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Internationalization Strategies of Multi-Product Firms: The Role of Technology

Abstract

High-performance firms typically have two features in common: i) they produce in more than one country and ii) they produce more than one product. In this paper, we analyze the internationalization strategies of multi-product firms. Guided by several new stylized facts, we develop a theoretical model to determine optimal modes of market access at the firm-product level. We find that the most productive firms sell core varieties via foreign direct investment (FDI) and export products with intermediate productivity. Shocks to trade costs and technology affect the endogenous decision to export or produce abroad at the product-level and, in turn, the relative productivity between parents and affiliates.

JEL-Codes: F120, F230, L250, L110.

Keywords: multi-product firms, FDI, exports, flexible manufacturing.

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1 Introduction

In international economics, one striking pattern emerges: internationalisation is for the few.[1] Many empirical studies show that international activity is concentrated in a small share of very large firms. These companies successfully compete in international markets because they are the most productive firms, spend most on R&D activities, and have the highest skilled workforce for whom they pay the highest wages. Among other characteristics, these high-performance firms typically have two features in common. First, they are multinationals, running affiliates in many countries around the world.[2] Second, these firms produce multiple products and contribute to a large extent to the product variety in the world economy.[3] The similarities between the documented stylized facts on multinationals on the one hand, and multi-product firms on the other hand, are striking, yet only few studies have analyzed multinational multi-product firms in a unified framework so far.[4]

In this paper, we analyze the internationalization strategies of multi-product firms at the firm-product level. We first present several stylized facts, making use of both representative Spanish firm-level data and very detailed firm-product-destination data of car producers that were recently used and made available by Head and Mayer (2019a,b). In particular, we show that the most productive firms choose both strategies, exporting and foreign direct investment (FDI), to serve foreign markets. As the evidence based on the car data confirms, this is true even for one and the same destination. In particular, car producers tend to use different market access modes for different products (i.e., car models). Guided by these stylized facts, we develop a theoretical model to determine optimal modes of market access at the firm-product level. In doing so, we focus on the role of a firm's production technology for the optimal mode of serving consumers. Firms are characterized by a flexible manufacturing technology and may decide on the optimal mode of internationalization for each of their products. As firms produce multiple varieties with heterogeneous productivities, differential strategies will be optimal for the various products. In particular, we ask the following questions: Which goods are productive enough to be sold on foreign markets? Where are those goods produced: abroad via horizontal foreign direct investment or at home, to be exported to the

[1] See, for instance, the respective chapter on European firms in Mayer and Ottaviano (2008).

[2] See, e.g., the recent surveys on multinationals by Yeaple (2013a) and Antràs and Yeaple (2014).

[3] For empirical evidence on the dominance of multi-product firms, see, e.g., Bernard et al. (2007), Bernard et al. (2009), Bernard et al. (2010, 2011), Broda and Weinstein (2010), Goldberg et al. (2010).

[4] Important exemptions from this are Baldwin and Ottaviano (2001), Yeaple (2013b), Tintelnot (2017), and Head and Mayer (2019a), which are discussed in greater detail below.

foreign market? What is the role of globalization and technology shocks in these decisions? And, finally, how do such shocks affect the relative plant-level productivities of parents versus affiliates in multinational firms?

Following the standard literature, firms choose to produce a given product abroad, if their gain from avoiding trade costs offsets their greater fixed cost of production (proximity-concentration trade-off).[5] The relative size of the gain depends importantly on the market share of the firm's product. In analogy to Helpman et al. (2004), the most productive firms choose multinational production to serve foreign consumers, however, they do not do so for their entire product range. In contrast to most existing models on the proximity-concentration trade-off, we allow for a second source of heterogeneity that affects a product's market share. Besides between-firm heterogeneity à la Melitz (2003), we introduce within-firm heterogeneity between products. Following Eckel and Neary (2010), firms operate with a flexible manufacturing technology such that the marginal cost of a product is increasing in its distance from the firm's core competence. Firms may endogenously decide on the range of products being produced, and the rank of a product within the portfolio of a firm will determine the optimal way of serving consumers abroad. We find that core products are sold via FDI, while products of an intermediate productivity are exported. As a direct consequence of that, foreign affiliates show a higher level of productivity at the plant-level compared to their parent firms.[6] This result differs importantly from a model with single-product firms, as in Helpman et al. (2004), where affiliate and parent firms have the same productivity. The reason behind this difference is that, in our case, the foreign plant only produces a subset of the products that are produced in the parent plant. Since FDI is only profitable for core varieties, plant-level productivity is higher in the foreign affiliate. In our model, also differently from Helpman et al. (2004), the most productive firms rely on both strategies, that is they both export and invest abroad, in line with the empirical evidence described above.

Having established the endogenous choice of the different modes of market entry at the product-level, we further investigate the role of technology in the internationalization decision. In particular, we analyze the impact of production flexibility on the relative sales in different modes at the firm level. For example, it could be that some firms operate a more flexible technology, where the

[5]See, for example, Horstmann and Markusen (1992), Brainard (1993, 1997), Markusen and Venables (2000), Markusen and Maskus (2002), Helpman et al. (2004).

[6]See Doms and Jensen (1998) on the U.S. and Girma et al. (2002) on the U.K. for corresponding evidence.

introduction of new varieties is associated with a lower increase in marginal costs. The flexibility of technology might also vary across industries. We find that more flexible firms have greater domestic sales as well as greater sales in both exports and FDI. Moreover, an increase in production flexibility increases the share of export sales for multinationals, whereas the opposite is true for firms that export but do not engage in FDI.[7] In these firms, greater flexibility decreases the share of export sales. The reason behind this result is that, as flexibility increases, firms skew their sales away from their best-performing products, that is products sold via FDI (exports) in the case of firms with high (medium) productivity.

As a direct implication of our analysis, we find that any shock (such as globalization, or technology) that affects the endogenous FDI/export decision changes the productivities of both affiliate and parent firms. Moreover, these shocks also determine whether profits of the most profitable core varieties are recorded at home (in case of exports) or abroad (in case of FDI). This is crucial from a policy perspective, as it defines the location where corporate taxes have to be paid. In addition, it determines the extent to which home workers or foreign workers are involved in production.

Our paper is related to two broad strands of the recent literature in international economics. First, it contributes to the literature on multi-product firms, which has been rapidly increasing in the past few years due to the availability of detailed product-level data.[8] Based on novel stylized facts from empirical work, a growing number of theoretical contributions implement the analysis of multi-product firms in existing models of international trade (see, for example, Feenstra and Ma, 2008, Bernard et al., 2010, 2011, Eckel and Neary, 2010, Dhingra, 2013, Qiu and Zhou, 2013, Yeaple, 2013a, Mayer et al., 2014, Nocke and Yeaple, 2014, Flach and Irlacher, 2018, and Arkolakis et al., 2020). They typically investigate the product scope within multi-product firms (intra-firm extensive margin) as an important margin of adjustment to changes in market conditions. In contrast to our paper, their focus is mainly on the effect of trade liberalization on export scope, whereas the role of FDI is not included in the analysis.

Second, our paper contributes to the literature that analyses firm's optimal mode of foreign

[7]These findings fit remarkably well with empirical evidence on U.S. multinationals first pointed out by Yeaple (2013b).

[8]A number of empirical contributions document the dominance of large multi-product firms in international markets (see, for example, Bernard et al., 2007, Bernard et al., 2009, Bernard et al., 2010, 2011, Broda and Weinstein, 2010, and Goldberg et al., 2010). Moreover, Bernard et al. (2010) and Broda and Weinstein (2010) show that most product creation and destruction happens within existing firms, which has important potential implications for aggregate product scope and welfare.

market access, distinguishing between multinational production and exporting as two different choices based on the so-called proximity-concentration trade-off (see, for example, Horstmann and Markusen, 1992, Brainard, 1993, 1997, Markusen and Venables, 2000, Markusen and Maskus, 2002, Helpman et al., 2004). In particular, similar to Helpman et al. (2004), we focus on the role of firm heterogeneity for individual market access strategies and the resulting pattern of aggregate international production and trade. However, we extend Helpman et al. (2004), who focus on single-product firms, in allowing for firms to produce more than one product. In this framework, we can analyze optimal product scope together with optimal market access at the firm-product level. Importantly, we distinguish between two different sources of heterogeneity: between-firm heterogeneity in (core) productivity and within-firm heterogeneity across products.

Our paper is most closely related to papers that combine the two strands of the literature discussed above. In an early contribution, Baldwin and Ottaviano (2001) build a model in an oligopolistic setting where multi-product firms reduce inter-variety competition (i.e. cannibalization) by relocating some varieties abroad. The driving force in their model is similar to the reciprocal dumping model in Brander and Krugman (1983) and fundamentally different to the logic in our analysis. Yeaple (2013b) provides an interesting set of novel stylized facts on multinational multi-product firms consistent with our predictions. However, in contrast to our model, his focus is not on production flexibility, but on managerial expertise as a scarce resource that has to be subdivided across products in different locations. Firms differ both in their endowments of managerial expertise and in their efficiency of transferring this expertise to foreign affiliates. The analysis investigates how these two sources of managerial heterogeneity affect the product range as well as the exports/FDI mix of multi-product firms. Tintelnot (2017) investigates the determinants of the location and production of multinational firms when foreign affiliates of multinationals may serve as export platforms. Head and Mayer (2019a) consider a model of multinational production in the car industry that accounts for the multi-product nature of car producers. Their framework allows for adjustments at the firm-product extensive margin in response to trade policy changes. Using French firm-product level data, Bricongne et al. (2019) analyze whether FDI and exports are complements or substitutes. They find that firms that do FDI export more, confirming the predominant result in the literature. However, consistent with our model, they also find that this is not true for core products, in particular for the most productive firms in countries with strong demand.

The structure of the remainder of this paper is as follows. In Section 2, we provide an empirical motivation for our subsequent analysis. In Section 3, we describe our theoretical model and derive our main results. Section 4 concludes.

2 Empirical motivation

To motivate our theoretical framework, we draw on a number of stylized facts. In the following, we first describe the relationship between firm productivity and the modes of serving foreign markets, making use of Spanish firm-level data. The drawback of these data is that they lack a product (and a highly disaggregated destination market) dimension. In a next step, we therefore make use of rich data for the car industry to describe more precisely the internationalization strategies of multi-product firms.

2.1 The link between firm productivity and the modes of serving foreign markets

We use the Spanish Encuesta sobre Estrategias Empresariales (ESEE), a representative sample of Spanish manufacturing firms with more than 10 employees.[9] The data set contains information on both export and FDI activities of firms. We are interested in the relationship between firm productivity and the mode of serving foreign markets. In Figure 1, (labor) productivity is measured as value added per hour worked by employees. Based on this measure, firms are grouped into deciles, normalized by industry and year. That is, we explore variation across firms within the same industry-year combination.

The graph shows that the composition of firms by mode of access changes along the productivity distribution. The share of firms engaged in only exporting increases steadily up to the 7th productivity decile and levels off thereafter. In contrast, hardly any firms are engaged in FDI in the bottom half of the productivity distribution, but the share rises steadily thereafter. Importantly, the entire increase is driven by firms doing both exports and FDI, while the share of firms with only

[9] It is a panel data set, which runs since 1990 and has a high response rate among repeatedly interviewed firms. Between 1,500 and 2,000 firms are interviewed each year. For the purpose of our data exploration, we make use of the waves of the years 2002, 2006, 2010, and 2014. Among others, these data have been used by Guadalupe et al. (2012), Garicano and Steinwender (2016), as well as Koch and Smolka (2019).

