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ABSTRACT

A growing literature seeks to understand how the characteristics of firms shape the manner in which they serve foreign markets. We consider an environment in which multiproduct firms can sell their products in multiple countries from multiple locations. We show that there are strong empirical regularities in the expansion strategies of U.S. multinational firms and that simple extensions of standard models do not explain these regularities. We augment these models by introducing a framework in which organizational capital is a scarce input within the firm that has to be allocated to particular products and production locations and show that the standard model, so amended, is consistent with the data. We then use the model to analyze the productivity effect of changes in international frictions both within and across firms.

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1 Introduction

The world's largest firms are incredibly complex organizations that sprawl across industries and countries. For instance, according to its annual report, Dupont operated production facilities in over 70 countries and produced a wide range of goods such as food, motor vehicle parts, electronics, plastics, construction materials, and industrial chemicals. Such multi-product firms dominate both domestic and international commerce. According to Bernard, Redding, and Schott (2010) U.S. manufacturing firms that produce multiple products account for 91% of U.S. manufacturing output. With respect to U.S. trade, the role of multiproduct firms is even more pronounced. According to Bernard, Redding, and Schott (2007), U.S. based firms that exported 5 or more products account for a staggering 98% of the value of U.S. exports. Further, most of these large, multiproduct exporters are in fact multinational corporations for whom exports are less than half of their total foreign sales.

In organizing the global activities of their firms, management must make a wide range of interrelated decisions: Which goods should they produce? Where should their focus lie? Where should it produce each good and for which markets? Standard models within the international trade literature typically deal with only a subset of a firm's activities and may miss important interactions between decisions. Indeed, it is the possibility that multiproduct firms internalize the cross-product impacts of their decisions that make their existence an interesting area of study.

This paper begins with a descriptive empirical analysis that establishes new facts from a confidential firm-level dataset for U.S. multinationals. This dataset allows us to link the domestic and export activity of the U.S. parent firms of U.S. multinationals to the activity of their foreign affiliates. We show that many large U.S. firms simultaneously sell to unaffiliated customers in a given foreign market through exports from the United States and through locally based affiliates. While there are other possible interpretations of this fact, we feel that the most natural interpretation is that firms export a subset of their products and produce a different subset abroad. We also show that while larger firms engage in more exports and affiliate sales in any given market, it is the more narrowly focused firms in terms of their industrial diversification that rely relatively more on foreign affiliates than on exports from the United States.

To understand the forces at work in the data, we introduce a simple model in which firms produce multiple products for multiple countries in multiple locations. As in

Bernard, Redding, and Schott (2011) firms may produce goods in a continuum of industries. We extend this setting to allow firms to tradeoff local production in foreign countries for export from the home country. As in Brainard (1993, 1997), Horstmann and Markusen (1992), and Helpman, Melitz, and Yeaple (2004) firms face a proximity-concentration tradeoff in choosing between these two modes of serving foreign markets.

The unique feature of the model is that production efficiency for any particular good requires organizational capital, which is in fixed supply within the firm. We think of organizational capital as embedded in the management structure of the firm, reflecting the organizational capacity of the firm due to its institutional structure, corporate culture, and set of established routines. Organizational capital cannot be increased by simply hiring more managers or by merging firms. Because organizational capital is in fixed supply within the firm, increasing productivity of some goods (or equivalently in our framework, raising quality) comes at the expense of productivity improvements in other goods. It is this tradeoff that is internalized by a multiproduct firm that make it behave differently than a continuum of single product firms.

Firms are heterogeneous along two dimensions with respect to their organizational capital. First, firms differ in their stock of organizational capital. Firms with greater organizational capital can support large global operations across a wider product mix. Second, firms differ in the adaptability of their organizational capital to foreign environments.

Our model has interesting implications for the geographic structure of production. Firms with larger endowments of organizational capital have higher aggregate sales in domestic markets, higher exports, and higher foreign affiliate sales. It turns out, however, that variation across firms that is exclusively in the stock of organizational capital cannot predict the relative importance of exports versus affiliate sales. This is inconsistent with the empirical facts as demonstrated in the empirical section of the paper.

It is the second source of firm heterogeneity in our model that can create the observed empirical link between small, concentrated parents and highly multinational operations. As one would expect, firms that can better adapt their organizational capital abroad tend to sell to foreign customers relatively more through a foreign affiliate rather than through exporting. However, because producing in multiple locations consumes organizational capital, there is less available to manage marginal product lines in the home market, leading the parent firm to be narrower and smaller than otherwise.

Finally, we use the model to analyze the impact of trade and MP frictions on the allocation of resources within the firm. Lower barriers to international activity affect the allocation of organizational capital across products through two forces. First, as product markets become more competitive, firms drop marginal products, and this pushes organizational capital into other uses within the firm. Second, as firms shift between exports and MP, organizational capital is pulled into international activities. The relative strength of these two effects differs across firms depending on their endowment of organizational capital.

This paper contributes to a broad range of the literature, including international economics, industrial organization, and productivity analysis. Most distinctively, it blends the elements of the literature on multiproduct firms with elements of the literature on multinational firms.[1] Its treatment of multiproduct firms as having a heterogeneous portfolio of productivities across products makes it similar to Bernard, Redding, and Schott (2011).[2] Further, in Bernard, Redding, and Schott (2011) firms are endowed with a 'core productivity' that raises the productivity (and hence profitability) of all of their products evenly, while in our model firms are endowed with organizational capital that can be used to raise the productivity of all or some of its products as management sees fit, but this organizational capital is in fixed supply within the firm. As managers have to make trade-offs across products, it is generally not optimal to allocate of organizational capital evenly across potential uses and a change in product market conditions will alter this allocation. Were managers forced to allocate organizational capital across goods evenly, the model collapses to a direct extension of Bernard, Redding, and Schott (2011) to allow for horizontal multinational production.

[1] Helpman (1985) does allow for multiproduct firms in his analysis of vertical FDI, but because firms are homogeneous, this feature of the model gets relatively little attention. Baldwin and Ottaviano (2001) do in fact analyze multi-product multinationals in an oligopolistic environment where cannibalization places center stage. Their paper does not consider firm heterogeneity and assumes that each product is produced exclusively in one location. By assuming that firms are heterogeneous in their endowment of organizational capital, our focus is more squarely on the implications of the congestion effects imposed by a broad product scope. Other examples of multiproduct firms and trade, include Eckel and Neary (2009) who focus on flexible manufacturing and cannibalization effects. Dhingra (2010) is another example of a multiproduct firm framework in which trade liberalization has productivity effects within the firm.

[2] In the published version of the paper, the authors consider heterogeniety in demand levels across countries at the level of the individual variety. A special case of this model in which demand levels are constant across countries would be consistent with our treatment.

This paper is also related to the literature on corporate finance that explores the multiproduct firm. The idea that there is a fixed stock of organizational capital within the firm that can be applied across products can also be found in Matsusaka (2001) and Phillips and Maksimovic (2002) whose focus is on the understanding diversification in conglomerates. In its focus on the span of control across product lines within the firm, the paper is similar to Nocke and Yeaple (2012) in exploring the implications of treating organizational capital as a scarce resource within the multiproduct firm. That paper is focused on the implications for firm performance (including export performance) of variation across firms in the span of control (held fixed in this paper) while the current paper focuses on how the possibility of multinational production affects internal resource allocation decisions within the firm.

The remainder of this paper is broken into four main sections. The next section describes a dimension of the data on multinational firms that has received less attention in the international trade literature: the firm-level composition of sales broken down by parent sales in the home market, parent exports by country, and affiliate sales by host country. Section three specifies our model of multi-product multinationals. In section four, the equilibrium of the model is characterized with a focus on the mapping of a firm's characteristics to its domestic and international operations. We show that a model in the tradition of Helpman et al (2004) naturally extended along the lines of Bernard et al (2011) cannot reproduce the facts presented in section two while a model featuring internal resource constraints can. In section five, we analyze the effects of a reduction in trade and MP frictions on the allocation of scarce organizational resources across product lines within the firm. The final section summarizes and concludes.

2 Features of Multiproduct Multinationals

In this section, we uncover several unknown or underappreciated features of the international expansion strategies of multinational firms. First, we show that large multinational firms tend to both export to and engage in local production for unaffiliated customers in a given foreign market. The most natural interpretation of the phenomenon is that firms sell multiple products and individual products are sold exclusively by one mode or another.[3] Second, we show that firms with large U.S. market shares and diverse product

[3]Rob and Vettes (2003) show that a firm might sell the same product through both modes when dynamic concerns are paramount. The model does not give rise to both trade and FDI in the long-run, however, as firms ultimately specialize in FDI.

portfolios disproportionately sell in foreign markets via exports from the United States rather from local affiliates. The fact that smaller, highly focused firms are more likely to engage in multinational operation is not a prediction of the standard models.

