ONLINE APPENDIX

Multinational Firms and International Business Cycle Transmission

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Appendix A   Data Assembly

This Appendix describes the downloading and cleaning steps that we followed in constructing the final dataset, as well as some additional statistics.

A.1   Downloading

The data were downloaded using the web-based utility available by subscription from Bureau Van Dijk. We downloaded the following variables from ORBIS: Company Name, Company ID, Global Ultimate Owner name (GUO name), Global Ultimate Owner ID (GUO ID), Consolidation Code, Independence Indicator, the firm's NACE Sector Code, and "Turnover" and Value Added denominated US$ in for each year available between 2004-2012.

In downloading the data we made a number of choices. First, in cases where several types of firm accounts were available, we prioritized *local registry filings* over *annual reports.* Second, we built the dataset based on "unconsolidated" accounts, since accounts that are consolidated across the many firms that comprise the corporation are not useful for our analysis. In particular, we downloaded companies with unconsolidated accounts only (consolidation code U1) and companies that present both consolidated and unconsolidated accounts (consolidation code C2/U2). By doing this we exclude firms with no recent financial information (NRF), with limited financial information (LF), no recent limited financial information (NRLF) and no financial variables at all (NF), since it is not clear which is the level of consolidation for these firms. Third, we only downloaded firms for which data on turnover was available in at least one of the years, since this is the main variable that we use in our analysis. This results in an initial download of 8,271,838 firms, 99% of which have a consolidation code U1, while the remaining have an consolidation code U2.

A.2   Defining ownership

The firm ownership matrix is constructed from an independence indicator provided by ORBIS, and variables reporting the Global Ultimate Owner (GUO) ID and name. The independence indicator characterizes the degree of independence of a company with regard to its shareholders. In defining the ownership structure, we took the following steps. First, we only assigned "owners" to those firms that have an independence indicator of "D", which is allocated to any company with a recorded shareholder with a direct ownership of over 50 percent.

Second, about 25% of the firms in ORBIS contain information on their GUO name but not the GUO ID. This issue arises mainly because some firms are owned by individuals or families,[1] and ORBIS only defines ID numbers for firms. In cases in which the ultimate owner is a person or a family, we need to establish which of the firms in the group will be assigned the role of the 'parent' of the group. In such cases, the parent firm is assumed to be the firm with the largest revenue owned by that GUO name (to be used in firm-level

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[1]For instance, family Porsche is the GUO owning Volkswagen and all its affiliates.

exercises), and source country is assumed to be the country in which the GUO name has the largest revenues (to be used in GUO-destination level exercises). The results in the paper remain unchanged if instead we exclude the firms for which the GUO IDs are not available. Firms with neither GUO ID or GUO name data are by default assumed to have no owner (that is, they are their own global ultimate owner).

The data do not contain the full ownership structure, implying that intermediate ownership links are not fully observable. Thus, we do not know whether a firm's "global ultimate owner" owns the firm directly or through owning another company (in perhaps another country) that in turn owns the firm.

A.3   Cleaning

This section describes all the steps to get the data ready for use. First, for those firms for which both consolidated and unconsolidated accounts are available, we keep the unconsolidated accounts. Second, we convert the revenue and value added to local currency and adjust for inflation using GDP deflator from the World Bank. Finally, for a subset of firms, we manually checked the data on the independence status and ownership, which resulted in corrections to independence indicators, GUO, and/or source country. The manual checks were performed by closer examination of the Bureau van Dijk web interface and internet searches. The manual coding supersedes any automatic algorithm discussed above. The following subsets were checked:

- The largest 15 domestic firms in each country (we include firms that are in the top 15 in any year), resulting in 42 manual recodes.

- The largest 15 GUOs in each country (we include GUOs that are top 15 in any year), resulting in 134 manual recodes.

- The largest 15 firms with a GUO name but not GUO ID in each country, resulting in 37 manual recodes.

- The largest 100 GUOs that are listed as being in offshore locations (i.e. Bermuda, Virgin Islands, Curaçao, Cayman Islands, Gibraltar, Bahamas, Marshall Islands, Mauritius, and unidentified "YY" and "WW" firms), resulting in 66 manual recodes.

- Some firms in Croatia have GUO IDs that do not identify the country of ownership, and are coded as "YY". We classify these firms as owned by an "unknown" country, while at the same time we manually checked the largest 100 of these firms, which resulted in 30 manual recodes.

In addition to this manual cleaning, we remove outliers by excluding observations in which DHS sales growth rates are below -2/3 and above 2/3 (where growth rates are defined as $\gamma_t \equiv \frac{1}{2}\frac{x_t - x_{t-1}}{x_t + x_{t-1}}$). The removal of the outlier growth rates should help cleaning out mergers and acquisitions, as those are likely to manifest themselves in extreme growth rates. Finally, in calculating growth rates at any level of aggregation (whether it is country-level, GUO-destination level, etc.), we include only firms that are present in two

consecutive years (e.g. the 2005 growth rate is computed using firms that are present in both 2004 and 2005; the 2006 growth rate is computed using firms present in both 2005 and 2006, etc.).

Bosnia-Herzegovina and the Philippines were dropped from the sample in spite of satisfying the three country selection criteria spelled out in the main text due to poor data quality. Mexico was kept in the sample despite having a correlation with GDP that is slightly below our threshold (0.49). Finally, ORBIS data for the US contains predominantly consolidated accounts, which implies that the aggregate unconsolidated revenues in ORBIS represent a low share of total revenues as reported in standard sources. We kept the US in the sample in spite of this issue due to its importance as a source country of multinational affiliates present in other countries, as well as its overall importance in the world economy. The data in ORBIS are collected in each destination country, which means that we have extensive information on the foreign operations of US-based multinationals even when data on their US operations are missing. The introduction of the US as a destination country does not affect our quantitative results for the remaining countries.

Note that while our sample is comprised of 34 destination countries, every country in the world is a potential source. In this section and in the remainder of the paper, we include all countries (and not just the ones in our sample) as sources. We estimate source country dummies for the 34 countries in our sample and for the following countries that are relatively important as sources for multinational firms: Canada, China, Switzerland, Russia, Brazil, UAE, Bahamas, Luxembourg, the Philippines, Cyprus, South Africa, and Bosnia-Herzegovina. The remaining countries in the world are lumped into a "rest of the world" category.

Country groups are defined as follows. High-Income Europe: Austria, Belgium, Germany, Spain, Finland, France, UK, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Sweden; Emerging Europe: Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Poland, Romania, Serbia, Slovenia, Slovakia, Ukraine; High-Income Rest of the World (ROW): Australia, Japan, South Korea, Singapore, USA; Emerging ROW: Mexico, Turkey.

A.4   Data validation

Appendix Figure A1 cross-checks the quality of our data on multinational revenue shares. It compares the share of foreign multinationals in total output in each destination country in our data and in the aggregate data compiled by Alviarez (2013) from OECD Statistics, EUROSTAT, and UNCTAD. The foreign multinationals' output shares are remarkably similar in ORBIS and the Alviarez (2013) data, with the exception of some Eastern European countries for which multinationals are underrepresented in ORBIS. In the sample of 28 countries for which multinational shares are available in both datasets, the average ORBIS shares are somewhat lower (mean of 0.28 in ORBIS vs. 0.36 in aggregate data). To the extent that the overall multinational production shares are understated in our data, our results on the aggregate importance of multinationals for business cycles will be conservative.

Appendix Table A2 presents the matrix of bilateral multinational shares. It displays, in percent, the share of aggregate revenue in the country in the row that is taken up by

the firms owned by the country in the column. Thus the diagonal terms correspond to the share of aggregate revenue that is taken up by domestically-owned firms. The salient feature of the table, important for the results below, is that bilateral multinational shares are small. In the square matrix of 34 sources and destinations, the mean cross-border revenue share is 0.7%, and the median is 0.025%. These low averages are driven partly by the fact that many countries in the sample (such as the small peripheral European countries) do not have many of their own multinationals. However, even in the G-7 economies, the average outward bilateral shares tend to be small. The largest source country, the US, accounts on average for 5.5% of revenue in a foreign destination country, followed by Germany (3.7%), the UK (2.9%), and France (2.3%). All of the other source countries have average foreign shares of under 1.5%.

Finally, Appendix Table A3 presents the distribution of firms and of foreign multinationals across 2-digit NACE sectors used in the empirical analysis below. The largest sectors in our sample are wholesale and retail trade respectively. The last column of the table shows that foreign multinationals represent an important share of revenues in various sectors, both within manufacturing and services categories.

Appendix B Robustness

This appendix and Tables A4-A8 present a set of robustness checks on the firm-level empirical results.

B.1 Vertical input linkages

Table A4 evaluates, in different ways, whether the results are driven by input linkages. To determine whether the estimated coefficients are driven exclusively by input-output linkages, in Table 1 in the main text we already restricted attention to parent-affiliate pairs that operate in the service sector. However, it could be that many firms in the service sector sample in fact have manufacturing facilities. Column 1 in Table A4 reports the results of restricting the sample to cases in which both the parent firm(s) and all the affiliates are in the service sector (thus ruling out manufacturing affiliates on both sides of the border). Columns 2 and 3 present the results excluding firms whose primary activity is listed as wholesale and retail trade respectively. These specifications verify that our results are not driven by firms that may be simply re-selling the output of their foreign counterparts. Columns 4 and 5 repeat the baseline fixed effects regression, but using value added and employment rather than sales data to calculate the growth rates. Value added information is only available for less than half of the observations in the sample, while employment is available for about two thirds of the observations in our sample. There is a strong positive correlation both in the value added growth and in the employment growth of parents and affiliates. This robustness check rules out a mechanical relationship that can occur with sales, when the parent sells some products to the affiliate, and the affiliate resells them in the local market.

Finally, we incorporate explicit information on input trade. That information is of course not available at the firm-pair level, but is available at the sector-pair level, by source-destination pair from the World Input-Output Database (WIOD). From WIOD, we know the input trade between each sector s in source country i and each sector p in destination n. We match this information to the country-sectors in our firm-level regressions, and interact our regressor of interest – parent sales growth – with this country-pair, sector-pair specific input coefficient. (The input coefficient itself is absorbed by the fixed effect.) The result, reported in column 6 or Table A4 shows that there is no statistically significant differential comovement between parent and affiliate growth in sectors characterized by greater input trade, whereas the main coefficient of interest is virtually unchanged.[2]

B.2 Alternative sources of comovement

Table A5 investigates alternative mechanisms that can induce correlation between affiliate and parent sales growth. First, we check whether comovement in sales growth is driven mainly by multinational firms shifting profits across markets for tax purposes. Column

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[2]The table reports the results when using the affiliate country-sector's usage of inputs from the parent's country-sector. The results are the same if we instead use the opposite coefficient: the parent country-sector's input usage of the affiliate's country-sector.

1 evaluates this hypothesis by repeating our baseline estimation excluding the two countries typically associated with tax sheltering behavior: Ireland and the Netherlands. The table shows that the result is unchanged when excluding these countries. Column 2 interacts parent growth with the corporate tax differential between the parent and the affiliate country. The corporate tax data come from the Oxford University Centre for Business Taxation and KPMG Country Tax Profiles, as assembled by Sharma (2015). The corporate tax rate differential between the parent and affiliate country is not significant in conditioning the parent-affiliate comovement.[3] Finally, the concern that tax shifting drives our results should be further alleviated by the fact that, as reported above, parent-affiliate comovement occurs for employment as well as for sales.

