Multinationals, Markets, and Markups*

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Abstract

Over the last several decades there is increasing concern whether the concentration of economic activity in a small number of large firms has meant an increase in firm market power. While on the one hand technical and legal barriers to entry may have increased the ability of incumbent firms to raise mark-ups without fear of entry, on the other hand the growing concentration may have more benign causes such as technological change that favors greater scale of operations. This paper studies global market power by analyzing activities of U.S. multinational firms through the lens of a model in which firms tailor their mark-up to the local degree of competition. Employing data on virtually all US-owned firms operating across 50 countries for the years 1999 to 2014, we first show that the market power of manufacturing firms has risen substantially, and mostly due to higher mark-ups firm-by-firm: market share reallocation playing a minor role. Second, we confirm the model's predictions that while high-productivity firms generally charge high mark-ups, they prefer to enter markets where a high degree of competition keeps mark-ups relatively low. Weaker firms, in contrast, tend to enter markets in which competition is low. This sorting implies that the average mark-up differences across locations taken at face value understate differences in the extent of competition across countries. Third, we show that the importance of firm sorting to countries has increased over time. The analysis highlights the importance of the firm-market dimension when studying market power.

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1 Introduction

Over the last several decades there is increasing concern over the concentration of economic activity in a small number of large firms. The share of sales revenue accruing to the largest firms has increased, the share of factor payments going to tangible inputs, such as labor, has fallen, and investment in new capital has stagnated. A key question is whether the market power of industry-leading firms has increased. On the one hand, technical and legal barriers to entry may have increased the ability of incumbent firms to raise mark-ups without fear of entry. On the other hand, growing concentration, with all its manifestations, may have relatively benign causes such a shift in technological change that reduces marginal costs but favors greater scale of operations. In this paper, we analyze the activities of U.S. multinational firms to better understand recent changes in global market power.

In our theoretical framework, firms with heterogeneous productivity face a trade-off of whether to serve a foreign market through exporting or local multinational sales. Mark-ups are variable, depending both on firm and on country characteristics. The model predicts that high-productivity firms charge relatively high mark-ups at the same time that they prefer to enter markets where a high degree of competition keeps mark-ups relatively low. We employ data on virtually all US-owned firms in close to 50 countries for the years 1999 to 2014 to evaluate this model and shed further light on trends in global market power.

U.S. multinationals are heavily research intensive, are large, and are highly productive and so will be representative of the global firms apt to have the greatest market power. Through their productive efficiency and operational sophistication, these firms are in an excellent position to exploit profitable opportunities that less capable firms cannot, and such firms—rather than the typical firm-- have been emphasized in the literature.[1] Furthermore, studying multinationals offers an opportunity to see how the affiliates of individual firms that are governed by the same technology and management perform in countries with different characteristics. An additional plus is that unlike for samples of independent firms in other cross-country datasets, our information is highly comparable across countries because it comes from the same source that has fixed reporting standards (US BEA).

We begin by showing that the sales revenue of U.S. multinationals' foreign affiliates has grown much faster than the compensation of their workers. This is evidence that our firms have grown more profitable in the sense that their mark-up of price over marginal costs has risen.[2] At the same time, U.S. firms have moved more of their payroll overseas as well.

[1] E.g., De Loecker, Eeckhout, and Unger (2020), Autor, Dorn, Katz, Patterson, and Van Reenen (2020).

[2] In the framework employed below changes in sales revenue over the wage bill are equal to mark-up changes, conditional on the output elasticity of labor (De Loecker and Warzynski 2012).

Over the period 1999-2014, the share of U.S. multinationals' payroll that is paid to overseas employees has risen from one-quarter to over one-third. U.S. firms have responded to profit opportunities overseas by expanding their investment there, and as a result they have come to rely more on their foreign affiliates for generating profits. A firm-and-country decomposition of our global average mark-up reveals that all of the mark-up increase is due to within-firm-country increases rather than due to the reallocation of production across countries or across firms.

Our econometric analysis of firm-level data finds strong empirical support that not all firms charge the same mark-up over their costs; rather, in line with the model high-productivity firms charge higher mark-ups than weaker firms. We also show that affiliates of a given firm that are located in different countries charge different mark-ups. In particular, the affiliate's mark-up is declining in the level of development and competition of the country. Moreover, high-productivity firms enjoy a smaller mark-up advantage over weaker firms in relatively competitive countries. Both findings attest to the fact that advanced countries are in a better position than less developed countries to see the price setting of powerful firms contained. The two findings also confirm the predictions of our model.

Interestingly, despite facing the highest competition in advanced countries, our firms sell larger volumes there than in the less developed world. This indicates high demand for the products sold by U.S. multinationals in these locations, which induces greater entry into the sectors populated by U.S. multinationals and hence greater competition.

As large as average mark-up differences across countries are, we show that they understate the true differences in the extent of market power across countries. This is due to the systematic sorting of firms with different degrees of market power into countries that differ in the extent of competition. The largest, most productive firms that charge the highest mark-ups tend to locate their operations in the richest, most competitive countries while smaller, lower mark-up firms tend to locate in poorer countries. This result is in line with another prediction of our model. Compositional effects of this sorting imply that the average mark-up differences across locations taken at face value understate differences in the extent of competition across countries.

The regression analysis also reveals that the positive relationship between firms' mark-ups with respect to firms' productivity has become stronger over time. The strong within effect found in the decomposition is due to firms with maximal market power in 1999 relative to other firms in their industry that have come to enjoying even greater pricing power by 2014. Over the same period, the advantage of countries with relatively high levels of competition to contain the pricing power of firms compared to less competitive countries has also increased. Thus, the increase in the dispersion of firms' market power is accompanied by an increase in the heterogeneity of countries to contain the pricing power of firms through competition. The pattern of sorting of firms to countries in determining aggregate market power has become more important over time.

Competition, mark-ups, and market power play central roles in many areas of economics, including Labor Economics, Macroeconomics, and Industrial Organization, and as a result the issues have attracted much attention recently, including Gutierrez and Philippon (2017), De Loecker, Eekhout, and Unger (2020), and Edmond, Midrigan, and Xu (2019); a recent survey is Syverson (2019). This paper belongs to the subset of research that examines market power in multiple countries to distill the forces that shape global market power (De Loecker and Eekhout 2018, Calligaris, Criscuolo, and Marcolin 2018, and Autor, Dorn, Katz, Patterson, and Van Reenen 2020). Despite recent improvements, a major challenge is that, as a rule, available firm-level is neither comparable across countries nor over time. By using administrative data from the same source on more than 9,000 firms operating across 50 countries for a period of one and a half decades, a first contribution of this paper is that our investigation is less likely than others derailed by measurement problems. While there is a genuine concern about the representativeness of the sample since most firms are not multinationals, the major trends in our sample are the same as in, for example, the KLEMS data (correlation of labor shares during the sample period of 0.82).

Our analysis also differs from existing work by examining firm entry into multiple countries, in contrast to treating the population of firms in each country as given and examining one country at a time. We show that heterogeneous firms systematically favor locating in one country versus another, they tailor their mark-up towards local conditions, and the extent to which firms sort into particular countries has increased over time. An important implication—novel, to the best of our knowledge—is that one cannot compare market power (or, equivalently, the level of competition) across countries or over time without taking account of the extent to which firms sort into particular countries.

Second, our analysis contributes additional evidence on recent trends in market power by studying mark-ups following De Loecker and Warzynski (2012). Our result that mark-ups have increased overall in a global sample is in line with the bulk of existing findings (see Syverson 2019).[3] Gutierrez and Philippon (2017) attribute recent low investment rates in

[3]This may not be surprising in light of the fact that our sample consists of the type of firms on the high end of the size distribution for which increases in mark-ups have been documented (Autor, Dorn, Katz, Patternson, and Van Reenen 2020, De Loecker, Eekhout, and Unger 2020).

the US to increased market power evidenced by high levels of concentration. Our finding that US multinationals have increasingly shifted their activity from the domestic to overseas markets suggests that this higher foreign investment might explain part of the domestic investment weakness. And yet, in contrast to other research, our analysis indicates that the increase in mark-ups of US-owned affiliates is mostly within-firm—between-firm market share reallocation play a limited role for the rise in mark-ups. While future research will shed light on any reasons for this difference, an increase of US multinational mark-ups that is mostly within-firm—perhaps due to higher entry barriers-- is more likely a concern for policy makers and anti-trust authorities than mark-up increases as the result of smooth market share reallocations to firms that operate more efficiently at a higher scale.

Third, our analysis advances the literature by linking rising mark-ups to the operations of multinational firms. On the one hand, multinational firms plausibly play a role for changing mark-ups because many explanations for rising mark-ups (e.g., scale advantages, intangible capital, information technology, and increased product market competition) are inherently related to multinational firms (see Antras and Yeaple 2014; Caves 1996). On the other hand, compared to the early theory of the multinational firm in which imperfect competition was central (Hymer 1960, Horstmann and Markusen 1992), recent work has typically abstracted from questions of market power by assuming monopolistic competition with CES preferences, yielding constant mark-ups (Helpman, Melitz, and Yeaple 2004, Arkolakis, Raimondo, Rodriguez-Clare, and Yeaple 2018). We place the analysis of endogeneous entry and variable mark-ups (Nocke 2006, Melitz and Ottaviano 2008) in the context of firms choosing to serve a foreign market through exports or multinational production to show that these features are critical to explain several key aspects of US multinational firm operations. Our analysis of multinationals as multi-plant firms operating in geographic space may also provide an input to research in regional economics, for example why trends in firm concentration at the local and national level differ (Rossi-Hansberg, Sarte, and Trachter 2020).

The remainder of this paper is divided into six sections. Section two provides a sketch of a simple, partial equilibrium model that elucidates the interaction between the firm and market characteristics that gives rise to mark-ups, entry probabilities, and sales volumes conditional on entry. We then describe our dataset and confirm that movements in labor share across markets and across time for the affiliates of U.S. multinationals strongly covary with movements in these countries' labor share overall. This means that the trends of U.S. multinationals can be extrapolated to other large firms in the local economy. We then begin our formal empirical analyses of three different features of multinationals' operations. In section 4 we consider variation across time and space in the mark-ups charged by U.S.

affiliates. In section 5, we turn our attention to the decision by U.S. based firms of where to own a foreign affiliate. In section 6, we analyze the impact of country and firm characteristics on the value of sales in host country markets, conditional on owning an affiliate there. In section 7, we summarize and synthesize our results and conclude.

2 Theory

In this section we sketch a simple, two-country, partial equilibrium model that describes the interaction between firms' productivities, market sizes, and intensities of competition in determining firm entry, firm output, and firm pricing behavior.

2.1 Model Assumptions

We consider a world with two countries, H and F, that are populated by L_H and L_F consumers. Following Melitz and Ottaviano (2008), the representative consumer in each country has preferences over a numeraire good and a continuum of varieties indexed by ω.[4] The preferences are given by

$$U = q_0 + \alpha \int_{\omega \epsilon \Omega} q^c(\omega) d\omega - \frac{\gamma}{2} \int_{\omega \epsilon \Omega} \left(q^c(\omega)\right)^2 d\omega - \frac{\eta}{2} \left(\int_{\omega \epsilon \Omega} q^c(\omega) d\omega \right)^2$$

where Ω is the set of varieties available and $q^c(\omega)$ is the representative consumer's consumption of variety ω. We choose units such that one unit of labor in each country is capable of producing one unit of the numeraire good so that there are no wage differences between countries to motivate vertical multinational production. As Melitz and Ottaviano (2008) show, the level of demand facing an individual variety producer in market i is given by

$$q_i(\omega) = \frac{L_i}{2\gamma} \left(p_i^{max} - p_i(\omega)\right), \tag{1}$$

where p_i^{max} is the endogenously determined choke price in country i, i.e. the price at which demand is zero, and $p_i(\omega)$ is the price of variety ω in country i. If M_i is the measure of varieties available in the market i and $\bar{p}_i$ is the average price of a variety available in country i, the choke price is given

$$p_i^{max} = \frac{\alpha\gamma + \eta M_i \bar{p}_i}{\eta M_i + \gamma}. \tag{2}$$

[4]The variable L need not be strictly a count of the number of consumers in a country but could instead be the measure of consumers that have access to a good or who desire to consume it at all. An analysis of non-homotheticity is outside of the scope of this paper.

From this expression, we see that a more competitive market is one in which there is a large mass of entrants M_i and in which the prices charged by competitors, summarized by $\overline{p}_i$, is low. Henceforth, we refer to the magnitude of p_i^{max} as the extent of competition and the magnitude of L_i as the market size of country i.

In each country there are a continuum of potential firms, each of which is potentially capable of producing a unique variety. In order to be able to produce, a firm must first pay the entry cost f^e in its source country. Upon incurring this fixed cost, an entrant becomes endowed with a production plant that is capable of producing the firm's variety in its country of entry. At entry the firm also draws its production technology which is captured by the pair (c, f), where c is the firm's marginal cost of production and f is the fixed cost that a firm would have to incur in order to open an additional plant in the other country, from a common joint distribution G with density function g. This distribution is known to all firms prior to entry and is common across countries. We assume that this distribution is not degenerate and allow for c and f to be correlated.