2.1 Data Description

The ideal dataset for the study of multi-product, multinational firms would contain information about firm activities across a large number of dimensions. Such a data set would contain information on the full set of products produced by the firm, where each product was produced and where the output was sold. Further the dataset would allow for productivity measurement at the product level, allowing outputs of each product to be linked to the inputs used in their production. Of the datasets that exist, the one closest to the ideal is the data from the Benchmark Survey of *U.S. Direct Investment Abroad* conducted by the Bureau of Economic Analysis (BEA). The data set contains excellent information on where firms own production facilities, solid information on the volume of sales in each market, modest information on the industrial classification of the goods sold by location, and some information on parent firm exports by country. It is this data that is used in our analysis.

The BEA surveys of *U.S. Direct Investment Abroad* are conducted for the purpose of producing aggregate statistics on direct investment activities for the general public.[4] 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.

For reasons of data availability, we rely on the 1994 benchmark survey of the Bureau of Economic Analysis.[5] We are interested in the manner in which U.S. firms serve *unaffiliated* customers (i.e. not related by ownership) in foreign markets; by exporting from the U.S. parent or by selling to these customers from a local affiliate. While every

[4] U.S. direct investment abroad is defined as the direct or indirect ownership or control of a single U.S. legal entity of at least ten percent of the voting securities of an incorporated foreign business enterprise or the equivalent interest in an unincorporated foreign business enterprise.

[5] For information on the survey, see the Methodology section of the data publication *U.S. Direct Investment Abraod: 1994 Benchmark Survey, Final Results*, which can be accessed on the BEA's web site at http://www.bea.gov/scb/account_articles/international/usdia94.htm.

benchmark survey collected detailed firm-level data by country on the value of sales of the foreign affiliates to unaffiliated customers in their host country markets, the last year that the BEA collected comprehensive data on parent exports to unaffiliated customers by destination country was 1994.[6]

We also collect data on the scale and scope of the parent firms operations in the United States that are geared toward serving the U.S. market. We observe a parent firm's sales to U.S. customers in the aggregate across all categories of goods, the number of three-digit manufacturing industries in which the parent is active, and the value of sales of each of these types of goods.[7] From these data, we can infer a firm's U.S. scope (the number of product categories), its scale (average U.S. sales per industrial category), and a Herfindahl index of the concentration of sales across product lines. We focus on U.S. firms whose main-line-of-business is manufacturing and count only the product classifications that correspond to manufacturing industries. The parent firm's export data does not provide useful disaggregation across product categories, but it is disaggregated by final destination.[8] To these sales, we added the sales by parents to their affiliates intended for resale without further processing.

For each parent firm, we observe their network of foreign affiliates by country and industry. Our measure of affiliate activity by firm and country is the sales of manufacturing affiliates to unaffiliated customers in their host country. In cases in which the same firm owned more than one manufacturing affiliate, we aggregated over affiliates to create a single firm-country observation so that it was comparable to the export data.

Descriptive statistics for our sample of 725 parent firms are reported in Table 1. These firms tend to be very large with average U.S. sales of $1.7 billion and their sales span multiple(highly aggregate) industries. The average parent firm exports to 11 countries and owns affiliates in 3.4 countries. The volume of sales by mode is very different, as the average export by country is only $2.4 million while the average affiliate sales by country is $97 million. Note that the distribution of both types of sales is highly skewed, which is why we consider a log-log specification below. Further, while firms tend to export

[6]Data collection on this variable was gradually phased out after 1994. In 1999, the reporting threshold was raised substantially so that smaller parents need not report. After 1999, this part of the survey was eliminated.

[7]In the 1994 benchmark survey, the BEA asked firms to report their top eight industries, so there are likely a number of firms for which this restriction binds.

[8]Only exports in excess of $500,000 are reported.

to a larger number of countries than they engage in affiliate sales, affiliate sales in the aggregate account for 57% of total foreign sales (77% unweighted average across firms).

2.2 Empirical Results

Our empirical analysis is entirely descriptive and intended only to highlight empirical regularities along dimensions of firm behavior that have not been previously explored. In particular, we regress measures of firms' expansion strategies on variables that measure aspects of parent firms' success in its home market controlling for destination country characteristics.

Table 2 reports the results of our simple regression analysis. Columns 1, 2, and 3 correspond to dependent variables that are (1) the logarithm of a firm's foreign affiliate to local customers, (2) the logarithm of the parents exports to unaffiliated local customers, and (3) the logarithm of the share of affiliate sales in total firm sales. The rows correspond to the explanatory variables. The first row corresponds to the logarithm of the parent firm's sales in the United States. The remaining four rows correspond to standard gravity controls: log GDP, log GDP per capita, log distance from the United States, and an indicator variable for English as the official language. Columns 4, 5, and 6 show the results of replacing the country characteristics with country fixed effects.

We begin by discussing the results for the levels of sales by each mode. Looking across the first row, we see that larger parents sell larger quantities to any given foreign country whether through their foreign affiliates (columns 1 and 4) or by exporting from the United States (columns 2 and 5). The coefficients on parent sales in the United States are highly statistically significant using standard errors that have been corrected for heteroskedasticity and for clustering by firm. Further, the results in columns 1 and 2 show that gravity fits quite well at the firm-level for both affiliate sales and for parent exports, although there are differences in the sizes of the coefficient estimates. Note the larger number of observations for the export specification demonstrates that parents are more likely to export to any given location than they are to open an affiliate there.

In columns 3 and 6, the coefficient estimates associated with a dependent variable that is the ratio of affiliate sales to total firm sales in a given foreign market. The coefficient is negative and highly statistically significant, indicating that while larger parents have larger affiliate sales and larger export sales to a given market, larger parent firms rely relatively more heavily on export sales to a given market than on affiliate sales. As our interest is on the coefficients on parent firm variables, we henceforth focus exclusively on country fixed-effect regressions.

In Table 3, we explore how other features of the structure of the parent firms' operations predict its approach to serving foreign markets. In column 1 parent sales are decomposed into scale (logarithm of U.S. sales per product) and scope (logarithm of number of products). The results indicate that both outcome variables for the parent firm predict the firm's foreign expansion strategies: high scale or high scope is associated with larger exports relative to affiliate sales. In column 2, we add two additional parent firm characteristics, the logarithm of their R&D intensity and the logarithm of their capital to labor ratio. We find that adding these additional parent firm characteristics only increases the coefficient on scope.

In column three of Table 3, we add a measure of concentration at the level of the parent firm: i.e. the logarithm of the sum of squared product category shares by firm. An increase in this variable, which represents a less diversified firm, is associated with an increase in the relative importance of affiliate sales in the expansion strategies of firms. Note that adding this variable makes the coefficient on scope change sign and to become statistically insignificant. In the last column of Table 3, we drop product scope and scale and add back our measure of parent sales in the United States. The coefficient estimates are consistent with our previous results: parents that are smaller and more highly focused on a narrow product range tend to expand relatively more through foreign affiliates than larger and more highly diversified parents.

We have run a number of robustness checks through which the essential message of Tables 2 and 3 remains intact. These include Heckman selection specifications using World Bank measures of business costs as an exclusion restriction and fixed effects specifications for the main-line-of-business. We also consider Tobit specifications with an upper limit of zero to account for observations in which only affiliate sales are observed. The effects are to increase the absolute values of the estimated coefficients, but not their sign or statistical significance.

We draw two main conclusions from the results presented in this section. First, parent firms that have larger domestic market shares tend to expand through both exports and foreign affiliate sales in absolute terms. Second, in relative terms it is the parent firms that are focused on a relatively narrow set of products in the U.S. market that are more engaged in multinational production relative to exports.

3 Model Assumptions

Our model framework is designed to analyze how multiple-product firms serve multiple markets in the presence of an internal resource constraint. To allow for firms to produce and sell their product in multiple locations we consider a world in which there are two identical countries indexed by l and j. To allow for firms to produce in multiple industries, we assume that there are a continuum of industries on the unit interval. Preferences over the goods produced in these industries are Cobb-Douglas with equal budget shares:

$$U = \int_0^1 \ln C(i) di. \tag{1}$$

Each industry is differentiated by variety with subutility function given by

$$Q(i) = \left[\int_{\omega \in \Omega_i} q(\omega)^{\frac{\sigma}{\sigma-1}} d\omega \right]^{\frac{\sigma-1}{\sigma}}, \tag{2}$$

where $\sigma > 1$ is the elasticity of substitution across individual varieties. For expositional convenience, we assume that the elasticity of substitution is common across goods i.