Next, we check whether parent-affiliate comovement is driven by internal capital markets. Column 3 of Table A5 interacts parent growth with the conventional measure of the affiliate country's financial development (Private credit/GDP, sourced from the World Bank's Global Financial Development Database). The interaction is not significant and the main effect is unchanged, suggesting that parent-affiliate comovement is not greater for destinations in which affiliates are likely to be especially dependent on the parent's capital markets. Relatedly, we check whether comovement in sales growth is a special consequence of the 2008 financial crisis, a period in which financial constraints are likely to have been especially relevant. Column 4 shows that the estimates are similar when restricting the sample to pre-crisis years.

B.3 Heterogeneous impact

Next, we check whether the parent-affiliate comovement is conditioned by country characteristics that affect the ease of technology transfer. For instance, this could be because multinationals are more reluctant to transfer technology to countries with weaker intellectual property rights (Javorcik, 2004; Branstetter et al., 2006). Column 5 of Table A5 uses the Ginarte-Park index of IPR protection to evaluate this conjecture. It interacts parent growth with a dummy variable for the destination country being above the median of the Ginarte-Park index in our sample of destinations. The interaction term is not significant and close to zero. One limitation of this exercise is that there is quite limited variation in the strength of IPR across the destination countries in our sample, and thus a reliable differential effect cannot be picked up. Another dimension of heterogeneity that may affect technology transfer is geographical distance. Column 6 of Table A5 interacts parent growth with the (log) geographical distance between the parent and the affiliate country. There is no statistically significant differential effect of distance on parent-affiliate comovement.

Cross-sectional models of frictional technology transfer within multinationals, such as Ramondo (2014), Ramondo and Rodríguez-Clare (2013), or Tintelnot (2016), imply that the the severity of the technology transfer friction will determine the multinational production shares themselves. This suggests a positive relation between the MP shares and

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[3]When we interact parent growth with the level of corporate tax in the affiliate country, the interaction is marginally significant but modest in magnitude, and the main effect remains virtually unchanged and strongly significant.

the strength of parent-affiliate comovement. Column 7 checks for this by dividing our sample of parent-affiliate pairs into quartiles according to the overall MP share of the parent's country in the affiliate's country, and estimate quartile-specific coefficients. It turns out that the differences in parent-affiliate comovement across MP share quartiles are minor. For observations in the lowest quartile, the coefficient on parent growth is 0.19, not much lower than in the baseline. The coefficient is marginally higher in the middle two quartiles, and only 0.06 higher for the top quartile, with a point estimate of 0.25. The top quartile coefficient is marginally significantly different from the bottom quartile. All in all, while there is some weak evidence that parent-affiliate transmission is stronger among country pairs that have more MP, interquartile differences are relatively minor and parent-affiliate transmission is present across the distribution of MP shares.

Finally, it may be that the transmission of shocks is only confined to high-income destination countries. Column 8 includes an interaction between the regressor of interest and a dummy variable indicating whether the destination country is a high-income country, to evaluate the extent to which the correlation arises exclusively between parents and affiliates operating in high-income countries. The table shows that there is a strongly significant, although lower, positive correlation between parents and affiliates even when affiliates are not in high-income countries.

B.4 Direction of shock transmission

An important question is whether it is possible to establish that the observed correlation between firms of the same multinational group is driven by shocks that are transmitted from the parent to the affiliates. We address this question by evaluating whether shocks are transmitted from the large to the small firms in the multinational group, irrespective of whether the large firms are the parent or one of the affiliates in the group. With this in mind, we reestimate a version of equation (1) in the main text in which, instead having the growth of the parent as the independent variable and the growth of the affiliate as the dependent variable, we use the growth of whichever firm is larger as the independent variable. Appendix Table A6 reports the estimates of ϕ in this model for different samples of firms. The first two columns show that when the affiliate is smaller than the parent there is a positive correlation between parents and affiliates, if anything the estimated ϕ's tend to get larger as the affiliate gets relatively smaller. In contrast, the last two columns show that in cases where the parent is smaller than the affiliate there is no significant correlation between the firms. Our interpretation of these results is that the data reject the notion that the shocks are transmitted from the largest to the smallest firm in the group, since this seems to hold only in cases in which the large party is also the parent.

B.5 Data construction and other checks

Column 1 of Table A7 shows that the results are virtually unchanged if we use conventional growth rates instead of the DHS growth rates. Columns 2 and 3 evaluate if the correlations between affiliate and parent sales growth are driven by aggregate trends that are not accounted for the fixed effects used in the baseline. Column 2 shows that we obtain a similar coefficient if the fixed effects are at the 4-digit (as opposed to 2-digit) level.

Column 3 estimates a placebo regression in which we link affiliates to random parents (as opposed to linking them to the affiliates' true parents). In particular, we link affiliates to firms that are parents from the same source country and that operate in the same sector as the true parent of the affiliate. The coefficient falls to zero and becomes insignificant.[4]

Table A1 in the paper makes it clear that data quality is not the same for all countries in the sample. For instance, Mexico fails the formal country sample selection criteria for the correlation of ORBIS data with GDP; in Ireland and Spain aggregate output in ORBIS data is marginally greater than in official sources; and in Australia there are very few firms and multinationals are actually smaller in average size than domestic firms. Column 4 drops all of these suspect countries, and shows that the results are robust.[5]

One limitation of our data is that the ownership indicator is not time-varying. That is, the ownership information is the latest information available to ORBIS at the time the data were downloaded. This implies that as we go further back in time, the ownership information would become noisier due to ownership changes. To establish that our results are robust to accounting for ownership changes, we make use of the vintage 2009 DVD-ROM (containing data up until 2007 due to the 2-year reporting lag). We extract the ownership information from the 2009 DVD-ROM, and compare it to the ownership information in the baseline data.[6] We perform 2 robustness checks with this information. In the first, we start with our original sample (the one underlying Table 1), and throw out all the firms for which the DVD-ROM lets us establish definitively that the owner has changed between 2007 and 2012.[7] The second, much more stringent, exercise is to restrict attention to only those firms for which we can be fully sure that the ownership didn't change between 2007 and 2012. This requires that the firm (i) be present in both the DVD-ROM and our online datasets; + (ii) contain information on the global ultimate owner in both datasets; + (iii) the ID numbers and/or names of the global ultimate owner to match in the two datasets. Since the match is imperfect and the ownership variable has poor coverage in the DVD-ROM, that leads to the removal of a lot of the sample. Columns 5 and 6 of Table A7 report the results of those two robustness checks. Accounting for ownership changes does not materially affect the results.

All of the above results were on the combined sales of the parent and affiliates in each country. That is, the parent observation was the growth rate of the combined sales of all the firms that the parent owns in the home country, and the affiliate observation was the combined sales of all the firms that the parent owns in a particular destination country. To establish that the results are not driven by this approach, Table A8 repeats the exercise

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[4]We implemented several different placebo specifications in which firms are shuffled randomly within different size bins, from pure random shuffling across the entire sample to a shuffling of firms within the same source-destination-sector pair (reported). In all the placebo experiments the coefficients were close to zero and insignificant.

[5]The results are also robust to dropping these countries one at a time.

[6]Even after accounting for ID changes across time in ORBIS, the firm match is imperfect. In addition, the coverage of the ownership variable is quite spotty in the 2009 DVD-ROM compared to our online data (that is, information on the "global ultimate owner" is missing for a far larger fraction of the DVD-ROM data than our online data). Thus, we cannot establish cleanly and unambiguously for each firm in our baseline sample whether or not the owner has changed between 2007 and 2012.

[7]Note that some observations for those firms may still be valid. For instance, if the ownership changes in 2008, then our baseline information for that firm for 2008-2012 is still correct.

on individual firms, rather than combined sales. In this specification, domestic affiliates of the parent firm are also included in the sample.[8] Column 1 shows the estimates based on the entire sample, column 2 for manufacturing, and column 3 for services. The last six columns estimate the relationship using value added and employment data, respectively. Throughout, we continue to find a strong positive and significant correlation between affiliates' and parents' growth.

We prefer the specifications that aggregate affiliate sales of the same firm in each country for two reasons. First, the source country shock need not originate in the headquarter firm only: some shocks may be transmitted directly from the source country affiliates to the destination country affiliates. Combining all the affiliates of a given firm in the source country yields a composite of all the shocks affecting the home operations of a multinational. Second, combining the sales of firms in each country averages out some of the noise in the sales growth data, especially in cases with small constituent firms.

Finally, the finding of strong positive comovement between parent and affiliate growth is robust to a variety of additional checks: estimation year-by-year instead of pooling years, including and excluding domestic affiliates, excluding parent-affiliate pairs in which the parent operates in the financial sector, and different configurations of fixed effects. We do not report those robustness checks to conserve space, but they are available upon request.

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[8]We checked whether the coefficient of interest is different between the parent and a domestic affiliate compared to a foreign affiliate. There was no economically meaningful or statistically significant difference.

Appendix C   Complete Model and Extensions

C.1   Complete derivations

This section derives the equilibrium growth rates in the model economy in the paper. Profit maximization implies a constant markup over marginal cost:

$$P_{in,t}(f) = \frac{\rho}{\rho-1}\frac{W_{n,t}}{Z_{in,t}(f)}. \tag{C.1}$$

The demand for firm's f product is given by:

$$Q_{in,t}(f) = \frac{P_{in,t}^{-\rho}(f)}{P_{in,t}^{-\rho}}Q_{in,t}, \tag{C.2}$$

where the price index of the country i product aggregate is

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

Cost minimization by final good producers implies:

$$Q_{in,t} = \frac{\widetilde{A}_{in,t}P_{in,t}^{-\rho}}{P_{n,t}^{-\rho}}\ Q_{n,t}, \tag{C.4}$$

where

$$P_{n,t} = \left[\sum_i\widetilde{A}_{in,t}P_{in,t}^{1-\rho}\right]^{\frac{1}{1-\rho}} = 1 \tag{C.5}$$

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

Utility maximization implies the following labor supply:

$$L_{n,t} = W_{n,t}^{\frac{1}{\phi-1}}. \tag{C.6}$$

As is well known, under GHH preferences the labor supply is independent of wealth effects. We exploit this property to derive predictions for output that are independent of the international asset market structure.[9]

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[9]The assumption of GHH preferences makes the model highly tractable. Some of the quantitative results do not rely on this assumption, conditional on the parameter ϕ. We discuss how this assumption affects the results in the following section.

Combining equations (C.1) and (C.3) we can write the real wage as:

$$W_{n,t} = \frac{\rho-1}{\rho} \left[\sum_i \sum_{f \in \Omega_i} \tilde{A}_{in,t} Z_{in,t} (f)^{\rho-1} \right]^{\frac{1}{\rho-1}}, \tag{C.7}$$

where Ω_i is the set of firms that are active in country i. Profit maximization implies that aggregate revenues are proportional to total labor payments:

$$\sum_i P_{in,t} Q_{in,t} = Q_{n,t} = \frac{\rho}{\rho-1} W_{n,t} L_{n,t}, \tag{C.8}$$

which in combination with (C.6) and (C.7) permits expressing the aggregate output as:

$$Q_{n,t} = \left(\frac{\rho-1}{\rho} \right)^{\psi-1} \left[\sum_i \sum_{f \in \Omega_i} \tilde{A}_{in,t} Z_{in,t} (f)^{\rho-1} \right]^{\frac{\psi}{\rho-1}} \tag{C.9}$$

where $\psi \equiv \frac{\bar{\psi}}{\bar{\psi}-1} > 1$.