Once a firm has observed its production technology, it makes production decisions for each of the two countries where it could potentially sell its variety. With respect to its home country, i, it will be willing to sell into its home market i as long as its marginal cost c does not exceed the choke price p_i^{max}. In deciding to sell its product in the other country it has two options. First, the firm could export its variety to other market but to do so it must incur the per unit cost t to ship its goods so that the marginal cost of supplying the foreign market is $c + t$.[5] Alternatively, the firm could open an affiliate in the other country and sell its product locally. Doing so allows the firm to avoid the shipping cost t but it requires the firm to open an additional plant at fixed cost f.

Finally, the market structure is one of monopolistic competition. Firms facing the demand curve (1) take the choke price p_i^{max} as given.

2.2 Equilibrium

In this section, we derive the main outcomes of interest to our empirical analysis and close the model via the free entry conditions for each of the two countries. We first derive a firm's optimal price, sales revenue, and profit generated by its activity in its domestic market. We then consider the behavior of the firms that sell their product internationally either through

[5] We have chosen specific trade costs rather than *ad valorem* costs in order to maintain the supermodularity of the profit function in marginal cost and shipping costs. This maintains the second-order selection effects as discussed by Mrazova and Neary (2019).

exports or through the operations of a foreign affiliate. We will refer to these expressions in the next section when we present the empirical implications of our model.

2.2.1 Firms' Domestic Activities

Consider a firm that has paid f^e to enter in country i and subsequently drew a marginal cost c and a fixed cost f. Suppose that the firm's marginal cost is sufficiently low so that it can profitably compete, i.e. $c < p_i^{max}$. As is well known, a firm facing demand (1) with marginal cost c will optimally charge a price equal to

$$p_i(c) = \frac{p_i^{max} + c}{2}, \tag{3}$$

and so the price depends only on the firm's productivity, $1/c$, and on the extent of competition in country i's product market, p_i^{max}. A firm that is selling into its domestic market i and charging a price given by (3) will earn sales revenue equal to

$$S_i^D(c) \equiv p_i^D(c) q_i(p_i^D(c)) = \frac{L_i}{4\gamma}\left((p_i^{max})^2 - c^2\right), \tag{4}$$

and generate profits in its domestic market sales of

$$\pi_i^D(c, f) = \begin{cases} \frac{L_i}{4\gamma}\left(p_i^{max} - c\right)^2 & \text{if } c < p_i^{max} \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

This expression will be important as an input into the free entry condition for country i.

2.2.2 Firms' International Activities

We now turn our attention to a firm's pricing decision and its profits generated on sales to the international market. We begin our analysis with the case of a firm from country i of type $(c,\ f)$ that exports to country $j \neq i$ from its plant in country i. As the firm would need to pay shipping costs t it will only be able to generate positive profits from exports if $c \leq p_j^{max} - t$. In this case, the firm would optimally charge a price of

$$p_i^X(c) = \frac{p_j^{max} + t + c}{2}.$$

Note that this expression shows that prices will vary across locations for two reasons. First, the marginal cost of selling locally and of exporting differ due to the trade cost. Second, countries differ in their level of competitiveness as determined by the local choke price. Given this pricing strategy, the firm will generate export revenue of

$$S_i^X(c) \equiv p_i^X(c) q_j(p_i^X(c)) = \frac{L_j}{4\gamma}\left(\left(p_j^{max}\right)^2 - (c+t)^2\right)$$

and earn profits on its exports of

$$\pi_{ij}^X(c,f) = \begin{cases} \frac{L_F}{4\gamma}\left(p_H^{max} - c - t\right)^2 & \text{if } c+t < p_j^{max} \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

Now suppose instead that this firm were to open an affiliate in country j. In this case, the firm will not have to pay any shipping cost t to sell its product but will instead have to incur a fixed cost f. The firm's affiliate in country j would then exactly behave as if it were a domestic firm in terms of its pricing decision and in terms of the sales enjoyed, but the profits enjoyed have to be adjusted for the fixed cost of maintaining a foreign affiliate. Specifically, the affiliate would generate profit of

$$\pi_{ij}^M(c,f) = \begin{cases} \frac{L_j}{4\gamma}\left(p_j^{max} - c\right)^2 - f & \text{if } c < p_j^{max} \\ -f & \text{otherwise.} \end{cases} \tag{7}$$

Contrasting the export profit function (6) with the multinational affiliate profit function (7), it is readily shown that a sufficient condition for a firm from i to open an affiliate in j is if its type $(c,\ f)$ satisfies

$$\left(p_j^{max} - \frac{t}{2}\right) - \frac{2\gamma f}{L_j t} \geq c. \tag{8}$$

This expression shows that an increase in the competeviness of a market (a reduction in p_j^{max}) reduces the number of firms that will choose multinational production, and that an increase in a market's size (L_j) tends to increase the number of firms engaged in multinational production. Of the two forces, only the first, the extent of competition, is endogenous. As we show in simulations of the model below there is a negative endogenous relationship between a country's market size L_j and the extent of competition in that market p_j^{max}. This fact, when combined with heterogeneity across firms in both c and f, has the implication that different types of firms will prefer to open affiliates in different types of countries. In order to be able to conduct the simulation, we now turn to the free entry condition.[6]

[6]As the countries are identical all but for scale and there are no other interactions between markets, we can interpret the different multinational behavior of firms from H in F and of firms from F in H as if these firms were from a third country that were considering investing in the two separate locations.

2.2.3 Free Entry Condition

As is standard in models of monopolistic competition, firms enter until their expected profits, net of the entry cost, are equal to zero. To derive the free entry condition, we need to aggregate over the potential profits associated with any draw $(c,\, f)$. For a firm that has paid its fixed entry cost in country i these profits can be compactly written

$$\Pi_i(c,f) = \pi_i^D(c,f) + max\left\{\pi_{ij}^M(c,f), \pi_{ij}^X(c,f)\right\}, \tag{9}$$

where the arguments in the expression are given by equations (5)-(7). Aggregating over all the possible values of c and f on the support of G yields the following simple expression for free entry

$$\int\int \Pi_i(c,f)g(c,f)dcdf - f^e \leq 0 \text{ for } i = H, F. \tag{10}$$

Note that $\Pi_i(c,f)$ in equation (9) is a strictly increasing function of both $p_H^{max}$and p_F^{max} and that it is easy to establish that it has a unique solution. Also, because of international frictions in shipping goods (t) and in opening foreign affiliates (f) the free entry condition for each country is more sensitive to its own choke price than it is to the choke price of the other country. It is this fact that will generate the negative relationship between p_i^{max} and L_i. Finally, note that given solutions for the choke prices in each country, we can solve for pricing decisions, entry decisions, and sales decisions of firms.

2.3 Predictions

In this section, we present three sets of predictions over the structure of multinational production that are relevant for understanding the cross country and cross time variation in the mark-ups charged by the foreign affiliates of U.S. multinationals. We begin with the mark-ups charged by individual firms conditional on their opening an affiliate in a given country. We then consider the decision of firms to open an affiliate in the first place. We will show that the sorting behavior of multinationals into markets creates strong compositional effects that can obscure the strength of competition across countries. Finally, we conclude with the size of an affiliate's operations conditional on opening an affiliate.

2.3.1 Mark-Ups

We define the mark-up charged by a firm as the ratio of the firm's price $\mu \equiv p/c$ as this is the object that is measured in the empirical section below. From equation (3), we see that conditional on being observed to operate locally in a market, the mark-up of a firm of marginal cost c is given by

$$\mu_i(c) \equiv \frac{p_i}{c} = \frac{1}{2}\left(\frac{p_i^{max}}{c} + 1\right). \tag{11}$$

We see that low marginal cost firms will have higher mark-ups in all markets and that these mark-ups will be even larger in countries with weak competition (high p^{max}). Moreover, equation (11) reveals that given a set of firms that vary in their marginal cost and that produce in a particular country, the gradient of mark-up across firms with respect to firm productivity ($1/c$) directly reveals the extent of competition in that country.[7] As this is a key result that we will use to interpret our empirical results we highlight it below:

Mark-ups: *The affiliates of (1) larger, more productive firms charge higher mark-ups, (2) mark-ups will be higher in less competitive markets, and (3) the increase in mark-ups for more productive firms is higher in less competitive markets.*

This result has the empirical implication that we would expect the gradient of mark-ups with respect to firm size to be higher in less competitive markets. This implication will be crucial to our empirical work as it allows us to identify which countries have more competitive markets and whether competition has increased or decreased.

2.3.2 Entry Decisions and Sorting

In this section, we demonstrate that in our model that firms sort into ownership of foreign affiliates on the basis of the interaction between firm competitiveness and country competitiveness. Specifically, we will show that high mark-up firms tend to prefer to entry low mark-up countries and that low mark-up firms tend to prefer to enter high mark-up countries. This is important because it means that composition effects can obscure the level of market power as measured by average mark-ups across countries. Due to the non-linearities of the free-entry conditions, equation (10), we develop our entry predictions through simulations.

In our simulation, we consider a parameterization in which one country, F, is twice as large as the other country, H, i.e. $L_F = 2L_H$. We construct a set of 10,000 draws of c and f from

[7] The prediction that mark-ups that the gradient of mark-ups with respect to firm productivity reveals the extent of competition is not unique to the linear demand system considered here. It can be shown that similar results obtain for demand systems derived from the Klenow and Willis (2006) parameterization of Kimball (1995) preferences, as well as the Addilog preference system of Bertoletti and Etro (2015). These systems feature choke prices and mark-ups that are not bounded above. Other demand systems, however, do not have the implication of gradients that increase in productivity with decreased competition (e.g., Generalized CES). These demand systems have an upper bound on mark-ups that restricts the flexibility of the gradient of mark-ups with respect to productivity.

a Clayton copula with moderate negative dependence between the two variables and impose that the marginal distribution of each is Pareto. These draws represent the distribution of firms in each of the two countries. For an initial guess of choke prices for H and for F, we use equations (5)-(7) for each country to solve for a firm's optimal behavior and profits and then vary the choke prices such that the zero profit condition bind.[8]

Figure 1 demonstrates how firms with different draws of the fixed cost f (horizontal axis) and the marginal c (the vertical axis) operate. The darker (red) line depicted in the figure represents the cutoff condition for firms that have entered in the small country H to invest in the large country F. Draws of c and f that fall below this line are firms that invest in F while firms with draws above do not. The lighter (green) line depicts the cutoff condition going the other direction and is interpreted similarly. The fact that the c-intercept is higher for investment into country H than into country F reflects the fact that competition is less fierce in the small country because it has induced fewer firms to enter. The fact that the gradient of the line is steeper for the cutoff condition for investment into H is because $L_H < L_F$ (see equation 8).

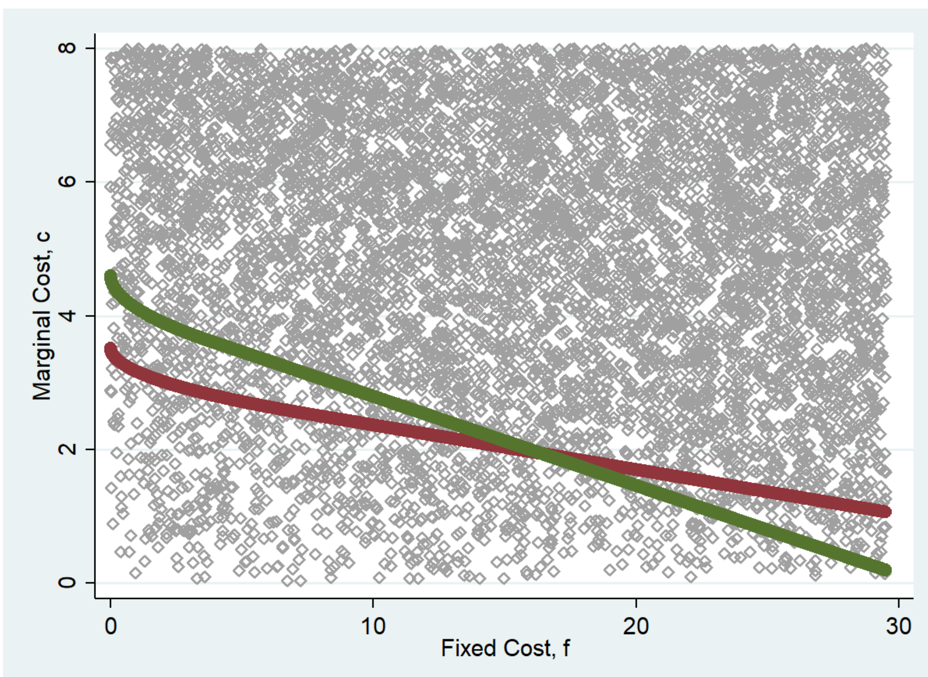

Figure 1: Sorting into Multinational Production by Host Country Size

The pattern of sorting depicted in Figure 1 reveals that the less competitive country H attracts multinational affiliates that have higher average marginal costs relative to those

[8]More details on the parameterization of the model can be found in Appendix B.1.

firms that enter country F. At the same time, country, H does not attract the low marginal cost but high fixed cost firms that favor the more competitive country F. Recall that mark-ups are strictly decreasing in a firm's marginal cost and increasing in a country's choke price. The sorting of firms on the basis of their marginal and fixed costs and the mapping of marginal costs to mark-ups means that high mark-up firms (low c) are disproportionately attracted to low mark-up countries (low p^{max}) and low mark-up firms are disproportionately attracted to high mark-up countries. We can label the countries as high-mark-up or low mark-up because a firm with a given type that invested in both countries would have a lower mark-up in country F than in country H.