All goods are produced using exclusively labor, which we choose as the numeraire, and an input we will refer to as organizational capital. There exists a continuum of ex ante identical entrepreneurs. When an entrepreneur incurs a fixed cost F^E, she receives a bundle of characteristics from distributions known ex ante. First, she receives the blueprint to produce one variety of each type of good. Each blueprint implies a level of "fundamental" productivity Z independently drawn from a Pareto distribution $G(Z) = 1 - Z^{-\kappa}$, where $\kappa > 1$. As all firms draw from the same distribution, there is no aggregate variation across firms due to this source of heterogeneity.[9]

The actual productivity with which the firm will produce a product of fundamental productivity Z depends as well on the quantity of organizational capital that is dedicated by the firm to the plant producing that variety. If $k_j(Z)$ is the quantity of this organizational capital allocated to a plant at location j that produces a variety of fundamental productivity Z then the productivity of that plant is

$$\widetilde{\varphi}(k_j(Z), Z) = Z \cdot k_j(Z)^{\widetilde{\theta}}, \tag{3}$$

[9] The heterogeneity across products is necessary to get firms to be willing to export some set of goods and to engage in MP in another set of goods.

where $\widetilde{\theta} \in (0, 1/(\sigma-1))$ is a measure of the span of control of organizational capital by product. By location $j \in \{d, f\}$, domestic and foreign is relative to the country that the firm entered. If a firm entered in l is producing in $k = l$ then $j = d$ whereas if $k \neq l$ then $j = f$.

When a firm enters it also receives a random draw that defines its organizational endowment, which is the source of intrinsic aggregate heterogeneity across firms. This types includes the firm's stock of organizational capital, K, and a parameter $\lambda \in [1, \overline{\lambda}]$ that governs the cost of adapting the firm's organizational capital for use in foreign countries. These characteristics are drawn from a joint probability distribution H with density h.

Equation (3) shows that a good-specific plant's productivity is endogenous and depends on the amount of organizational capital that the entrepreneur allocates to it. In allocating organizational capital to the various goods produced by the firm, the manager must respect the constraint that she can allocate no more than K units of her organizational capital to all goods that are produced:

$$K \geq \int_0^\infty \sum_j \lambda_j k_j(Z) dG(Z), \tag{4}$$

where $k_j(Z)$ is the organizational capital allocated to a plant of productivity Z that is located in country $j \in \{d, f\}$.[10] If $j = d$, then $\lambda_j = 1$, otherwise $\lambda_j = \lambda$.

An active firm must decide where to produce each good. If a firm produces a particular variety at home, it must pay a fixed cost F. If it chooses to export that good to the foreign country, it must pay a variable iceberg-type trade cost $\tau \geq 1$. We will use in our exposition below the transformed, "freeness" of trade parameter $\rho \equiv \tau^{1-\sigma} < 1$. In addition, the firm must pay a fixed cost F^x to find a distributor for its product. Finally, the firm might choose to produce abroad to serve the local market from a local affiliate. As is standard in the proximity-concentration literature, by opening the affiliate, the producer avoids trade costs τ but must pay a fixed cost F^m. To obtain an interior solution in which all modes will be observed by at least some firms, we make the following

[10] It is possibilible to rewrite the model so that productivity draws instead corresponds to heterogeneity across products in the extent to which organizational capital can be adapted for the production of the particular good. This would give the model a "core competency" type flavor as in Eckel and Neary (2011).

parameter restriction:[11]

$$F < \frac{F^x}{(1+\rho)^{\frac{1}{1-\theta}} - 1} < F^m. \tag{5}$$

The timing of decisions is as follows. First, firms draw their type (K, λ) and their good-specific productivities. Second, firms decide which goods to produce, which markets to serve, and where to locate production for each good and market (mode choice). Third, firms choose how much organizational capital to allocate to production of each good at each location. Finally, firms compete in monopolistically competitive fashion in each market.

In summary, the model extends the simplest version of Bernard, Redding, and Schott (2011) (henceforth BRS) to a setting in which firms face a proximity-concentration trade-off between exports and multinational production as in Helpman, Melitz, and Yeaple (2004) (henceforth HMY). While firms are heterogeneous in their productivity in various good categories, this heterogeneity is entirely idiosyncratic and not the origin of aggregate productivity differences across firms. Instead, productivity of individual products depend on the characteristics of management that enter the resource constraint (4). Note that because all fixed costs (aside from the entry fixed cost) are product specific so that once a firm has entered, it will sell at least some goods in all markets, i.e. we have eliminated selection effects across firms to focus on selection and resource allocation across goods within firms.[12]

4 The Expansion Strategies of Multiproduct Firms

In this section we characterize the equilibrium choices of heterogeneous firms as a function of their types (K, λ). We solve the model backwards by first deriving sales and profits for each good and production location taking as given the allocation of organizational capital to each product and the production location of that product vis-a-vis the final market served. Then, we solve for the optimal allocation of organizational capital within a given firm across goods as a function of that good's productivity Z and its production location (domestic or foreign). Next, we solve for the production location of each good.

[11] In the special case that $\theta = 0$ this is equivalent to the parameter restriction made in Helpman et al (2004).

[12] Such effects could be easily added by having fixed costs of serving various markets that occur at the firm level. As these selection effects are very well understood we leave this extension to the interested reader.

Finally, we impose a free entry condition.

Throughout the exposition of this section, our derivation is entirely from the perspective of a firm from the country l which has its mirror image in country $j \neq l$.

4.1 Profits and Sales Volumes

The preference system given by (1) and (2) combined with the symmetry of the model implies a demand system with constant elasticity σ and location determined by aggregate expenditure E and by the price index P given by

$$P_l^{1-\sigma} = \int_{\omega \in \Omega_l} p(\omega)^{1-\sigma} d\omega,$$

where Ω_l is the set of goods available for sales in country l. Given the symmetry across industries, demand conditions are identical in each industry.

As is well known, profit maximizing firms from country j facing iso-elastic demand in country l optimally charge a price that is a constant mark-up over marginal cost for serving that country. For a good of fundamental productivity Z we have

$$p_{jl}(Z) = \frac{\sigma}{\sigma - 1} C_{jl}(Z) \tag{6}$$

where

$$C_{jl}(Z) = \begin{cases} \frac{1}{\widetilde{\varphi}(k_j(Z), Z)} \text{ if } j = l \\ \frac{\tau}{\widetilde{\varphi}(k_j(Z), Z)} \text{ if } j \neq l \end{cases}. \tag{7}$$

Note that a firm will never produce in a foreign market for sale in the domestic market because doing so would require it to incur both adaption costs λ and shipping costs τ which is never sensible given the symmetry of the two countries. Note also that we have normalized the wage in the two identical countries to unity.

Given the optimal pricing formula, and the cost function, we can derive the profits that accrue to any particular mode of serving global markets. For instance, a firm that sells a particular good Z only in its domestic market faces only the domestic fixed cost F and faces no costs of shipping a good or of adapting organizational capital to foreign use. Hence, the profit associated with a purely domestic mode of operation for a product line with specific productivity Z of a type (K, λ) can be written

$$\pi^D(k_d, Z) = AZ^{\sigma-1}(k_d)^\theta - F, \tag{8}$$

where $\theta = \widetilde{\theta}(\sigma - 1) < 1$, and A is the mark-up adjusted demand level in each country given by

$$A \equiv \frac{1}{\sigma} \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} EP^{\sigma-1}.$$

The firm may also choose to serve foreign markets in addition to its domestic market. If it chooses to export its product, it must incur fixed costs F and F^x and it must also incur variable costs τ on its sales to foreign customers. The resulting profit associated with exporting is thus

$$\pi^X(k_d, Z) = (1 + \rho) A Z^{\sigma-1} (k_d)^\theta - F - F^x, \tag{9}$$

where we have used $\rho \equiv \tau^{1-\sigma}$ to simplify notation.

A firm that decides to engage in horizontal FDI avoids all trade costs, but is now exposed to costs of adapting its organizational capital to a foreign environment. Further, the firm must incur the higher fixed costs associated with international production given by F^m. The resulting profit is

$$\pi^M(k_d, k_f, Z) = A Z^{\sigma-1} \left((k_d)^\theta + (k_f)^\theta \right) - F - F^m. \tag{10}$$

This expression makes clear that a significant cost to multinational production vis-a-vis the export mode is the need to use organizational capital for both the domestic and foreign operation. It also implies that the foreign plants of a firm are likely to be at productivity disadvantage relative to their home-country counterparts, which is consistent with the fact that overseas production tends to be less productive than domestic production (see Keller and Yeaple, 2013).

Given the profits associated with each mode in equations (8)-(10), the aggregate profits of a multiproduct, multinational firm are

$$\pi(K, \lambda) = \int_1^\infty \max(0, \pi^D(k_d(Z), Z), \pi^X(k_d(Z), Z), \pi^M(k_d(Z), k_f(Z), Z)) dG(Z). \tag{11}$$

We now turn to the optimal allocation of organizational capital across goods and locations conditional on the location decisions of the firm for each variety.