Let lower-case variables denote growth rates of the corresponding upper-case variables. Equation (C.9) implies that aggregate growth in country n is approximated by:

$$\gamma_{n,t} = \psi \sum_i \sum_{f \in \Omega_i} \omega_{in,t} (f) \left[\frac{\tilde{a}_{in,t}}{\rho-1} + z_{in,t} (f) \right], \tag{C.10}$$

where $\omega_{in,t} (f) \equiv \frac{P_{in,t}(f)Q_{in,t}(f)}{P_{n,t}Q_{n,t}}$ denotes the share of country $n's$ revenues generated by firm f from source country i.[10] Using the functional form for $z_{in,t} (f)$, equation (C.10) becomes

$$\gamma_{n,t} = \frac{\psi}{\rho-1} \sum_i \omega_{in,t} [a_{in,t} + \phi (\rho-1) z_{i,t}] + \psi (1-\phi) z_{n,t}, \tag{C.11}$$

where $\omega_{in,t} \equiv \frac{P_{in,t}Q_{in,t}}{P_{n,t}Q_{n,t}}$ denotes the share of country $n's$ revenues generated by firms from

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[10]Note that this theoretical measure is consistent with the way real GDP growth is computed by national statistical agencies. In particular, real GDP is calculated as the deflated value of final sales. In our model, the final good $Q_{n,t}$ is tradeable across countries, so it is natural to think that the sales and price of the final good are directly observable by the statistical agency. In this case, real GDP would be measured as:

$$RGDP_{n,t} = P_{n,t}Q_{n,t}/P_{t,t-1}^{IX}.$$

where the price index is given by $P_{t,t-1}^{IX} = P_{n,t}/P_{n,t-1}$. Given our choice of the numeraire, the growth of real GDP is given by $\gamma_{n,t}$. Aggregate productivity is measured as $RGDP_{n,t}/L_{n,t}$, so measured productivity growth is given by $\frac{1}{\psi}\gamma_{n,t}$. If by contrast the price of the final good $Q_{n,t}$ is not directly observable by the statistical agency, the growth rate of measured real GDP is still $\gamma_{n,t}$ to a first-order approximation, as long as the price changes measured by statistical agencies reflect changes in $\tilde{a}_{in,t}$. See Burstein and Cravino (2015) for a detailed discussion of how to compute aggregate measures of economic activity in heterogeneous-firm models.

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source country i, and the bilateral term encompasses the idiosyncratic terms specific to the country pair: $a_{in,t} = (\rho - 1) \sum_{f \in \Omega_i} \frac{\omega_{in,t}(f)}{\omega_{in,t}} \left[\frac{\tilde{a}_{in,t}}{\rho - 1} + \phi z_{i,t}(f) + (1 - \phi) z_{n,t}(f) \right]$.

C.1.1 Interpreting affiliate-parent comovement

We now derive the equations in Sections 4.2 and 4.3. Using equations (C.1) and (C.2) and the functional form for $Z_{in,t}(f)$, the growth rate of firm f's sales in destination n can be written as:

$$\gamma_{in,t}(f) \;=\; \bar{a}_{in,t} + (\rho - 1)\phi z_{i,t}(f) + (\rho - 1)(1 - \phi) z_{n,t}(f). \tag{C.12}$$

where $\bar{a}_{in,t} \equiv (1 - \rho)[w_{n,t} - \phi z_{i,t} - (1 - \phi) z_{n,t}] + \rho p_{in,t} + q_{in,t}$. The growth rate of the firm in its home country is:

$$\gamma_{ii,t}(f) \;=\; \bar{a}_{ii,t} + (\rho - 1) z_{i,t}(f). \tag{C.13}$$

Substituting we obtain:

$$\gamma_{in,t}(f) \;=\; \bar{\bar{a}}_{in,t} + \phi \gamma_{ii,t}(f) + \epsilon_{in,t}(f), \tag{C.14}$$

where $\bar{\bar{a}}_{in,t} \equiv \bar{a}_{in,t} - \phi \bar{a}_{ii,t}$ and $\epsilon_{in,t}(f) \equiv (\rho - 1)(1 - \phi) z_{n,t}(f)$.

To see that the identifying assumption stated in the paper is satisfies, note that if $z_{i,t}(f)$ and $z_{n,t}(f)$ are correlated, we can orthogonalize the destination shock with respect to the source shock: $z_{n,t}(f) = \beta_0 + \beta z_{i,t}(f) + (1 - \beta)\epsilon_{n,t}(f)$, where $\epsilon_{n,t}(f)$ is orthogonal to $z_{i,t}(f)$. The growth rate of the affiliate in (C.12) is then $\gamma_{in,t}(f) = \bar{a}_{in,t} + (\rho - 1)\tilde{\phi} z_{i,t}(f) + (\rho - 1)(1 - \tilde{\phi})\epsilon_{n,t}(f)$, with $\tilde{\phi} \equiv (\phi + (1 - \phi)\beta)$. The assumption of an orthogonal error term in the estimating equation (C.14) is satisfied, and the regression coefficient is now an estimate of $\tilde{\phi}$, interpreted as the combination of technology transfer and the underlying exogenous correlation between the shocks of the affiliate to those of the parents, which is what will ultimately matter for the aggregate comovement in this model. The common components $z_{i,t}$ and $z_{n,t}$ can be correlated as they are absorbed by the fixed effect in the estimation in Section 3.1.

To derive equation (9) in the paper, combine expressions (C.1), (C.4), (C.5), and (C.9) to write the total revenues by multinationals from source country i operating in country n as:

$$P_{in,t} Q_{in,t} \;=\; A_{in,t} S_{i,t} D_{n,t}, \tag{C.15}$$

where $S_{i,t} = Z_{i,t}^{\phi(\rho - 1)}$ is a term common to all firms from source country i, $D_{n,t} = \left[\sum_i A_{in,t} Z_{i,t}^{\phi(\rho-1)} \right]^{\frac{\psi - \rho + 1}{\rho - 1}} Z_{n,t}^{\psi(1 - \phi)}$ is a term common to all firms operating in destination country n, and $A_{in,t} = \widetilde{A}_{in,t} \sum_{f \in \Omega_i} \left[Z_{i,t}^{\phi}(f) Z_{n,t}^{(1-\phi)}(f) \right]^{\rho - 1}$.

C.2 Armington final goods aggregation

This subsection extends the model to a case in which the final goods produced in each country are differentiated by origin. In particular, we assume that the consumption composite is given by:

$$C_t = \left[\sum_n Q_{n,t}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}, \tag{C.16}$$

so that $C_t = \sum_i C_{i,t}$. The inverse demand for the final output of each country n is given by:

$$P_{n,t} = [Q_{n,t}]^{-1/\epsilon} \left[\frac{C_t}{P_{c,t}^{-\epsilon}} \right]^{-1/\epsilon},$$

where $P_{c,t}$ is the price index associated with the aggregator (C.16). Aggregate revenues in country n are given by:

$$P_{n,t} Q_{n,t} = Q_{n,t}^{\frac{\epsilon-1}{\epsilon}} \left[\frac{C_t}{P_{c,t}^{-\epsilon}} \right]^{-1/\epsilon}.$$

The growth rate is

$$\gamma_{n,t} = \frac{\epsilon-1}{\epsilon} \psi \sum_i \sum_{f \in \Omega_i} \omega_{in,t}(f) \left[\frac{a_{in,t}}{\rho-1} + z_{in,t}(f) \right],$$

which coincides with equation (C.10) up to the constant $\frac{\epsilon-1}{\epsilon}$. Hence, equations (15) and (16) remain unchanged. Differences in growth rates across countries are given by:

$$\gamma_{n,t} - \bar{\gamma}_t = \frac{\epsilon-1}{\epsilon} \left[\bar{q}_{n,t} - \bar{q}_t \right],$$

while the counterfactual growth rates will be given by

$$\gamma_{n,t}^c - \bar{\gamma}_t^c = \frac{\epsilon-1}{\epsilon} \left[\bar{q}_{n,t}^c - \bar{q}_t^c \right].$$

Thus, for given values of ϕ and shares ω_{in}, the ratio of actual to counterfactual growth rates and variances is independent of ϵ.

C.3 Low elasticity of substitution between Z_i and Z_n

This subsection presents an extension of the model to a setting in which parent and affiliate productivities are combined by a CES aggregator, as opposed to Cobb-Douglas. In particular, we assume that the individual firm production function is given by:

$$Q_{in,t}(f) = Z_{in,t}(f) L_{in,t}(f), \tag{C.17}$$

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where

$$Z_{in,t}(f) = \left[\phi Z_{i,t}(f)^{\frac{\eta-1}{\eta}} + (1-\phi) Z_{n,t}(f)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{C.18}$$

The formulation in the main text corresponds to the limiting case of $\eta = 1$.

Aggregate output is given by equation (C.9), and output growth is given by (C.14). Differences from out baseline framework are driven by the effect of η on the growth rate of $Z_{in,t}(f)$ (C.18). We show that the difference is zero to a first order approximation. In particular, log-linearizing (C.18) around a symmetric $Z_n = Z_i$ we obtain:

$$z_{in,t} = \phi z_{i,t} + (1-\phi) z_{n,t}.$$

which coincides with the growth rate used in the text.

C.4   Intermediate input linkages

In this section we present a version of the model in which the transmission of shocks within multinationals is driven by vertical production linkages. In particular, we maintain the structure of the model in the paper, but assume that each firm operates a Cobb-Douglas technology that uses labor in the destination country and intermediate inputs that are produced in the firm's headquarter. The firm-level production function is given by:

$$Q_{in,t}(f) = (Z_{n,t}(f) L_{in,t}(f))^{1-\phi} X_{in,t}(f)^{\phi}, \tag{C.19}$$

where $Z_{n,t}(f)$ is a firm-specific productivity component, and $X_{in,t}(f)$ is a intermediate input that is specific to the multinational group. In what follows we refer to $Q_{in,t}(f)$ as intermediate goods, and to $X_{in,t}(f)$ as intermediate inputs. Intermediate inputs are produced by the firm's parent using the homogeneous final good. Crucially, affiliates cannot produce the intermediate input themselves and cannot use the intermediate inputs produced by other firms.

Parent firms operate a technology that turns one unit of the final good into $Z_{i,t}(f)$ units in of the firm-specific intermediate input,

$$X_{i,t}(f) = Z_{i,t}(f) M_{i,t}(f), \tag{C.20}$$

where $M_{i,t}(f)$ is the amount of the final good used by firm f in country i to produce intermediate inputs. Note that market clearing in intermediate inputs implies: $X_{i,t}(f) = \sum_n X_{in,t}(f)$, that is, production of intermediate inputs by the headquarter is equal to the combined the demand of intermediate inputs by the parents affiliates in all destinations (including the domestic destination). The firm's parent can also produce intermediate inputs $Q_{ii,t}(f)$ with the production function given in (C.19).