This result, which has the flavor of the sorting result in Nocke (2006), is sharply different from those implied by standard models of the proximity-concentration framework in which multinational entry is strictly on the basis of marginal cost (e.g. Helpman, Melitz, and Yeaple 2004). Note that a generalized decrease in competitiveness, or an increase in p^{max}, as might happen if the cost of entry were to rise would be to shift up the entry (c, f) threshold function given by equation (8). In this case, firms across the productivity spectrum would be induced to enter the foreign market. To provide emphasis for these implications of the model, we highlight them below:

Selection: *(1) Small firms are more likely to open affiliates in small, less competitive markets while large firms are more likely to open affiliates in large, more competitive markets. (2) Weaker competition by itself induces entry of multinational enterprises across the productivity spectrum of firms.*

The selection patterns illustrated in Figure 1 have important implications for the measurement of competition across countries when firms can sort internationally. The figure shows qualititatively that the highest mark-up firms tend to locate in the most competitive markets and the lowest mark-up firms tend to locate in the least competitive markets. This means that a comparison of average mark-ups across countries may fail to reveal how competitive a market is.

To get a sense of how large this compositional effect can be, consider Table 1. The columns of this table shows simple and input cost weighted average mark-ups charged by affiliates in F and H, respectively. The first row is the average over all affiliates operating in each country while the second row shows the averages for only the set of firms that operate affiliate in both countries. Several features of these simulation results are worth noting. First, we see from the last row that the choke price in H is substantially higher than in F and the difference in competition is accurately reflected in the second row where the average mark-ups are higher for the affiliates located in H than in F. This is due to the reduction in the size of the composition effect because the set of firms represented in each sample is the same. Looking at the first row, where the composition of firms is different, we see that the average mark-up is no longer consistent with the true level of competition in the two countries. Intuitively, the affiliates in H have higher average marginal costs and so tend to have low mark-ups relative to F where the set of firms is skewed more to high mark-up firms.

Table 1: Composition and Average Mark-Ups

	Affiliates in F		Affiliates in H	
	Unweighted	Weighted	Unweighted	Weighted
All Entrants	3.21	2.26	2.89	2.11
Invest in Both, Only	2.69	2.04	3.37	2.39
Memo: Choke Price	3.53		5.63	

2.3.3 Sales

This part of our analysis concerns observable characteristics of the affiliates that are in operation. The last object that has a direct empirical analog in our data is affiliate sales in their host country market. It is straight-forward to show that the sales of an affiliate operating in the foreign market are given by equation (4), which show that low marginal cost firms make larger sales and that sales are larger in large, uncompetitive markets.[9] Equation (4) combined with (11) will help us to tease out from the data how country characteristics that drive mark-ups (p^{max}) differ from country characteristics that drive sales volumes (L). We highlight the predictions below:

Sales: *Low marginal cost firms sell more in any market than high marginal cost firms. If a country characteristic raises market size faster than it increases the extent of competition, then sales volumes will rise for all operating firms.*

Below we use the insights gleaned from this simple model together with data on the operations of U.S. multinationals to provide a geography of the strength of market power across firms, across countries, and over time. We will focus in turn on mark-ups, entry decisions, and affiliate sales conditional on entry. Before doing so, we first describe our data.

[9]While equation (4) suggests interactions between the various variables, these interactions are sensitive to functional form assumptions. For instance, c and L interact in levels but not in logarithms while p^{max} and c do not interact in levels but do interact in logarithms.

3 Data

3.1 Data Sources

Firm-level data of the international structure of U.S. multinationals operations come from the Bureau of Economic Analysis (BEA) surveys of U.S. Direct Investment Abroad, which are conducted for the purpose of producing aggregate statistics on direct investment activities for the general public. A U.S. multinational entity is the combination of a single U.S. legal entity that has made the direct investment, called the U.S. parent, and at least one foreign business enterprise, called the foreign affiliate. As a result of confidentiality assurances and penalties for non-compliance, the BEA believes that coverage in this survey is close to complete and the level of accuracy is high.

Our database is assembled from the Benchmark surveys that were conducted in the years 1999, 2004, 2009, and 2014. In these years, the BEA surveys attempt to reach all U.S. head-quartered multinational firms and obtain a broad set of data for both parent and all affiliates. For each majority-owned U.S. affiliate, we observe for each year an unique firm-identfier that allows us to link affiliates with their parents across countries and across time. In addition, we observe the country, main industry, value of sales, and employment compensation of every affiliate. These variables will form the backbone of the dependent variables that correspond to the highlighted predictions in the previous section: mark-ups, entry decisions, and affiliate sales by firm, country, and year.

We also use some of the survey data to construct additional measures as described below. We briefly discuss these variables now and elaborate in more detail in the next section. For all parents we observe the value of sales to all customers, the value of sales in the United States, the value of employee compensation and the number of employees, the book value of capital, and parents' related-party trade with its affiliates.[10] For each affiliate above a size threshold, we observe the value of sales, the value of employee compensation, the book value of capital, and related party trade with all other entities including the parent firm.[11]

A key input into the analysis of mark-ups in our setting will be the trend across countries, industries, and time in labors share of income, which is inversely related to mark-ups. We will be using data for the affiliates of U.S. multinationals to infer trends across countries and time in the strength of competition in each market. This raises the question as to

[10] We have chosen to work with an unbalanced panel to avoid dropping smaller affiliates which have a higher likelihood to enter or exit. However, the results are qualitatively similar when we employ a balanced sample.

[11] Addtional information regarding the data can be found in the appendix.

whether the trends among U.S. multinational affiliates are similar to the trends of their host countries. We now consider a simple exercise using publicly available data to confirm that the trends within U.S. manufacturing affiliates tend to positively covary with those of their host countries.

We begin by plotting the labor's share of sales for the affiliates of U.S. multinationals that operate in the 15 European countries that are represented in the KLEMS dataset against the aggregate labor share in those same countries over the period 1999-2014. The data is plotted in Figure 2. The figure reveals two important features of the data. First, we see that the labor share of U.S. affiliates closely track the aggregate labor share of all firms operating in Europe over the period. Second, we observe that the labor share of sales revenue has been falling consistently for both U.S. affiliates and for the entire European economy.

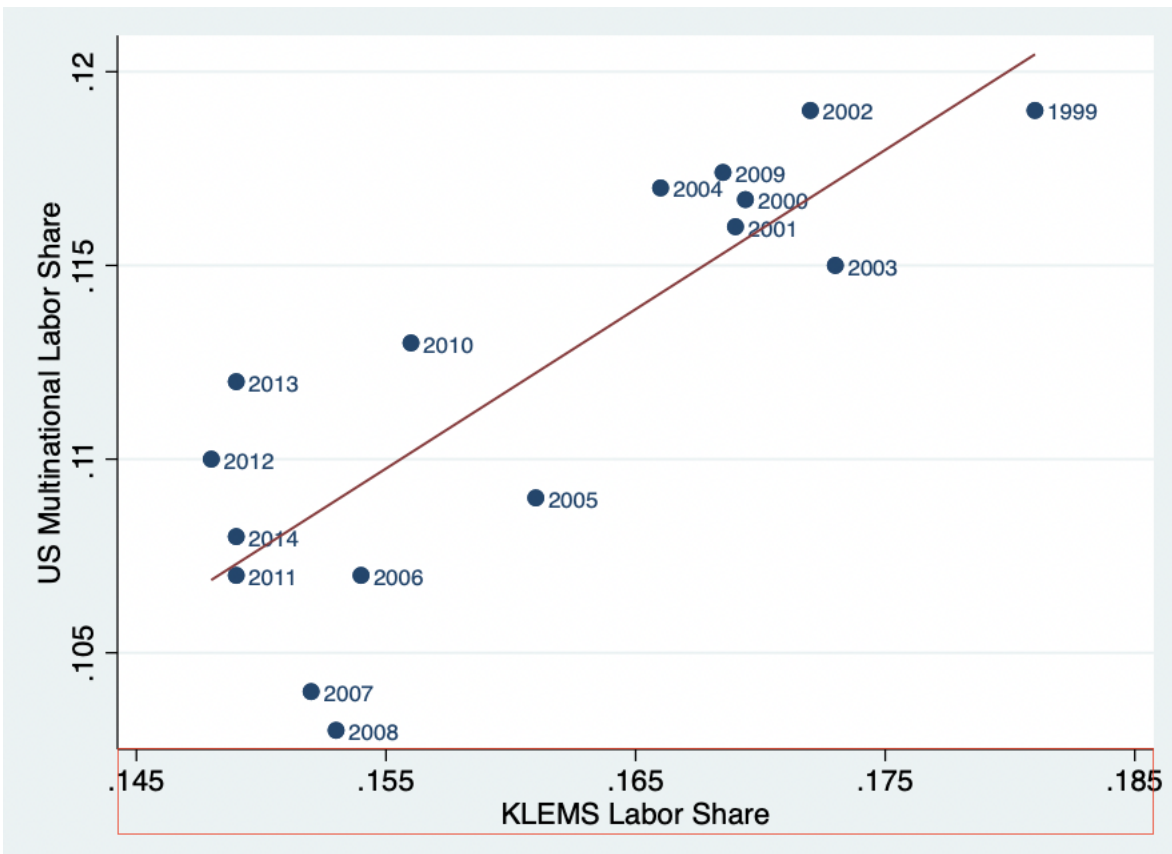

Figure 2: U.S. Foreign Affiliates' Labor Share versus Host Country Aggregates

We also employ publicly available data for further tests that allows us to control for heterogeneity across time and across countries. Table 2 shows the results obtained by regressing the logarithm of labor's share of sales for all manufacturing in 15 European countries over the years 1998-2015 on the logarithm of labor's share of sales for U.S. manufacturing affiliates operating in the same countries over the same period.[12] The first column of Table 2 are the results obtained when including year fixed effects in the regression while the second column shows the results obtained when including country and year fixed effects. In both cases, the coefficient on the labor share of U.S. multinational affiliates is positive and precisely estimated. This provides evidence that we can infer changes in competition trends in the host country from the behavior of U.S. multinationals.

Table 2: Aggregate Labor Share in Europe versus U.S. Affiliates

	(1)	(2)
US MNE Labor Share	0.432 (0.026)	0.103 (0.031)
Fixed Effects	Year	Country, Year
N	281	281
R-Squared	0.57	0.93

Notes: The dependent variable is the logarithm of aggregate manufacturing labor share for 15 KLEMS countries. The independent variable is the logarithm of manufacturing labor share for the affiliates of U.S. multinationals. Sample period is the years 1998 to 2015. Robust standard errors in parentheses.

3.2 Markup Measurement

We measure mark-ups using the approach by De Loecker and Warzynski (2012), which makes it possible to infer mark-ups from using only data on the cost share of a single adjustable factor of production and an estimate of this factor's output elasticity without making strong assumptions about the nature of competition in a market. In our data, labor cost shares are available for every U.S. parent and every foreign affiliate owned by these parents.

We begin this section with an overview of this framework. This is followed by making explicit a set of assumptions on the output elasticities of labor that allow us to decompose the weighted average mark-ups of the foreign affiliates of U.S. multinationals. We will find evidence that mark-ups have tended to have risen in manufacturing industries but to have fallen in service industries and that most of these trends have been driven by changes within the large multinationals that have been present throughout the sample period.

[12]The BEA data was downloaded from the Bureau's website at https://www.bea.gov/, and the European data is from downloaded from the KLEMS database at http://www.worldklems.net/data.htm .

We then adopt an econometric strategy that allows us to relax the assumptions over variation in the output elasticity of labor across firms and countries. This analysis provides a portrait of how mark-ups have changed within existing firms. We will find that the two approaches provide a consistent picture of how market power has evolved globally.