4.2 Allocation of Organizational Capital across Products

Suppose that a firm has made production location decisions by allocating product lines into three sets, Φ_D, Φ_X, and Φ_M, which are the product-specific productivities Z of goods allocated to pure domestic sales, export, and multiplant production, respectively. Goods whose Z is not an element of the union of these sets are not produced by the firm. Using the profit functions by mode (8)-(10), the aggregate profit function (11), and the organizational capital constraint (4), the first-order conditions for the optimal choice of the amount of organizational capital to allocate across various goods then imply

$$k_j(Z;\lambda,K)=\begin{cases}\frac{K}{B}Z^{\frac{\sigma-1}{1-\theta}} & \text{if } j=d \text{ and } Z\in\Phi_D\\ \frac{K}{B}(1+\rho)^{\frac{1}{1-\theta}}Z^{\frac{\sigma-1}{1-\theta}} & \text{if } j=d \text{ and } Z\in\Phi_X\\ \frac{K}{B}\lambda^{-\frac{1}{1-\theta}}Z^{\frac{\sigma-1}{1-\theta}} & \text{if } j=d,f \text{ and } Z\in\Phi_M\end{cases} \tag{12}$$

where

$$B=\int_{Z\in\Phi_D}Z^{\frac{\sigma-1}{1-\theta}}dG(Z)+\int_{Z\in\Phi_X}(1+\rho)^{\frac{1}{1-\theta}}Z^{\frac{\sigma-1}{1-\theta}}dG(Z) \tag{13}$$
$$+\lambda^{-\frac{\theta}{1-\theta}}\int_{Z\in\Phi_M}Z^{\frac{\sigma-1}{1-\theta}}dG(Z)$$

measures the total burden of the firm's production network on its stock of organizational capital. Equations (12) and (13) illustrate trade-offs facing firms. First, everything else equal, a firm that expands the number of goods that it manages will have less organizational capital to allocate to each good that it produces and so will tend to be less productive on average (higher B). Second, the allocation of organizational capital magnifies differences in the initial productivities across products produced within the firm. Third, a firm that reallocates a product from an export mode to a multinational production mode will use less organizational capital on the foreign affiliate than it did in the exporting plant in the home country but may use more on the product line in total because it needs to support two, rather than one plant.

Given the optimal allocation of organizational capital across products, we can rewrite the profits by mode from the system (8)-(10) as

$$\begin{aligned}\pi^D(Z;\lambda,K)&=AK^\theta B^{-\theta}Z^{\frac{\sigma-1}{1-\theta}}-F,\\ \pi^X(Z;\lambda,K)&=AK^\theta B^{-\theta}Z^{\frac{\sigma-1}{1-\theta}}(1+\rho)^{\frac{1}{1-\theta}}-F-F^x,\\ \pi^M(Z;\lambda,K)&=AK^\theta B^{-\theta}Z^{\frac{\sigma-1}{1-\theta}}\left(1+\lambda^{-\frac{\theta}{1-\theta}}\right)-F-F^m.\end{aligned} \tag{14}$$

We now focus our attention to the manner in which firms assign various goods in their portfolio to various modes of serving global markets.

4.3 Allocation of Goods to Modes

Profits per mode are given by the equations in (14). Given this formulation, we can use the logic in Helpman et al (2004) to assign products to modes. From the assumptions (5), it follows from the expressions in (14) that there exist cutoffs z_D and $z_X > z_D$ such that for $Z < z_D$ goods are not produced, goods $Z > z_D$ will be sold in at least the domestic market, and goods $Z > z_X$ will be sold in both markets. For firms for which the organizational adaption costs abroad are sufficiently low, i.e.

$$\lambda^{-\frac{\theta}{1-\theta}} > \Delta,$$

where $\Delta \equiv (1+\rho)^{\frac{1}{1-\theta}} - 1$ there will be at least some products for which multinational production is optimal. We henceforth assume that the support of distribution of firm inefficiencies λ is such that this condition is meant. Specifically, we assume that the upper bound of the support of international inefficiency satisfies $\overline{\lambda}^{-\frac{\theta}{1-\theta}} > \Delta$.[13] It follows immediately that there exists an additional cutoff, $z_M > z_X$, such that goods $Z > z_M$ will be produced (and sold) in both countries.

Given the existence of the three cutoffs $z_D < z_X < z_M$ that define the sets Φ_D, Φ_X, and Φ_M, we may use equations (14), (13) to rewrite (11) as

$$\begin{aligned} \pi = {} & AK^{\theta} B(z_D, z_X, z_M)^{1-\theta} - (1 - G(z_D))F \\ & -(1 - G(z_M))F^m - (G(z_m) - G(z_x))F^x \end{aligned} \tag{15}$$

where the function B is now written

$$\begin{aligned} B(z_D, z_X, z_M) = {} & \int_{z_D}^{z_X} Z^{\frac{\sigma-1}{1-\theta}} dG(Z) + (1+\rho)^{\frac{1}{1-\theta}} \int_{z_X}^{z_M} Z^{\frac{\sigma-1}{1-\theta}} dG(Z) \\ & + \left(1 + \lambda^{-\frac{\theta}{1-\theta}}\right) \int_{z_M}^{\infty} Z^{\frac{\sigma-1}{1-\theta}} dG(Z). \end{aligned} \tag{16}$$

The first order conditions for profit maximization associated with (15) imply the following

[13] Relaxing this assumption is straightforward and will result in firms that are large and productive in their home market but that choose not to own any foreign affiliates.

expressions for the three cutoffs:

$$z_D = \left((1-\theta) A K^\theta B(z_D, z_X, z_M)^{-\theta} \frac{1}{F} \right)^{-\frac{1-\theta}{\sigma-1}}, \tag{17}$$

$$z_X = \left((1-\theta) A K^\theta B(z_D, z_X, z_M)^{-\theta} \frac{\Delta}{F^X} \right)^{-\frac{1-\theta}{\sigma-1}}, \tag{18}$$

$$z_M = \left((1-\theta) A K^\theta B(z_D, z_X, z_M)^{-\theta} \frac{(\lambda^{-\frac{\theta}{1-\theta}} - \Delta)}{F^I} \right)^{-\frac{1-\theta}{\sigma-1}}, \tag{19}$$

where $F^I \equiv F^m - F^x$. To complete the characterization of a firm's choices, we integrate (16) using the Pareto distribution and substitute the cutoffs (17), (18), and (19) to obtain:

$$B(K,\lambda) = \left(\frac{a \left((1-\theta) A K^\theta \right)^{a-1}}{a-1} \Theta(\lambda) \right)^{\frac{1}{1-\theta+a\theta}}. \tag{20}$$

where $a \equiv \kappa(1-\theta)/(\sigma-1) > 1$ is a bundle of parameters and

$$\Theta(\lambda) \equiv F^{1-a} + \Delta^a \left(F^x\right)^{1-a} + \left(\lambda^{-\frac{\theta}{1-\theta}} - \Delta\right)^a \left(F^I\right)^{1-a} \tag{21}$$

is an index of the various costs facing a firm including its foreign organizational adaption costs, λ. As λ rises, $\Theta(\lambda)$ falls. By substituting (20) into the cutoff equations (17)-(19), we obtain reduced form expressions for each cutoff. We will use these expressions in the following section to analyze the cross-firm structure of international production.

4.4 The Firm-Level Structure of Production

In this section, we aggregate across products within a firm to obtain firm-level measures that correspond to objects used in the empirical section of the paper. Most derivations and the proof of proposition 3 can be found in the appendix.

We begin by analyzing the level of firm sales by destination and production location of a firm of type (K,λ). The level of sales by the parent firm in the domestic market for a good of productivity Z is given by $S^D(K,\lambda,Z) = p(Z)q_d(Z) = \sigma A Z^{\sigma-1} k_d(Z)^\theta$, where $k_d(Z)$ is the solution to (12). Integrating over Z, we find

$$S^D(K,\lambda) = \sigma \widetilde{A} \left(\frac{K}{\Theta(\lambda)} \right)^{\frac{a\theta}{1-\theta+a\theta}} \times \tag{22}$$
$$\left[F^{1-a} + \left((1+\rho)^{\frac{\theta}{1-\theta}} - 1 \right) \left(\left(\frac{\Delta}{F^x} \right)^{a-1} - \left(\frac{\lambda^{-\frac{\theta}{1-\theta}} - \Delta}{F^I} \right)^{a-1} \right) \right],$$

where

$$\widetilde{A} \equiv (A)^{\frac{a}{1-\theta+a\theta}} \left(\frac{a(1-\theta)^{a-1}}{a-1} \right)^{\frac{1-\theta}{1-\theta+a\theta}}$$

is an alternative measure of demand. When organizational capital is important (i.e. $\theta > 0$), costs that affect international markets have an indirect effect on the level of sales in the domestic market because of the intra-firm resource allocation effect.