The production function in equation (C.20) implies that the cost of producing a unit of the intermediate input is given by $C_{i,t}^x(f) = P_t^W / Z_{i,t}(f) = 1/Z_{i,t}(f)$. The marginal cost of producing a unit of the intermediate good in destination country n is given by:

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$C_{in,t}(f) = \bar{\phi}^{-1}(W_{n,t}/Z_{n,t}(f))^{1-\phi}(1/Z_{i,t}(f))^{\phi}$, where $\bar{\phi} \equiv \phi^{\phi}(1-\phi)^{1-\phi}$ is a constant. The multinational firm chooses $X_{in,t}(f)$ and $L_{in,t}(f)$ to maximize world-wide profits subject to equations (C.20) and (C.2). Profit maximization implies a constant markup over marginal cost:

$$P_{in,t}(f) = \frac{\rho}{\rho-1}\bar{\phi}^{-1}\left(\frac{W_{n,t}}{Z_{n,t}(f)}\right)^{1-\phi}\left(\frac{P_t^W}{Z_{i,t}(f)}\right)^{\phi}. \tag{C.21}$$

Combining equations (C.3) and (C.21) we can write the real wage as:

$$\frac{W_{n,t}}{P_{n,t}} = \bar{\phi}^{-1}\frac{\rho-1}{\rho}\left[\sum_i\sum_{f\in\Omega_i}A_{in,t}Z_{in,t}(f)^{(\rho-1)}\right]^{\frac{1}{(1-\phi)(\rho-1)}}. \tag{C.22}$$

Profit maximization by intermediate good producers implies that aggregate revenues are a constant share ϕ of total labor payments:

$$\sum_i P_{in,t}Q_{in,t} = P_{n,t}Q_{n,t} = \frac{\rho}{\rho-1}\frac{1}{1-\phi}W_{n,t}L_{n,t}, \tag{C.23}$$

which in combination with (C.7) and (C.6) permits expressing the aggregate production function as:

$$Q_{n,t} = \frac{1}{1-\phi}\left[\sum_i\sum_{f\in\Omega_i}A_{in,t}Z_{in,t}(f)^{\rho-1}\right]^{\frac{\bar{\bar{\psi}}}{1-\rho}}. \tag{C.24}$$

Equation (C.24) implies that the growth rate of output and value added (which is a fraction $1-\phi$ of output) in the model is given by equations (C.10) and (C.11), where the parameter ψ is now substituted with $\bar{\bar{\psi}} \equiv \frac{\psi}{1-\phi}$.

We can parameterize ϕ in this version of the model using either firm-level or source-destination level data, as in the paper. In particular, since value added at the firm level is proportional to firm-level revenues, equation (C.14) represents value added growth at the firm level.[11] Hence, we can interpret the coefficients of our value added regression in Appendix (B) as ϕ in this model, which gives us $\phi = 0.14$. Alternatively, equation (2) represents value added growth rate at the source-destination level, which for a given combination of the GE parameters $\frac{\bar{\bar{\psi}}}{1-\rho}$ can be used to calibrate ϕ. Given values for ϕ and, revenue shares $\omega_{in,t}$ and a the composite parameter $\frac{\bar{\bar{\psi}}}{1-\rho}$, we can reinterpret our quantitative results in the paper through the lens of this model featuring intermediate input linkages.

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[11]In this version of the model, equation (C.12) represents both value added and revenue growth for the affiliates. Note, however, that the parent's revenue now includes exports of the intermediate input, so that equation (C.13) does not represent the parents' revenue growth, though it does represent parents' value added growth.

C.5 Multinational location decisions with fixed costs and uncertainty

This section presents an extension to our baseline model in which firms choose the markets in which to open foreign affiliates in a context of uncertainty about the aggregate state, as in Ramondo and Rappoport (2010) and Ramondo et al. (2013). The section has two goals. The first is to show how the main results from our baseline framework can be interpreted through the lens of a model in which the location of multinational firms depends on the correlation of shocks across countries. In particular, we show that the key equations, the parameter estimation approaches, and the counterfactual analyses in the main text are still valid in this extended model. Second, we discuss how the extended model relates to the literature on endogenous MP location under sunk costs and uncertainty, and provide conditions under which MP shares do not depend on the correlation of shocks across countries.

C.5.1 Setup

Preliminaries Consider a world economy consisting of I countries indexed by i and n. Each country is populated by a representative household with preferences over leisure and a homogeneous final good. Countries are initially endowed with an amount of the final good, $Q_{i,0}$, and with a mass $M_{i,0}$ of firms that can produce differentiated intermediate goods. The firms are heterogeneous in their productivity and monopolistically competitive. Competitive producers aggregate the intermediate goods to make the final good. All goods are non-storable. As in the framework in the main text and Ramondo and Rappoport (2010), only the final good can be traded (costlessly) across countries.

The only way that a producer of an intermediate variety can serve a foreign market is by opening an affiliate in that market. At date 0, firms from each country i make the irreversible decision of whether to open an affiliate in each foreign market n. A firm from country i that opens an affiliate in country n must pay a sunk cost of F_{in} units of the date 0 consumption good. There are no fixed costs for serving the domestic market, $F_{ii} = 0$, and thus all $M_{i,0}$ firms produce in market i. After all the entry decisions at date 0, production starts at date 1.

The only source of aggregate uncertainty are shocks to the primitive productivities in each country i. There are S possible states of nature that can be realized in each date t, where states are indexed by $s_t = \{1, 2, ..., S\}$. Let $\mathbf{Z}(s_l) = [Z_1(s_l), Z_2(s_l), ..., Z_I(s_l)]$ denote the realization of each country's primitive productivity under state s_l, and let $s^t = \{s_0, s_1, ..., s_t\}$ denote the history of states up to date t. The initial state s_0 is known. The unconditional probability as of date 0 of history s^t being realized is denoted by $\mu(s^t)$. Households can trade the full set of Arrow-Debreu securities at date 0.

Households The representative household in country i has preferences over the stream of consumption $C_i = \{C_i(s^t)\}_{t=0}^{\infty}$ and labor $L_i = \{L_i(s^t)\}_{t=0}^{\infty}$ given by

$$U(C_i, L_i) = \frac{C_{i,0}^{1-\sigma}}{1-\sigma} + \sum_{t=1}^{\infty} \sum_{s^t} \frac{\beta^t \mu(s^t)}{1-\sigma} \left[C_i(s^t) - \frac{\psi_0}{\bar{\psi}} L_i^{\bar{\psi}}(s^t) \right]^{1-\sigma}.$$

Let $\varphi(s^t)$ denote the date 0 price of an Arrow-Debreu security that delivers one unit of consumption in history s^t. The budget constraint of the household is

$$C_{i,0} + \sum_{t=1}^{\infty} \sum_{s^t} \varphi\left(s^t\right) C_i\left(s^t\right) = \sum_{t=1}^{\infty} \sum_{s^t} \varphi\left(s^t\right) W_i\left(s^t\right) L_i\left(s^t\right) + V_{i,0} + Q_{i,0}, \qquad \text{(C.25)}$$

where $W_i\left(s^t\right)$ is the real wage, denominated in units of the consumption good in history s^t, and $V_{i,0}$ denotes the date 0 value of the firms from country i. The first-order conditions of the household's problem imply:

$$\varphi\left(s^t\right) = \frac{\beta^t \mu\left(s^t\right) \left[C_i\left(s^t\right) - \frac{\psi_0}{\bar{\psi}} L_i^{\bar{\psi}}\left(s^t\right)\right]^{-\sigma}}{C_{i,0}^{-\sigma}}, \qquad \text{(C.26)}$$

and

$$W_i\left(s^t\right) = \psi_0 L_i^{\bar{\psi}-1}\left(s^t\right). \qquad \text{(C.27)}$$

Production of final goods   As in the main text, the production function of the final good at any history s^t is an Armington aggregator of goods produced by firms owned by various countries:

$$Q_n\left(s^t\right) = \left[\sum_i \bar{A}_{in,t}^{\frac{1}{\rho}} Q_{in}\left(s^t\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}},$$

where the parameter $\bar{A}_{in,t}$ can potentially change non-stochastically through time.[12] $Q_{in}\left(s^t\right)$ is the bundle of the output produced by firms from source country i that operate in country n

$$Q_{in}\left(s^t\right) = \left[\int_{f \in \Omega_{in}} Q_{in}\left(f;s^t\right)^{\frac{\rho-1}{\rho}} df\right]^{\frac{\rho}{\rho-1}},$$

and $Q_{in}\left(f;s^t\right)$ is the output of firm f from country i operating in destination country n. Note that the set of firms from country i that operate in country n Ω_{in} is not history-dependent, as all entry decisions are made at date 0.

Cost minimization by final good producers implies the demand for the country i bundle in n $Q_{in}\left(s^t\right)$ and for firm f's output in n $Q_{in}\left(f;s^t\right)$:

$$Q_{in}\left(s^t\right) = \frac{\bar{A}_{in,t} P_{in}^{-\rho}\left(s^t\right)}{P_n^{-\rho}\left(s^t\right)} Q_n\left(s^t\right),$$

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[12]To avoid cluttering notation, we let $\bar{A}_{in,t}$ stand for $A_{in}\left(s^t\right)$, since $A's$ do not depend on the realization of the state at time t.

and

$$Q_{in}(f; s^t) = \frac{P_{in}^{-\rho}(f, s^t)}{P_{in}^{-\rho}(s^t)} Q_{in}(s^t).$$

Here,

$$P_{in}(s^t) = \left[\int_{f \in \Omega_{in}} P_{in}^{1-\rho}(f; s^t) df \right]^{\frac{1}{1-\rho}}, \tag{C.28}$$

is the price index of the country i product bundle, $P_{in}(f; s^t)$ is the price of the intermediate produced by firm f, both expressed in units of the final consumption good in history s^t. Then,

$$P_n(s^t) = \left[\sum_i \bar{A}_{in,t} P_{in}(s^t)^{1-\rho} \right]^{\frac{1}{1-\rho}} = 1, \tag{C.29}$$

is the price of the final good produced in country n, where the second equality follows from the fact that we are expressing all prices in history s^t in units of that history's final consumption.

Production of intermediate goods Each country starts with an exogenous mass of firms $M_{i,0}$, each of which can produce a differentiated intermediate variety. Productivity is stochastic and heterogeneous across firms and locations. A firm from country i that operates in country n has a linear technology that uses labor in the destination country as the only input in production:

$$Q_{in}(f; s^t) = Z_{in}(f; s^t) L_{in}(f; s^t).$$

Here $L_{in}(f; s^t)$ is the quantity of labor employed by the firm, and $Z_{in}(f; s^t)$ is a firm-destination-state specific productivity term. This productivity is given by

$$Z_{in}(f; s^t) = \chi(f) [Z_i(s_t) \eta_i(f; s_t)]^\phi [Z_n(s_t) \eta_n(f; s_t)]^{1-\phi}. \tag{C.30}$$

The firm-specific productivity is a composite of a time-invariant firm-specific component $\chi(f)$, the aggregate shock in the source country $Z_i(s_t)$, the aggregate shock in the destination $Z_n(s_t)$, and idiosyncratic shocks in both source and destination countries $\eta_i(f; s_t)$ and $\eta_n(f; s_t)$.[13] We assume that the permanent component of firm productivity is distributed $\chi(f) \sim Pareto(1, \theta)$ in every country, with $\theta > \rho - 1$, and that the idiosyncratic shocks $\eta_i(f; s_t)$ are i.i.d. across firms, dates, and states, and independent of all firm-level productivities $\chi(f)$ and aggregate productivities $Z_i(s_t)$.