Consider a firm, f that owns an affiliate in country c at time t. The firm faces inverse demand $p_c\left(q_{ct}\right)$, where q_{ct} is the total output in this market. Let the production technology for the affiliate be

$$q_{ct} = \varphi_{ct} f\left(K_{ct}, L_{ct}, V_{ct}\right), \tag{12}$$

where φ_{ct} is the productivity of the affiliate, K_{ct} is the stock of capital available at the affiliate, e, L_{ct} is is the employment of the affiliate, and V_{ct} is is the quantity of intermediate inputs used by the affiliate. We assume that this production function is increasing and concave in its arguments and that all cross partials are positive. Assuming that the capital stock is initially fixed at the beginning of any given period, that labor and materials are freely adjustable at prices w_{ct} and p^m_{fct}, and that the firm does not have power to influence factor prices, the firm chooses the amount of labor to employ to maximize

$$p_{fc}\left(q_{fct}\right) q_{fct} - w_{ct} L_{fct} - p^m_{fct} V_{fct}, \tag{13}$$

subject to the technology constraint given by equation (12).[13] Taking the first-order condition and reorganizing the resulting expression, we obtain an expression that relates the affiliate of firm f's mark-up in country c at time t, μ_{fct}, to the ratio of its sales revenue, $S_{fct} \equiv p_{fc}\left(q_{fct}\right) q_{fct}$, to its employee compensation

$$\mu_{fct} = \theta^L_{fct} \frac{S_{fct}}{w_{ct} L_{fct}}, \tag{14}$$

scaled by the output elasticity of labor, θ^L_{fct}.

Equation (14) makes clear that given data on the value of a firm's sales and its wage bill and an estimate of the output elasticity of labor for the technology that firm is using, the mark-up can be calculated directly. Most work using equation (14) also has to make auxiliary assumptions to confront issues of aggregation. For instance, a firm may sell in many markets, charging a different mark-ups in each, but will not report labor allocation across products so that the measured mark-up is some kind of weighted average of the markets the firm serves.

[13] The BEA data does not include data on intermediate input usage but does include employment and total worker compensation. Hence, we focus on the firms choice of employment. Note that if the firm can influence local factor prices then the mark-up we are measuring reflects market power in both output and input markets.

Alternatively, the allocation of factors across the different products of a conglomerate raises the additional problem that output elasticities may differ across goods sold. We make the same set of auxiliary assumptions.

Other issues arise in how the output elasticity, θ^L_{fct} is to be measured. Below we will conduct a decomposition of aggregate mark-ups whose implementation that does not requires that output elasticities be observed but that they be constant across firms and across time. We will find strong evidence that for the affiliates of U.S. multinationals, much of the variation in explaining global and regional trends in mark-ups can be traced to within firm effects. We then turn from decompositions to an econometric analysis of the evolution of firm level mark-ups. Our econometric approach, which allows us to flexibly control for unobserved variation in the output elasticity of labor, θ^L_{fct}, will rely on the intuition developed in the theory section in order to draw inferences about how mark-ups are changing over space, industry, and time.

3.3 A Multi-Dimensional Decomposition of Mark-ups

The decomposition of aggregate phenomena into orthogonal components has proven to be a powerful tool for empirical analysis in many contexts.[14] In the typical case the decomposition is two-dimensional; Autor, Dorn, Katz, Patterson, and Van Reenen (2019), for example, break down the change in the labor share for a country into a within- and between-firm component.[15] However, in the context of multinational firms, which by their very nature span several countries, it is natural to analyze how mark-ups of different countries are linked because firms operate affiliates in multiple markets. In the national-firm approach, global mark-ups can rise if in each country market share is re-allocated towards high-mark-up firms or if firms charge higher mark-ups for given market shares. If a given firm is present in multiple markets (countries), it is instructive to separate the part of mark-up changes that is due to market share reallocation across countries from the part of mark-up changes that is due to market share reallocation across firms.[16] The following introduces a multi-dimensional decomposition to begin to shed light on this.

Abstracting for present purposes from the time dimension (subscript t), let the average

[14]See, for example, the Oaxaca-Blinder decomposition on the sources of wage differences (cite), the within- versus between industry decomposition in the analysis of the skill premium (Berman, Bound, and Griliches 1993), and the between- versus within-firm sources of productivity growth (Olley and Pakes 1996).

[15]An adjustment for entry and exit as in Melitz and Polanec (2015) is considered as well.

[16]Analogous arguments apply to the analysis of multi-plant firms in a domestic economy.

mark-up of firms (f) that operate affiliates in several countries (c) be given by

$$M = \sum_c \sum_f w_{fc} m_{fc},$$

where m_{fc} is firm f's mark-up in country c and w_{fc} is the firm's size in market c.[17] The following analysis begins by expressing M as the weighted average of country level mark-up decompositions. To do so, we focus on surviving firms (no entry and exit) and define N_c as the number of firms that operate an affiliate in country c; further, define the average size of firms in country c as

$$\overline{w}_c \equiv \sum_f w_{fc},$$

while the (unweighted) average mark-up in country c is denoted as

$$\overline{m}_c = \frac{1}{N_c} \sum_f m_{fc}.$$

Using these definitions, we can write

$$\begin{aligned} M &= \textstyle\sum_c \left[\overline{w}_c \sum_f \frac{w_{fc}}{\overline{w}_c} m_{fc}\right] \\ &= \textstyle\sum_c \left[\overline{w}_c \left(\overline{m}_c + \sum_f \left(\frac{w_{fc}}{\overline{w}_c} - \frac{1}{N_c}\right) m_{fc}\right)\right] \qquad (15) \\ &= \textstyle\sum_c \left[\overline{w}_c \left(\overline{m}_c + \sum_f \left(\frac{w_{fc}}{\overline{w}_c} - \frac{1}{N_c}\right) (m_{fc} - \overline{m}_c)\right)\right]. \end{aligned}$$

The second line follows because the average mark-up of firms in a given country is equal to the simple (unweighted) average plus the covariance in firm size and firm mark-up. The third line follows because $\overline{m}_c$ can be pulled out of the summation over firms and $\sum_f \left(\frac{w_{fc}}{\overline{w}_c} - \frac{1}{N_c}\right)$ is equal to zero.

If we write the average mark-up in country c as

$$M_c = \overline{m}_c + \sum_f \left(\frac{w_{fc}}{\overline{w}_c} - \frac{1}{N_c}\right)(m_{fc} - \overline{m}_c), \qquad (16)$$

[17] As noted above, we will begin by measuring m_{fc} by the ratio of the firm's local sales over the wage bill, S_{fc}/E_{fc}, while size is measured in terms of the firm's wage bill, $w_{fc} = \frac{E_{fc}}{\sum_{c'} \sum_{f'} E_{f'c'}}$. By assuming that the output elasticity for labor is fixed over time, we can attribute any movement in the sales to labor compensation ratio to changes in firm mark-ups.

the average mark-up overall can be written as

$$M = \sum_c \overline{w}_c M_c. \tag{17}$$

Equation (17) clarifies that the overall mark-up is the appropriately weighted average of the country-level decompositions.

Furthermore, let N be the number of countries, and $\overline{M}$ is the average of $\overline{m}_c$ across countries,

$$\overline{M} = \frac{1}{N}\sum_c \overline{m}_c,$$

and denote the covariance between firm size and firm mark-up in a country as

$$cov_c = \sum_f \left(\frac{w_{fc}}{\overline{w}_c} - \frac{1}{N_c}\right)(m_{fc} - \overline{m}_c). \tag{18}$$

Furthermore, define $\overline{cov}$ as the mean of these covariances,

$$\overline{cov} = \frac{1}{N}\sum_c cov_c. \tag{19}$$

Then

$$\begin{aligned} M &= \sum_c \left[\overline{w}_c \left(\overline{m}_c + cov_c\right)\right] \\ &= \sum_c \overline{w}_c \overline{m}_c + \sum_c \overline{w}_c cov_c \\ &= \overline{M} + \sum_c \left(\overline{w}_c - \tfrac{1}{N}\right)\left(\overline{m_c} - \overline{M}\right) \\ &\quad + \overline{cov} + \sum_c \left(\overline{w}_c - \tfrac{1}{N}\right)\left(cov_c - \overline{cov}\right). \end{aligned} \tag{20}$$

The last two rows of equation (20) indicate that an increase in the (weighted) average mark-up from one year to the next is due to (1) the increase in the simple average of mark-ups across countries and firms ($\overline{M} = \frac{1}{N}\sum_c \overline{m}_c = \frac{1}{N}\sum_c\left(\frac{1}{N_c}\sum_f m_{fc}\right)$), (2) to the reallocation of global market share to countries with high average mark-ups ($\sum_c \left(\overline{w}_c - \frac{1}{N}\right)\left(\overline{m_c} - \overline{M}\right)$), to (3) the increase in the average covariance between firm size and firm mark-up country by country ($\overline{cov}$), and finally (4) to the increase in global market share of countries in which the covariance between firm size and firm mark-up is relatively high ($\sum_c \left(\overline{w}_c - \frac{1}{N}\right)\left(cov_c - \overline{cov}\right)$).

A standard two-dimensional decomposition into within- and between effects will have elements corresponding to a subset of terms in equation (20). For example, a within- versus between-firm decomposition of the increase in mark-ups will have the increase in mark-ups due from the increase in the unweighted mark-up over time plus the increase in mark-ups coming from the reallocation of market share from low- to high mark-up firms over time. This corresponds in our setting to the third line in equation (20), with terms (1) and (2), except that within- and between firm is replaced by within- and between country.

What is new with more than two dimensions is that the degree to which market share is shifting below the country level–namely, at the firm level–, is an additional source of change in the mark-up. There are two parts to this: the first is changes in the typical covariance of firm size and firm mark-up in the world (changes in $\overline{cov}$). If the covariance of mark-ups and firm sizes in the world typically increases, the global mark-up will increase on this account as well. The reason for this is that in the average (typical?) country the degree of sorting between firm size and firm mark-up increases.

Second, the global mark-up will also increase if market shares shift from countries with relatively low covariance of firm size and firm mark-up to countries where this covariance is higher (changes in $\sum_c \left(\overline{w}_c - \frac{1}{N}\right)(cov_c - \overline{cov})$). That is, global mark-ups can rise (i) due to a reallocation of market share to countries with high mark-ups as such (line 3 in equation (20), and they can rise (ii) due to a reallocation of market share to countries where the co-variance (or, the extent of positive sorting) of firm size and firm mark-up is relatively strong.

It is also instructive to reverse the role of firm- and country-variation in the decomposition of the average (weighted) mark-up. To see this, let $\overline{w}_f$ be the firm's size across all countries,

$$\overline{w}_f = \sum_c w_{fc}.$$

Also, let N_f be the number of countries that firm f has affiliates in, and $\overline{m}_f$ the average of firm f's mark-ups across all countries in which it has affiliates

$$\overline{m}_f = \frac{1}{N_f} \sum_c m_{fc}.$$

Then the mark-up can be written as

$$\begin{aligned} M &= \sum_f \left[\overline{w}_f \sum_c \frac{w_{fc}}{\overline{w}_f} m_{fc}\right] \\ &= \sum_f \left[\overline{w}_f \left(\overline{m}_f + \sum_c \left(\frac{w_{fc}}{\overline{w}_f} - \frac{1}{N_f}\right) m_{fc}\right)\right] \\ &= \sum_f \left[\overline{w}_f \left(\overline{m}_f + \sum_c \left(\frac{w_{fc}}{\overline{w}_f} - \frac{1}{N_f}\right)(m_{fc} - \overline{m}_f)\right)\right]. \end{aligned} \tag{21}$$

Defining the weighted average firm mark-up, M_f, as

$$M_f = \overline{m}_f + \sum_c \left(\frac{w_{fc}}{\overline{w}_f} - \frac{1}{N_f} \right) (m_{fc} - \overline{m}_f) \, ,$$

we obtain

$$M = \sum_f \overline{w}_f M_f, \tag{22}$$

that is, the overall mark-up can be seen as an appropriately weighted average of firm mark-ups. Also, let cov_f be defined as

$$cov_f = \sum_c \left(\frac{w_{fc}}{\overline{w}_f} - \frac{1}{N_f} \right) (m_{fc} - \overline{m}_f) \, . \tag{23}$$

It is useful to compare the expression (23) with the counterpart at the country level, cov_c, shown above in equation (18). That covariance examines the extent that firms in a given country exhibit a positive sorting pattern of their sizes and mark-ups. In contrast, the covariance cov_f reveals whether for a given firm there is a positive sorting pattern between the size of its affiliates and the mark-ups they are charging across the markets in which they are operating.

What factors could there be that would strengthen these sorting patterns? Take the familiar heterogeneous firm trade model of Melitz (2003), for example. There, a symmetric move to lower trade costs increases the correlation of firm productivity and its sales because the trade liberalization reallocates market share from low- to high-productivity firms, which is a between-firm effect analogous to those that are reflected in cov_c changes.[18] Much less is known about factors that may change the relative importance of different markets for a given firm, and how that affects the mark-up the firm will charge in each market (that is, cov_f). To begin to shed light on this, we will compute these expressions below.

Furthermore, let N^F be the total number of firms, and

$$\widetilde{\overline{cov}} = \frac{1}{N^F} \sum_f cov_f$$

is the average of these firm-level covariances. Also, let

$$\overline{M}^F = \frac{1}{N^F} \sum_f \overline{m}_f .$$

[18] Mark-ups in this model are constant (CES).