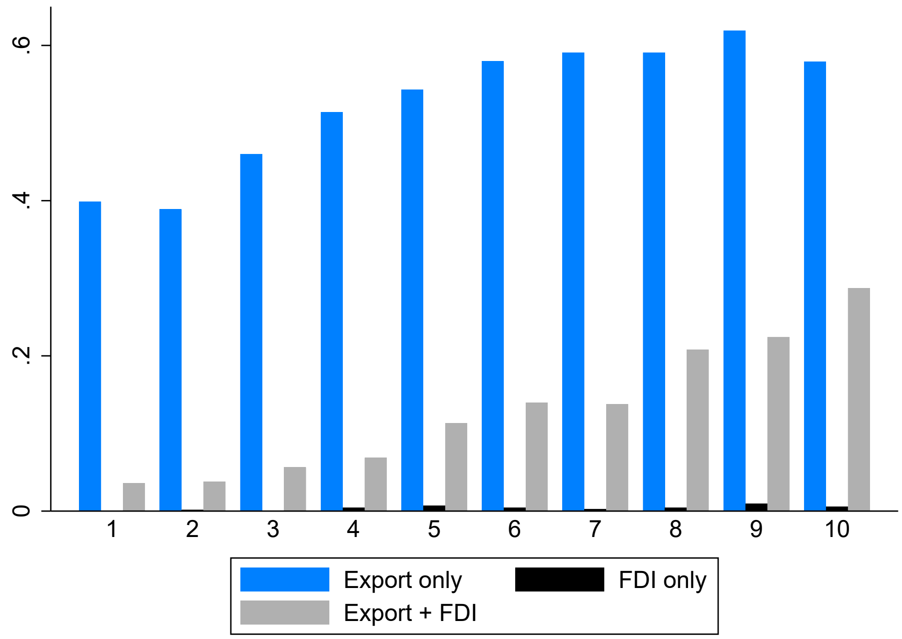

Figure 1: Share of firms doing exports and/or FDI across productivity deciles

FDI (and no exports) is extremely low along the entire distribution.

Stylized facts I (at the firm level) *Relating firm productivity to the differential modes of serving foreign markets, we find the following facts:*

I.1 the share of firms engaged in only exporting increases steadily up to the 7th productivity decile and levels off thereafter,

I.2 the share of firms that rely on both exports and FDI strictly increases in productivity,

I.3 the share of firms that only rely on FDI is close to zero across all deciles.

While the first fact above is consistent with the standard model of Helpman et al. (2004), the remaining two are not.[10] A number of studies analyze the relationship between exports and FDI at the firm level. For US firms, Lipsey and Weiss (1984) and Desai et al. (2005) show that increased

[10]They could, however, be reconciled with a multi-country version of Helpman et al. (2004), where the proximity-concentration tradeoff arises for each destination. Firms might therefore export to some destinations and conduct FDI in others. To explore this possibility, we have redone Figure 1 at the firm-destination level, which yields a very similar pattern (see Appendix B.1). Unfortunately, the Spanish ESEE data only allow us to distinguish four broad destination regions: EU, Latin America, OECD (outside EU), and rest of the world. We therefore cite additional firm-destination level evidence below.

production in foreign affiliates is related to larger parent exports. Similarly, Lipsey et al. (2000) and Head and Ries (2001) find a positive correlation between exports and foreign production for Japanese firms. These studies indicate that firms may rely on both strategies in serving a particular region or country.[11] There are several possible reasons. First, foreign production may promote the exports of intermediate goods in firms that are vertically integrated.[12] Second, firms may serve a given foreign market via FDI at one point in time and via exports at another (see, e.g., the dynamic models of Rob and Vettas, 2003, Conconi et al., 2016, and Gumpert et al., 2020). Third, firms may produce some products abroad and export others (Yeaple, 2013a). The latter fits well with evidence at the product level, where exports and FDI have been shown to constitute substitutes rather than complements (see, e.g., Blonigen, 2001, Swenson, 2004, Bricongne et al., 2019).

Clearly, Figure 1 does not allow us to distinguish between these reasons. To motivate our multi-product perspective further, we make use of very rich data about export and FDI activities at the firm-product-country-of-destination level in a specific industry: the car industry.

2.2 Internationalization strategies of multi-product car producers

We use detailed data about the origin-destination flows of car producers, which were collected by the automotive industry consultancy IHS Markit and recently used in Head and Mayer (2019a). We make use of the anonymized replication data kindly provided by the authors (Head and Mayer, 2019b) to reproduce and augment some of the stylized facts presented in their paper. The data set contains yearly information about the country of assembly and the country of sale at the level of *brands* and *models*, which Head and Mayer (2019a) link to the theoretical concepts of *firms* and *varieties*, respectively.[13] The final replication sample contains information on 93 brands and 76 destination markets over the time period 2000–2016.[14]

We first reproduce a striking pattern already exposed in Head and Mayer (2019a): 98% of models sold in a given year in a given destination market are sourced from a single country of

[11] Lipsey et al. (2000) control for the region of destination. Gumpert et al. (2020), referred to below, document the coexistence of FDI and exports in Norwegian firms at the firm-country-of-destination-year level.

[12] Head and Ries (2001) find some evidence for this.

[13] We associate brands with firms and models with products in our theoretical framework. In the following, however, we stick to the terms brands and models to avoid confusion.

[14] In the replication data, brands, models, countries, and years have been anonymized. Also, it is not possible to link models of brands across different markets and years.

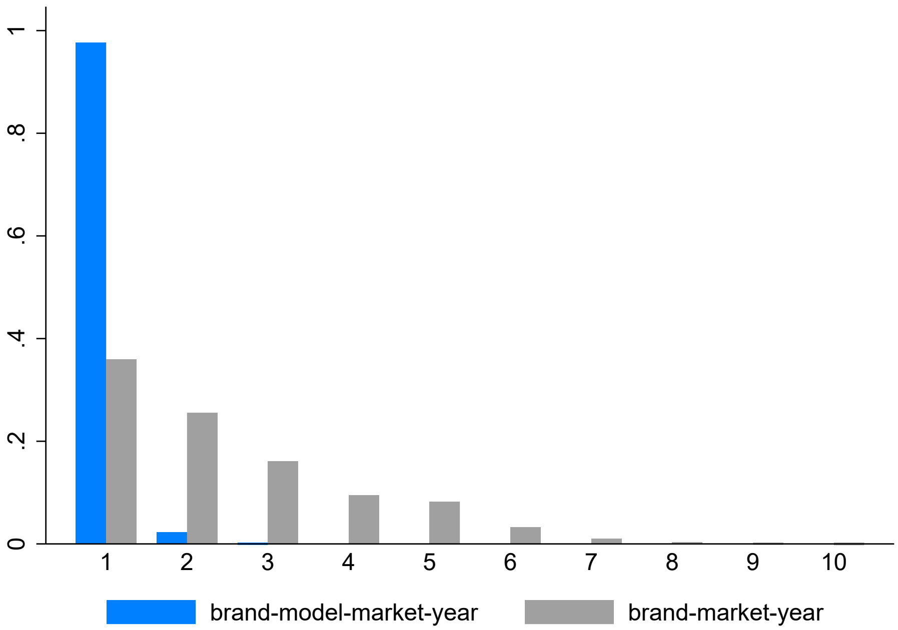

Figure 2: Frequency distribution of the number of sourcing locations

assembly (Figure 2). Thus, for each model, producers almost always choose a unique mode of accessing a particular destination market. However, the pattern looks different if we focus on the brand-destination-year level, i.e. if we aggregate across models sold by the same brand. Now, only 36% of destination markets are served from a single country of origin. Instead, the distribution is much more right-skewed, the median number being 2 and the mean 2.4. Thus, the combined evidence in Figure 2 suggests that, for a given year and a given destination market, brands tend to choose different sourcing locations for different models.

For our purposes, it is useful to distinguish between three types of assembly locations that are connected to different market access modes: (i) in the home country of the headquarter; (ii) in the destination country; (iii) in a third country. From the perspective of the headquarter, (i) constitutes exporting, (ii) pure horizontal FDI, and (iii) export-platform FDI. In the following, to reduce complexity further and in line with our simplified two-country theoretical framework, we combine export-platform FDI and pure horizontal FDI into one combined FDI category. In doing so, we assume that both strategies (typically) imply greater proximity to the destination market, but less concentration of production at the headquarter. Table 1 shows how car producers combine different

Table 1: Modes of foreign market access at the brand-destination-year level

	Share of obs	Share of models served via FDI	
		Mean	Std. dev.
Export only	0.31	0.00	0.00
FDI only	0.09	1.00	0.00
Export + FDI	0.61	0.43	0.21
Total	1.00	0.35	0.33

Notes: The table shows foreign market access modes from the perspective of the brand's headquarter location, conditional on serving the foreign market. Pure horizontal FDI (assembly location in the destination market) and export-platform FDI (assembly location in a third country) are grouped into one combined FDI category. Exporting is implied by the assembly location being at the brand's headquarter location.

internationalization strategies to serve a given destination market in a given year. 31% of all brand-destination-year observations feature only exporting, 9% only FDI, and 61% both exporting and FDI (excluding the home market of the headquarter).[15] On average, 35% of the models sold by a particular brand in a particular market and year are served via FDI and 65% are exported.[16] However, there is substantial variation in the share of models served via FDI (standard deviation of 33%-points). To get a better sense of the sources of this variation, we decompose the variance into a between and within component along two different dimensions (Table 2). Panel A shows that only 42% of the variance is between origin-destination-years and 58% is within origin-destination-years (i.e. between brands headquartered in the same country of origin that sell to the same destination in the same year). Thus, brand heterogeneity is important. On the other hand, it is also the case that a non-negligible share of 36% of the variance is within brand-years (i.e. across destinations served by the same brand; see Panel B). In sum, we derive the following additional stylized facts.

Stylized facts II (at the firm-product-destination level)

II.1 For each model (i.e. product), car producers tend to choose a unique mode of accessing a particular destination market.

[15] In contrast to the evidence presented above based on the Spanish ESEE data, now the shares sum to 100%, as we condition on serving the foreign market.

[16] Coşar et al. (2018) is another paper that studies the automobile industry using a worldwide dataset containing the assembly plant locations of 598 car models. They find that 43% of the models are assembled in more than one country and account for 64% of total revenue. This indicates that, in line with our theoretical predictions, foreign assembly takes place in particular for core varieties within the firm.

Table 2: Variance decomposition of the share of models served via FDI at the brand-destination-year level

	Variance	Share of total (in %)
Total	0.106	100
Panel A		
Between origin-destination-years	0.045	42.2
Within origin-destination-years	0.061	57.8
Panel B		
Between brand-years	0.068	64.0
Within brand-years	0.038	36.0

Notes: The table reports the results of two separate within- and between-group decompositions. Data include: 93 brands; 21 headquarter locations (i.e. origins), 76 destinations; 15 years. In total, there are 11,234 origin-destination-years and 927 brand-years, respectively, and the number of observations is 37,732.