Similarly, parent firm export sales are given by

$$S^X(K,\lambda) = \sigma \widetilde{A} \left(\frac{K}{\Theta(\lambda)} \right)^{\frac{a\theta}{1-\theta+a\theta}} \times \rho(1+\rho)^{\frac{\theta}{1-\theta}} \left[\left(\frac{\Delta}{F^x} \right)^{a-1} - \left(\frac{\lambda^{-\frac{\theta}{1-\theta}} - \Delta}{F^I} \right)^{a-1} \right] \tag{23}$$

and the sales of foreign affiliates are given by

$$S^M(K,\lambda) = \sigma \widetilde{A} \left(\frac{K}{\Theta(\lambda)} \right)^{\frac{a\theta}{1-\theta+a\theta}} \lambda^{-\frac{\theta}{1-\theta}} \left(\frac{\lambda^{-\frac{\theta}{1-\theta}} - \Delta}{F^I} \right)^{a-1} \tag{24}$$

The following proposition follows directly from inspection of expressions (22), (23), and (24).

Proposition 1 *An increase in a firm's endowment of organizational capital, K, increases the firm's domestic sales, export sales, and local affiliate sales.*

Firm that have higher levels of organizational capital use it to expand along all dimensions. In a sense, it is as if they have higher "core productivity" as in BRS. This result is consistent with the empirical fact in section 2: parent firms with larger domestic sales have a larger value of aggregate export sales and multinational sales by foreign market.

We now decompose a firm's parent sales into its **scale** (local sales per product or its intensive margin) and its **scope** (number of products managed or its extensive margin) and explore the manner in which a firm's type is revealed by these observable characteristics. In the model, a parent firm's **scope** is the share of product categories above the domestic production cutoff: $N(K,\lambda) = (z_D)^{-\kappa}$. Using (17) and (20), we find that

$$N(K,\lambda) = F^{-a} \left[(1-\theta) A K^{\theta} \left(\frac{a}{a-1} \Theta(\lambda) \right)^{-\theta} \right]^{\frac{a}{1+\theta(a-1)}}. \tag{25}$$

As shown in the appendix, a parent firm's domestic **scale** is

$$\frac{S^D(K,\lambda)}{N(K,\lambda)} = \frac{\sigma}{1-\theta}\frac{a}{a-1} \times \left[F + \left((1+\rho)^{\frac{\theta}{1-\theta}} - 1\right) F^a \left(\left(\frac{\Delta}{F^X}\right)^{a-1} - \left(\frac{\lambda^{-\frac{\theta}{1-\theta}} - \Delta}{F^I}\right)^{a-1}\right)\right]. \tag{26}$$

Inspection of (25) and (26) establishes the following proposition that summarizes the relationship between a firm's type and the parent scale and scope.

Proposition 2 *A firm's **scale** is independent of K and increasing in λ. A firm's **scope** is increasing in both K and λ.*

The proposition shows us how to perceive variation in a firm's type from its scale and scope. The intuition for why a parent firm's scale is independent of K is as follows. An increase in K leads firms to add more organizational capital to each of the products in its existing portfolio and to expand into weaker products, which shows up as an increase in scope. As these products have smaller sales than the average product sold previously, the Pareto parameterization of product-level productivity requires that the within-firm extensive and intensive margins cancel out leaving average sales per product unchanged.

Now consider the effect of an increase in λ. This shift induces the firm to allocate organizational capital away from organizational capital-intensive multinational operations toward domestic production. The resulting impact on the firm's domestic operations is similar to that of an increase in K. There is, however, an additional effect. As the share of foreign sales shifts toward exports, more organizational capital is allocated to this end. Because the plants that produce for export also produce for the domestic market, the productivity of these export plants rises, lowering the cost of selling in the domestic market and raising the average size of domestic operations.

We now turn our attention to firms' international expansion strategies as measured by the ratio of the firm's aggregate export to its local affiliate sales. Dividing (23) by (24), we obtain

$$\frac{S^X(K,\lambda)}{S^M(K,\lambda)} = \rho(1+\rho)^{\frac{\theta}{1-\theta}}\lambda^{\frac{\theta}{1-\theta}} \left[\left(\frac{F^I}{F^x}\frac{\Delta}{\lambda^{-\frac{\theta}{1-\theta}} - \Delta}\right)^{\frac{\tilde{\kappa}}{\sigma-1}-1} - 1\right], \tag{27}$$

where $\widetilde{\kappa} \equiv \kappa(1-\theta)$. This expression is very similar to the industry level measures that appear in HMY, and when organizational capital is unnecessary for production ($\theta = 0$) it simplifies exactly to the industry-level expression found in HMY.

Note that K does not appear in (27). As K is similar to 'core productivity' in BRS, it follows that purely selection driven models cannot explain the empirical patterns that were documented in section 2. This result obtains because as K expands, the cutoffs Z_M and Z_X both shift down with the implication that both types of sales rise, but by exactly the same proportion. This stark result is in part due to the curious features of the Pareto distribution, but the general tendency would be present for other distributional assumptions.

One might propose that firms differ in the degree of productivity dispersion across industry: i.e. that lower κ might be a feature of particular types of firms. If so, a model without scarce organizational resources within the firm is unnecessary to explain the facts in the empirical section. While this does generate the proposed effect on S^X/S^M as can be seen from (27), the following proposition shows that in a model without scarce organizational resources, increased dispersion within the firm is not consistent with the data (proof is in appendix).

Proposition 3 *Suppose that $\theta = 0$. An increase in within-firm heterogeneity (lower $\widetilde{\kappa}$) increases the multinational sales relative to exports and increases both the domestic sales of the same firm and the number of varieties sold in the domestic market.*

Intuitively, increasing within-firm productivity dispersion increases the mass of activity above an given cutoff value. This is precisely the point made in HMY: as productivity becomes more dispersed, more of the productivity draws exceed the domestic productivity cutoff raising both domestic sales and the number of products sold in the domestic market. As this runs counter to the facts demonstrated in section 2, we turn to the role played by heterogeneity in λ.

A quick glance at equation (27) confirms that variation in λ plays the role one would expect. The greater the difficulty that a firm has in providing organizational inputs to its affiliate, the higher the export to multinational production ratio will be. The next proposition, which follows from inspection of equations (25), (26), and (27), shows that the organizational capital mechanism is consistent with the empirics shown in section 2.

Proposition 4 *Holding fixed firms' absolute organizational capital K, firms that have difficulty adapting their organizational capital to foreign use (high λ) sell a wider range of goods in their domestic market (scope), have larger sales per product in the domestic market (scale) and tend to serve foreign markets through exports rather than affiliate sales.*

When a firm chooses not to open many foreign plants because it is relatively costly to do so, it frees up organizational capital that can then be used to raise the productivity of marginal domestic plants. As a result, parent firms expand domestically by increasing both their product scale and their product scope. Hence, the model can generate the facts described in section 2 both in terms of absolute levels of sales across modes (Proposition 1), and in terms of the relationship between domestic levels and the relative mode choice by firms in international markets (Proposition 4).

4.5 Free Entry

Using the results from the previous sections, we can compute the profits of a firm of type (K, λ):

$$\pi(K, \lambda) = \frac{1 - \theta + a\theta}{a} \widetilde{A} K^{\frac{a\theta}{1-\theta+a\theta}} \left[\Theta(\lambda)\right]^{\frac{1-\theta}{1-\theta+a\theta}} . \tag{28}$$

Let the joint distribution of firm types be given by $H(K, \lambda)$ with joint probability density $h(K, \lambda)$ the free entry condition can then be written

$$\int \int \pi(K, \lambda) h(K, \lambda) dK d\lambda - F^E = 0 \tag{29}$$

4.6 Discussion

We now briefly discuss the empirical relevance of our model in explaining the evidence and other potential explanations. The most obvious alternative explanation is that firms are not constrained in their activities due to intangible "organizational capital" but rather simply physical capital constraints. Physical capital constraints would have many of the same implications as would shortages of managerial resources. However, a firm's stock of physical capital was included as a control in the empirical analysis of section 2, raising questions as to whether this explanation is a more attractive explanation than shortages of organizational capital.

A more difficult alternative explanation to address is the possibility that the fact that firms export and produce locally for unaffiliated customers is not due to specialization across product lines but rather multi-sourcing of the same product as in Rob and Vlettas (2003). The lack of data in the BEA dataset on the commodity composition of firm-level trade prevents us from addressing this possibility. However, we believe that our explanation is more reasonable as it provides an explanation for why less diversified firms tend to be more engaged in multinational production relative to exports whereas Rob and Vlettas (2003) does not.

