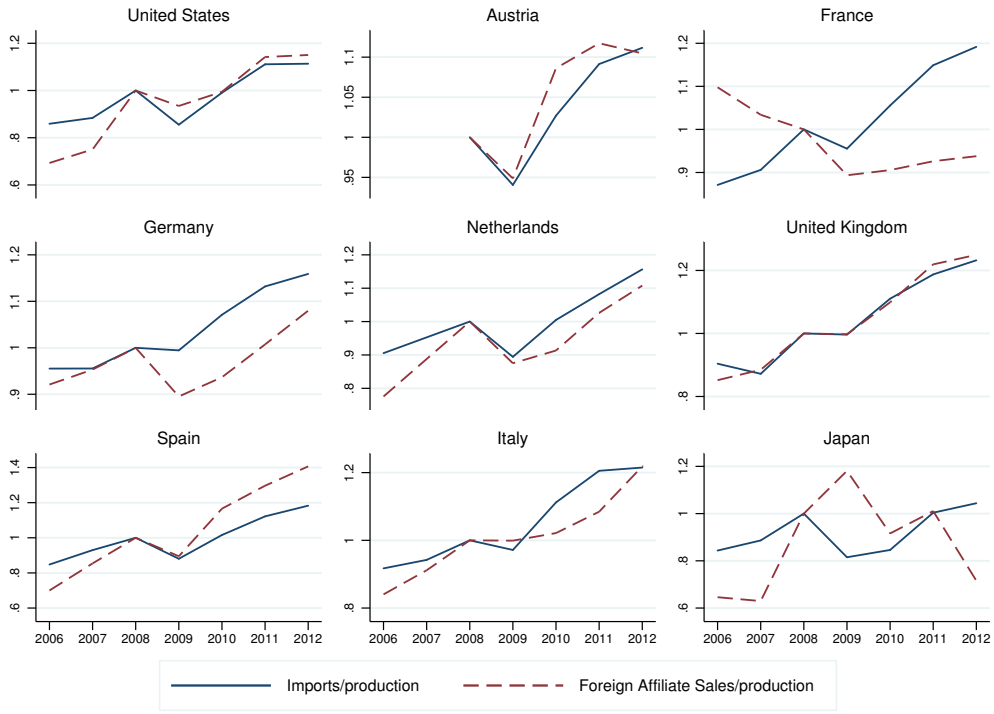
Notes: This table reports the Unconditional Mean Difference (UMD) and the Average Treatment Effect on the Treated (ATT) in each year. The dependent variable is the annual sales growth rate measured as:$\hat{\gamma}_{in,t} = \frac{x_{j,t} - x_{j,t-1}}{x_{j,t-1}}$. In every year we assume common support, ties and a caliper of 0.005. The propensity scores were estimated using a probit model with log sales, age and multi-product status as explanatory variables.

Table A4: Firm-level growth rates, controlling or log sales

	(1)	(2)	(3)
Dep. Var.: $\gamma_{in,t}(f)$			
$\mathbb{I}_{\{f \in FMN\}}$	0.0273	0.0278	0.0278
	(0.0045)	(0.0017)	(0.0017)
$\mathbb{I}_{\{f \in FMN\}} \times \mathbb{I}_{\{t=2009\}}$	0.0040	0.0036	0.0057
	(0.0106)	(0.0036)	(0.0025)
ln(sales)	-0.0027	-0.0046	-0.0055
	(0.0010)	(0.0007)	(0.0007)
ln(sales)$\times\mathbb{I}_{\{t=2009\}}$	-0.0147	-0.0156	-0.0122
	(0.0017)	(0.0014)	(0.0010)
Number of Observations	31,521,858	31,521,858	31,302,684
Number of Firms	6,639,262	6,639,262	6,563,480
Number of Multinationals	214,851	214,851	212,988
R^2	0.013	0.027	0.036
Year	YES	NO	NO
Destination$\times$Year	NO	YES	NO
Destination$\times$Sector$\times$Year	NO	NO	YES