II.2 For a given destination market, car producers use different market access modes for different models.

II.3 There is considerable variation in the share of models served via FDI:

- *within country pairs, across producers,*
- *within producers, across different destination markets.*

In the following, we build on these stylized facts and develop a model to determine optimal modes of market access at the firm-product level. We find that the most productive firms sell their most productive products via FDI, and the products with intermediate productivity via exports. Firms with medium productivity sell their most productive products via exports. They do not engage in FDI. Firms with low productivity sell only at home. Our findings are consistent with the stylized facts above and provide a novel explanation for the relative importance of exports and FDI, as well as the relative performance of parent firms and affiliates.

3 The model

We extend the model of Helpman et al. (2004) to explain how heterogeneous multi-product firms choose to enter foreign markets, and to explore the role of production technology in these decisions.

As in the standard model, there is heterogeneity in the productivity between firms. In addition, there is heterogeneity in the productivity between products within firms due to flexible manufacturing à la Eckel and Neary (2010). As a result, the model features two sources of firm heterogeneity: first, in absolute core productivity (between-firm heterogeneity) and, second, within-firm heterogeneity between products due to flexible manufacturing. Firms decide whether to enter the market or not, how many goods to produce, where to supply these goods, and whether to serve a foreign market via exports or FDI.[17] Importantly, the last two decisions are made at the product level. We find that there is firm dispersion in total sales, in product scope (the number of products sold domestically and abroad via exports or FDI), and in the decision of whether to supply a given product to a foreign market via exports or FDI (or not at all). In particular, in line with our empirical motivation, we find that the most productive firms choose to serve foreign markets through both FDI and exports.

3.1 Consumers

We consider a world of two symmetric countries i and j. Both countries use labor to produce goods in $M+1$ sectors. We take the homogeneous good as the numeraire and assume that both countries always produce it with one unit of labor per unit output. As a result, the wage rate is equal to one in both countries. The remaining M sectors are characterized by monopolistic competition and produce differentiated varieties with a constant elasticity of substitution $\sigma > 1$. Consumers in country j spend a share β_m of their income E_j on goods from sector m and the remaining fraction $1-\sum_{m=1}^{M}\beta_m$ on the outside good. Each country's representative consumer has preferences described by the following utility function:

$$U = \left(1 - \sum_{m=1}^{M} \beta_m\right) logz + \sum_{m}^{M} \beta_m logC_m, \tag{1}$$

$$C_m = \left(\int_{\omega\in\Omega_{ijgm}} (c_{ijgm}(\omega))^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where z is the consumed quantity of the homogeneous good, and $c_{ijgm(\omega)}$ is the quantity of variety ω of product g from sector m produced in country i and consumed in country j.[18] Here,

[17] We abstract from the possibility of exports by foreign affiliates (see also Helpman et al. (2004)).

[18] Sectors are defined such that firms produce all their products within the same sector.

ω indexes varieties of product g supplied from country i to country j and Ω_{ijgm} is the endogenous set of these varieties.[19] Consumers maximize utility subject to the budget constraint $z + \sum_{m=1}^{M} \int_{g=0}^{\infty} \sum_{i=1}^{2} \int_{\omega \in \Omega_{ijgm}} p_{ijgm}(\omega) c_{ijgm}(\omega) d\omega dg \leq E_j$. In the following, we focus on a sector-by-sector analysis and drop the subscript m, as well as the subscripts g, i, and j, unless required. Utility maximization implies that product demand in country j in any particular sector is given by:

$$c_j(\omega) = B_j p_j(\omega)^{-\sigma}, \tag{3}$$

where $B_j = \frac{\beta E_j}{P_j^{1-\sigma}}$ is the demand level, which depends on the price index

$$P_j = \left(\sum_{m=1}^{M} \int_{g=0}^{\infty} \sum_{i=1}^{2} \int_{\omega \in \Omega_{ijgm}} p_{ijgm}(\omega)^{1-\sigma} d\omega dg \right)^{\frac{1}{1-\sigma}}.$$

3.2 Firms

Starting a firm in a differentiated sector requires a fixed cost of entry f_e. Firms are heterogeneous in productivity and draw a firm-specific efficiency parameter $\phi \in [0, \infty]$ from a cumulative distribution function $F(\phi)$ that is the same across countries. After a firm has paid the fixed entry cost, it observes its core productivity, ϕ, and decides whether to exit or remain in the market. In case it remains, it also decides how many products to sell in a given country and – if it decides to sell a given product also in a foreign country – whether to do so via exports or via FDI. Serving the domestic market requires a fixed cost f_d per variety. Serving a foreign market via exports requires a fixed cost f_x and, in addition, for each product that is exported, firms face common (across firms and products) iceberg trade costs, so that $\tau_{ij} > 1$ units must be shipped from country i to country j for one unit to arrive.[20] Firms that serve a foreign market via FDI avoid variable trade costs but have to pay a higher fixed cost f_m. Importantly, in contrast to the fixed market entry cost f_e, the fixed costs f_d, f_x, and f_m are product-specific. We follow Helpman et al. (2004) and assume the following parameter restriction:

Assumption 1 $f_d < \tau^{\sigma-1} f_x < f_m$.

[19] It is assumed here for simplicity that the elasticity of substitution across varieties within products is the same for all products and equal to the elasticity of substitution across products. Moreover, each firm produces at most one variety of product g (see also, e.g., Bernard et al. (2011)).

[20] There are no transport costs for products that are sold domestically ($\tau_{ii} = 1$).

Throughout our analysis, we assume that both fixed as well as variable trade costs are identical for all firms in a given sector but may vary across sectors. This allows us to compare results across sectors with a different cost structure.

3.2.1 Technology

Following Eckel and Neary (2010), we assume that firms operate with a flexible manufacturing technology, such that introducing additional varieties is associated with a lower productivity. Firms produce each product according to a linear production technology using labor with product-specific efficiency ϕ_g. Marginal costs are constant for a given product, but increase in distance from a firm's core competence, such that:

$$\phi_g \equiv \phi/h(g) \quad \text{with} \quad h'(g) > 0,\ h(1) = 1, \tag{4}$$

where goods are ordered in increasing distance from the core competence product.

To derive closed form solutions, we follow Arkolakis et al. (2020) and parameterize the cost function as follows:

$$h(g) = g^{\alpha}, \quad \alpha \in [0, +\infty). \tag{5}$$

The parameter α plays an important role, as it governs the flexibility of the production process. Smaller values of α imply a higher flexibility of production, as marginal costs increase only moderately with distance from a firm‘s core competence. In principle, this parameter could vary between firms such that firms differ in the flexibility of production. In the main part of this paper, we do not need to take a stand on whether α varies between firms within an industry or between industries.[21] In the Appendix, we solve for the general equilibrium and assume that, similarly to the fixed costs of production, the flexibility of production technology is sector-specific (i.e., identical for all firms within a given sector). There, comparative statics with respect to α should be interpreted as comparing results across sectors with different production flexibility.

In analogy to Arkolakis et al. (2020), we define an efficiency index at the plant-level. The average product efficiency of a plant producing a total of G products (not taking into account fixed costs

[21] In Appendix A.1, we provide a model extension that not only allows for heterogeneity in variable production costs but also in per variety fixed costs.

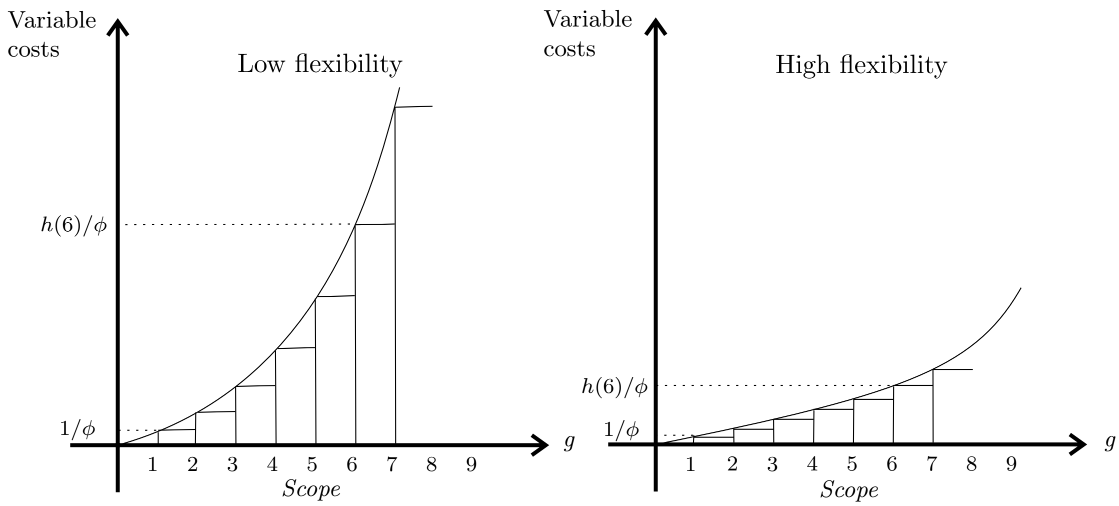

Figure 3: Production flexibility

of production) is given by:

$$H(G) = \left(\sum_{1}^{G} g^{-\alpha(\sigma-1)} \right)^{-\frac{1}{\sigma-1}}. \tag{6}$$

This index decreases in the number of varieties G, and the drop in average efficiency for each additional variety is larger the greater the value of α (see Figure 3). Note that this index converges to one for large values of the technology parameter α or the elasticity of substitution σ, which reflects the the scenario where almost all sales are concentrated in the core variety.

3.2.2 Optimal firm behavior

Each firm chooses product prices to maximize profits under monopolistic competition given consumer demand (3) and productivity $\phi/h(g)$.[22] This results in identical markups $\sigma/(\sigma-1)$ over marginal costs:[23]

$$p_{ii} = \frac{\sigma}{\sigma-1}\frac{g^{\alpha}}{\phi} \quad \text{and} \quad p_{ij} = \frac{\sigma}{\sigma-1}\tau_{ij}\frac{g^{\alpha}}{\phi}. \tag{7}$$

In the next step, we derive per-variety profits for domestic sales, exports as well as FDI sales. Before we do that, it is convenient to define the operating profit of the core product of a firm with

[22]Monopolistic competition implies that the price of each product variety can be chosen independently of the prices of other varieties. That is, there is no strategic interaction, unlike in, e.g., Eckel and Neary (2010).

[23]Optimal prices are derived from the expressions for total firm operating profits by mode of production given in Appendix A.2.

productivity ϕ:

$$\tilde{\pi}(\phi) = A\phi^{\sigma-1}, \tag{8}$$

where $A \equiv \frac{1}{\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1} B$ denotes the mark-up adjusted revenue shifter (identical across the two countries due to the symmetry assumption). Obviously, firms with a higher core productivity ϕ are more profitable in their core variety $g = 1$. Substituting optimal prices into the firm's profit functions, we obtain the respective profits for the different modes of serving a market (domestically or abroad via exports or FDI):

$$\pi_d(g) = \tilde{\pi}(\phi)g^{-\alpha(\sigma-1)} - f_d, \tag{9}$$

$$\pi_x(g) = \tilde{\pi}(\phi)\tau^{1-\sigma}g^{-\alpha(\sigma-1)} - f_x, \tag{10}$$

$$\pi_m(g) = \tilde{\pi}(\phi)g^{-\alpha(\sigma-1)} - f_m. \tag{11}$$

Equations (9)-(11) indicate that in any mode of market entry, per-variety profits decrease in distance from the core competence. This drop in profitability is more pronounced the lower is the flexibility of production (higher values of α).