Since the production function is linear and the intermediate goods are non-tradeable,

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[13] The productivity specification in (C.30) is a special case of the assumption on firm productivity (5) in the paper, where $Z_{i,t}(f) = \chi(f) \eta_i(f; s_t)$ and $Z_{n,t}(f) = \chi(f) \eta_n(f; s_t)$.

both the firm's profit maximization problem and the firm's entry decision problem for each of the markets can be solved independently. If the firm enters market n, it sets a constant markup over its marginal cost in every t and s^t:

$$P_{in}(f;s^t) = \frac{\rho}{\rho-1} \frac{W_n(s^t)}{Z_{in}(f;s^t)}, \tag{C.31}$$

and its revenues in units of the consumption good in history s^t are given by

$$P_{in}(f;s^t)Q_{in}(f;s^t) = \left(\frac{\rho}{\rho-1}\right)^{1-\rho} \bar{A}_{in,t} Z_{in}(f;s^t)^{\rho-1} W_n(s^t)^{1-\rho} Q_n(f;s^t). \tag{C.32}$$

The firm's period profits are proportional to its revenues:

$$\pi_{in}(f;s^t) = \frac{1}{\rho} P_{in}(f;s^t) Q_{in}(f;s^t).$$

Using equation (C.30), we can write this profit function as:

$$\pi_{in}(f;s^t) = \left[\chi(f)\, \eta_i^\phi(f;s_t)\, \eta_n^{1-\phi}(f;s_t)\right]^{(\rho-1)} \pi_{in}(s^t),$$

where $\pi_{in}(s^t) \equiv \frac{1}{\rho}\left(\frac{\rho}{\rho-1}\right)^{1-\rho} \bar{A}_{in,t} \left[Z_i(s_t)^\phi Z_n(s_t)^{(1-\phi)}\right]^{(\rho-1)} W_n(s^t)^{1-\rho} Q_n(f;s^t)$ is a term common to all firms from country i that operate in destination n.

At date $t = 0$, each firm from each country i must decide whether to enter (i.e. open an affiliate) in each possible foreign market. A firm f from country i will open an affiliate in market n if

$$\sum_{t=1}^{\infty} \sum_{s^t} \varphi_t(s^t)\, \pi_{in}(f;s^t) \geq F_{in}. \tag{C.33}$$

At the time of the entry decision into foreign markets, the firm knows the permanent component of their productivity $\chi(f)$ and the distributions of $Z_i(s_t)$ and $\eta_i(f;s_t)$, but not their realizations. Since the idiosyncratic shocks η_i are independent of $\chi(f)$, this implies that all firms from i for which the permanent component of productivity is above a cutoff $\bar{\chi}_{in}$ will choose to enter the market n.

C.5.2 Equilibrium

Since the household's labor supply in each state only depends on the real wage in that state, and all entry decisions are made at date 0 and are irreversible, we can characterize the equilibrium in this economy in two stages. In the first stage, we solve for all intratemporal relative prices and production decisions in each possible history taking the location of foreign affiliates as given. In the second stage, we solve for the consumption allocations, the prices of the Arrow-Debreu securities, and the date 0 location decisions of the

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firms.

Definition 1. An *intratemporal equilibrium at history* s^t is a set of wages $\{W_n(s^t)\}_n$, intermediate good prices $\{P_{in}(f;s^t)\}_{i,n,f}$, and resource allocations $\{L_{in}(f;s^t), Q_{in}(f;s^t)\}_{i,n,f}$ and $\{L_n(s^t), Q_n(s^t)\}_n$, such that, given the productivity cutoffs $\{\bar{\chi}_{in}\}_{i,n}$, and the realization of the shocks:

i. **Consumers maximize utility:** The labor supply is given by equation (C.27).

ii. **Firms maximize profits:** The price of the final good in each history is given by equation (C.29). The price of an intermediate bundle of goods is given by (C.28). Intermediate goods producers set prices according to (C.31).

iii. **Labor markets clear:** $L_n\left(s^t\right) \equiv \sum_i \int_{\bar{\chi}_{in}}^{\infty} L_{in}\left(f;s^t\right) dG\left(\chi\right) \forall n$, where $G(\chi)$ is the cdf of χ.

We now characterize the intratemporal equilibrium prices and quantities as a function of the realization of the shocks and the set of firms that are active in each market. Combining equations (C.29) and (C.31) we can write the real wage expressed in units of history s^t consumption as

$$W_n(s_t) = \frac{\rho-1}{\rho}\left[\sum_i \tilde{\bar{A}}_{in,t}\left(Z_i\left(s_t\right)^\phi Z_n\left(s_t\right)^{1-\phi}\right)^{\rho-1}\right]^{\frac{1}{\rho-1}}, \tag{C.34}$$

where $\tilde{\bar{A}}_{in,t} \equiv \bar{A}_{in,t}\frac{\theta M_{i,0}\bar{\eta}}{\theta+1-\rho}\bar{\chi}_{in}^{\rho-1-\theta}$ and $\bar{\eta} \equiv E\eta_i^{\phi(\rho-1)}E\eta_n^{(1-\phi)(\rho-1)}$. Equation (C.34) implies that given the productivity cutoffs $\bar{\chi}_{in}$ and the realization of the state in period t, s_t, the real wage does not depend on the history s^t.

Profit maximization by intermediate producers implies that aggregate revenues are proportional to labor payments. Aggregating across firms and using the labor market clearing condition gives:

$$Q_{n,t}(s^t) = \frac{\rho}{\rho-1}W_{n,t}(s^t)L_{n,t}(s^t), \tag{C.35}$$

which in combination with (C.27) and (C.34) permits expressing the aggregate output as

$$Q_n(s_t) = \left(\frac{\rho-1}{\rho}\right)^{\frac{1}{\bar{\psi}-1}}\left[\sum_i \tilde{\bar{A}}_{in,t}\left(Z_i\left(s_t\right)^\phi Z_n\left(s_t\right)^{1-\phi}\right)^{\rho-1}\right]^{\frac{\psi}{\rho-1}}, \tag{C.36}$$

where $\psi \equiv \frac{\bar{\psi}}{\bar{\psi}-1} > 1$. Equation (C.36) characterizes aggregate output as a function of the productivity cutoffs $\bar{\chi}_{in}$ and the realization of the state s_t. Having characterized the intratemporal equilibrium for each history, we now characterize the dynamic stochastic equilibrium for this economy.

Definition 2. *A stochastic equilibrium with endogenous location decisions is a set of Arrow-Debreu prices* $\{\varphi(s^t)\}_{s^t}$, *consumption allocations* $\{C_n(s^t)\}_{n,s^t}$, *and productivity cutoffs* $\{\bar{\chi}_{in}\}_{i,n}$, *such that, given initial endowments,* $Q_{i,0}$ *and* $M_{i,0}$:

i. **Each firm's entry decision maximize the firm's value:** The cutoff for the firm's deterministic productivity $\bar{\chi}_{in}$ to operate in destination n is given by equation (C.33) when evaluated as an equality.

ii. **Goods markets clear under each history s^t:**

$$C_W(s^t) \equiv \sum_i C_i(s^t) \;=\; Q_W(s^t) \equiv \sum_i Q_i(s^t)$$

where $Q_i(s^t)$ are the allocations of the *intratemporal equilibrium in history s^t* for the cutoffs $\{\bar{\chi}_{in}\}$.

iii. **Goods markets clear at date 0:**

$$C_{W,0} + \sum_i M_{i,0} \sum_n F_{in} \left[1 - G\left(\bar{\chi}_{in}\right)\right] \;=\; Q_{W,0}.$$

iv. **Consumption plans solve the households' problem:** Given prices $\varphi(s^t)$, consumption allocations $C_n(s^t)$ for each country are given by equation (C.26) and by the budget constraint (C.25), where $W(s^t)$, $L(s^t)$ and $V_{i,0} \equiv \sum_n \int_{\bar{\chi}_{in}}^\infty \left[\sum_{t=1}^\infty \sum_{s^t} \varphi(s^t) \pi_{in}(f; s^t) - F_{in}\right] dG(\chi)$ are consistent with an *intratemporal equilibrium in history s^t* under the cutoffs $\{\bar{\chi}_{in}\}_{i,n}$.

Note that the equilibrium conditions (i)-(iii) are independent how consumption is split across countries (condition iv).

We can now complete the characterization of the stochastic equilibrium of this economy. Aggregating across countries, we can write the equilibrium price of an Arrow-Debreu security as

$$\varphi(s^t) \;=\; \beta^t \mu(s^t) \left[\frac{C_W(s^t) - \frac{\psi_0}{\bar{\psi}} \sum_i L_i^{\bar{\psi}}(s^t)}{C_{W,0}}\right]^{-\sigma}. \tag{C.37}$$

Combining equations (C.35), (C.37), and the goods market clearing condition, the Arrow-Debreu security price becomes:

$$\varphi(s^t) \;=\; \beta^t \mu(s^t) \left(1 - \frac{\rho - 1}{\rho\bar{\psi}}\right)^{-\sigma} \left[\frac{Q_W(s_t)}{C_{W,0}}\right]^{-\sigma}. \tag{C.38}$$

Then we can write the productivity cutoff as:

$$\bar{\chi}_{in} \;=\; \left[\frac{C_{W,0}^\sigma \bar{\eta}}{F_{in}} \left(1 - \frac{\rho - 1}{\rho\bar{\psi}}\right)^{-\sigma} \sum_{t=0}^\infty \beta^t E_0 \left[Q_W(s_t)^{-\sigma} \pi_{in}(s^t)\right]\right]^{\frac{1}{1-\rho}}. \tag{C.39}$$

C.5.3 Relationship to the baseline model

The two-stage procedure for characterizing the equilibrium described above highlights that given productivity cutoffs $\bar{\chi}_{in}$, the model's predictions for aggregate, bilateral, and firm-level growth rates coincide with those of the baseline model. In particular, the aggregate growth rate in the economy is still given by equation (C.11), where the shares are now given by $\omega_{in}(s_t) \equiv \frac{\tilde{\bar{A}}_{in,t}Z_i(s_t)^{\phi(\rho-1)}}{\sum_k \tilde{\bar{A}}_{kn,t}Z_k(s_t)^{\phi(\rho-1)}}$. Firm-level sales still take the form in (C.14), so that after controlling for source-destination-year effects, the coefficient on the parent's growth rate can be interpreted as ϕ. Finally, total sales by firms from country i into country n take the form (C.15), where $S_i(s_t) = Z_i(s_t)^{\phi(\rho-1)}$ is the term common to all firms from source country i, and $D_n(s_t) = \left[\sum_i \tilde{\bar{A}}_{in,t}Z_i(s_t)^{\phi(\rho-1)}\right]^{\frac{\psi}{\rho-1}-1} Z_n(s_t)^{\psi(1-\phi)}$ is the term common to all firms operating in destination country n. Expressed in growth rates, this allows a decomposition identical to that in equation (2) and estimated in Section 3.2 in the paper.