5 Trade Liberalization and Intra-Firm Productivity

In this section, we use the model to analyze the effects on firm organization of 1) lower variable trade costs (greater ρ), and 2) lower fixed costs of foreign investment F^I. All proofs are in the appendix.

The intra-firm productivity effects work through the mechanisms in (12) and (13). For instance, a reduction in trade cost (increase in ρ) directly causes a reallocation of organizational capital toward exported goods. Because organizational capital is in limited supply within the firm, there is also an impact on all goods that works through changes in B. Further, to the extent that the change in the external environment causes firms to switch modes for individual products (changes in the cutoffs z_D, z_X, and z_M) this too will have an impact on the resources available to any individual good.

We begin by showing that a reduction in international friction leads to a rationalization effect within the firm as plants producing marginal products are closed.

Proposition 5 *An increase in the freeness of trade or a reduction in the fixed cost of investing abroad reduces the product range of all firms.*

A reduction in an international friction has a push and a pull effect on the resource allocation within the firm. First, as international frictions get less intense, the free entry condition requires that the mark-up adjusted demand level A must fall, which discourages the production of marginal goods within the firm. The same reduction in trade frictions will also encourage a reallocation of organizational capital away from goods that are produced exclusively for the domestic market toward goods that are sold in both the domestic and foreign markets.

We now consider the within-firm productivity effects of a reduction in trade costs τ (a rise in trade freeness ρ). We summarize the effects of trade and multinational production liberalization through its effect on the productivity of individual goods within the firm defined as $\varphi(Z) = Z \cdot k(Z)^{\widetilde{\theta}}$. We begin with the following intermediate result:

Lemma 1: *An increase in trade freeness, ρ, causes at least some products produced by a firm to switch from not being exported to being exported.*

At least some of the goods that were previously produced in both the domestic and foreign market will have their production rationalized to being exported from a domestic plant. It is also possible that some products that were previously sold exclusively in the domestic market will also begin to be exported. The following proposition establishes how the productivity of this plant will change as it begins to export:

Proposition 6 *A plant that switches from not exporting its product to exporting its product after an increase in trade freeness must see its productivity rise.*

The productivity of the plants that produce goods that switch from not being exported to being exported rises relative to the productivity of plants producing other goods in the firm's portfolio and in absolute terms. This is consistent with the empirical results of Lileeva and Trefler (2009), who show that Canadian plants that switch from domestic only to export become more productive. What is novel about our approach is that the effect is due to the reallocation of organizational capital within the firm. Once a firm consolidates the production of a good in one location for two markets the plant producing that good receives a higher proportion of the firm's organizational capital.

We now expand our analysis of how globalization affects the productivity of the entire portfolio of firms' product lines and how this impact depends on firm characteristics. The following proposition considers the effect of a reduction in variable trade costs, or an increase in the freeness of trade.

Proposition 7 *Consider an increase in trade freeness, ρ. There exists a cutoff level of domestic comparative advantage, $\widehat{\lambda} < \overline{\lambda}$ such that for all firms with $\lambda < \widehat{\lambda}$ the productivity of all goods produced by the firm increases while for $\lambda > \widehat{\lambda}$ the productivity of all non-exported goods falls.*

The effect of an increase in trade freeness on firm-level productivity depends on the firm's initial orientation toward the foreign market. If the firm has a high comparative cost advantage producing in the domestic market for export (i.e. $\lambda > \widehat{\lambda}$), then much of its organizational capital was already allocated toward exporting. In this case, the pull of the export market leads to such a large reallocation of organizational capital out of non-exported goods that the productivity of non-exported goods ultimately falls. If the firm exports relatively few products, then the fall in the mark-up adjusted demand level A brought about by the increase in trade freeness pushes enough organizational capital out of marginal plants, leading to an increase in the productivity of remaining plants.

The asymmetric effect of a change in the international environment across firms also appears when we consider the effect of a reduction in the fixed cost of engaging in multinational production as the following proposition makes clear.

Proposition 8 *Consider a reduction in the fixed cost of international operations, F^I. There exists a $\widetilde{\lambda} < \overline{\lambda}$ such that for firms of type $\lambda < \widetilde{\lambda}$ the productivity of all goods decreases and for firms of type $\lambda > \widetilde{\lambda}$ the productivity of all goods increases.*

Unlike an increase in the freeness of trade, a reduction in the fixed cost of international operations has no direct effect on the allocation of organizational capital across goods. Two indirect effects are at work. First, there is a tendency for firms to substitute on the margin multinational production for exports. While less organizational capital is allocated to any one plant for a switching good, collectively the two plants require more organizational capital than a single plant. This tends to divert organizational capital from other goods. Second, as noted above, the marginal domestic plant closes as the mark-up adjusted demand level falls, freeing organizational capital for use in the remaining plants.

Discussion The key result that obtains in this section is that shocks to the international trading environment will change the focus of multi-product firms and that this change in focus alters the productivity of incumbent plants. Changes in focus within the firm have been shown elsewhere to have exactly such effects on productivity. For instance, Schoar (2002) shows that firms that acquire new product lines see the total factor productivity (TFP) of incumbent product lines fall. Such changes in TFP are not obviously associated with capital constraints, leading Schoar to attribute the fall in TFP to a reduction in managerial attention to these product lines. Note that Schoar's empirical analysis could potentially be repeated in an international context: a change in policies that increase foreign access to a large trading partner should have the effect of lowering TFP of the plants producing goods that are not exported to that foreign market.

6 Conclusion

The key feature of multiproduct firms is that they can internalize the effects of decisions directed toward one set of goods on the outcomes of another. The types of effects that are internalized can either be on the product market side (cannibalization effects) or on the production side. This paper has been squarely focused on the latter. We have shown that when organizational capital is a scarce resource in the firm that is a key input in production (as in Lucas 1977 and Rosen 1982), that the decision of how many goods to produce, where to produce them (export versus FDI), and for which markets to produce all become inter-related.

Several important insights emerge from our analysis. First, we show that considering the internalization effects of scarce organizational capital provides insight into the standard "proximity-concentration" model. An important benefit to consolidating production in a single location is that organizational capital is conserved, allowing the firm to produce the same set of goods more efficiently while also producing a wider range of goods.

Second, we have derived a new set of facts on the behavior of large multiproduct firms that both export and engage in MP in foreign markets and demonstrated that standard proximity-concentration models naively adapted to a multiproduct setting heterogeneity cannot explain these facts. Comparative advantage in domestic versus foreign management across firms combined with an internal resource constraint within the firm is consistent with these facts, however.

Third, we have shown how an internal organizational capital resource constraint leads to within-firm productivity effects that differ substantially from those of purely selection driven models. Changes in the international trading environment affect the way that firms allocate scarce organizational capital across products with the implication that some firms will become more productive as they narrow their product range and concentrate production in fewer locations, while other firms will appear to become less productive as they expand their product range and allocate more resources to foreign production.

There are several natural extensions to the model. First, by adding additional countries one can generate export platform multinational production that provides a firm with the benefit of conserving scarce organizational capital relative to replicating production in many locations. Second, by adding idiosyncratic differences in demand across countries and products, it becomes possible to generate a number of new outcomes such as the same firm exporting “both ways” between two countries.

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7 Appendix

7.1 Derivation of Aggregate Sales

7.1.1 Domestic Sales

As noted in the text, the definition of domestic sales is $S^D(K,\lambda) = \sigma A \left[\int_{z_D}^{\infty} Z^{\sigma-1} k_d(Z)^{\theta} dG(Z)\right]$ where $k(Z)$ was derived in (12). Substituting for the allocation of organizational capital, we have

$$S^D(K,\lambda) = \sigma A K^{\theta} B^{-\theta}\left[\int_{z_D}^{z_X} Z^{\frac{\sigma-1}{1-\theta}} dG(Z) + (1+\rho)^{\frac{\theta}{1-\theta}} \int_{z_X}^{z_M} Z^{\frac{\sigma-1}{1-\theta}} dG(Z) + \int_{z_M}^{\infty} Z^{\frac{\sigma-1}{1-\theta}} dG(Z)\right]$$

Integrating using the Pareto distribution, we obtain

$$S^D(K,\lambda) = \sigma A K^{\theta} B^{-\theta} \frac{\widetilde{\kappa}}{\widetilde{\kappa}-(\sigma-1)}\left[(z_D)^{\frac{\sigma-1}{1-\theta}-\kappa} + \left((1+\rho)^{\frac{\theta}{1-\theta}} - 1\right)\left((z_X)^{\frac{\sigma-1}{1-\theta}-\kappa} - (z_M)^{\frac{\sigma-1}{1-\theta}-\kappa}\right)\right]$$

Now substituting for the cutoffs using (17), (18), and (19), and defining $a = \widetilde{\kappa}/(\sigma - 1)$, we obtain

$$S^D(K,\lambda) = \frac{\sigma F}{1-\theta}(z_D)^{-\kappa}\frac{a}{a-1}\left[1 + \left((1+\rho)^{\frac{\theta}{1-\theta}} - 1\right)\left(\left(\frac{F^x}{F\Delta}\right)^{1-a} - \left(\frac{F^I}{F(\lambda^{-\frac{\theta}{1-\theta}} - \Delta)}\right)^{1-a}\right)\right]$$

Reorganizing this expression yields parent firm scale, which is equation (26) in the text. Finally, substituting for z_D using (17) and substituting out B using (20), we obtain (22).