Productivity cutoffs The profit equations above determine the survival cutoff (ϕ_d^*) as well as the minimum productivities for selling the core product abroad via exports (ϕ_x^*) or FDI (ϕ_m^*). The first two cutoffs are the solutions to $\pi_d(1) = 0$ and $\pi_x(1) = 0$, respectively. The cutoff for FDI is the solution to $\pi_x(1) = \pi_m(1)$. The solutions for the three cutoffs are given by:

$$\phi_d^* = \left(\frac{f_d}{A}\right)^{\frac{1}{\sigma-1}}, \tag{12}$$

$$\phi_x^* = \left(\frac{f_x}{A\tau^{1-\sigma}}\right)^{\frac{1}{\sigma-1}}, \tag{13}$$

$$\phi_m^* = \left(\frac{f_m - f_x}{A(1-\tau^{1-\sigma})}\right)^{\frac{1}{\sigma-1}}. \tag{14}$$

Our parameter restrictions according to Assumption 1 ensure that $\phi_d^* < \phi_x^* < \phi_m^*$.[24] Hence, low-productivity firms sell their core product only in the domestic market, medium-productivity firms sell it abroad via exports, and high-productivity firms sell it abroad via FDI.

In general equilibrium, the cutoffs ϕ_d^*, ϕ_x^* and ϕ_m^*, together with the demand level A, are solutions to equations (12)-(14) in combination with the free entry condition (see Appendix A.3). In the following, we focus on firm-level adjustments in an industry equilibrium with a given number of firms. We postpone the general equilibrium analysis to the Appendix of this paper.[25]

Optimal scope in each mode We define the scope of products sold domestically and abroad via exports or FDI as G_d, G_x, and G_m. Given our parameter restrictions on fixed costs, the minimum operating profit required to cover fixed costs is smallest for products that are sold domestically, and smaller for products that are exported compared to products that are sold via FDI. As a product's price increases and, therefore, its revenue[26] and operating profit[27] decrease in distance from the core competence, products that are closest to a firm's core will be sold via FDI (given that the firm undertakes any FDI at all, i.e., conditional on $\phi \geq \phi_m^*$). Products that are further away will be exported, and the products with the greatest distance from the core will only be sold domestically.[28]

Next, we define the marginal products g_d and $g_x \in \{0, 1, ...\}$, that is, the largest $g \in \{0, 1, ...\}$ such that $\pi_d(g)$ and $\pi_x(g)$ are equal to (or greater than) zero, respectively. Furthermore, the marginal product $g_m \in \{0, 1, ...\}$ is the largest $g \in \{0, 1, ...\}$ such that $\pi_m(g) \geq \pi_x(g)$. The determination of marginal products is graphically illustrated for two firms with different productivity levels in Figure 4. Consider first the example of firm 1. At the marginal product g_d, the operating profit of the core product, $\widetilde{\pi}(\phi_1)$, is equal to the combined incremental cost for domestic scope, $f_d g^{\alpha(\sigma-1)}$. At the

[24] In fact, the productivity cutoffs are identical to the proximity-concentration framework with single-product firms in Helpman et al. (2004). Moreover, they are very similar to models of firm heterogeneity relying on CES preferences that focus on tradeoffs between high fixed costs and low marginal costs (see for instance Bustos (2011) for a model focusing on innovation activities or a framework by Ahn et al. (2011) who investigate how firms serve export markets — either directly or indirectly through an intermediary). The reason behind this similarity comes from the fact that each cutoff is derived for the core variety of the firm which would represent the sole variety in a framework with single-product producers.

[25] Note that, given the symmetry assumptions we made, the two countries share the same cutoffs and demand levels in general equilibrium. As long as wages are equalized, this result also holds for different country sizes. As discussed in Helpman et al. (2004), the larger country attracts a larger measure of entrants.

[26] This is because demand is elastic ($\sigma > 1$).

[27] Operating profit is proportional to revenue due to CES preferences.

[28] Products are sold abroad via FDI or exports in addition to being sold domestically.

marginal product g_x, it is equal to the combined incremental cost for export scope, $f_x g^{\alpha(\sigma-1)}\tau^{\sigma-1}$:

$$\pi_d(g) = 0 \Rightarrow \widetilde{\pi}(\phi_1) = f_d g^{\alpha(\sigma-1)} \quad \text{and} \quad \pi_x(g) = 0 \Rightarrow \widetilde{\pi}(\phi_1) = f_x g^{\alpha(\sigma-1)}\tau^{\sigma-1}. \tag{15}$$

The comparatively larger slope for the incremental export scope cost follows from Assumption 1. In our example, firm 1 with intermediate productivity ($\phi_m^* > \phi_1 > \phi_x^*$) exports its core varieties (1 and 2) and additionally produces three more varieties for domestic sales. Now consider firm 2 with productivity $\phi_2 > \phi_m^*$. The marginal product g_m is determined by the following equation:

$$\pi_x(g) = \pi_m(g) \;\Rightarrow \widetilde{\pi}(\phi_2) = \frac{(f_m - f_x)\, g^{\alpha(\sigma-1)}}{(1-\tau^{1-\sigma})}. \tag{16}$$

Compared to the loci for domestic and export scope costs, the FDI locus, $\frac{(f_m - f_x) g^{\alpha(\sigma-1)}}{(1-\tau^{1-\sigma})}$, has the largest slope, by Assumption 1. Operative profits of the core variety of the firm with productivity $\phi_2 > \phi_m^*$ are above the FDI locus such that this firm prefers multinational production for its most productive varieties (1 and 2) and exports its products with intermediate productivity. Here, the firm exports three varieties and has an overall product range of eight varieties. We summarize this analysis in our first proposition, which is in line with our empirical motivation.

Proposition 1 *Firms with productivity $\phi > \phi_m^*$ engage in both multinational production and exporting. They sell core products via FDI and export products with an intermediate productivity.*

Solving for the marginal products in each mode, we derive:

$$g_d = \text{int}\{\left(\frac{A\phi^{\sigma-1}}{f_d}\right)^{\frac{1}{\alpha(\sigma-1)}}\}, \tag{17}$$

$$g_x = \text{int}\{\left(\frac{A\phi^{\sigma-1}\tau^{1-\sigma}}{f_x}\right)^{\frac{1}{\alpha(\sigma-1)}}\}, \tag{18}$$

$$g_m = \text{int}\{\left(\frac{A\phi^{\sigma-1}(1-\tau^{1-\sigma})}{f_m - f_x}\right)^{\frac{1}{\alpha(\sigma-1)}}\}. \tag{19}$$

The total range of products is given by $G_d = g_d$, $G_x = g_x - g_m$, $G_m = g_m$, respectively (see Figure 4). Using (12)-(14), we express marginal products in terms of the cutoff productivity level for the

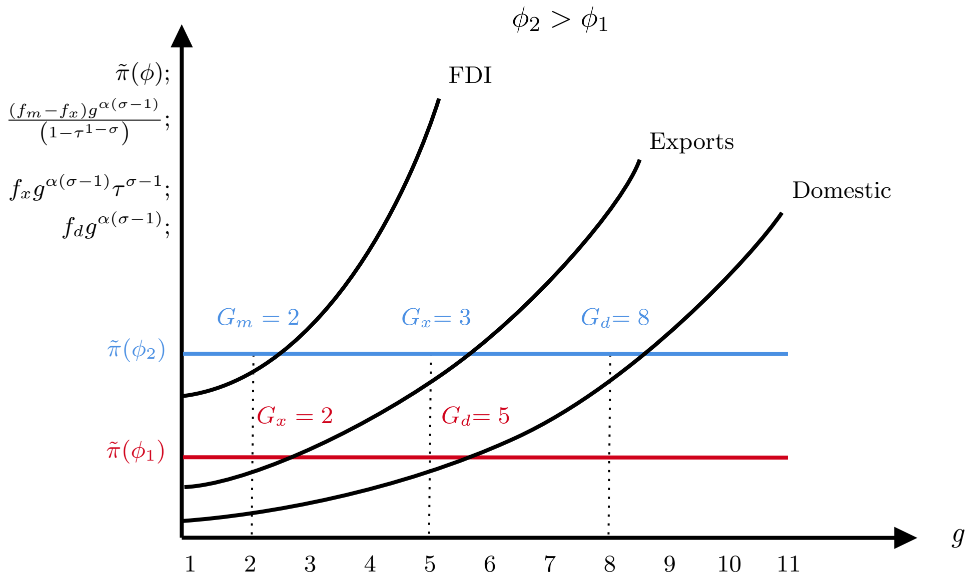

Figure 4: Exports versus FDI at the product-level

Notes: To draw this figure, we refer to equation (15) for the Domestic and Exports loci and to equation (16) for the FDI locus.

core product:

$$g_d = \text{int}\{(\phi/\phi_d^*)^{\frac{1}{\alpha}}\}, \quad g_x = \text{int}\{(\phi/\phi_x^*)^{\frac{1}{\alpha}}\}, \quad \text{and} \quad g_m = \text{int}\{(\phi/\phi_m^*)^{\frac{1}{\alpha}}\}. \tag{20}$$

Note that, for any strictly positive product scopes, we have $g_m < g_x < g_d$, since $\phi_d^* < \phi_x^* < \phi_m^*$ by Assumption 1. It follows that $G_d > G_x + G_m$, such that varieties sold abroad are a subset of all varieties within the portfolio of a firm. Marginal varieties are only sold domestically, since they are not profitable enough to be sold abroad.

In a next step, we investigate the effect of production flexibility on the optimal product range in each mode. In partial equilibrium (i.e. conditional on given cutoffs), a more flexible production (lower levels of α) increases optimal scope in each mode since the marginal product is getting more efficient in production. In Figure 4, this corresponds to an outward rotation of the respective loci for all three modes. We summarize these results in the next proposition.

Proposition 2 *In any given mode of entry, more productive firms produce a greater range of products. For given cutoff productivities, product scope in all modes increase in production flex-*

ibility (smaller values of α).[29]

To conclude this section, we briefly investigate the effects of trade liberalization on the product scopes of multi-product firms. In Appendix A.3, we show that, in general equilibrium, lower variable trade costs (τ) or lower fixed costs of exporting (f_x) increase domestic competition and, therefore, the survival cutoff ϕ_d^*. According to equation (20), any shock that increases the survival productivity cutoff (ϕ_d^*) induces firms to focus more on their core varieties and reduce total product scope.[30]

3.3 Exports versus FDI at the firm-product level

In this section, we derive results with respect to the share of FDI and export products and sales at the firm level. This disaggregate analysis of optimal market entry strategies allows us to compare our results for different types of firms (i.e. multinationals versus exporters only). In addition, it allows us to compare plant-level productivities of multinational affiliates to their respective parent firms.