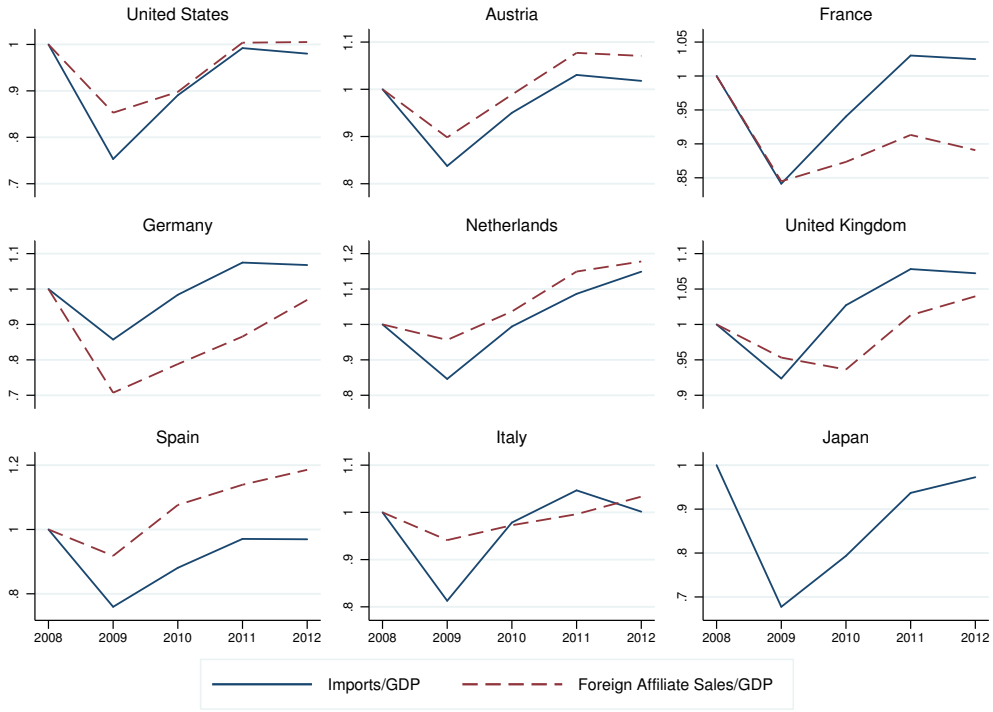
Notes: Standard errors clustered at the source-destination level in parentheses. This table reports the results of estimating equation (1) including the log of firms sales in the previous year as a control variable.

Figure A1: Imports and affiliate sales relative to industrial production



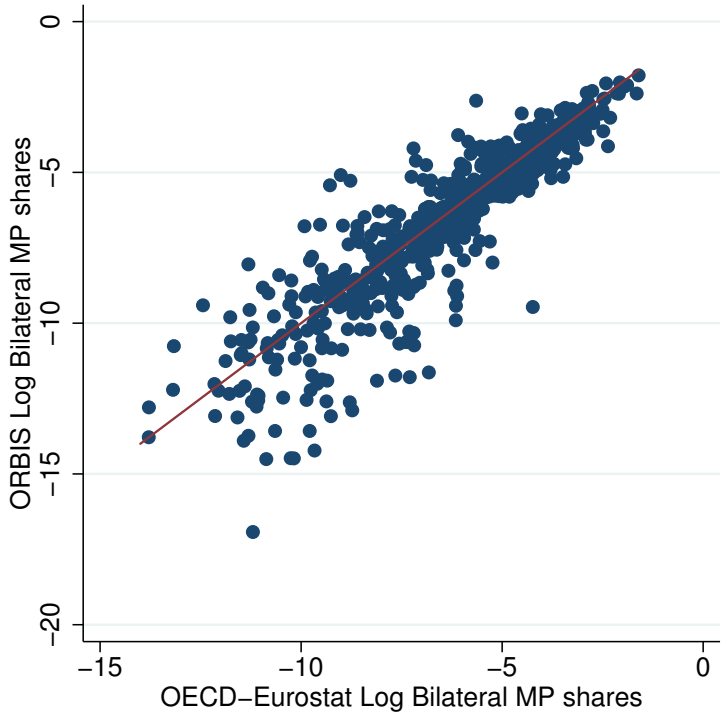
Notes: This figure reports the evolution of goods imports relative to industrial production and foreign affiliate sales relative to industrial production, normalized to 1 in 2008. Source: Authors' calculations based on OECD Statistics database. We use goods imports, inward turnover by the foreign affiliates of multinational firms in the manufacturing sector, and the manufacturing production index.