Then we can obtain an expression analogous to equation (20) from above, but now focusing on firms instead of countries. It is given by

$$\begin{aligned} M &= \sum_f \left[\overline{w}_f \left(\overline{m}_f + cov_f\right)\right] \\ &= \sum_f \overline{w}_f \overline{m}_f + \sum_f \overline{w}_f cov_f \\ &= \overline{M}^F + \sum_f \left(\overline{w}_f - \tfrac{1}{N^F}\right)\left(\overline{m_f} - \overline{M}^F\right) \\ &\quad + \widetilde{\overline{cov}} + \sum_f \left(\overline{w}_f - \tfrac{1}{N^F}\right)\left(cov_f - \widetilde{\overline{cov}}\right). \end{aligned} \tag{24}$$

We will show results on the individual components of both equations (20) and (24) below.

3.4 Econometric Strategy

Our decomposition analysis highlighted the potential importance of within firm changes in mark-ups on movements in global aggregates. These statements were conditional on the assumption of output elasticity stability across firms, countries, and years. In this section, we devise an econometric strategy that allows us to flexibly control for variation in the output elasticity across all three dimensions. We then interpret the partial correlations that we estimate through the lens of the model presented in section 2. To operationalize equation (14), we put additional structure on the output elasticity θ^L_{fct}. Reorganizing equation (14) we obtain

$$log\left(\frac{S_{fct}}{w_{ct}L_{ct}}\right) = log\, m_{fct} - log\, \theta^L_{fct}.$$

We model the output elasticity as $log\, \theta^L_{fct} = log\, \theta^L_{i(f)t} + \alpha_0 log\ \left(K_{fct}/L_{fct}\right)$, where $i(f)$ is the industry of the affiliate of firm f, to obtain

$$log\left(\frac{S_{fct}}{w_{ct}L_{ct}}\right) = log\, m_{fct} - log\, \theta^L_{i(f)t} - \alpha_0 log\ \left(K_{fct}/L_{fct}\right).$$

Intuitively, the output elasticity facing a firm will depend on a time-varying industry component reflecting common technology and a component that represents adaptation to local factor prices that are reflected in the mix of inputs chosen by the firm.[19]

We allow an affiliates mark-up to be a function of the local market conditions and of the

[19] Sun (2017) shows that parent firm capital intensity predicts well the capital intensity of affiliates which suggests little adaption in techniques across markets.

firms productivity. We hypothesize that mark-ups should be at least weakly lower in large competitive markets and should be larger for large, more productive firms. As it is not immediately obvious which markets are the most competitive, we instead choose to allow the data to tells us in which countries mark-ups are behaving as if the country were competitive. Specifically, we model mark-ups as a function of country and firm characteristics:

$$log\, m_{fct} = \beta_Y GDPW_{ct} + \beta_F PS_{ft},$$

where $GDPW_{ct}$ is the real GDP per worker of country c at time t, and PS_{ft} is the sales of the U.S. parent of firm f at time t in the United States.[20] Data for GDP and workforce size are from the Penn World Tables.

We use the parent sales in the United States as our proxy for a firm's productivity as a firm's technology and organizational capital employed by the parent firm will be available across affiliates that are within the firm's ownership boundaries. Note that in our specification with industry-year fixed effects, variation in parent sales in the U.S. is equivalent to variation in parent firms market shares in the United States. Further, in our theoretical setting their is a unique mapping from a firm's productivity to its rank in an industry's size distribution.

Combining these equations we obtain as our estimating equation

$$log\left(\frac{S_{fct}}{w_{ct}L_{ct}}\right) = \beta_Y GDPW_{ct} + \beta_F PS_{ft} - \theta^L_{i(f)t} - \alpha_0 ALK_{fct} + \gamma X_{fct} + \varepsilon_{fct}, \qquad (25)$$

where $ALK_{fct} \equiv log\,(K_{fct}/L_{fct})$ is the affiliate capital to labor ratio and X_{fct} is a vector of firm, country, and time varying controls to account for other determinants of mark- ups and to allow for systematic mismeasurement; ε_{fct} is a residual that captures unobserved heterogeneity across firms in their output elasticities and in terms of their quality of measurement. In order to allow for ALK_{fct} to be correlated with the residual, we instrument for affiliates capital to labor ratio with the logarithm of the capital to labor ratio of the US parent firm (PLK_{fct}), the aggregate capital labor ratio in country c at time t (CKL_{ct}), and the interaction between these two variables.

The controls that we include in equation (25) are chosen to ameliorate any remaining mea-

[20]Note that our theory makes distinct predictions for an increase in market size of a country (measured either by its GDP or labor force) versus an increase in *GDPW*, that is, productivity, which may be indicative of the degree of competition. Our theory tells us that mark-ups depend only on competitiveness so that market size only matters through the way that it influences competitiveness. Generally, we find that if we include both a country's GDP and labor force in the regression, the coefficients are similar in size and of opposite sign, so we focus on GDP per worker; see Appendix section x for results with GDP and labor force separately.

surement error in firm sales S_{fct}. One source of mismeasurement might stem from the fact that many firms are vertically integrated and that some of their affiliates may rely on purchased intermediates more than others. We do not have data on intermediates, but we do know which firms are highly vertically integrated. We measure firm-level vertical integration, $VERT_{ft}$, as the total value of sales to related customers to total sales at the firm-level.

Another concern is that firms may engage in transfer pricing so as to be able to report high sales in low tax countries. We deal with this concern by including a dummy TAX_c which is equal to one when the country has been identied in the literature as a tax haven. The list of countries that are tax havens was taken from Bilir and Morales (2018). We also include the interaction of this indicator variable with $VERT_{ft}$ as firms that engage in related party trade have a greater scope for transfer pricing. To further control for variation across firms in terms of tax planning strategies, we consider specications in which we replace industry-year fixed effects with firm and year fixed effects.

Another potential source of variation in output per employee could stem from productivity variation across affiliates within the firm. As shown by Keller and Yeaple (2013), more distant affiliates suffer from productivity disadvantages relative to affiliates more proximate to their headquarters. To control for this, we include gravity variables to allow for remoteness from the parent to influence productivity. These variables are distance to the United States, $DIST_c$, a dummy for English as an official language, ENG_c, and a dummy for Canada and Mexico, $BORDER_c$. These variables are from the CEPII dataset.

Finally, to allow for variation across time in terms of the competitive environment facing firms, we include industry-year 4-firm concentration ratio data from the United States Census of manufacturing in specifications in which industry-year fixed effects are not included. Descriptive statistics for the variables used in our study of the geography of mark- ups can be found in Table 3. It shows the data for each variable for the sample of manufacturing affiliates and service-industry affiliates separately. Of particular interest is the mean of the mark-up variable. We have average mark-ups in the service industry of 46% and among manufacturers of approximately 84%. Note that these averages are skewed in the data so that the median mark-up is smaller.The descriptive statistics for our data set are available in the following table.

Table 3: Descriptive Statistics

	Manufacturing		Services	
	Mean	Std dev	Mean	Std dev
Mark-Up	1.837	1.258	1.589	1.459
Affiliate K/L	3.579	1.544	2.677	1.693
Parent Sales	14.2	2.099	14.21	2.415
Vertical Integration	0.079	0.084	0.046	0.077
Tax Haven	0.108	0.310	0.146	0.353
GDP/Worker	10.85	0.696	10.94	0.649
Employment	3.130	1.511	2.814	1.423
Concentration	25.37	10.08	20.25	14.31

Notes: Mark-up, Local Sales, Affiliate capital-labor ratio, Parent Sales, GDP/Worker and Employment are in logarithms. Other variables are in levels.

4 The Geography of Global Mark-ups

This section contains the main results of our empirical analyses. We begin with the decomposition results for manufacturing industries over the 15 year period.[21] The decompositions are done from two perspectives. The first is from the perspective of shifting mark-ups and economic activities across countries in which U.S. firms operate while the second is a decomposition from the perspective of shifting market shares across individual firms. Both decompositions reveal that most of the increase in aggregate mark-ups is due to increases in the mark-ups charged by individual firms and that reallocations of market shares across firms tend to offset rising mark-ups at the firm level. We then proceed to our econometric analysis to explore how individual firms are adjust their mark-ups within and across countries and how their market shares have been affect by entry into new markets and by adjustments in there market shares within existing markets.

4.1 Decomposing Markup Changes

The following Table 4 shows the results.

[21]We focus on manufacturing sectors in this section because the industrial composition within manufacturing is relatively stable over the period of our sample so that the assumption of a consistent output elasticity over time is relatively reasonable. The industrial composition of service industries has been less stable making the decomposition analysis less appropriate in the aggregate. Future drafts of the paper will disaggregate the analysis to narrower industrial categories.

Table 4: Mark-up Decomposition at the Country-Level: Manufacturing Sector

	(1)	(2)	(3)	(4)	(5)
Year	Change Markup	Change Within Country Markup	Reallocation High Markup Countries	Change Within Country Cov(Markup, Size)	Reallocation High Cov (Markup, Size) Countries
1999-2004	0.403	0.938	-0.335	-0.132	-0.067
2004-2009	0.078	0.195	0.049	-0.473	0.309
2009-2014	0.404	0.869	0.039	-0.591	0.086

First, note that global markups of US multinational firms have increased over the period 1999 to 2014, especially in the early 2000s and the early 2010s (column (1)). This is in line with other findings (De Loecker, Eekhout, and Unger 2020). The remaining columns (2) to (5) give figures for the four expressions in equation (20), last two lines; their sum is equal to column (1) by construction.

We notice that the increase in global markups is largely due to increases in the average markups country by country (column (2)).[22] The reallocation effect towards countries with higher mark-ups is not very strong; if anything US multinational economic activity has tended to move away from high-markup countries over the 15 years (column (3)). The main offsetting factor to the strong increase in markups country by country is that even though the simple average of markups in most countries increased, market shares within countries have tended to shift toward lower mark-up firms (column (4)). As we will show below, these firms tend to be the relatively smaller firms with less market power. Hence, within country reallocation has tended to lower aggregate mark-ups. Finally, as we can see from column (5), there is also a modest reallocation of economic activity to countries in which the sorting of firm size and markup is relatively strong.

Overall, while we find evidence for reallocation effects in determining global markups, within effects tend to dominate according to Table 4. The within effects go in opposite directions. On the one hand, country-level average markups sharply increase. On the other hand, country-level covariances of firm size and markups tend to decline over these fifteen years. Both of these are within effects in that they do not capture changes in firm size from one country to another.We now turn to a decomposition that focuses on firms, see equation (24). Table 5 shows the results.

[22]The within country markup is $\overline{M} = \frac{1}{N}\sum_c \left(\frac{1}{N_c}\sum_f m_{fc}\right)$, with N the number of countries and N_c the number of firms operating in country c.

Table 5: Mark-up Decomposition at the Firm-Level: Manufacturing Sector

Year	(1) Change Markup	(2) Change Within Firm Markup	(3) Reallocation High Markup Firms	(4) Change Within Firm Cov(Markup, Size)	(5) Reallocation High Cov (Markup, Size) Firms
1999-2004	0.403	0.746	-0.072	0.024	-0.296
2004-2009	0.078	0.074	-0.176	-0.107	0.289
2009-2014	0.404	0.780	-0.031	-0.152	-0.194

Starting from the overall markup changes for the three subperiods in column (1), the following four columns decompose these changes in the four components shown in in equation (24).

Table 5 indicates an increase in the within-firm markup, $\overline{M}^F$, has contributed strongly to the overall increase in markups (column (2)). This is in line with our finding for countries (Table 4, column (2)). In the fully balanced case where all firms operate in all countries, it would be the case that $\overline{M} = \overline{M}^F$.[23] Our finding that either the simple country markup average or the simple firm markup average–in Table 5 and Table 4, respectively– accounts for much of the increase in global markups indicates that the influence of entry in particular countries (or, that the sample is not balanced) for our results is limited.

Next, figures in column (3) are negative though not very far from zero. Global market shares have shifted over the sample period towards lower mark-up firms. All else equal, firms with relatively low mark-up are on the lower end of the productivity distribution. At the same time, we have seen above that global market share has also tended to move towards lower mark-up countries (Table 4, column (3)), which, all else equal, would be countries that are relatively competitive (low p^{max}). Thus, our results do not rule out global market share shifting to relatively high productivity firms operating in relatively competitive, advanced-country markets.

We find that that the within firm covariance between markup and size has tended to fall between 1999-2014, see column (4). This means that across the markets that a firm operates, the correlation between the size of the affiliate and its markup has generally declined: bigger sales in lower-markup markets. The decline in this covariance is in line with the country-covariance result (Table 4, column (4)), however in the country dimension it was more

[23]Recall that $\overline{M}^F = \frac{1}{N^F}\sum_f \left(\frac{1}{N_f}\sum_c m_{fc}\right)$, with N^F defined as the number of firms in the sample, and N_f the number of countries in which firm f operates, while the within country markup is $\overline{M} = \frac{1}{N}\sum_c \left(\frac{1}{N_c}\sum_f m_{fc}\right)$, with N the number of countries and N_c the number of firms operating in country c. If $N_f = N$ and $N_c = N^F$, we have that $\overline{M} = \overline{M}^F$.

pronounced: much bigger sales of lower-markup firms. Finally, we find mixed results over time for column (5), and the figures tend to be lower than in the country dimension, compare with column (5) of Table 4. Hence, there is more evidence for a reallocation of global market share to countries with high covariance of size and markups (across firms) than there is evidence for a reallocation of global market share to firms with high covariance of size and markups (across countries).