Share of FDI products In the following, we determine the share of a firm's FDI products in the total number of its varieties sold domestically and abroad. Using the expressions for marginal products (20) and substituting for the cutoff productivities (12)-(14), we derive:

$$\frac{G_m}{G_d} = \frac{g_m}{g_d} = \left(\frac{\phi_d^*}{\phi_m^*}\right)^{\frac{1}{\alpha}} = \left(\frac{(1-\tau^{1-\sigma})f_d}{f_m - f_x}\right)^{\frac{1}{\alpha(\sigma-1)}}, \tag{21}$$

$$\frac{G_m}{G_x + G_m} = \frac{g_m}{g_x} = \left(\frac{\phi_x^*}{\phi_m^*}\right)^{\frac{1}{\alpha}} = \left(\frac{f_x}{(f_m - f_x)}\frac{(1-\tau^{1-\sigma})}{\tau^{1-\sigma}}\right)^{\frac{1}{\alpha(\sigma-1)}}. \tag{22}$$

Equations (21)-(22) show that the share of FDI products does not depend on firm productivity (ϕ): conditional on being a multinational firm, the share of FDI products is constant across firms with different productivities. The FDI share does, however, depend on the flexibility of the production technology. Comparing two industries (or firms) that only differ in the flexibility of production (the parameter α), equations (21) and (22) suggest that the share of FDI products is higher in

[29] This direct negative effect of α on product scope is counteracted by an indirect positive effect, since product scope decreases, as α becomes smaller, via an increase in the cutoff productivities in general equilibrium (i.e., $\partial\phi_d^*/\partial\alpha < 0$, see Appendix A.3).

[30] This confirms a well-known result in the literature on multi-product firms saying that, as trade costs fall, competition in the domestic market rises such that firms drop products with the highest marginal costs (see, for instance, Eckel and Neary (2010), Bernard et al. (2010) or Mayer et al. (2014)).

the industry (firm) with a lower flexibility of production (higher values of α).[31] Intuitively, a lower flexibility of production implies that marginal costs increase faster in distance from the core competence, such that marginal varieties exhibit a greater cost disadvantage compared to core varieties. Since FDI products are closest to the core competence, they represent a higher share in total products.

Share of exported products Next, we analyse a firm's share of exported products in its total number of products. We distinguish between two different types of firms: Firm (1) is a multinational enterprise and firm (2) is an exporter only. The respective shares of exported products are given by:

$$\frac{G_x^{(1)}}{G_d^{(1)}} = \frac{g_x - g_m}{g_d} = \left(\frac{\phi_d^*}{\phi_x^*}\right)^{\frac{1}{\alpha}} - \left(\frac{\phi_d^*}{\phi_m^*}\right)^{\frac{1}{\alpha}}, \tag{23}$$

$$\frac{G_x^{(2)}}{G_d^{(2)}} = \frac{g_x}{g_d} = \left(\frac{\phi_d^*}{\phi_x^*}\right)^{\frac{1}{\alpha}}. \tag{24}$$

From (23)-(24), it follows that the qualitative effect of production flexibility on export share differs by firm type. Our model predicts that a lower flexibility of production within an industry is associated with a lower share of exported products in multinationals but a higher share of exported products within firms that export only (and do not engage in FDI at the same time). This is because a lower flexibility of production results in a drop of the marginal varieties of a firm, increasing the share of the most productive varieties within the firm's portfolio. Hence, regarding exporting firms, the share of exported varieties is greater when the flexibility of production is lower. For multinationals, this is different because exported varieties are less efficient than the (core) varieties for which the firm chooses multinational production. Thus, while for exporting-only firms the share of exported products is greater when the flexibility of production is lower, the opposite is true for multinational firms.

Relative sales Next, we determine the composition of firm sales by domestic, export, and FDI sales. This allows us to compare relative sales by mode of market entry similar to Helpman et

[31] Note that the FDI share (as well as other relative measures of firm performance that follow) does not depend on the economy-wide productivity cutoff ϕ_d^*. Therefore, we do not need to consider general equilibrium effects here, and can directly compare firms with different values of α. In the presence of general equilibrium effects, however, we could only allow α to vary at the industry level.

al. (2004). The key difference is that we can compare relative sales not only between but also within firms.[32] Similarly to our analysis above, we will again consider the effect of the degree of (in)flexibility of production (α) on the composition of firm sales.

Using the definitions above, domestic and FDI sales of any given product g are given by[33]

$$y_d(\phi) = y_m(\phi) = \sigma f_d \left(\frac{\phi}{\phi_d^*}\right)^{\sigma-1} g^{-\alpha(\sigma-1)}, \tag{25}$$

and export sales are given by

$$y_x(\phi) = \sigma \tau^{1-\sigma} f_d \left(\frac{\phi}{\phi_d^*}\right)^{\sigma-1} g^{-\alpha(\sigma-1)}. \tag{26}$$

Aggregating (at the level of the firm) over the varieties sold in each mode and using the efficiency index defined in equation (6), we can express total sales in the domestic market and abroad via exports and FDI for a firm with productivity ϕ as follows:

$$t_d(\phi) = \sigma f_d \left(\frac{\phi}{\phi_d^*}\right)^{\sigma-1} H_d(\phi)^{-(\sigma-1)}, \quad H_d(\phi) \equiv \left(\sum_{g=1}^{g_d} g^{-\alpha(\sigma-1)}\right)^{-\frac{1}{\sigma-1}}, \tag{27}$$

$$t_x(\phi) = \sigma \tau^{1-\sigma} f_d \left(\frac{\phi}{\phi_d^*}\right)^{\sigma-1} H_x(\phi)^{-(\sigma-1)}, \quad H_x(\phi) \equiv \left(\sum_{g=g_m+1}^{g_x} g^{-\alpha(\sigma-1)}\right)^{-\frac{1}{\sigma-1}}, \tag{28}$$

$$t_m(\phi) = \sigma f_d \left(\frac{\phi}{\phi_d^*}\right)^{\sigma-1} H_m(\phi)^{-(\sigma-1)}, \quad H_m(\phi) \equiv \left(\sum_{g=1}^{g_m} g^{-\alpha(\sigma-1)}\right)^{-\frac{1}{\sigma-1}}. \tag{29}$$

Note that the terms $H_k(\phi)^{-(\sigma-1)}$ increase in produce scope g_k ($k \in d, x, m$) and, in turn, product

[32]Note that, assuming that firms draw their core productivity from a Pareto distribution with shape parameter κ, the ratio of aggregate export sales (s_x) to aggregate sales via FDI (s_m) in an industry is given by

$$\frac{s_x}{s_m} = \tau^{1-\sigma}\left[\left(\frac{f_m - f_x}{f_x}\frac{1}{\tau^{\sigma-1}-1}\right)^{\frac{\kappa-(\sigma-1)}{\sigma-1}} - 1\right].$$

This is identical to the corresponding expression in the case of single-product firms (see equation (7) in Helpman et al. (2004)). In consequence, all the comparative statics results with respect to cross-sectoral variation in relative export sales derived for single-product firms continue to hold in a framework with multi-product firms. That is, relative export sales decrease in the costs of exporting, f_x and τ, and increase in the fixed cost of FDI, f_m. Furthermore, relative export sales are lower in sectors with higher dispersion in firm domestic sales, i.e. those with lower κ or greater σ.

[33]To see this, use $y(\phi) = cp = p^{1-\sigma}\beta E P^{\sigma-1}$ and substitute for p using (7) and $\left(\frac{P}{\tilde{\sigma}}\right)^{\sigma-1}\beta E = \sigma A$. Using (12), we can express sales in terms of the productivity cutoff ϕ_d^*.

scope weakly increases in ϕ according to (17)-(19). Hence, total sales in each mode increase in firm productivity (ϕ). Using (27)-(29), we can express relative firm-level sales via FDI as follows:

$$\frac{t_m}{t_d} = \frac{H_m^{-(\sigma-1)}}{H_d^{-(\sigma-1)}}, \quad \frac{t_m}{t_x} = \tau^{\sigma-1} \frac{H_m^{-(\sigma-1)}}{H_x^{-(\sigma-1)}}. \tag{30}$$

According to equation (30), relative sales via FDI, $\frac{t_m}{t_d}$ and $\frac{t_m}{t_x}$, increase in relative scopes g_m/g_d and g_m/g_x as defined in equations (21) and (22), respectively. Again, production technology governed by the parameter α plays an important role. As shown above, the relative share of FDI products decreases in the flexibility of production (smaller values of α). The higher is the flexibility of production, the lower is the cost differential among varieties within the firm and, hence, the smaller is the share of products sold via FDI. In turn, relative FDI sales according to equation (30) also decrease in production flexibility.

Next, we use (27)-(28) to derive the expression for export sales relative to domestic sales:

$$\frac{t_x}{t_d} = \tau^{1-\sigma} \frac{H_x^{-(\sigma-1)}}{H_d^{-(\sigma-1)}}. \tag{31}$$

Similarly to our discussion regarding relative product scope, the effect of technology depends on whether the firm is a multinational or not. For firms that conduct FDI, the share of export relative to domestic sales increases in the flexibility of production (smaller α). The opposite is true for firms that only export. As mentioned above, a greater flexibility increases product scope and hence decreases the sales share of the most productive varieties. Since the most productive varieties are sold via FDI (exports) in multinational (exporting-only) firms, we derive differential effects for the two types of firms.

We summarize the above results in the following two propositions.

Proposition 3 *For FDI firms (with productivity $\phi \geq \phi_m^*$), both the share of products sold via FDI and the share of FDI sales*

i) decreases in the flexibility of production (smaller α): $\partial(g_m/g_d)/\partial\alpha > 0$, $\partial(g_m/g_x)/\partial\alpha > 0$, $\partial(t_m/t_d)/\partial\alpha > 0$, $\partial(t_m/t_x)/\partial\alpha > 0$,

ii) is constant in firm productivity ϕ, *iii) increases in f_x, τ, and*

iv) decreases in f_m.

Proof. See the proof to Proposition 3 in Appendix A.4. This result also holds in general equilibrium.

Proposition 4 *The flexibility of production affects both the share of exported products in total firm products and the share of export sales in domestic sales differently in multinational and exporting-only firms.*

i) For multinational firms (with productivity $\phi \geq \phi_m^*$), the share of exported products and the share of export sales increases in flexibility (smaller α): $\partial(G_x/G_d)/\partial\alpha < 0$, $\partial(t_x/t_d)/\partial\alpha < 0$.

ii) For exporting-only firms (with productivity $\phi_x^* \leq \phi < \phi_m^*$), the share of exported products and export sales decreases in flexibility (smaller α): $\partial(G_x/G_d)/\partial\alpha > 0$, $\partial(t_x/t_d)/\partial\alpha > 0$.

Proof. See the proof to Proposition 4 in Appendix A.5. Again, this result also holds in general equilibrium.

We can test our results in Proposition 3 *ii)* and *iii)* using the car data and indeed find empirical support for them. First, we show that for a given origin-destination-year, the probability of conducting FDI increases in the brand's domestic market share (which we use as a proxy for productivity), but conditional on serving the foreign market via FDI, the share of FDI products does not. Second, we show that, for a given brand, the share of products sold via FDI increases in the distance to the destination market, which we use as a proxy for trade costs. See Appendices B.2.2 and B.2.3 for details. Unfortunately, we are not able to test our predictions linking the flexibility of production to the relative prevalence of exporting and FDI at the firm level, since we lack a proper proxy for the flexibility parameter α. Specifically, for the latter, we would have to know the firm's variable costs as a function of product scope.