Figure A2: Imports and affiliate sales in all sectors (manufacturing and non-manufacturing) relative to GDP



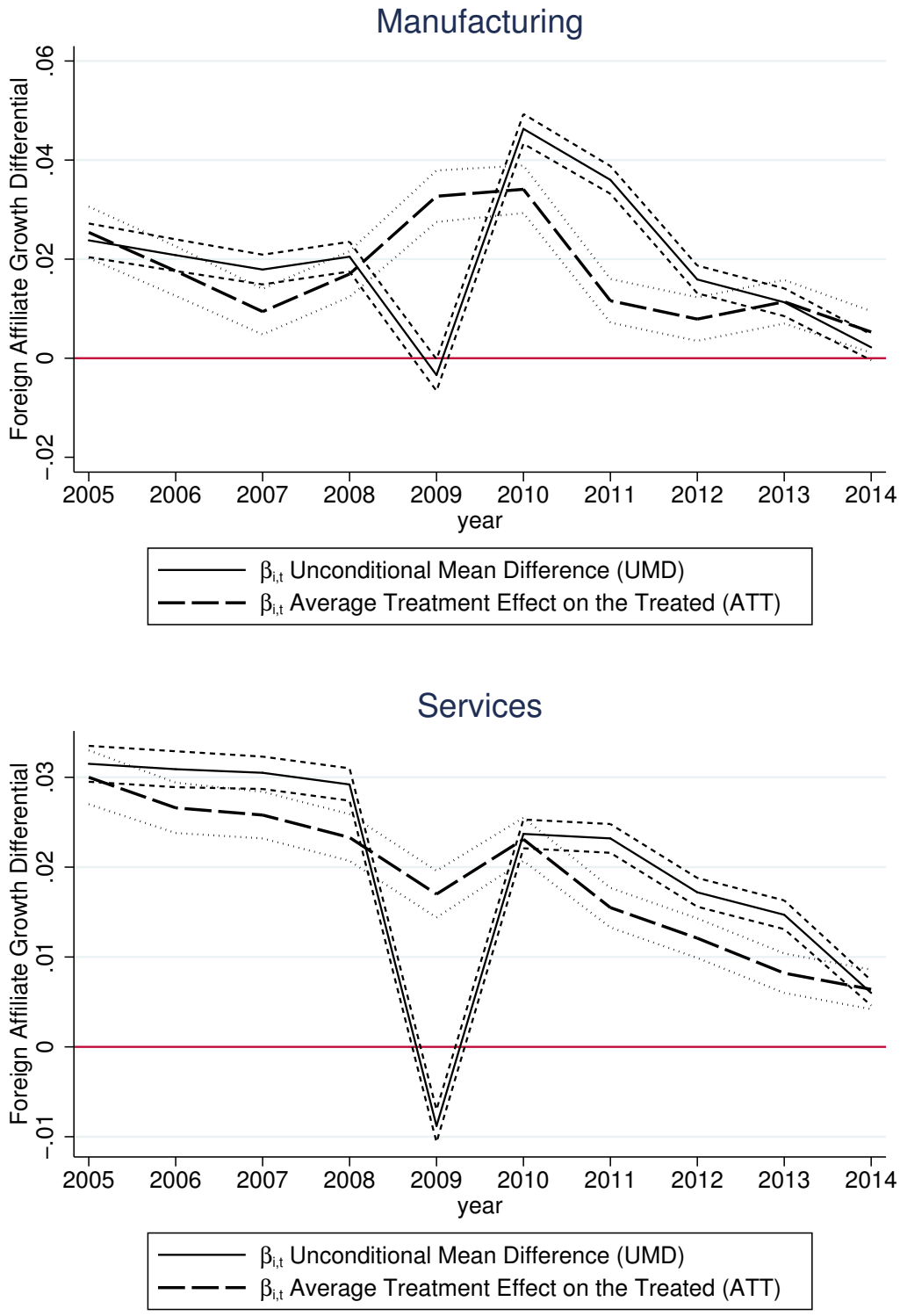
Notes: This figure reports the evolution of goods imports relative to GDP and foreign affiliate sales in the whole economy relative to GDP, normalized to 1 in 2008. Source: Authors' calculations based on OECD Statistics database.

Figure A3: Multinational production shares in ORBIS vs. OECD-Eurostat



Notes: This figure is a scatterplot of log bilateral multinational production shares in our ORBIS data against the log multinational production shares from the OECD and Eurostat data compiled by Alviarez (2013), with the 45-degree line. The multinational shares are constructed as the combined sales of all firms owned by each foreign country in total sales in each destination country.

Figure A4: Estimated ATT and the UMD



Notes: This figure plots the estimates of the Unconditional Mean Difference (UMD) and the Average Treatment Effect on the Treated (ATT) in each year, along with a 2-standard error band, for manufacturing and services separately.