The main difference with the baseline model arises from the fact that the revenue shares in this version of the model potentially depend on the correlation of shocks across countries. In particular, the revenue shares can be written as:

$$\omega_{in}(s_t) = \frac{\bar{A}_{in,t}M_{i,0}\bar{\chi}_{in}^{\rho-1-\theta}Z_i(s_t)^{\phi(\rho-1)}}{\sum_k \bar{A}_{kn,t}M_{k,0}\bar{\chi}_{kn}^{\rho-1-\theta}Z_k(s_t)^{\phi(\rho-1)}}. \tag{C.40}$$

From equation (C.39), the cutoffs $\bar{\chi}_{in}$, and hence the revenue shares ω_{in}, potentially depend on the covariance of country aggregate shocks in non-trivial ways. Equation (C.40) makes it clear this dependence can be easily nested within our baseline approach. The procedures in the main text rely directly on the observed MP shares, and the baseline model rationalizes those using the destination-source shifters $\widetilde{A}_{in,t}$, which are free parameters. For any configuration of uncertainty, we can pick a different set of free parameters $\bar{A}_{in,t}$ in order to get us back to the observed MP shares.

Since ω_{in} and the elasticities are sufficient statistics for our quantitative exercises, given data on ω_{in} and an estimate for ϕ, impulse responses using equation can be computed using equation (15) in the paper. Given values for the shares ω_{in}, the correlation across country pairs under the assumption that the Z_i's are uncorrelated would still be given by formula (16) in the paper. In this case, that equation captures the contribution of multinationals to aggregate comovement by answering the question: "what would be the correlation across countries in a world where multinational shares are as they are in the data, but the correlation of primitive shocks is zero?" Finally, given parameters, equations (19)-(21) in the paper can be used to compute the counterfactual growth rates $\gamma_{n,t}^c$ as in equation (18) in the paper. Note that the very last counterfactual ("Changing the correlation in firm-level growth" in Section 5.3) would need to be caveated, as the revenue shares ω_{in} will generally change with the value of ϕ, whereas the exercise in the text keeps them constant.

C.5.4 Relation to the literature and special cases

We now discuss how the extended model relates to the literature on endogenous MP location under uncertainty, such as Ramondo and Rappoport (2010) and Ramondo et al. (2013), and provide conditions on the model's parameters under which the shares do not depend on the correlation of shocks across countries, despite the uncertainty. We start by substituting equation (C.38) in (C.39) to make explicit how the entry cutoffs depend on the covariance of shocks across countries:

$$\bar{\chi}_{in} = \left[\frac{\Xi}{F_{in}} \sum_{t=0}^{\infty} \beta^t E_0 \left[Q_W(s_t)^{-\sigma} \pi_{in}(s^t) \right] \right]^{\frac{1}{1-\rho}},$$

where $\Xi = \bar{\eta} \left[\frac{C_{W,0}\rho\bar{\psi}}{\rho\bar{\psi}-(\rho-1)} \right]^{\sigma}$ is a constant. If shocks are i.i.d over time, and the $\bar{A}_{in}$'s are constant through time, we can write the cutoff as:

$$\bar{\chi}_{in} = \left[\frac{\Xi}{F_{in}[1-\beta]} \right]^{\frac{1}{1-\rho}} E_0 \left[Q_W(s)^{-\sigma} \pi_{in}(s) \right]^{\frac{1}{1-\rho}}.$$

Substituting in equation (C.40) leads to the MP shares:

$$\omega_{in}(s_t) \equiv \frac{\bar{A}_{in} M_{i,0} Z_i(s_t)^{\phi(\rho-1)} F_{in}^{\frac{\rho-1-\theta}{\rho-1}} E_0 \left[Q_W(s)^{-\sigma} \pi_{in}(s) \right]^{\frac{\rho-1-\theta}{1-\rho}}}{\sum_k \bar{A}_{kn} M_{k,0} Z_k(s_t)^{\phi(\rho-1)} F_{kn}^{\frac{\rho-1-\theta}{\rho-1}} E_0 \left[Q_W(s)^{-\sigma} \pi_{kn}(s) \right]^{\frac{\rho-1-\theta}{1-\rho}}}. \tag{C.41}$$

The covariance of shocks affects MP shares through the term $E_0 \left[Q_W(s)^{-\sigma} \pi_{in}(s) \right]^{\frac{\rho-1-\theta}{1-\rho}}$. The expression for MP shares (C.41) can be used to relate our framework to the Ramondo and Rappoport (2010) and Ramondo et al. (2013) models. As in Ramondo and Rappoport (2010), profits depend on the covariance between world output/consumption $Q_W(s)^{-\sigma}$ and the source-destination profit term $\pi_{in}(s)$. In the original Ramondo and Rappoport (2010) framework, the common component of profits is not source-country specific: $\pi_{in}(s) = \pi_n(s)$. In that case, the MP shares can be rewritten as

$$\omega_{in}(s_t) = \frac{\bar{A}_{in} M_{i,0} Z_i(s_t)^{\phi(\rho-1)} F_{in}^{\frac{\rho-1-\theta}{\rho-1}}}{\sum_k \bar{A}_{kn} M_{k,0} Z_k(s_t)^{\phi(\rho-1)} F_{kn}^{\frac{\rho-1-\theta}{\rho-1}}},$$

and are independent of the covariance of country shocks with world output. In that case, all firms will want to open affiliates in destinations that yield high profits in bad states of the world (low $Q_W(s_t)$). Since this incentive affects firms from all source countries in the same way, it does not affect the revenue shares.

To relate our framework to Ramondo et al. (2013) assume, as in that paper, that con-

sumers are risk neutral: $\sigma = 0$. Then the MP shares can be written as:

$$\omega_{in}(s_t) = \frac{\bar{A}_{in} M_{i,0} Z_i(s_t)^{\phi(\rho-1)} F_{in}^{\frac{\rho-1-\theta}{\rho-1}} E_0[\pi_{in}(s)]^{\frac{\theta}{\rho-1}-1}}{\sum_k \bar{A}_{kn} M_{k,0} Z_k(s_t)^{\phi(\rho-1)} F_{kn}^{\frac{\rho-1-\theta}{\rho-1}} E_0[\pi_{kn}(s)]^{\frac{\theta}{\rho-1}-1}}.$$

In this case, the covariance of country shocks can still affect revenue shares through $E_0[\pi_{in}(s)]$. Whether profits, and therefore MP shares, increase or decrease in the covariance of the primitive shocks depends on whether Z_i and Z_n are complements or substitutes in the profit function. Note that the common component of profits can be written as:

$$\pi_{in}(s_t) = S_i(s_t) D_n(s_t)$$

Taking a first order approximation to $S_i(s_t)$ and $D_n(s_t)$ around a non-stochastic steady state, we can write expected profits as:

$$E_0[\pi_{in}(s)] = \bar{S}_i \bar{D}_n +$$
$$+ \frac{\bar{S}_i \bar{D}_n \phi(\rho-1)\psi}{\bar{Z}_i \bar{Z}_n}\left[\left[\phi\left(1-\frac{\rho-1}{\psi}\right)\omega_{nn}+(1-\phi)\right]\sigma_{in}+\phi\left(1-\frac{\rho-1}{\psi}\right)\sum_{i'\neq n}\frac{\bar{Z}_i}{\bar{Z}_{i'}}\omega_{i'n}\sigma_{ii'}\right]$$

where $\sigma_{in} \equiv cov(Z_i, Z_n)$ is the covariance between the primitive shocks of countries i and n, and for every variable we define mean $\bar{X} \equiv E_0[X(s)]$.

First note that when either $\phi = 0$; or $\phi = 1$ and the general equilibrium parameter $\frac{\psi}{\rho-1} = 1$ (i.e. the general equilibrium effects cancel out), then $E_0[\pi_{in}(s)] = \bar{S}_i \bar{D}_n$ and does not depend on the covariance of the shocks. In these two special cases the profit function is linear in either Z_i or in Z_n. More generally, the expected profits of i firms in n can be increasing or decreasing in the covariance σ_{in} depending on the sign of the term $\psi\left[\phi\left(1-\frac{\rho-1}{\psi}\right)\omega_{nn}+(1-\phi)\right]$. Rearranging, whether $E_0[\pi_{in}(s)]$ rises or falls in σ_{in} is determined by the sign of

$$\underbrace{(\rho-1)(1-\phi)}_{\text{Direct Effect}}+\underbrace{(\rho-1)\left(\frac{\psi}{\rho-1}-1\right)[(1-\phi)+\phi\omega_{nn}]}_{\text{General Equilibrium Effect}} \lessgtr 0.$$

Consider an increase in the destination's primitive productivity Z_n. It raises the profits of foreign firms by $(\rho-1)(1-\phi)$ through directly increasing their productivity. However, a higher Z_n makes all the other firms in n more productive, which can have a positive or a negative effect on the profits of the foreign firm through general equilibrium effects, depending on parameter values. When the net effect of a rise in Z_n on foreign profits is positive, $E_0[\pi_{in}(s)]$ increases in the covariance between Z_i and Z_n for essentially the same reason as in Ramondo et al. (2013): the firm wants to have low costs in states of the world in which demand is high. When high Z_n means high demand, the firms prefer to

also have high Z_i (low costs and high market share) when Z_n is high. Note that in the special case in which $\phi \left(\frac{\rho - 1}{\psi} - 1 \right) \omega_{nn} = (1 - \phi)$, the direct and indirect effects exactly offset each other, so that expected profits do not depend on σ_{in}.

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Figure A1: MP shares: ORBIS vs. OECD-EUROSTAT data
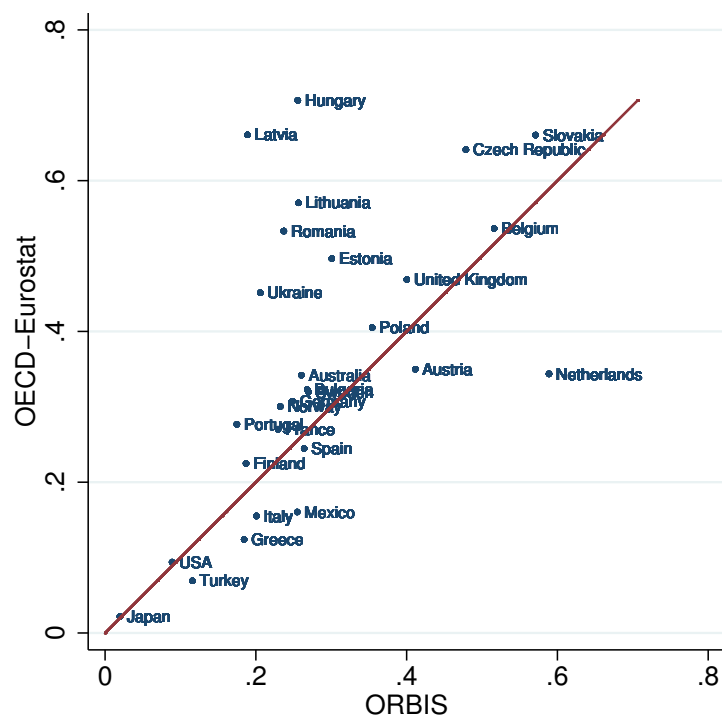
Notes: This figure displays a scatterplot of the multinational production shares (defined as the share of gross output in a country produced by affiliates of foreign multinationals), in the ORBIS data against the those from OECD and EUROSTAT, as compiled by Alviarez (2013). The line through the data is the 45-degree line.