3.4 Productivities at the plant level

In this subsection, we compare productivities of parent and affiliate plants of multinational multi-product firms. To do so, we make use again of the efficiency indices defined in equation (6) and used in equations (27)-(29). The respective productivities of the parent ($H_d(\phi)$) and the affiliate plant ($H_m(\phi)$) of a firm with core productivity ϕ are given by:

$$H_d(\phi) \equiv \left(\sum_{g=1}^{g_d} g^{-\alpha(\sigma-1)} \right)^{-\frac{1}{\sigma-1}} \quad \text{and} \quad H_m(\phi) \equiv \left(\sum_{g=1}^{g_m} g^{-\alpha(\sigma-1)} \right)^{-\frac{1}{\sigma-1}}. \tag{32}$$

Note again that firms face diseconomies of scope such that plant efficiency decreases in the number of produced varieties. Since we determine product scope at the plant level endogenously, our framework provides a rationale for differences in plant-level productivities, which are not present in standard models with single-product firms. Considering the ratio between the efficiency indices of foreign and domestic production (H_m/H_d) allows us to analyse relative productivity between the affiliate and the parent company. This ratio is equal to one in a framework with single-product firms (Helpman et al. (2004)), whereas it is endogenous and larger than one in our case, i.e. $\frac{H_m}{H_d}_{MPF} > \frac{H_m}{H_d}_{SPF} = 1$.[34] In consequence, any shock that affects relative product scope (e.g., globalization or a change in technology) will affect the relative productivity between affiliate and parent plants in our framework. This is an important novel implication of our model. According to our analysis above, core varieties are sold via FDI. Hence, our model implies that affiliates are more productive than parent plants, which produce a comparatively larger range of domestic products.[35]

We can use our framework to analyze the change in the relative efficiency between affiliates and parents, H_m/H_d, in response to changes in underlying parameter values. According to equations (32), relative efficiency decreases in the share of FDI products (g_m/g_d) defined in equation (21). Hence, we can directly use previous insights regarding relative product scope in Proposition 3 to determine how given changes in cost parameters or technology affect the relative productivity of plants. We summarize our findings in the following proposition.

Proposition 5 *In a setting with horizontal FDI and multi-product firms, affiliates are more efficient in production than parent firms, i.e.* $H_m/H_d > 1$. *Any shock that decreases the relative scope of FDI products,* g_m/g_d, *increases the relative productivity advantage of the foreign affiliate.*

[34] In our framework, it would be equal to one only in the hypothetical case where $g_m = g_d$, i.e. where all varieties that are sold in the domestic market are also sold abroad via FDI. This case, however, is ruled out by the existence of fixed costs.

[35] Note that this result is derived in a setting where firms seek foreign market access and is, therefore, only valid for horizontal but not for vertical FDI. Eckel and Irlacher (2017) analyze vertical FDI in a setting of multi-product firms where marginal varieties with low productivities are relocated to save on factor costs. In such a setting, the productivity ranking between domestic and foreign plants is different to the one in our framework.

Discussion The result above is derived based on the efficiency index defined in equation (6), which relies on variable costs only and endogenously adjusts to product scope. Empirical studies, however, often rely on plant sales and revenue-based measures of productivity.[36] Comparing foreign sales to domestic sales given by $\frac{t_m}{t_d} = \frac{H_m^{-(\sigma-1)}}{H_d^{-(\sigma-1)}}$ shows that foreign sales are lower than domestic sales, as varieties sold via FDI are only a subset of all varieties within the firm. Hence, our framework is in line with papers such as Keller and Yeaple (2013) and Tintelnot (2017) that focus on relative sales between headquarters and affiliates. Moreover, in Appendix A.6, we show that the revenue-based productivity of varieties sold via FDI is lower than the productivity of the respective domestic counterpart.

Throughout our analysis, we have assumed that a firm uses the same technology at home and abroad. Extending the model by a parameter $\mu_{ij} > \mu_{ii} = 1$ that captures iceberg-type communication costs of production in destination j would have two opposing effects on the efficiency index, with an overall effect that is unclear a priori.[37] On the one hand, productivity of each variety g produced abroad would be lower and given by: $\phi_g = \frac{\phi}{\mu_{ij} g^{\alpha}}$. On the other hand, the efficiency index for the affiliate could even increase, as the introduction of communication costs would induce firms to produce fewer (more productive) varieties via FDI and instead export more. To allow a better comparison to the benchmark framework with single-product firms in Helpman et al. (2004), we have abstracted from modeling communication costs in multinational production.

4 Conclusion

In this paper, we analyze the international expansion strategies of multi-product firms. While the most productive firms choose to become multinationals, FDI is not the optimal mode of serving foreign consumers for each variety within a firm. Firms that operate with a flexible manufacturing technology open new affiliates for the production of their core varieties (i.e., the varieties with the highest productivity) and, hence, the largest sales. Exporting is chosen as the optimal mode for varieties with an intermediate productivity. This way, our model is able to rationalize the empirical fact that the most productive firms typically rely simultaneously on both FDI and exporting. After

[36] See, for example, Syverson (2011).

[37] Starting with the seminal contribution by Hymer (1976), the literature on multinationals often assumes a cost disadvantage of foreign production due to communication costs. Note that this parameter would have to be smaller than τ for FDI to remain an attractive choice for a firm.

having determined the conditions for the endogenous export versus FDI decision at the product-level, we derive a range of comparative statics results with respect to both changes in technology as well as globalization. This is important, since understanding the export versus FDI decision at the product-level is crucial for productivity at the plant-level. Our model suggests that any shock that affects production decisions at the product level also affects the relative productivity between the parent firm and its affiliate. These shocks also determine where the profits of the most profitable core varieties are recorded: at home in case of exporting, or abroad in case of FDI.

It should be interesting to further test empirically, with the help of suitable data at the firm-product-destination level, our predictions regarding the productivity effects of product reallocations within the boundaries of the firm as well as the role of production technology for the export/FDI mix in multinational firms.

References

Ahn, JaeBin, Amit K. Khandelwal, and Shang-Jin Wei, "The role of intermediaries in facilitating trade," *Journal of International Economics*, 2011, *84* (1), 73–85.

Antràs, Pol and Stephen R. Yeaple, "Multinational firms and the structure of international trade," in "Handbook of International Economics," Vol. 4, Elsevier, 2014, pp. 55–130.

Arkolakis, Costas, Sharat Ganapati, and Marc-Andreas Muendler, "The extensive margin of exporting products: a firm-level analysis," *American Economic Journal: Marcroeconomics (forthcoming)*, 2020.

Baldwin, Richard E. and Gianmarco I.P. Ottaviano, "Multiproduct multinationals and reciprocal FDI dumping," *Journal of International Economics*, 2001, *54* (2), 429–448.

Bernard, Andrew B., J. Bradford Jensen, and Peter K. Schott, "Importers, exporters, and multinationals: a portrait of firms in the U.S. that trade goods," in T. Dunne, J.B. Jensen, and M.J. Roberts, eds., *Producer dynamics: new evidence from micro data*, Chicago: University of Chicago Press, 2009.

_ , _ , and _ , "Multiple-Product Firms and Product Switching," *American Economic Review*, 2010, *100*, 70–97.

_ , _ , and _ , "Multiple-Product Firms and Trade Liberalization," *Quarterly Journal of Economics*, 2011, *126*, 1271–1318.

_ , _ , Stephen Redding, and Peter K. Schott, "Firms in international trade," *Journal of Economic Perspectives*, 2007, *21*, 105–130.

Blonigen, Bruce A., "In search of substitution between foreign production and exports," *Journal of International Economics*, 2001, *53* (1), 81–104.

Brainard, S. Lael, "A simple theory of multinational corporations and trade with a trade-off between proximity and concentration," *NBER Working Paper No. 4269*, 1993.

_ , "An empirical assessment of the proximity-concentration tradeoff between multinational sales and trade," *American Economic Review*, 1997, *87* (4), 520–544.

Brander, James and Paul Krugman, "A reciprocal dumping model of international trade," *Journal of International Economics*, 1983, *15* (3-4), 313–321.

Bricongne, Jean-Charles, Sebastian F. Bedoya, and Margarita L. Forero, "The proximity-concentration trade-off with multi-product firms: are exports and FDI complements or substitutes?," *mimeo*, 2019.

Broda, Christian and David E. Weinstein, "Product creation and destruction: evidence and price implications," *American Economic Review*, 2010, *100* (3), 691–723.

Bustos, Paula, "Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms," *American Economic Review*, 2011, *101* (1), 304–40.

Coşar, A. Kerem, Paul L.E. Grieco, Shengyu Li, and Felix Tintelnot, "What drives home market advantage?," *Journal of International Economics*, 2018, *110* (Supplement C), 135–150.

Conconi, Paola, Andre Sapir, and Maurizio Zanardi, "The internationalization process of firms: from exports to FDI," *Journal of International Economics*, 2016, *99*, 16–30.

Desai, Mihir A, C Fritz Foley, and James R Hines Jr, "Foreign direct investment and domestic economic activity," Technical Report, National Bureau of Economic Research 2005.

Dhingra, Swati, "Trading away wide brands for cheap brands," *American Economic Review*, 2013, *103* (6), 2554–2584.

Doms, Mark E. and J. Bradford Jensen, "Comparing wages, skills, and productivity between domestically and foreign-owned manufacturing establishments in the United States," in Robert E. Baldwin, Robert E. Lipsey, and J. David Richardson, eds., *Geography and ownership as bases for economic accounting*, Chicago: NBER Studies in Income and Wealth, Vol. 59, University of Chicago Press, 1998, pp. 235–255.

Eckel, Carsten and J. Peter Neary, "Multi-product firms and flexible manufacturing in the global economy," *Review of Economic Studies*, 2010, *77*, 188–217.

_ **and Michael Irlacher**, "Multi-product offshoring," *European Economic Review*, 2017, *94*, 71–89.

Feenstra, Robert C. and Hong Ma, "Optimal choice of product scope for multiproduct firms," in E. Helpman, D. Marin, and T. Verdier, eds., *The organization of firms in a global economy*, Cambridge, MA: Harvard University Press, 2008.

Flach, Lisandra and Michael Irlacher, "Product versus process: Innovation strategies of multiproduct firms," *American Economic Journal: Microeconomics*, 2018, *10* (1), 236–77.

Garicano, Luis and Claudia Steinwender, "Survive another day: Using changes in the composition of investments to measure the cost of credit constraints," *Review of Economics and Statistics*, 2016, *98* (5), 913–924.

Girma, Sourafel, Steve Thompson, and Peter W. Wright, "Why are productivity and wages higher in foreign firms?," *Economic and Social Review*, 2002, *33* (1), 93–100.

Goldberg, Pinelopi K., Amit Khanelwal, Nina Pavcnik, and Petia Topalova, "Multiproduct firms and product turnover in the developing world: evidence from India," *Review of Economics and Statistics*, 2010, *92* (4), 1042–1049.