Overall, the country-level and firm-level results of Tables 4 and 5 indicate that market share reallocations (or, "between" effects) have played a limited role in the increase of global markups of US multinational firms. This is different, for example, from Autor, Dorn, Katz, Patterson, and Van Reenen (2020) who emphasize the importance of between effects in their related analysis of recent labor share trends. There are at least two important differences between their and our analysis. First, by employing census data for the US in their main set of firm-level results, Autor, Dorn, Katz, Patterson, and Van Reenen (2020) rely on a broader sample than we do, albeit for a single country. To the extent that multinational firms are all "superstar" firms, the finding of market share reallocation to such firms is consistent with limited reallocation between such firms. Second, Autor, Dorn, Katz, Patterson, and Van Reenen (2020) treat all firms in a given country as national firms; the absence of a firm by country dimension implies a more restricted set of elements in the markup decomposition (see equations (24) and (20)).

4.2 Markups of Heterogeneous Firms Around the World

4.2.1 Baseline Results

We begin with the simplest specification for our analysis of the firm and country determinants of market power. First, we instrument the affiliates' capital-labor ratios, as described in the previous section. The first-stage regression yields a relatively large F-statistics, indicating the instruments are strong, and the coefficients indicated that capital-intensive parents tend to have capital-intensive affiliates, and that relatively capital-intensive techniques are chosen in capital abundant countries are as expected.[24] Table 6 shows the second-stage results, with coefficients for manufacturing on the left and results for service affiliates on the right. For each sample, one specification includes industry-year fixed effects (columns (1) and (3)) while the other specification includes instead firm and year fixed effects (columns (2) and (4)). Standard errors are clustered by country.

[24]See the Appendix for full first-stage results.

Table 6: Global Markups: Baseline Results

	Manufacturing		Services	
	(1)	(2)	(3)	(4)
Productivity	0.069** (0.007)	0.050* (0.020)	0.057** (0.005)	0.091** (0.017)
GDP/Worker	−0.175** (0.026)	−0.106+ (0.064)	−0.093** (0.025)	−0.140** (0.039)
Employment	−0.021 (0.020)	−0.009 (0.021)	−0.022* (0.010)	−0.026** (0.013)
Capital-Labor Ratio	0.229** (0.041)	−0.072 (0.270)	0.150** (0.035)	0.332+ (0.177)
Vertical Integration	0.788** (0.152)	−0.239 (0.198)	0.680** (0.140)	0.717** (0.254)
Tax Haven	0.035 (0.062)	0.011 (0.055)	0.070+ (0.041)	0.051 (0.053)
Vertical x Tax H	1.965** (0.467)	2.056** (0.441)	1.119** (0.164)	1.187** (0.252)
Concentration		0.421** (0.142)		0.356** (0.119)
Industry x Year FE	Y		Y	
Firm FE		Y		Y
Year FE		Y		Y
N	42,821	42,821	59,017	59,017
R-squared	0.085	0.229	0.221	0.275

Notes: Dep. var. is log of the ratio between affiliate sales and affiliate wage bill. Estimation by OLS. Productivity is measured by the firm's sales in the United States. Concentration is measured by the sales share of the top four firms in each industry. All independent variables that are not indicator variables except Concentration are in logs. Not shown are results for distance to the U.S. and the indicator variables for English language and land border to United States. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

We start with the discussion of some of the control variables. First, looking at the coefficients on the capital-labor ratio we see that in the specifications with industry-year fixed effects they have the expected sign and are statistically signicant while in the firm and year fixed effects results they tend to be less statistically significant and can even change sign. We attribute this to affiliate output elasticities that are stable over time within firm.

Second, looking at the firm-level vertical integration measure ($VERT_c$), we see that in most specifications the coefficient is positive and statistically signicant. This is consistent with the idea that vertically integrated firms manage affiliates that are relatively intensive in their use of imported intermediates and so will tend to have higher output to wage bill ratios. Furthermore, the interaction of $VERT_c$ with the indicator for a tax haven ($TAXH_c$) has a positive coefficient. When a firm is vertically integrated, it reports unusually high sales relative to its wage bill, a result that is consistent with transfer pricing.

We now turn to the variables that are of central interest in this paper, firm productivity and the competitiveness of the market (measured by parent sales and GDP per worker, respectively). Recall that after controlling for the output elasticity of production (through capital intensity), the coefficients on the other independent variables are interpreted as the variables' impact on the markup of the affiliate.[25] The first key result is that affiliates of parents that have larger sales in the United States tend to have larger mark-ups than the affiliates of smaller parents. The productivity coefficient is positive and remarkably stable across samples and specifications. Not only is it the case that U.S. multinationals with large U.S. market shares have affiliates that charge higher mark-ups, the coefficients in the firm fixed effects specifications indicate that productivity growth between 1999 and 2014 is associated with rising affiliate mark-ups. This result mirrors that of the De Loecker and Warzynski (2012) and Autor, Dorn, Katz, Patterson, and Van Reenen (2020) who did not have information on multinational ownership structures.

To assess the size of the implied effect, we consider the impact of a standard deviation increase in firm size on the implied mark-up. We use the coefficient estimate of 0.05 which is the lower coefficient obtained in specifications underlying column (1) and (2). If one assumes an employment output elasticity of 0.3, then if firm's productivity increases by one standard deviation this is associated with a 20 percentage point increase in its mark-up. This is substantial increase in market power.

Second, the coefficient on GDP per worker is negative across all samples and specifications. In countries with higher GDP per worker U.S. multinational affiliates charge lower markups, both within industry-year (columns 1 and 3) and within firm across industries and years (columns 2 and 4). This finding provides strong evidence that firms charge lower markups in more competitive markets. What matters is a large market size achieved through high

[25]Note that estimating the output elasticity directly and then regressing the implied mark-up on the remaining independent variables yields essentially the same results.

labor productivity: including Employment as a measure of a country's size in addition to GDP per worker yields small and often insignificant coefficients, see Table 6[26]

To assess the magnitude of the competition effect on mark-ups, we perform a back-of-the-envelope calculation using the coefficient estimate from column 1. A one percent increase in GDP per worker lowers the logarithm of sales revenue per dollar of wages by -0.175. If we assume an labor-output elasticity of 0.3, then a one standard deviation increase in GDP per worker leads to a reduction in the mark-up of about 40 percentage points for a firm in the sample that charges the average mark-up (log sales over wage bill). This is a substantial competition effect.

There has been growing interest in the effect of increasing industrial concentration on mark-ups in the recent literature. To shed new light on this we turn to the role of industry concentration for the evolution of mark-ups within the firm (columns (2) and (4)), where concentration is measured as the market share accounted for by the largest four firms (four-firm concentration ratio). We see that with coefficients of about 0.4, in both manufacturing and in services more US concentration is associated with higher markups of US multinational firms around the world. The is consistent with a global component of market power.

The result that changes in U.S. industry concentration are reflected in within-firm changes in mark-ups has important implications. One potential explanation for recent increases in concentration rates is that global competition may have been falling. This explanation, however, is hard to reconcile with recent evidence that competition has risen, not fallen (Autor, Dorn, Katz, Patterson, and Van Reenen 2020). At the same time, in line with the importance of within-firm effects in our decomposition our results reflect within-firm changes in mark-ups, and not primarily between-firm effects. An alternative explanation is that technological change has induced concentration, perhaps because of growing minimum efficient scales, and the resulting reduction of competition explains the rising mark-ups of U.S. firms. Consistent with that is that U.S. multinationals are relatively likely to be active in high technology industries.

4.2.2 Interaction of Firm and Country Characteristics

Through the lens of our model the results reported so far are consistent with large firms having greater market power and with high GDP per worker countries as enjoying a higher extent of competition. We now dig deeper into the structure of mark-ups across firms and

[26]It is worth emphasizing that a naive understanding of sales per dollar of worker productivity as associated with TFP-Q would lead to much confusion as successful firms in high productivity markets would appear to have low productivity. Of course, TFP-Q is not what is being measured here; rather it is mark-ups.

countries by analyzing the interaction between firm-level competitiveness and country-level competitiveness. The hypothesis developed in the theory section is that in more competitive markets, larger and more productive firms have comparatively little pricing power relative to their weaker competitors. If the markets in high income countries are more competitive, we expect that firm productivity affects mark-ups in these countries than in lower-income countries. Table 7 shows the results, focusing on coefficients that speak to the key interaction of firm-level and country-level characteristics.

Table 7: Firm Productivity, Country Competitiveness, and Markups

	Manufacturing		Services	
	(1)	(2)	(3)	(4)
Firm Productivity	0.452**	0.414**	0.173*	0.459**
	(0.107)	(0.135)	(0.070)	(0.094)
Country Competitiveness	0.346**	0.409*	0.060	0.342**
	(0.130)	(0.064)	(0.093)	(0.125)
Productivity x Competitiveness	−0.034**	−0.032**	−0.010+	−0.031**
	(0.009)	(0.021)	(0.006)	(0.008)
Employment	0.048	0.068	−0.008	0.110*
	(0.060)	(0.270)	(0.035)	(0.046)
Productivity x Employment	−0.004	−0.005	−0.001	−0.009**
	(0.004)	(0.004)	(0.002)	(0.003)
Industry x Year FE	Y		Y	
Firm FE		Y		Y
Year FE		Y		Y
N	42,821	42,821	59,017	59,017
R-squared	0.084	0.230	0.221	0.345

Notes: Dep. var. is log of the ratio between affiliate sales and affiliate wage bill. Estimation by OLS. Productivity is measured by the firm's sales in the United States, country competitiveness by the country's GDP per worker. All independent variables that are not indicator variables are in logs. Not shown are results for other variables included in Table 3, column (1), with the exception of distance in columns (1), (3). Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

The results indicate the same, significant interaction between firm productivity and country competitiveness: in the more competitive high income countries, the link between a firm's marginal cost advantage and its mark-up is attenuated. Put differently, the ability of high-productivity firms to charge higher mark-ups is lower in competitive countries (columns (1) to (4), Productivity x Competitiveness coefficients).[27] The result holds regardless of the multinational firm's industry and whether we exploit within-firm variation or not. This confirms the prediction of our model.

We now consider the magnitude of this effect, based on results in column (1):

$$\frac{\partial Markup}{\partial Productivity} = 0.452 - 0.034\, Competitiveness.$$

This means that a ten percent increase in a country's competitiveness reduces the elasticity of the affiliate's mark-up with respect to firm productivity by 0.34.[28] We conclude that the extent of competition in the industries in which U.S. multinationals operate is subtantially higher in more advanced countries.

4.2.3 Firm and Country Characteristics in the Global Evolution of Markups

In this section we shed new light on the role of firm and country characteristics in how markups have changed over time. To do so, we distinguish the early from the later years in our sample (the variable Later is equal to one for the years 2009 and 2014, and zero otherwise). Results are shown in Table 8.

[27] Country size as such, measured by the size of the workforce, does generally not interact with firm productivity to affect markups, see Table 7.

[28] As before, country competitiveness is measured by the logarithm of GDP per worker and firm productivity is measured by the logarithm of firm's parent sales.

Table 8: Firm and Country Characteristics in the Global Evolution of Markups

	Manufacturing		Services	
	(1)	(2)	(3)	(4)
Productivity	0.047** (0.008)	0.041* (0.020)	0.038** (0.008)	0.086** (0.017)
Productivity x Later	0.035** (0.009)	0.034** (0.009)	0.030** (0.009)	0.014 (0.009)
Competitiveness	−0.131** (0.031)	0.011 (0.057)	−0.094** (0.024)	−0.128** (0.033)
Competitiveness x Later	−0.081+ (0.043)	−0.117** (0.039)	−0.003 (0.026)	−0.010 (0.026)
Employment	−0.002 (0.004)	0.019 (0.017)	−0.032** (0.011)	−0.038** (0.003)
Employment x Later	−0.018 (0.017)	−0.029+ (0.016)	0.019 (0.012)	0.021+ (0.012)
Industry x Year FE	Y		Y	
Firm FE		Y		Y
Year FE		Y		Y
N	42,821	42,821	59,017	59,017
R-squared	0.084	0.228	0.221	0.344

Notes: Dep. var. is log of the ratio between affiliate sales and affiliate wage bill. Estimation by OLS. Productivity is measured by the firm's sales in the United States, country competitiveness by the country's GDP per worker. Later is an indicator variable for the years 2009 and 2014. All independent variables that are not indicator variables are in logs. Not shown are results for other variables included in Table 3, column (1), with the exception of distance. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

Notice the positive coefficients for both Productivity and the interaction variable Productivity x Later in Table 8.[29] In particular, the interaction terms suggests that after the Great Recession of 2008-9 a given productivity advantage translated into a higher markup than before the Great Recession. This is consistent with a generalized reduction in the competition facing American firms in the countries and industries in which they operate.