Table A2: Bilateral multinational shares

Source → / Dest ↓	AUT	AUS	BEL	BUL	CZE	DEU	EST	ESP	FIN	FRA	GBR	GRE	HRV	HUN	IRL	ITA	JPN	KOR	LTU	LVA	MEX	NLD	NOR	POL	PRT	ROM	SRB	SWE	SGP	SVN	SVK	TUR	UKR	USA	ROW
AUT	58.9	0.0	0.2	0.0	0.0	13.1	0.0	0.2	0.4	1.4	4.6	0.0	0.0	0.1	0.2	1.4	3.8	0.5	0.0	0.0	0.1	1.4	0.2	0.1	0.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	3.5	9.3
AUS	0.0	74.0	0.1	0.0	0.0	0.7	0.0	0.2	0.1	1.1	5.4	0.0	0.0	0.0	0.1	0.0	2.7	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.0	5.7	8.6
BEL	0.2	0.1	48.4	0.0	0.0	4.6	0.0	0.2	0.2	14.0	1.8	0.2	0.0	0.0	0.2	1.4	5.8	0.2	0.0	0.0	0.0	3.1	0.2	0.0	0.0	0.0	0.0	1.4	0.1	0.0	0.0	0.0	0.0	10.9	6.9
BUL	2.3	0.0	0.4	73.2	1.4	4.0	0.0	0.1	0.0	0.6	0.9	1.5	0.2	0.1	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.9	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.1	1.6	10.9
CZE	3.4	0.0	0.4	0.0	52.1	14.8	0.0	1.3	0.2	2.9	3.3	0.0	0.0	0.1	0.2	1.9	1.9	0.7	0.0	0.0	0.0	2.3	0.3	0.4	0.0	0.0	0.0	0.8	0.0	0.0	0.6	0.0	0.1	3.8	8.4
DEU	0.7	0.1	0.5	0.0	0.0	75.1	0.0	0.2	0.3	1.9	3.5	0.0	0.0	0.0	0.1	0.8	2.3	0.5	0.0	0.0	0.1	2.0	0.3	0.1	0.0	0.0	0.0	1.4	0.2	0.0	0.0	0.0	0.0	5.9	4.2
EST	0.3	0.0	0.1	0.0	0.0	1.9	69.9	0.0	7.2	1.5	2.2	0.0	0.0	0.0	0.2	0.1	0.5	0.0	0.5	0.4	0.0	0.6	1.0	1.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.2	1.3	3.9
ESP	0.2	0.0	0.2	0.0	0.0	3.7	0.0	73.6	0.1	5.2	1.9	0.0	0.0	0.0	0.2	2.2	0.9	0.2	0.0	0.0	0.1	1.6	0.1	0.0	0.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.9	4.8
FIN	0.2	0.0	0.2	0.0	0.0	1.8	0.0	0.0	81.3	0.9	1.0	0.0	0.0	0.0	0.2	0.2	0.9	0.3	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	2.3	5.3
FRA	0.1	0.1	1.0	0.0	0.0	2.9	0.0	0.4	0.2	77.1	2.6	0.0	0.0	0.0	0.2	1.1	1.1	0.2	0.0	0.0	0.0	2.7	0.1	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	5.7	3.9
GBR	0.1	0.6	0.3	0.0	0.0	4.2	0.0	1.1	0.2	3.8	60.0	0.0	0.0	0.0	1.0	0.6	2.0	0.3	0.0	0.0	0.2	1.5	0.2	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	14.2	9.2
GRE	0.1	0.0	0.9	0.0	0.0	2.1	0.0	0.2	0.2	1.1	2.6	81.6	0.0	0.0	0.4	0.7	0.3	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	2.4	6.1
HRV	4.6	0.0	0.1	0.0	0.2	4.4	0.0	0.1	0.0	1.6	0.3	0.0	78.3	0.4	0.1	2.3	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.2	0.2	0.0	1.8	0.0	0.0	0.0	0.9	3.8
HUN	1.4	0.0	0.1	0.0	0.0	6.8	0.0	0.1	1.7	2.6	1.5	0.0	0.0	74.4	0.0	0.9	1.1	0.9	0.0	0.0	0.1	1.2	0.3	0.0	0.0	0.0	0.0	0.6	0.2	0.0	0.0	0.0	0.0	3.5	2.0
IRL	0.0	0.2	0.6	0.0	0.0	4.0	0.0	3.4	0.2	4.9	18.2	0.0	0.0	0.1	16.5	1.8	2.7	0.6	0.0	0.0	0.0	1.3	0.3	0.0	0.0	0.0	0.0	0.6	0.9	0.0	0.0	0.0	0.0	35.7	8.7
ITA	0.2	0.0	0.2	0.0	0.0	2.6	0.0	0.3	0.2	3.7	1.7	0.0	0.0	0.1	0.1	79.9	0.7	0.1	0.0	0.0	0.0	1.4	0.1	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	3.6	4.8
JPN	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.5
KOR	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.8	95.6	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.6
LTU	0.2	0.0	0.1	0.0	0.0	1.7	1.6	0.0	1.7	1.3	0.4	0.0	0.0	0.0	0.0	0.2	0.3	0.2	74.4	0.3	0.1	1.1	1.6	0.7	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	2.7	9.2
LVA	0.1	0.0	0.1	0.0	0.0	1.0	0.7	0.0	2.3	0.4	0.6	0.0	0.0	0.0	0.0	0.1	0.1	0.2	1.6	81.1	0.1	0.3	1.8	1.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.4	4.5
MEX	0.7	0.0	0.4	0.0	0.0	1.3	0.0	2.3	0.3	0.3	1.0	0.0	0.0	0.1	0.1	6.6	0.6	0.7	0.0	0.0	74.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	15.2	2.3
NLD	0.2	0.1	0.4	0.0	0.0	2.5	0.0	0.3	0.3	1.9	9.7	0.0	0.0	0.0	0.2	2.9	2.0	0.3	0.0	0.0	0.0	41.1	0.4	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	20.2	10.7
NOR	0.1	0.0	0.1	0.0	0.0	1.2	0.0	0.1	0.5	2.3	1.6	0.0	0.0	0.0	0.0	0.7	0.6	0.2	0.0	0.0	0.0	0.6	76.8	0.0	0.0	0.0	0.0	5.2	0.3	0.0	0.0	0.0	0.0	6.6	3.5
POL	0.8	0.0	0.4	0.0	0.1	6.9	0.0	0.6	0.5	4.9	2.4	0.0	0.0	0.1	0.2	2.0	1.2	0.7	0.0	0.0	0.1	1.9	0.3	64.6	0.8	0.0	0.0	1.6	0.1	0.0	0.3	0.0	0.1	4.1	5.2
PRT	0.1	0.0	0.2	0.0	0.0	2.6	0.0	3.7	0.1	3.1	1.5	0.0	0.0	0.0	0.1	0.5	0.7	0.1	0.0	0.0	0.0	0.2	0.0	0.2	82.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	1.7	2.7
ROM	3.7	0.0	0.2	0.2	0.2	3.1	0.0	0.2	0.2	2.7	1.5	0.4	0.0	0.5	0.1	1.4	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	76.3	0.0	0.2	0.0	0.0	0.0	0.1	0.0	1.2	6.1
SRB	1.8	0.0	1.5	0.2	0.1	2.3	0.0	0.1	0.1	1.5	0.5	1.6	1.5	0.3	0.1	1.0	0.1	0.0	0.0	0.0	0.0	0.9	0.4	0.1	0.0	0.1	70.1	0.2	0.0	1.9	0.1	0.0	0.0	1.5	12.1
SWE	0.2	0.0	0.1	0.0	0.0	4.2	0.0	0.1	3.2	1.5	2.2	0.0	0.0	0.0	0.1	1.0	1.6	0.1	0.0	0.0	0.0	1.3	1.8	0.2	0.0	0.0	0.0	73.0	0.1	0.0	0.0	0.0	0.0	3.6	6.5
SGP	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.1	14.8	0.0	0.0	0.0	0.7	0.1	10.7	3.2	0.0	0.0	0.0	1.8	0.1	0.0	0.0	0.0	0.0	0.2	43.1	0.0	0.0	0.0	0.0	13.6	10.3
SVN	3.8	0.1	0.1	0.0	0.1	3.0	0.0	0.1	0.1	3.1	1.9	0.0	0.8	0.2	0.0	0.9	0.4	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	79.3	0.0	0.0	0.0	2.2	2.6
SVK	4.0	0.0	0.6	0.0	1.7	16.2	0.0	0.2	0.1	4.5	2.0	0.0	0.0	4.0	0.2	3.2	0.7	5.2	0.0	0.0	0.1	3.4	0.5	0.3	0.0	0.0	0.0	0.4	0.0	0.0	42.9	0.0	0.0	4.3	5.5
TUR	1.2	0.0	0.1	0.0	0.0	1.5	0.0	0.1	0.1	1.0	2.2	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	1.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	88.4	0.0	0.5	2.5
UKR	0.3	0.0	0.1	0.0	0.1	0.8	0.0	0.0	0.0	0.5	1.2	0.0	0.0	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.0	1.2	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	79.4	1.8	13.7
USA	0.0	0.1	0.0	0.0	0.0	1.3	0.0	0.3	0.0	0.2	1.2	0.0	0.0	0.0	0.2	0.1	0.6	0.2	0.0	0.0	0.1	0.8	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	91.1	3.9

Notes: This table reports the 2011 shares of revenue (in percent) of firms owned by the country in the column in total revenues of all firms in the row country, in percent.