Guadalupe, Maria, Olga Kuzmina, and Catherine Thomas, "Innovation and foreign ownership," *American Economic Review*, 2012, *102* (7), 3594–3627.

Gumpert, Anna, Haishi Li, Andreas Moxnes, Natalia Ramondo, and Felix Tintelnot, "The life-cycle dynamics of exporters and multinational firms," *Journal of International Economics*, 2020, p. 103343.

Head, Keith and John Ries, "Overseas investment and firm exports," *Review of International Economics*, 2001, *9* (1), 108–122.

_ and Thierry Mayer, "Brands in Motion: How Frictions Shape Multinational Production," *American Economic Review*, September 2019, *109* (9), 3073–3124.

_ and _ , "Replication data for: Brands in Motion: How Frictions Shape Multinational Production," Technical Report V1 [2019–12–07], Inter-University Consortium for Political and Social Research [distributor], Ann Arbor, MI 2019. https://doi.org/10.3886/E116187V1.

Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple, "Export versus FDI with Heterogeneous Firms," *American Economic Review*, 2004, *94*, 300–316.

Horstmann, Ignatius and James Markusen, "Endogenous market structures in international trade," *Journal of International Economics*, 1992, *32*, 109–129.

Hymer, Stephen H., *International operations of national firms*, MIT press, 1976.

Keller, Wolfgang and Stephen R. Yeaple, "The gravity of knowledge," *American Economic Review*, 2013, *103* (4), 1414–1444.

Koch, Michael and Marcel Smolka, "Foreign ownership and skill-biased technological change," *Journal of International Economics*, 2019, *118*, 84–104.

Lipsey, Robert E. and Merle Yahr Weiss, "Foreign production and exports of individual firms," *Review of Economics and Statistics*, 1984, pp. 304–308.

_ , Eric Ramstetter, and Magnus Blomström, "Outward FDI and parent exports and employment: Japan, the United States, and Sweden," *Global Economy Quarterly*, 2000, *1* (4), 285–302.

Markusen, James R. and Anthony Venables, "The theory of endowment, intra-industry and multi-national trade," *Journal of International Economics*, 2000, *52* (2), 209–234.

_ and Keith E. Maskus, "Discriminating among alternative theories of the multinational enterprise," *Review of International Economics*, 2002, *10*, 694–707.

Mayer, Thierry and Gianmarco I.P. Ottaviano, "The happy few: The internationalisation of european firms," *Intereconomics*, 2008, *43* (3), 135–148.

_ , Marc J. Melitz, and Gianmarco I.P. Ottaviano, "Market Size, Competition, and the Product Mix of Exporters," *American Economic Review*, 2014, *104* (2), 495–536.

Melitz, Marc J., "The impact of intra-industry reallocations and aggregate industry productivity," *Econometrica*, 2003, *71* (6), 1695–1725.

Nocke, Volker and Stephen Yeaple, "Globalization and multiproduct firms," *International Economic Review*, 2014, *55* (4), 993–1018.

Qiu, Larry and Wen Zhou, "Multiproduct firms and scope adjustment in globalization," *Journal of International Economics*, 2013, *91* (1), 142–153.

Rob, Rafael and Nikolaos Vettas, "Foreign Direct Investment and Exports with Growing Demand," *Review of Economic Studies*, 2003, *70* (3), 629–648.

Steingress, Walter, "Market size and entry in international trade: Product versus firm fixed costs," *Review of International Economics*, 2019, *27* (5), 1351–1370.

Swenson, D.L., "Foreign investment and the mediation of trade flows," *Review of International Economics*, 2004, *12* (4), 609–629.

Syverson, Chad, "What determines productivity?," *Journal of Economic Literature*, 2011, *49* (2), 326–365.

Tintelnot, Felix, "Global production with export platforms," *Quarterly Journal of Economics*, 2017, *132* (1), 157–209.

Yeaple, Stephen R., "The multinational firm," *Annual Review of Economics*, 2013a, *5* (1), 193–217.

—, "Scale, scope, and the international expansion strategies of multiproduct firms," *NBER Working Paper 19166*, 2013b.

A Theoretical Appendix

A.1 Non-constant product-specific fixed costs

In this section, we extend our framework by modifying the modeling of product-specific fixed cost for the three different modes (d, x, and m). While in our main analysis fixed costs are independent of scope, we now assume that fixed costs in each mode may increase or decrease with scope. In particular, we parameterize the fixed costs for product g in the three different modes as follows:

$$F_d = f_d g^{\delta}, \; F_x(g) = f_x g^{\delta}, \text{ and } F_m(g) = f_m g^{\delta} \text{ for } \delta \in (-\infty, +\infty). \tag{33}$$

The parameter δ (equal to zero in our main analysis) captures the scope elasticity of fixed costs. In contrast to α, we also allow δ to take negative values as long as the following assumption is fulfilled:

Assumption 2 $\delta + \alpha(\sigma - 1) > 0$.

This assumption ensures that the combined incremental scope costs are strictly increasing in scope. Introducing the new parameter δ allows discussing additional aspects of production technology. On the one hand, negative values of δ could imply that different products rely on similar technologies such that each additional variety may partly use previous investments of core varieties and, hence, face lower product-specific fixed costs. Analyzing exporting firms, Steingress (2019) relies on a related modeling of fixed costs, which decrease with the number of exported products. This intra-firm spillover effect allows MPFs to benefit from economies of scope. On the other hand, core technologies could be better developed and, hence, easier to be moved abroad (through exporting or FDI) when δ is positive. In this case, fixed costs increase in product scope.

All our propositions continue to hold under this modified technology. To see this, note that the productivity cutoffs in equations (12)-(14) remain unaffected, and the new optimal range of products in each mode is given by:

$$g_d = (\phi/\phi_d^*)^{\frac{1}{\alpha+\delta/(\sigma-1)}}, \; g_x = (\phi/\phi_x^*)^{\frac{1}{\alpha+\delta/(\sigma-1)}}, \text{ and } g_m = (\phi/\phi_m^*)^{\frac{1}{\alpha+\delta/(\sigma-1)}}. \tag{34}$$

Comparing the optimal scope in each mode in equation (34) to our results in equation (20) in the main text shows that the scope elasticity of fixed costs δ may both reinforce and counteract the effect of production flexibility α. More precisely, optimal scope in each mode will be larger in case of intra-firm spillovers ($\delta < 0$) and smaller, when firms face diseconomies of scope ($\delta > 0$). Moreover, inspection of equation (34) shows that the relative impact of production flexibility α and scope elasticity of fixed costs δ is determined by the elasticity of substitution σ. Higher values of σ (higher substituability) increase the relative importance of production flexibility α, as this parameter directly affects prices (see equation (7)) and, hence, quantities. When substituability and, therefore, competition among products is high, a less flexible production technology (higher values of α) will lead to a more pronounced drop in per-variety sales when moving away from a firm's core competence.

A.2 Total operating profits

Total operating profits from selling an optimal number of products G_{id}, G_{ix} and G_{im} at optimal prices p_{ijg} domestically, and via exports and FDI, respectively, are

$$\pi_{id}(\phi) = \max_{G_{id}} \sum_{g_{id}=1}^{G_{id}} \left[\max_{\{p_{iig}\}_{g_{id}=1}^{G_{id}}} \left(p_{iig} - \frac{w_i}{\phi/h(g)} \right) \left(\frac{p_{iig}}{P_i} \right)^{-\sigma} \frac{\beta E_i}{P_i} \right],$$

$$\pi_{ix}(\phi) = \max_{G_{ix}} \sum_{g_{ix}=1}^{G_{ix}} \left[\max_{\{p_{ijg}\}_{g_{ix}=1}^{G_{ix}}} \left(p_{ijg} - \tau_{ij} \frac{w_i}{\phi/h(g)} \right) \left(\frac{p_{ijg}}{P_j} \right)^{-\sigma} \frac{\beta E_j}{P_j} \right],$$

$$\pi_{im}(\phi) = \max_{G_{im}} \sum_{g_{im}=1}^{G_{im}} \left[\max_{\{p_{ijg}\}_{g_{im}}^{G_{im}}} \left(p_{ijg} - \frac{w_j}{\phi/h(g)} \right) \left(\frac{p_{ijg}}{P_j} \right)^{-\sigma} \frac{\beta E_j}{P_j} \right].$$

A.3 General equilibrium

Due to free entry, expected profits are zero in equilibrium. That is, expected operating profits of a potential entrant are equal to market entry costs, given by f_e:

$$f_e = \int_{\phi_d^*}^{\infty} \Pi_d(\phi, g) dF(\phi) + \int_{\phi_x^*}^{\phi_m^*} \Pi_x(\phi, g) dF(\phi) + \int_{\phi_m^*}^{\infty} \Pi_m(\phi, g) dF(\phi), \tag{35}$$

where

$$\Pi_d(\phi, g) \equiv \sum_{g=1}^{g_d} \pi_d(\phi, g), \quad \Pi_x(\phi, g) \equiv \sum_{g=1}^{g_x} \pi_x(\phi, g), \quad \Pi_m(\phi, g) \equiv \sum_{g=1}^{g_m} \pi_m(\phi, g) + \sum_{g=g_m+1}^{g_x} \pi_x(\phi, g).$$

Using (9)-(11) to substitute for $\pi_d(\phi, g)$, $\pi_x(\phi, g)$ and $\pi_m(\phi, g)$ and (17)-(19) to substitute for g_d, g_x and g_m, the free-entry condition (35) and the zero-cutoff-profit conditions (12)-(14) provide implicit solutions for the cutoff productivities ϕ_d^*, ϕ_x^* and ϕ_m^* and the demand level $A \equiv \frac{1}{\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1} B$, which depends on the range of available varieties via the price index P (see equation (3)).

Averaging first over the g-th variety produced by all firms and then summing over all g (compare Mayer et al. (2014)), we can write:[38]

$$\begin{aligned} f_e &= \sum_{g=1}^{\infty}\int_{g^{\hat{\alpha}}\phi_d^*}^{\infty}(A\phi^{\sigma-1}g^{-\alpha(\sigma-1)} - f_d)dF(\phi) + \sum_{g=1}^{\infty}\int_{g^{\hat{\alpha}}\phi_x^*}^{g^{\hat{\alpha}}\phi_m^*}(A\tau^{1-\sigma}\phi^{\sigma-1}g^{-\alpha(\sigma-1)} - f_x)dF(\phi) \\ &+ \sum_{g=1}^{\infty}\int_{g^{\hat{\alpha}}\phi_m^*}^{\infty}(A\phi^{\sigma-1}g^{-\alpha(\sigma-1)} - f_m)dF(\phi). \end{aligned} \tag{36}$$

To pin down ϕ_d^* (and, hence, ϕ_x^* and ϕ_m^*), consider the free entry condition (36) and use the zero-cutoff-profit conditions (12)-(14) to substitute for $A = \frac{f_d}{(\phi_d^*)^{\sigma-1}}$, $A\tau^{1-\sigma} = \frac{f_x}{(\phi_x^*)^{\sigma-1}}$ and $A(1-\tau^{1-\sigma}) = \frac{f_m - f_x}{(\phi_m^*)^{\sigma-1}}$. We further assume that firm productivities are drawn from a Pareto distribution following Helpman et al. (2004) with a scale parameter $b = 1$ and shape parameter $\kappa > 1/\alpha$, such that $F(\phi) = 1 - \phi^{-\kappa}$ with $dF(\phi) = \kappa\phi^{-\kappa-1}$.[39] Solving for the integrals and simplifying, we get:

$$\phi_d^* = (B\Omega)^{\frac{1}{\kappa}}, \tag{37}$$

where

$$\begin{aligned} B &\equiv \frac{\kappa}{f_e}\left(\frac{1}{\kappa-\sigma+1} - \frac{1}{\kappa}\right) f_d^{\frac{\kappa}{\sigma-1}}\left[f_d^{1-\frac{\kappa}{\sigma-1}} + f_x^{1-\frac{\kappa}{\sigma-1}}\tau^{-\kappa} + (f_m - f_x)^{1-\frac{\kappa}{\sigma-1}}(1-\tau^{1-\sigma})^{\frac{\kappa}{\sigma-1}}\right] \text{ and} \\ \Omega &\equiv \sum_{g=1}^{\infty} g^{-\alpha\kappa}. \end{aligned}$$

Note that $\sum_{g=1}^{\infty} g^{-\alpha\kappa}$ converges due to the assumption that $\alpha\kappa > 1$.