Next, we turn to the results on country competitiveness in Table 8. While a competitive

[29] In this set of results the focus should be on the industry x year fixed effects results of columns (1) and (3) because four years plus a subperiod shifter (Later) may make it chaellenging to robustly identify within-firm changes (in columns (2) and (4)).

environment seems to put a lid on the markups that can be charged by both manufacturing and services multinational firms, there is evidence that the constraints imposed by this have become stronger after the Great Recession, especially for manufacturing firms. This is consistent with high income countries that host U.S. multinational firms presenting a more competitive environment after the Great Recession. For service multinationals, instead, there is some evidence that over time it has become easier to charge high markups in large (but not highly competitive) countries, as the Employment x Later interaction results for services in Table 8 indicates.

Overall, we have seen that highly productive firms charger higher mark-ups then less productive firms. The CES framework implying a constant markup for all firms fails to address that. Comparing the sales of a high- with those of a low-productivity firm, the dollar sales difference overstates the difference between high and low sales in physical, welfare terms, because the high-productivity firm charges a higher markup than the low-productivity firm. We have also seen that in advanced countries with relatively high GDP per workers, the competitive environment forces firms to charge lower mark-ups than they charge in other, less competitive countries. Thus, a country's degree of competition can be a powerful antidote to firms' exploiting their market power, as basic economic principles would suggest it would. Moreover, the higher is the productivity of firms (and hence their markup), the more powerful it is to improve the country's competitive environment to limit the firms abilities to charge high markups. These results are in line with the prediction of our model laid out above.

We have also seen that over time, generally the ability of high-productivity firms to charge higher markups as well as the effectiveness of countering this by generating a competitive country enviroment have increased. Apparently, the stakes have risen. Furthermore, if the market power of highly productive firms can to some extent be contained by creating a competitive environment, from a policy perspective is a good idea, or bad, to attract low marginal cost firms to ones market? While a full welfare analysis is left for future work, the following section will examine a necessary ingredient of such an analysis by examining the factors that determine firms' location choice.

Before concluding this section, we mention some additional controls that have been included in the benchmark specification but which have been found to have no impact on the key results. First, a possible concern is that mark-ups are higher in poor countries because low GDP per capita countries may be riskier. In this case, high mark-ups would be the necessary risk premium to induce firms to enter. However, in exploratory analysis we found that standard measures of country risk do not predict mark-ups after controlling for GDP per capita. Second, including measures of trade openness in the mark-ups specifications also yield coefficients of essentially zero. Trade openness by itself does not predict (lower) mark-ups which suggests that the goods that multinationals produce locally face relatively little import competition.

We now turn our attention to how competition and market size affect the decision of firms to open local affiliates as seen through the lens of our model.

5 Multinational Entry

In the previous section we have seen that mark-ups vary systematically across firms and across countries. More productive firms charge higher mark-ups at the same time when firms charge lower mark-ups in high income countries than in poor countries. The latter result suggests that competition is stiffer in high income countries. We now examine the covariates that affect the decisions of heterogeneous firms to open a local affiliate, starting with those that influence the size of the markup they are setting.

5.1 Econometric Model

We estimate a discrete choice model of firm entry with an interaction effect between country and firm characteristics. Specifically, we estimate the following model via ordinary least squares: [30]

$$I_{fct} = \beta_F PS_{ft} + \beta_Y GDPW_{ct} + \beta_E EMP_{ct} + \beta_{YI} \left[PS_{ft} \times GDPW_{ct} \right] + \gamma X_{fct} + \epsilon_{fct}, \quad (26)$$

where I_{fct} is equal to one if firm f at time t owns an affiliate in country c and zero otherwise, while EMP_{ct} is the size of the labor force of country c at time t. The vector X_{fct} includes the distance, border, and language variables employed before, the control for tax haven countries, as well as two alternative sets of fixed effects.[31] Also included in X_{fct} in a subset of specifications is the four-firm concentration share and interaction between firm productivity and a country's labor force, $PS_{ft} \times EMP_{ct}$. The term ϵ_{fct} is a mean-zero regression error, and we allow for dependence by clustering at the country level.

[30]Given the difficulties of interpreting interaction effects in Probit and Logit models and because we are concerned about incidental parameter problems, we focus on a linear probability model. See Ai and Norton (2003).

[31]We have dropped the vertical integration measure from this part of the analysis because of endogeneity concerns.

An important feature of equation (26) is that it allows a firm's characteristics to interact with a country's GDP per worker. Our theoretical framework indicates that if market size and level of competition tend to be positively correlated then we expect that more productive firms favor relatively productive countries whereas less productive firms prefer less productive "niche" markets; that is, we anticipate coefficient $\beta_{YI} > 0$.

The dataset used to estimate equation (26) is the same as in the previous section but it has been expanded to allow for observations of all possible investment opportunities by firm-country-year. One important feature of the data is how rare it is for even a multinational to own an affiliate in a foreign country. The unconditional probability of entry into any given market is about 0.05. The flip side of this is that the sample sizes are now considerably larger, about 940K and 1.2 million observations for manufacturing and services multinationals, respectively.

5.2 Results

We begin by estimating a simplied version of equation (26) that restricts the interaction coefficient to zero. The results are shown in Table 9. The probability that US multinationals enter a foreign market is increasing in the firms productivity. Even within-firm increases in productivity raise the probability of market entry both for manufacturing and for services multinational firms (columns (2), (4)).

Also, the positive coefficient on Employment indicates that U.S. firms are more likely to enter large markets. Furthermore, multinationals favor relatively competitive markets, both in manufacturing and in services industries. These results suggest that U.S. multinationals on average are attracted to large and highly productive markets that were found to have lower mark-ups in the previous section. While this is true for both manufacturing and services firms the responsiveness of manufacturing affiliates appears to be somewhat larger to country characteristics than that of affiliates operating in services industries.

Table 9: Determinants of Firm Entry

	Manufacturing		Services	
	(1)	(2)	(3)	(4)
Productivity	0.020** (0.002)	0.007** (0.001)	0.008** (0.001)	0.005** (0.001)
Competitiveness	0.030** (0.004)	0.030** (0.004)	0.020** (0.003)	0.020** (0.003)
Employment	0.026** (0.004)	0.026** (0.004)	0.017** (0.003)	0.017** (0.003)
Concentration		0.001 (0.002)		0.007* (0.003)
Industry x Year FE	Y		Y	
Firm FE		Y		Y
Year FE		Y		Y
N	941,532	941,532	1,218,176	1,218,176
R-squared	0.147	0.215	0.103	0.176

Notes: Dep. var. is an indicator equal to one if firm f owns an affiliate at time t in country c, zero otherwise. Estimation by OLS. Productivity is measured by the firm's sales in the United States, country competitiveness by the country's GDP per worker. Employment is the country's number of workers. Concentration is the industry share of the four largest firms. Productivity, Competitiveness, and Employment in logs. Not shown are results for distance from the US, English language, land border, and tax havens. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

Next, we allow for the interaction of firm and country characteristics, see equation (26). Table 10 shows the results in columns (1), (3), (5), and (7). The former two are for manufacturing firms while the latter two are for affiliates operating in services industries, and for each industry one specification employs industry- while the other firm fixed effects.

As predicted by our model, we find that the interaction between firm productivity and country competitiveness is positive and highly significant in all specifications. Higher firm productivity increases the probability of entry the most in the most competitive countries. To quantify the magnitude of these effects we focus for concreteness on the specification in column 1 of Table 10.

First, consider differences in the competitiveness of countries. For all firms with logarithm of U.S. sales–our productivity measure–greater than 9, an increase in GDP per worker predicts an increase in the likelihood of owning a local affiliate. This accounts for almost all firms in the sample as 9 is about two standard deviations below the sample mean. For the average firm in the sample, an increase in competitiveness (measured by GDP per worker) of 1 percent is associated with an in the likelihood of investing by 5.2 percentage points, but this rises to 7.8 percentage points for a firm with U.S. sales one standard deviation above the mean. These figures quantify the extent to which highly productive firms enter disproportionately into the more competitive markets. The impact for service industries is qualitatively similar but in some sense more extreme.

Table 10: Entry Heterogeneity by Country, Firm, and Time

	Manufacturing				Services			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Productivity	−0.108**	0.021**	−0.125**	0.032**	−0.041**	0.011**	−0.046**	0.003**
	(0.010)	(0.003)	(0.012)	(0.004)	(0.005)	(0.001)	(0.006)	(0.001)
Competitiveness	−0.113**	0.032**	−0.118**	0.005**	−0.030**	0.026**	−0.033**	0.026**
	(0.010)	(0.004)	(0.011)	(0.001)	(0.004)	(0.004)	(0.005)	(0.004)
Productivity x Competitiveness	0.012**		0.012**		0.004**		0.005**	
	(0.001)		(0.001)		(0.001)		(0.001)	
Employment	−0.067**	0.025**	−0.070**	0.025**	−0.013**	0.020**	−0.014	0.020**
	(0.007)	(0.004)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Productivity x Employment	0.008**		0.008**		0.003**		0.003**	
	(0.001)		(0.001)		(0.001)		(0.001)	
Productivity x Later		−0.003**		0.003**		−0.004**		0.003**
		(0.001)		(0.001)		(0.001)		(0.001)
Competitiveness x Later		−0.003*		−0.003*		−0.009**		−0.009**
		(0.002)		(0.002)		(0.002)		(0.002)
Employment x Later		0.001		0.001		−0.004*		−0.004*
		(0.003)		(0.003)		(0.002)		(0.002)
Industry x Year FE	Y	Y			Y	Y		
Firm FE			Y	Y			Y	Y
Year FE			Y	Y			Y	Y
N	941,532	941,532	941,532	941,532	1,218,176	1,218,176	1,218,176	1,218,176
R-squared	0.179	0.147	0.248	0.215	0.117	0.105	0.192	0.178

Notes: Dep. var. is an indicator equal to one if firm f owns an affiliate at time t in country c, zero otherwise. Estimation by OLS. Productivity is measured by the firm's sales in the United States, country competitiveness by the country's GDP per worker. Employment is the country's number of workers. Productivity, Competitiveness, and Employment in logs. Not shown are results for four-firm share, distance from the US, English language, land border, and tax havens. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

Next, consider how the role of firm productivity for the entry decision depends on the size of the local market (measured by the size of the workforce). Based on column (1), conditional on the influence of competitiveness, the impact of firm productivity on entry affects entry according to $-0.108+0.008\times Employment$. This means that for small countries, an increase in firm productivity may have a negligible or even negative impact on the probability of entry. For a country with labor force that is one standard deviation above the mean, the effect is very different. A one percent increase in the parents sales in the United States raises the probability of investment by 2.5 percentage points. Given the small unconditional probability of investment (about five percent), this is a substantial increase. Note that the results for the service industries (columns 5 and 7) qualitatively mirror those of the manufacturing industries (columns 1 and 3) suggesting that this phenomenon is wide spread across industries.

Overall, these results provide strong evidence that small firms prefer niche markets where their sales will be relatively low, but their mark- ups large, while large firms prefer mass market locations where their sales will be large but their mark-ups relatively low.

We also present results on changes in entry decisions of US firms over time, see columns (2), (4), (6), and (8) of Table 10.[32] Over time, productivity appears to become relatively less important in predicting affiliate ownership. This is what one would expect if markets have become globally less competitive as would occur if higher corporate level fixed costs had risen internationally. There is strong evidence for an erosion in the relative attractiveness of more productive countries, especially in services industries, perhaps because these markets have become relatively even more competitive over time (see the previous section).

Having explored the extensive margin of affiliate activity abroad (entry) we now turn our attention in the next section the intensive margin (sales per affiliate) to further glean information about trends in the strength of competition across space and time.

6 Multinational Sales

In this section we examinie the size of individual affiliates operations across countries conditional on entry to provide further information regarding the strength of competition over time and space. Our empirical specification mirror that of mark-ups in section 4 but will use the logarithm of the sales to unaffiliated customers in their host countries as the dependent

[32] Our focus here are the industry-by-year fixed effect results given the challenge to identify within-firm changes that with four years and a time shifter.

variable. As before, we will start with a baseline specification (Table 11) and then move to firm-country and over time interactions (Table 12).

We see that firm productivity has a consistently positive and statistically significant impact across all specifications (Table 11). The estimates are also similar for manufacturing and services multinationals. Large and growing multinational parents have large and growing affiliates.