7.1.2 Export Sales

The definition of export sales is $S^X(K,\lambda) = \sigma A\rho \int_{z_X}^{z_M} Z^{\sigma-1}k_d(Z)^\theta dG(Z)$, where $k(Z)$ was derived in (12). Substituting for the allocation of organizational capital we obtain

$$S^X(K,\lambda) = \sigma AK^\theta B^{-\theta}\rho\left[(1+\rho)^{\frac{\theta}{1-\theta}}\int_{z_X}^{z_M} Z^{\frac{\sigma-1}{1-\theta}}dG(Z)\right].$$

Integrating using the Pareto distribution yields

$$S^X(K,\lambda) = \frac{a\sigma\rho}{a-1}AK^\theta\left(\frac{K}{B(\Phi,\lambda)}\right)^\theta(1+\rho)^{\frac{\theta}{1-\theta}}\left[(z_X)^{\frac{\sigma-1}{1-\theta}-\kappa} - (z_M)^{\frac{\sigma-1}{1-\theta}-\kappa}\right].$$

Applying the appropriate cutoff conditions (18) and (19), we obtain

$$S^X(K,\lambda) = \frac{a\sigma(1-\theta)^{a-1}\rho}{a-1}\left(AK^\theta B^{-\theta}\right)^a(1+\rho)^{\frac{\theta}{1-\theta}}\left[\left(\frac{F^x}{\Delta}\right)^{1-a} - \left(\frac{F^I}{\lambda^{-\frac{\theta}{1-\theta}} - \Delta}\right)^{1-a}\right]$$

Finally, substitute for B using (20) to arrive at the equation in the text.

7.1.3 Local Affiliate Sales

The definition of aggregate multinational sales is $S^M(K,\lambda) = \sigma A\int_{z_M}^{\infty} Z^{\sigma-1}\left(\frac{k_f(Z)}{\lambda}\right)^\theta dG(Z)$ where $k(Z)$ was derived in (12). Following the same steps as above we obtain

$$S^M(K,\lambda) = \sigma\left(AK^\theta\right)^{\frac{a}{1-\theta+a\theta}}\lambda^{-\frac{\theta}{1-\theta}}\frac{\Psi\left(\frac{\lambda^{-\frac{\theta}{1-\theta}}-\Delta}{F^I}\right)^{a-1}}{[\Theta(\lambda)]^{\frac{a\theta}{1-\theta+a\theta}}}$$

7.2 Proof of Proposition 3

Setting $\theta = 0$, the expression for domestic sales (22) simplifies to

$$S^D(a) = \frac{\sigma a}{a-1} (A)^a F^{1-a},$$

where we have written sales as a function of a because we have put all firm heterogeneity into this variable. Note that a decrease in a is associated with an increase in dispersion across goods within an industry. Taking the logarithms of this expression we obtain

$$\log S^D(a) = \log \sigma + \log(a) - \log(a-1) + a \log(A) + (1-a) \log F$$

Now differentiating, we obtain

$$\frac{dS^D(a)}{da} = -\frac{1}{a(a-1)} - \log\left(\frac{F}{A}\right)$$

Because $z_D = \left(\frac{F}{A}\right)^{\frac{1}{\sigma-1}} \geq 1$ we have $dS^D(a)/da < 0$. So an increase in dispersion must raise local sales.

7.3 Free Entry Condition Derivation

From (15) profits are defined as

$$\pi = AK^\theta B^{1-\theta} - (1 - G(z_D))F - (1 - G(z_M))F^m - (G(z_m) - G(z_x))F^x$$

Substitute for the Pareto Distribution to obtain

$$\pi = AK^\theta B^{1-\theta} - (z_D)^{-\kappa} F - (z_X)^{-\kappa} F^x - (z_M)^{-\kappa} F^I$$

Substitute for the cutoffs using (17)-(19) to obtain

$$\pi = AK^\theta B^{1-\theta} - \left((1-\theta)AK^\theta B^{-\theta}\right)^a \Theta(\lambda)$$

Using the definition of B, solving for $\Theta(\lambda)$, and substituting the resultant expression, this can be simplified to

$$\pi = \frac{1 + \theta(a-1)}{a} AK^\theta B^{1-\theta}.$$

Now, substitute for B and simplify to obtain

$$\pi = \frac{1 + \theta(a-1)}{a} \widetilde{A} K^{\frac{a\theta}{1-\theta+a\theta}} \Theta(\lambda)^{\frac{1-\theta}{1-\theta+a\theta}}.$$

Combining these (15) and (29), we obtain

$$\frac{1+\theta(a-1)}{a}\widetilde{A}\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(\lambda)\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,\lambda)dKd\lambda - F^{E} = 0.$$

As our model delivers no extensive margin across firms by abstracting from on-going corporate fixed costs, this parameter never changes in any comparative statics.

7.4 Proof of Proposition 5

The least productive good produced by a firm is given by equation (17). Let a prime denote the value of a variable after a reduction in an international friction. We have

$$\frac{z_D'}{z_D} = \left(\frac{A}{A'}\left(\frac{B'}{B}\right)^{\theta}\right)^{\frac{1-\theta}{\sigma-1}}$$

Neither trade or MP friction enters this expression, so all the effects work through the endogenous variables $AB^{-\theta}$. Using the definition of B given by (20) we find

$$\frac{z_D'}{z_D} = \left(\left(\frac{A}{A'}\right)^{\frac{1}{1-\theta+a\theta}}\left(\frac{\Theta(\lambda)'}{\Theta(\lambda)}\right)^{\frac{\theta}{1-\theta+a\theta}}\right)^{\frac{1-\theta}{\sigma-1}}$$

Note that if this variable falls with a reduction in international frictions, then the cutoff rises as we now show. Let primed variables be the values after a trade or MP liberalization. It is immediate from our parameter restrictions that $\Theta(\lambda)' > \Theta(\lambda)$ for all firms. Using the free entry condition (29), we obtain

$$A^{\frac{1}{1-\theta+a\theta}} = \left(\frac{F^{E}}{\frac{1+\theta(a-1)}{a}\left(\frac{a(1-\theta)^{a-1}}{a-1}\right)^{\frac{1-\theta}{1-\theta+a\theta}}\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(l)\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,l)dKdl}\right)^{\frac{1}{a}}.$$

Hence, we have

$$\left(\frac{A'}{A}\right)^{\frac{1}{1-\theta+a\theta}} = \left(\frac{\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(l)\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,l)dKdl}{\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(l)'\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,l)dKdl}\right)^{\frac{1}{a}} < 1$$

So either type of liberalization lowers the mark-up adjusted demand level. Thus, we have

$$\frac{z_D'}{z_D} = \left(\left(\frac{\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(l)'\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,l)dKdl}{\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(l)\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,l)dKdl}\right)^{\frac{1}{a}}\left(\frac{\Theta(\lambda)'}{\Theta(\lambda)}\right)^{\frac{\theta}{1-\theta+a\theta}}\right)^{\frac{1-\theta}{\sigma-1}} > 1$$

The cutoff for operating a good for all firms must rise.

7.5 Proof of Lemma 1

Consider the ratio of cutoffs z_M/z_D. Using the cutoff definitions (17) and (19), we have

$$\frac{z_M}{z_D} = \left(\frac{F_I}{F} \frac{1}{\lambda^{-\frac{\theta}{1-\theta}} - \Delta} \right)^{\frac{1-\theta}{\sigma-1}} .$$

An increase in trade freeness raises Δ directly, and by proposition 5 raises z_D thus at least some goods that were previous produced in both locations (and thus not exported) become exported.