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Table A3: Sectoral shares

NACE code	Sector description	Fraction of firms	Fraction of groups	Average share of sector in aggregate sales	Average share of foreign firms in the sector
01	Crop and animal production, hunting and related service activities	0.016	0.017	0.008	0.068
02	Forestry and logging	0.003	0.004	0.002	0.063
03	Fishing and aquaculture	0.001	0.001	0.001	0.115
05	Mining of coal and lignite	0.000	0.000	0.002	0.108
06	Extraction of crude petroleum and natural gas	0.001	0.001	0.016	0.338
07	Mining of metal ores	0.000	0.000	0.004	0.311
08	Other mining and quarrying	0.002	0.003	0.002	0.236
09	Mining support service activities	0.001	0.001	0.002	0.267
10	Manufacture of food products	0.014	0.015	0.029	0.268
11	Manufacture of beverages	0.002	0.002	0.007	0.435
12	Manufacture of tobacco products	0.000	0.000	0.002	0.461
13	Manufacture of textiles	0.005	0.005	0.004	0.213
14	Manufacture of wearing apparel	0.006	0.006	0.004	0.166
15	Manufacture of leather and related products	0.002	0.002	0.002	0.188
16	Manufacture of wood and of products of wood and cork, except furniture	0.007	0.008	0.006	0.186
17	Manufacture of paper and paper products	0.003	0.003	0.007	0.338
18	Printing and reproduction of recorded media	0.006	0.007	0.003	0.130
19	Manufacture of coke and refined petroleum products	0.001	0.001	0.021	0.372
20	Manufacture of chemicals and chemical products	0.006	0.006	0.018	0.420
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.001	0.001	0.008	0.515
22	Manufacture of rubber and plastic products	0.007	0.008	0.010	0.365
23	Manufacture of other non-metallic mineral products	0.006	0.007	0.010	0.362
24	Manufacture of basic metals	0.003	0.003	0.020	0.383
25	Manufacture of fabricated metal products, except machinery and equipment	0.019	0.020	0.015	0.222
26	Manufacture of computer, electronic and optical products	0.006	0.007	0.020	0.433
27	Manufacture of electrical equipment	0.005	0.005	0.011	0.455
28	Manufacture of machinery and equipment n.e.c.	0.011	0.012	0.016	0.366
29	Manufacture of motor vehicles, trailers and semi-trailers	0.003	0.003	0.028	0.512
30	Manufacture of other transport equipment	0.001	0.002	0.005	0.292
31	Manufacture of furniture	0.005	0.006	0.004	0.133
32	Other manufacturing	0.005	0.006	0.004	0.302
33	Repair and installation of machinery and equipment	0.007	0.007	0.005	0.204
35	Electricity, gas, steam and air conditioning supply	0.005	0.005	0.045	0.219
36	Water collection, treatment and supply	0.001	0.001	0.002	0.073
37	Sewerage	0.001	0.001	0.001	0.074
38	Waste collection, treatment and disposal activities; materials recovery	0.004	0.004	0.004	0.174
39	Remediation activities and other waste management services	0.001	0.001	0.000	0.067
41	Construction of buildings	0.050	0.053	0.025	0.102
42	Civil engineering	0.012	0.013	0.015	0.154
43	Specialized construction activities	0.059	0.064	0.016	0.137
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	0.027	0.029	0.030	0.325
46	Wholesale trade, except of motor vehicles and motorcycles	0.134	0.145	0.200	0.328
47	Retail trade, except of motor vehicles and motorcycles	0.081	0.086	0.075	0.287
49	Land transport and transport via pipelines	0.026	0.028	0.021	0.116
50	Water transport	0.002	0.002	0.004	0.304
51	Air transport	0.001	0.001	0.004	0.160
52	Warehousing and support activities for transportation	0.013	0.013	0.019	0.247
53	Postal and courier activities	0.001	0.001	0.003	0.193
55	Accommodation	0.010	0.011	0.004	0.179
56	Food and beverage service activities	0.024	0.025	0.004	0.214
58	Publishing activities	0.007	0.007	0.004	0.214
59	Motion picture, video and television program production, sound recording and music publishing	0.004	0.004	0.002	0.229
60	Programming and broadcasting activities	0.001	0.001	0.002	0.224
61	Telecommunications	0.003	0.003	0.018	0.432
62	Computer programming, consultancy and related activities	0.021	0.022	0.012	0.360
63	Information service activities	0.004	0.004	0.001	0.312
64	Financial service activities, except insurance and pension funding	0.026	0.027	0.051	0.316
65	Insurance, reinsurance and pension funding, except compulsory social security	0.003	0.002	0.032	0.357
66	Activities auxiliary to financial services and insurance activities	0.011	0.011	0.009	0.266
68	Real estate activities	0.068	0.071	0.016	0.137
69	Legal and accounting activities	0.020	0.022	0.003	0.139
70	Activities of head offices; management consultancy activities	0.033	0.036	0.018	0.250
71	Architectural and engineering activities; technical testing and analysis	0.027	0.029	0.009	0.195
72	Scientific research and development	0.003	0.003	0.002	0.267
73	Advertising and market research	0.012	0.013	0.006	0.325
74	Other professional, scientific and technical activities	0.012	0.013	0.002	0.195
75	Veterinary activities	0.001	0.001	0.000	0.052
77	Rental and leasing activities	0.008	0.008	0.005	0.326
78	Employment activities	0.004	0.004	0.002	0.311
79	Travel agency, tour operator reservation service and related activities	0.007	0.007	0.004	0.279
80	Security and investigation activities	0.003	0.003	0.001	0.293
81	Services to buildings and landscape activities	0.009	0.010	0.007	0.188
82	Office administrative, office support and other business support activities	0.013	0.014	0.006	0.250
84	Public administration and defense; compulsory social security	0.002	0.002	0.003	0.069
85	Education	0.014	0.015	0.004	0.044
86	Human health activities	0.019	0.020	0.009	0.065
87	Residential care activities	0.003	0.004	0.001	0.040
88	Social work activities without accommodation	0.011	0.012	0.002	0.007
90	Creative, arts and entertainment activities	0.004	0.005	0.001	0.094
91	Libraries, archives, museums and other cultural activities	0.001	0.002	0.000	0.093
92	Gambling and betting activities	0.001	0.001	0.005	0.107
93	Sports activities and amusement and recreation activities	0.008	0.009	0.002	0.108
94	Activities of membership organizations	0.017	0.019	0.002	0.019
95	Repair of computers and personal and household goods	0.003	0.003	0.001	0.184
96	Other personal service activities	0.012	0.013	0.002	0.173
97	Activities of households as employers of domestic personnel	0.000	0.000	0.000	0.000
98	Undifferentiated goods-and services-producing activities of private households for own use	0.009	0.011	0.000	0.005
99	Activities of extraterritorial organizations and bodies	0.000	0.000	0.000	0.040

Notes: This table reports the distribution of the number of firms, revenues across sectors. The last column reports the share of sales in each sector by foreign firms. All numbers are simple averages across countries and years.

Table A4: Affiliate-parent comovement: Vertical input linkages

	(1)	(2) Sales	(3)	(4) Value Added	(5) Employment	(6) Sales
Specification	Services, parent and affiliate operating only in the service sector	Services, excluding wholesale trade	Services, excluding retail trade	All	All	All
ϕ	0.195***	0.180***	0.225***	0.140***	0.0831***	0.231***
	(0.0189)	(0.0205)	(0.0123)	(0.0163)	(0.0134)	(0.0129)
IO interaction						0.0141
						(0.0113)
Obs.	65853	111836	169854	68721	123626	156440
N. mult.	9825	12828	17275	7595	13655	15964
R^2	0.724	0.829	0.726	0.732	0.734	0.720
FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors clustered at the parent level in parentheses. ***: significant at the 0.1% level. This table presents the results of estimating equation (1) in the paper using different specifications of the outcome variable and the sample of firms. All specifications include source × destination × affiliate sector × parent sector × year fixed effects. Sectors are defined at the 2 digits of the NACE classification.

Table A5: Affiliate-parent comovement: Alternative sources of comovement and heterogeneous impact

	(1) Excluding Netherlands and Ireland as source and destination	(2) Corporate tax rate difference between destination and source	(3) Private Credit/GDP	(4) Excluding crisis years (2008-2012)	(5) Ginarte-Park index	(6) Bilateral distance	(7) ω_{in} quartiles	(8) High income interaction
ϕ	0.228*** (0.0118)	0.224*** (0.0122)	0.202*** (0.0247)	0.179*** (0.0209)	0.264*** (0.0241)	0.185* (0.0811)	0.191*** (0.0261)	0.155*** (0.0264)
Tax inter.		-0.120 (0.113)						
Fin. dev. inter.			0.000344 (0.000272)					
IPR inter.					-0.0255 (0.0266)			
DST. inter.						0.00649 (0.0121)		
2nd quart. ω_{in} inter.							0.0282 (0.0326)	
3rd quart. ω_{in} inter.							0.0482 (0.0331)	
4th quart. ω_{in} inter.							0.0607^{+} (0.0329)	
High income inter.								0.0912** (0.0290)
Obs.	170186	181953	182029	55812	165023	181957	182025	182029
N. mult.	18178	18873	18886	10958	16652	18874	18885	18886
R^2	0.717	0.724	0.724	0.720	0.716	0.724	0.724	0.724
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors clustered at the parent level in parentheses. ***: significant at the 0.1% level; **: significant at the 1% level; *: significant at the 5% level, $^{+}$: significant at the 10% level. This table presents the results of estimating equation (1) in the paper. "FE" refers to source × destination × affiliate sector × parent sector × year fixed effects. Sectors are defined at the 2-digit NACE classification. "Tax inter." is the interaction between parent growth and the difference in the corporate tax rates between the parent and affiliate countries. "Fin. dev. inter." is the interaction between parent growth and private credit/GDP ratio of the affiliate's country. "IPR inter." is the interaction between parent growth and the dummy variable indicating that the affiliate's Ginarte-Park index is above the median in the sample. "DST. inter." is the interaction between parent growth and log bilateral distance between the parent and affiliate countries. "2nd quart. ω_{in} inter." is the interaction between parent growth and the dummy variable for whether the parent-affiliate country pair are in the second quartile of the distribution of MP shares ω_{in}, similarly for other quartiles. "High income inter." is the interaction between parent growth and the dummy variable for whether the affiliate country is high-income.

Table A6: Affiliate-parent comovement by parent and affiliate size

	(1)	(2)	(3)	(4)
	Affiliate sales < parent sales	Affiliate sales < $\frac{1}{4}\times$ parent sales	Affiliate sales > parent sales	Affiliate sales > $4 \times$ parent sales
ϕ	0.261***	0.277***	0.0790	0.110
	(0.0131)	(0.0158)	(0.0704)	(0.226)
Obs.	164533	134669	17496	7423
N. mult.	17401	14446	4128	1887
R^2	0.731	0.747	0.906	0.962
FE	Yes	Yes	Yes	Yes

Notes: Standard errors clustered at the parent level in parentheses. ***: significant at the 0.1% level. This table presents the results of estimating equation (1) in the paper. "FE" refers to source $\times$ destination $\times$ affiliate sector $\times$ parent sector $\times$ year fixed effects. Sectors are defined at the 2 digits of the NACE classification.

Table A7: Affiliate-parent comovement: Other checks

	(1)	(2)	(3)	(4)	(5)	(6)
	Conventional Growth Rates	4 digit sector classification	Placebo	Excluding Ireland, Mexico, Spain and Australia	Data merged with DVD-ROM:Liberal	Data merged with DVD-ROM: Conservative
ϕ	0.221***	0.208***	-0.071	0.217***	0.223***	0.297***
	(0.0120)	(0.0378)	(0.00913)	(0.0126)	(0.0127)	(0.0319)
Obs.	182029	182029	182029	151357	164462	54531
N. mult.	18886	18886	18886	16441	17960	2975
R^2	0.722	0.933	0.710	0.726	0.732	0.799
FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors clustered at the parent level in parentheses. ***: significant at the 0.1% level. This table presents the results of estimating equation (1) in the paper. "FE" refers to source $\times$ destination $\times$ affiliate sector $\times$ parent sector $\times$ year fixed effects. Sectors are defined at the 2 digits of the NACE classification, with the exception of column (2), which defines the sectors at the 4-digit NACE classification.

Table A8: Affiliate-parent comovement: Firm-level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Sales			Value Added			Employment	
	All	Manufacturing	Services	All	Manufacturing	Services	All	Manufacturing	Services
ϕ	0.084***	0.194***	0.077***	0.072***	0.136***	0.067***	0.039***	0.077***	0.038***
	(0.001)	(0.007)	(0.002)	(0.002)	(0.008)	(0.003)	(0.002)	(0.008)	(0.002)
Obs.	1638060	104193	1142409	524548	48365	347530	771951	70645	490234
N. mult.	223275	14137	169595	83583	7758	59301	118754	11100	83919
R^2	0.249	0.406	0.194	0.273	0.355	0.216	0.297	0.382	0.244
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors clustered at the parent level in parentheses. ***: significant at the 0.1% level. This table presents the results of estimating equation (1) in the paper. "FE" refers to source × destination × affiliate sector × parent sector × year fixed effects. Sectors are defined at the 2 digits of the NACE classification.