Table 11: Local U.S. Multinational Sales

	Manufacturing (1)	Manufacturing (2)	Services (3)	Services (4)
Productivity	0.348**	0.198**	0.356**	0.235**
	(0.011)	(0.028)	(0.015)	(0.034)
Competitiveness	0.657**	0.781**	0.802**	0.688**
	(0.066)	(0.127)	(0.056)	(0.074)
Employment	0.277**	0.348**	0.269**	0.376**
	(0.035)	(0.039)	(0.046)	(0.013)
Capital-Labor Ratio	0.208**	0.284	−0.210**	1.229**
	(0.062)	(0.454)	(0.045)	(0.285)
Vertical Integration	1.051**	−1.435**	1.179**	−0.779*
	(0.209)	(0.278)	(0.252)	(0.302)
Tax Haven	−0.159*	0.125	0.080	0.182+
	(0.076)	(0.079)	(0.100)	(0.053)
Vertical x Tax H	−0.045	−0.010	−0.864+	−1.168*
	(0.835)	(0.830)	(0.474)	(0.583)
Concentration		0.675**		0.745**
		(0.189)		(0.250)
Industry x Year FE	Y		Y	
Firm FE		Y		Y
Year FE		Y		Y
N	42,821	42,821	59,017	59,017
R-squared	0.212	0.367	0.266	0.442

Notes: Dep. var. is log of local affiliate sales. Estimation by OLS. Productivity is measured by the firm's sales in the United States, Competitiveness by a country's GDP per worker. Concentration is measured by the sales share of the top four firms in each industry. All independent variables that are not indicator variables except Concentration are in logs. Not shown are results for distance to the U.S. and the indicator variables for English language and land border to United States. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

Another robust finding is affiliates in large markets tend to be large, and this is particularly true if the country is large because it is competitive, as indicated by high output per worker. Interpreting these results through the lens of our model and in the context of our earlier results on mark-ups, large developed markets are more competitive but the increase in competitiveness does not outweigh the market size effect. It also suggests that in richer markets demand for the output of U.S. multinational firms tends to be particularly high.

With regard to the remaining controls, the coefficients of greatest interest are those on the concentration variable, see columns (2) and (4). For both manufacturing and service industries, growing concentration in the United States is associated with the substantial growth of the foreign affiliates of U.S. firms in those industries. These results suggest that greater concentration in the U.S. predicts expansion abroad. In the context of our proximity-concentration framework it is intuitive that a decrease in competitiveness leaves more market share for the largest firms and so is consistent with the conjecture of Autor, Dorn, Katz, Patterson, and Van Reenen (2020) that between-firm effects are important. Put another way, mark-ups are rising in industries with greater concentration as reported in section 4, but it also appears that it has induced the most productive firms to grow dramatically, adding a compositional dimension to the increase in the aggregate mark-up or decrease in labor's share of income.

We now turn to the interaction of firm- and country-characteristics determining affiliate sales, see Table 12.

Table 12: Local Affiliate Sales Heterogeneity by Country, Firm, and Time

	Manufacturing				Services			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Productivity	0.087	0.325**	0.238	0.169**	−0.218	0.345**	0.778**	0.207**
	(0.208)	(0.015)	(0.431)	(0.030)	(0.147)	(0.017)	(0.183)	(0.035)
Competitiveness	0.397	0.735**	0.930**	0.664**	0.099	0.830**	1.390**	0.622**
	(0.280)	(0.075)	(0.315)	(0.125)	(0.204)	(0.054)	(0.246)	(0.067)
Productivity x Competitiveness	0.018		−0.008		0.048**		−0.045**	
	(0.018)		(0.019)		(0.013)		(0.016)	
Employment	−0.038	0.299**	0.147	0.346**	0.003	0.266**	0.614**	0.365**
	(0.138)	(0.037)	(0.165)	(0.038)	(0.073)	(0.039)	(0.003)	(0.043)
Productivity x Employment	0.022*		0.014		0.018**		−0.016**	
	(0.001)		(0.012)		(0.005)		(0.006)	
Productivity x Later		0.044**		0.045**		0.014		0.059**
		(0.015)		(0.015)		(0.001)		(0.001)
Competitiveness x Later		−0.217**		−0.204**		−0.082		0.065
		(0.052)		(0.049)		(0.053)		(0.062)
Employment x Later		−0.073**		−0.067**		−0.029		0.036
		(0.017)		(0.018)		(0.026)		(0.024)
Industry x Year FE	Y	Y			Y	Y		
Firm FE			Y	Y			Y	Y
Year FE			Y	Y			Y	Y
N	42,821	42,821	42,821	42,821	59,017	59,017	59,017	59,017
R-squared	0.213	0.213	0.368	0.368	0.266	0.264	0.442	0.442

Notes: Dep. var. is log of local sales of affiliate belonging to firm f at time t in country c. Estimation by OLS. Productivity is measured by the firm's sales in the United States, country competitiveness by the country's GDP per worker. Employment is the country's number of workers. Productivity, Competitiveness, and Employment in logs. Not shown are results for capital-labor ratio, distance from the US, English language, land border, and tax havens. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

The results on the interactions of firm- and country-characteristics tend to be not stable across specifications and industries (columns (1), (3), (5), and (7) in Table 12). This is not surprising as the theory section suggested that such interactions are likely to depend on the specific functional form of the empirical specification.

The analysis over time yields a number of additional results (see columns (2), (4), (6), and (8) of Table 12). First, we find that firm productivity predicts affiliate sales much more strongly in later years which is consistent with a shift in affiliate market shares toward more productive firms. Not only are the more productive firms raising their mark-ups relative to the less productive but they are also increasing their global market shares. Furthermore, there is additional evidence that the effects of country competitiveness and size were weaker in later years than in earlier years. This is also consistent with earlier evidence that large, competitive markets became more relatively competitive over time relative to less developed countries.

7 Conclusions

This paper combined theory and data on the foreign operations of U.S. multinational enterprises to measure the strength of competition across countries and its evolution over time. Our theory elucidated how shifts in the strength of firms' market power can be inferred from the gradient of mark-ups with respect to firm productivity even after controlling for industry-year fixed effects and observable firm and country characteristics. This is essential given rapid technological change that can affect the measurement of the output elasticities that are critical to the cost minimization methodology for measuring mark-ups. Our theory also shows that average mark-ups across firms in a country can be a biased measure of market power because high mark-up firms tend to produce in high competition countries. Our data allows us to observe the same firm's performance along multiple dimensions using uniform accounting rules across countries. These features of our theory and our data allow for us to implement an unique and powerful methodology for inferring variation in the strength of market power.

Our results bring into sharp focus variation in the strength of competition across firms, countries, and time. The foreign affiliates of more productive firms charge higher mark-ups and enjoy larger global market shares, and this pattern has only grown stronger over time. Holding fixed a firm's productivity, the firm charges lower mark-ups in rich, developed countries than in less developed countries, and the gap in mark-ups between productive and less productive firms is smaller in developed countries than in less developed countries.

This implies that developed countries are more competitive than developing countries and that this gap has also grown over time. U.S. multinationals appear to have responded to this growing gap in competition by gradually reorienting their production toward less competitive markets. Over time, the focus of U.S. foreign investments has shifted toward developing countries where competition is weaker and has grown relatively faster in industries that feature growing U.S. industrial concentration.

Finally, our paper demonstrated that composition effects can play an important role in driving aggregate mark-ups. As predicted by theory, the most productive firms that charge the highest mark-ups tend to be attracted to the most competitive markets while less competitive firms that charge small mark-ups tend to be attracted to less competitive countries. This sorting behavior has the affect of moderating differences across location in the average mark-ups observed. Hence, comparisons of average mark-ups across countries can understate variation in the firms' market power.

The key strength of our novel methodology is that allows inference on the extent of market power while flexibly controlling for industry-year fixed effects. Most of the literature, however, has progressed by backing out firm level measures of the level of mark-ups and making comparisons of this object over time. According to that form of methodology, average changes across firms over time are the industry-year fixed effects and so are vulnerable to systematic mismeasurement of mark-ups by industry year. Hence, we are looking at evolution in market power through a very different lens. It is our goal in future drafts of the paper to compare the conclusions implied by the competing methodologies.

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A Additional Results from Multi-Dimensional Decompositions

A.1 Data Description

All U.S. incorporated firms that own a controling interest in a foreign productive enterprise are required to respond to BEA benchmark surveys. Basic information on all affiliates in a given industry-country combination must be provided to the BEA. The basic data is the location of the affiliate, the industry of the affiliate, total revenue and total compensation. Larger affiliates are required to provide a large set of data that includes the types of information that appear in Compustat. In addition substantial information regarding the destination of sales is also collected. Parent firms are also required to provide similar information regarding their U.S. operations but here the BEA allows parents to consolidate their U.S. business enterprises.

The firms and affiliates that appear in our dataset are those that were required in each benchmark year to provide information regarding the size of their exports to related customers, their capital stocks, and their local sales to unaffiliate customers in addition to the basic information provided by all affiliates of U.S. multinationals. This means that the size of the affiliates is slightly larger than the population of U.S. affiliates. There are a total of 3,509 manufacturing firms in the sample with an average number of foreign affiliates of 3. There are 5,691 firms in the service industry sample. These firms are somewhat less engaged in foreign production with an average number of foreign affiliates of 2.6.

Most of the sales of U.S. affiliates abroad are to foreign entities with only a small fraction (less than an eighth) returning to the United States. It is for this reason that our conceptual framework is built around a setting where the motivation to invest abroad is to avoid transportation costs rather than to seek low cost inputs.

A.2 First Stage Regression for Affiliate Capital-Labor Ratio

In this subsection of the appendix, we report the first stage regression results for the mark-up regressions. The coefficient estimates are contained in the following table:

Table A.1: First Stage Regression Results

	Manufacturing		Services	
	(1)	(2)	(3)	(4)
Parent K/L	1.347**	0.592**	0.551**	0.221+
	(0.182)	(0.179)	(0.155)	(0.138)
Country K/L	0.486**	0.276**	0.303**	0.185+
	(0.103)	(0.096)	(0.104)	(0.107)
Interaction K/L	−0.092**	−0.044**	−0.025*	−0.012
	(0.016)	(0.015)	(0.013)	(0.010)
Parent Sales	−0.038**	0.006	−0.002	0.013
	(0.012)	(0.021)	(0.008)	(0.015)
Vertical Integration	−0.044	0.180	−0.208	0.062
	(0.209)	(0.199)	(0.173)	(0.267)
Tax Haven	0.027	0.002	0.034	0.034
	(0.075)	(0.068)	(0.067)	(0.067)
Vertical x Tax H	−0.032	0.215	−0.139	−0.049
	(0.521)	(0.582)	(0.319)	(0.305)
GDP/Worker	0.141	0.122	−0.033	−0.019
	(0.093)	(0.089)	(0.115)	(0.123)
Employment	0.046**	0.034**	−0.014	−0.025
	(0.015)	(0.016)	(0.017)	(0.017)
Distance	−0.168**	−0.125**	−0.131**	−0.161**
	(0.050)	(0.045)	(0.015)	(0.053)
Border	−0.655**	−0.509**	−0.417**	−0.526**
	(0.104)	(0.085)	(0.150)	(0.160)
English	0.177**	0.128**	0.158**	0.170**
	(0.059)	(0.054)	(0.045)	(0.049)
Industry x Year FE	Y		Y	
Firm FE		Y		Y
Year FE		Y		Y
N	42,821	42,821	59,017	59,017
R-squared	0.138	0.267	0.157	0.312

Notes: The dependent variable is the logarithm of an affiliates book value of capital to its employment. The instruments are the logarithm of the parent book value of capital to its employment, the logarithm of the country's capital stock to labor force, and the interaction between the parent and country capital to labor ratios. Robust standard errors allowing for clustering at the country level shown in parentheses. **/*/+ means significant at 1%/5%/10% level.

For the most part, the coefficient estimates are sensible. Parents that choose capital intensive technologies have affiliate that do so too. Countries that are capital abundant also tend to have affiliates that are capital intensive. One interesting outcome that is not directly relevant for the topic at hand is the geography of affiliate capital intensities. All of the coefficients on the gravity variables come in with high degrees of statistical significance.

B Model Appendix

B.1 Supporting Material for Simulations

Their are two conditions for engaging in multinational production. The first is that the affiliate will generate positive profits and the second is that the firm will earn higher profits than it would by engaging in export. The first condition requires that equation (7) is strictly non-negative. For entry into country i this requires

$$c < c^{MO}(f) := p_i^* - 2\sqrt{\frac{\gamma f}{L_i}}.$$

The second condition was given by equation (8) in the text we boils down to

$$c < c_i^{MX}(f) := p_i^* - \frac{t}{2} - \frac{2\gamma}{tL_i}f.$$

It can easily be established that $c^{MO}(f) \geq c_i^{MX}(f)$ and is inequality is strict for all f other than

$$\hat{f} = \frac{L_i}{4\gamma}t^2.$$

Hence for $f < \hat{f}$ the relevant cutoff for affiliate operations is $c < c^{MO}(f)$ because exporting would result in negative profits for some c for which multinational production yields positive profits. This is why equation (8) in the text was only a sufficient condition. For $f > \hat{f}$ the relevant cutoff condition is $c_i^{MX}(f)$.

In the simulations, $L_F = 30$, $f^e = 5$, $t = 1$, $\gamma = 1.5$, and the support of the distribution of c and f is $[0, 20]$ and $[0, 30]$respectively. The marginal distribution for c is Pareto with shape parameter 5 and the marginal distribution for f is Pareto with shape parameter 1.005. The dependence parameter for the Clayton copula is 1.5. An artificial dataset of 10,000 firms was drawn and treated as entrants into each country. Given a guess of the choke prices $p_H^*$and p_F^*, firms were sorted into domestic and foreign market operations and the expected profits calculated for each country. Choke prices were then adjusted until the constraint that expected profit equal zero held. On the basis of the originals draws and the choke prices, the statistics shown in the text were generated.