7.6 Proof of Proposition 6

For a small change in the freeness of trade there are two types of goods that could switch from not being exported to being exported. First there are goods that were not sold abroad at all (Z near z_M). Second, there are goods that were sold abroad through a multinational affiliate (see Lemma 1) whose production is rationalized with an increase in the freeness of trade. Let a prime indicate the value of a variable after a change, the change in organizational capital allocated to that plant is

$$\frac{k(Z)'}{k(Z)} = \frac{B}{B'} (1 + \rho')^{\frac{1}{1-\theta}} .$$

There are two possibilities. First, B falls. In this case, the organizational capital allocated to all remaining plants must rise including those that are exported. Second, B might rise so that $B/B' < 1$. In this case, equations (12) shows that all goods that are not exported must have less organizational capital allocated to them. The change in $k(Z)$ for an incumbent exporter is

$$\frac{k(Z)'}{k(Z)} = \frac{B}{B'} \left(\frac{1 + \rho'}{1 + \rho} \right)^{\frac{1}{1-\theta}} ,$$

which is strictly less than for a good that has switched from non-exporting to exporting. Hence, as some goods must receive more organizational capital, the resource allocation constraint binds and so the productivity of switchers must rise.

7.7 Proof of Proposition 7

The firm-level variable B plays a key role in the productivity effects of any economic shock. We start by differentiating (20) to obtain

$$\frac{1}{B}\frac{dB}{\partial\rho} = \frac{1}{1+\theta(a-1)}\left[(a-1)\frac{dA}{A} + \eta(\lambda)\right].$$

where

$$\eta(\lambda) \equiv \frac{\partial\Theta(\lambda)}{\partial\rho}\frac{1}{\Theta(\lambda)} = \frac{\frac{a}{1-\theta}(1+\rho)^{\frac{\theta}{1-\theta}}\left(\left(\frac{F^x}{\Delta}\right)^{1-a} - \left(\frac{F^I}{\lambda^{-\frac{\theta}{1-\theta}}-\Delta}\right)^{1-a}\right)}{F^{1-a} + \Delta^a\left(F^x\right)^{1-a} + \left(\lambda^{-\frac{\theta}{1-\theta}} - \Delta\right)^a\left(F^I\right)^{1-a}} > 0.$$

Next, totally differentiate the zero profit condition (29) to obtain

$$\frac{dA}{A} = -\frac{1-\theta}{a}\int\int w(K,\lambda')\eta(\lambda')d\lambda' dK < 0$$

where

$$w(K,\lambda) = \frac{K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(\lambda')\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,\lambda')}{\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(\lambda'')\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,\lambda'')dK d\lambda''}.$$

A reduction in trade costs must increase entry and so make the mark-up adjusted demand level fall and the magnitude of this fall is proportional to a weighted average of percent change in the cost index $\Theta(\lambda)$ across firms. Combining expressions, we obtain

$$\frac{dB}{Bd\rho} = \frac{1}{1+\theta(a-1)}\left[\eta(\lambda) - \frac{(a-1)(1-\theta)}{a}\int\int w(K,\lambda')\eta(\lambda')d\lambda' dK\right]$$

From this expression we note two things. First, $\frac{(a-1)(1-\theta)}{a} < 1$ and second because $\partial\eta(\lambda)/\partial\lambda > 0$ there must exist a $\widehat{\lambda} < \overline{\lambda}$ such that for all $\lambda > \widehat{\lambda}$, $dB/d\rho > 0$ and for $\lambda < \widehat{\lambda}$, $dB/d\rho < 0$, and it may be that $\widehat{\lambda} < 1$ in which case $dB/d\rho > 0$ for all firms. For the firms with λ above this cutoff, the productivity of non-export goods will fall.

7.8 Proof of Proposition 8

The firm-level variable B plays a key role in the productivity effects of any economic shock. We start by differentiating (20) to obtain

$$\frac{dB}{d\rho B} = \frac{1}{1+\theta(a-1)}\left[(a-1)\frac{dA}{A} + \frac{\partial\Theta(\lambda)}{\partial F^I}\frac{1}{\Theta(\lambda)}\right].$$

where

$$\frac{\partial \Theta(\lambda)}{\partial F^I}\frac{1}{\Theta(\lambda)} = \frac{(1-a)\left(\frac{\lambda^{-\frac{\theta}{1-\theta}}-\Delta}{F^I}\right)^a}{F^{1-a}+\Delta^a\left(F^x\right)^{1-a}+\left(\lambda^{-\frac{\theta}{1-\theta}}-\Delta\right)^a\left(F^I\right)^{1-a}} < 0.$$

Next, totally differentiate the zero profit condition (29) to obtain

$$\frac{dA}{A} = -\frac{1-\theta}{a}\int\int w(K,\lambda')\frac{\partial \Theta(\lambda')}{\partial F^I}\frac{1}{\Theta(\lambda')}d\lambda' dK > 0$$

where

$$w(K,\lambda) = \frac{K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(\lambda')\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,\lambda')}{\int\int K^{\frac{a\theta}{1-\theta+a\theta}}\left[\Theta(\lambda'')\right]^{\frac{1-\theta}{1-\theta+a\theta}}h(K,\lambda'')dKd\lambda''}.$$

An increase in F^I must reduce and so make the mark-up adjusted demand level fall and the magnitude of this fall is proportional to a weighted average of percent change in the cost index $\Theta(\lambda)$ across firms. Combining expressions, we obtain

$$\frac{dB}{BdF^I} = \frac{1}{1+\theta(a-1)}\left[\frac{\partial \Theta(\lambda)}{\partial F^I}\frac{1}{\Theta(\lambda)} - \frac{(a-1)(1-\theta)}{a}\int\int w(K,\lambda')\frac{\partial \Theta(\lambda')}{\partial F^I}\frac{1}{\Theta(\lambda')}d\lambda' dK\right]$$

From this expression we note two things. First, $\frac{(a-1)(1-\theta)}{a} < 1$ and second because $\partial\left[\frac{\partial\Theta(\lambda)}{\partial F^I}\frac{1}{\Theta(\lambda)}\right]/\partial\lambda < 0$ there must exist a $\widetilde{\lambda} < \overline{\lambda}$ such that for all $\lambda > \widetilde{\lambda}$, $dB/dF^I < 0$ and for $\lambda < \widetilde{\lambda}$, $dB/dF^I > 0$, and it may be that $\widetilde{\lambda} < 1$ in which case $dB/dF^I > 0$ for all firms. Our result follows as we consider a decrease in F^I.

Table 1: Descriptive Statistics

	Number of Observations	Average	Standard Deviation
Parent US Sales	725	$1.7 billion	$620 million
Parent Number of Product lines	725	2.7	2
Parent Concentration	725	0.71	0.29
Parent Exports	8,244	$2.4 million	$19 million
Affiliate Sales	2,579	$96.5 million	$443 million
Share of Affiliate Sales in Total Sales*	2,579	0.77	0.53

Notes: Data are levels.
* indicates that average is conditional on Affiliate Sales observed.

Table 2: Foreign Market Activity and the Domestic Operations of Multinational Firms

	Local Affiliate Sales	Parent Exports	Share of Affiliate Sales in total	Local Affiliate Sales	Parent Exports	Share of Affiliate Sales in total
Parent Dom. Sales	0.58 (0.03)	0.46 (0.03)	-0.07 (0.01)	0.57 (0.03)	0.47 (0.03)	-0.052 (0.01)
GDP	0.57 (0.04)	0.31 (0.02)	0.01 (0.01)			
GDPPC	0.08 (0.07)	0.18 (0.03)	-0.06 (0.02)			
DIST	-0.20 (0.03)	-0.37 (0.02)	0.08 (0.02)			
LANG	0.13 (0.07)	0.19 (0.04)	0.03 (0.02)			
Fixed Effects by Country?	No	No	No	Yes	Yes	Yes
N R-sq	2,579 0.38	8,244 0.25	2,579 0.03	2,579 0.42	8,244 0.30	2,579 0.61

Notes: All variables (except language) are in logarithms. Standard errors (shown in parentheses) are robust to heteroskedascity and clustered by firm. Column headings indicate the dependent variable.

Table 3: Scale versus Scope and the Within Firm Composition of Commerce

Dependent Variable: logarithm of affiliate sales in exports plus affiliate sales

Scale	-0.03 (0.01)	-0.05 (0.02)	-0.03 (0.01)	
Scope	-0.12 (0.02)	-0.12 (0.02)	0.04 (0.05)	
Parent Dom. Sales				-0.05 (0.01)
Herfindahl			0.24 (0.08)	0.15 (0.04)
R&D intensity		-0.01 (0.02)	-0.02 (0.02)	0.01 (0.03)
Capital Intensity		0.05 (0.02)	0.03 (0.02)	0.01 (0.03)
N R-sq	2586 0.09	2468 0.09	2468 0.10	2468 0.16

Notes. All specifications include country fixed effects. All variables in logarithms. All standard errors (shown in parentheses) are robust to heteroskedasticity and clustered by firm.