Result. *The cutoff productivity ϕ_d^* increases in response to i) greater production flexibility (smaller values of α), and ii) a reduction in trade costs, f_x and τ. In turn, domestic product scope,*

[38] The bounds of the three integrals correspond to the values of ϕ such that $E(\pi_d(g)) \geq 0$ (first integral, lower bound), $E(\pi_x(g)) \geq 0$ and $E(\pi_x(g)) \geq E(\pi_m(g))$ (second integral, lower and upper bound), and $E(\pi_m(g)) \geq E(\pi_x(g))$ (third integral, lower bound).

[39] We assume $\kappa > \sigma + 1$. This ensures that the distribution of productivity draws has a finite variance. (A Pareto random variable has a finite variance if and only if $\kappa > 2$.)

g_d, *decreases.*

Proof. Regarding i), $\frac{\partial \phi_d^*}{\partial \alpha} < 0$ directly follows from (37). Regarding ii), note that $\frac{\partial \phi_d^*}{\partial f_x} = \frac{1}{\kappa}\left(B\Omega\right)^{\frac{1}{\kappa}-1}\Omega\frac{\partial B}{\partial f_x}$ and $\frac{\partial \phi_d^*}{\partial \tau} = \frac{1}{\kappa}\left(B\Omega\right)^{\frac{1}{\kappa}-1}\Omega\frac{\partial B}{\partial \tau}$, where

$$\frac{\partial B}{\partial f_x} = \frac{f_d^{\frac{\kappa}{\sigma-1}}}{f_e}\left[-f_x^{\frac{-\kappa}{\sigma-1}}\tau^{-\kappa} + \left(f_m - f_x\right)^{\frac{-\kappa}{\sigma-1}}\left(1-\tau^{1-\sigma}\right)^{\frac{\kappa}{\sigma-1}}\right] < 0$$

and

$$\frac{\partial B}{\partial \tau} = \frac{f_d^{\frac{\kappa}{\sigma-1}}}{f_e}\frac{\left(\sigma-1\right)\kappa}{\kappa-\sigma+1}\left[-f_x^{\frac{\sigma-1-\kappa}{\sigma-1}}\tau^{-\kappa-1} + \left(f_m - f_x\right)^{\frac{\sigma-1-\kappa}{\sigma-1}}\left(1-\tau^{1-\sigma}\right)^{\frac{\kappa-\sigma+1}{\sigma-1}}\tau^{-\sigma}\right] < 0$$

since $f_m > \tau^{\sigma-1}f_x$. Furthermore, $\frac{\partial g_d}{\partial \phi_d^*} < 0$ according to (20). ■

A.4 Proof of Proposition 3

Proof. The share of a firm's FDI sales, t_m/t_d and t_m/t_x, increases in the relative scope for FDI, g_m/g_d and g_m/g_x, according to equation (30). Differentiating equation (21) with respect to α, we derive: $\partial\left(\frac{g_m}{g_d}\right)/\partial\alpha = \partial\left(\frac{\phi_d^*}{\phi_m^*}\right)^{\frac{1}{\alpha}}/\partial\alpha = -\ln\left(\frac{\phi_d^*}{\phi_m^*}\right)\left(\frac{\phi_d^*}{\phi_m^*}\right)^{\frac{1}{\alpha}}/\alpha^2 > 0$, which follows from $\ln\left(\frac{\phi_d^*}{\phi_m^*}\right) < 0$ due to $\phi_d^* < \phi_m^*$. Analogously, we can differentiate equation (22) to derive $\partial\left(\frac{g_m}{g_d}\right)/\partial\alpha > 0$. Note that this result also holds in general equilibrium. The indirect effect of α on the cutoffs in general equilibrium affects both cutoffs in the same way and, hence, cancels out when considering relative cutoffs. A firm's FDI share also varies with the costs of exporting and FDI. Equations (21)-(22) show that it increases in f_x and τ and decreases in f_m. ■

A.5 Proof of Proposition 4

Proof. Relative exports sales t_x/t_d increase in relative export scope G_x/G_d according to equation (31). Differentiating equations (23) and (24) with respect to α, we derive:

$$\frac{\partial\frac{G_x^{(1)}}{G_d^{(1)}}}{\partial\alpha} = -\frac{1}{\alpha^2}\left(\ln\left(\frac{\phi_d^*}{\phi_x^*}\right)\left(\frac{\phi_d^*}{\phi_x^*}\right)^{\frac{1}{\alpha}} - \ln\left(\frac{\phi_d^*}{\phi_m^*}\right)\left(\frac{\phi_d^*}{\phi_m^*}\right)^{\frac{1}{\alpha}}\right) < 0.$$

$$\frac{\partial\frac{G_x^{(2)}}{G_d^{(2)}}}{\partial\alpha} = -\frac{1}{\alpha^2}\ln\left(\frac{\phi_d^*}{\phi_x^*}\right)\left(\frac{\phi_d^*}{\phi_x^*}\right)^{\frac{1}{\alpha}} > 0.$$

To see this, note that Assumption 1 implies that $1 > (\phi_d^*/\phi_x^*)^{\left(\phi_d^*/\phi_x^*\right)^{1/\alpha}} > (\phi_d^*/\phi_m^*)^{\left(\phi_d^*/\phi_m^*\right)^{1/\alpha}}$. Again, this result also holds in general equilibrium (compare the proof to Proposition 3 above). ■

A.6 Productivities at the plant level

Empirical work often relies on revenue-based measures of productivity. The constant mark-up (CES preferences) implies that product prices are inversely proportional to product-specific productivity. Hence, revenue per variable input is constant across products. Revenue-based productivity per variety, however, varies because of the fixed production cost. To see this, we construct an empirically relevant measure of revenue-based productivity of product g for a firm with productivity draw ϕ. The respective revenue and labor input are given by: $r(g) = B\left(\frac{\sigma-1}{\sigma}\frac{\phi}{g^\alpha}\right)^{\sigma-1}$ and $l(g) = f + q(g)\frac{g^\alpha}{\phi} = f + B\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}\left(\frac{g^\alpha}{\phi}\right)^{1-\sigma}$ where $f = f_d$ in case of domestic sales and $f = f_m$ when the product is sold via FDI. Revenue-based productivity of product g is then given by:

$$\frac{r(g)}{l(g)} = \frac{\sigma}{\sigma-1}\left[1 - \frac{f}{l(g)}\right] \tag{38}$$

The later expression decreases in f, as:

$$\frac{\partial\left(\frac{r(g)}{l(g)}\right)}{\partial f} = -\frac{\sigma}{\sigma-1}\frac{q(g)\frac{g^\alpha}{\phi}}{\left(f + q(g)\frac{g^\alpha}{\phi}\right)^2} < 0. \tag{39}$$

Since $f_m > f_d$, revenue-based productivity of variety g in the foreign affiliate is lower than in the domestic plant.

B Empirical Appendix

B.1 The link between firm productivity and the modes of serving foreign markets at the firm-destination level

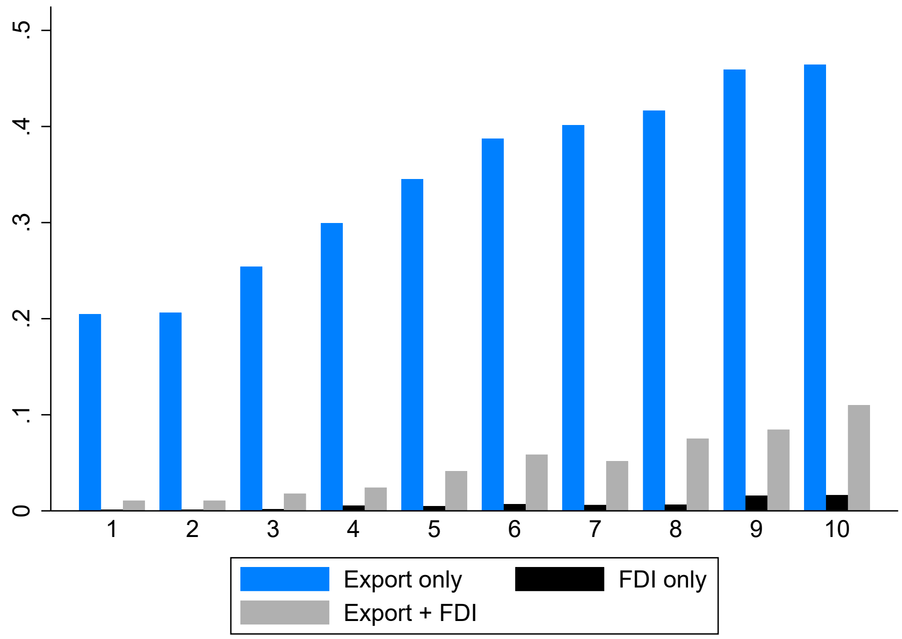

Figure 5: Share of firm-destination observations engaged in exports and/or FDI across productivity deciles

The Spanish ESEE data distinguish exports and FDI at the level of four broad destination regions: EU, Latin America, OECD (outside EU), and rest of the world. We reorganize the data at the firm-destination-year level and redo the graph from Figure 1, which was based on the firm-year level. Again, firms are grouped into labor productivity deciles, normalized by industry and year.

Compared to the graph in the main text, the fraction of observations featuring exports and/or FDI is generally lower, reflecting the fact that only a subset of firms is active in all of the four regions. Qualitatively, the pattern is similar, though. In particular, most firms engaged in FDI in a particular region also export to the same region.

B.2 Internationalization strategies of multi-product car producers

B.2.1 Data source and data preparation

We make use of the anonymized replication data kindly provided by Head and Mayer (2019b), which in turn combine data on the origin-destination flows of car producers collected by the automotive industry consultancy IHS Markit and gravity data assembled from various sources (CEPII, WITS, and WTO).[40]

Specifically, we make use of three different data files provided by Head and Mayer (2019b). First, we use the *Estimating_sample_sourcing_annual_anon.dta* data file to reproduce the results pertaining to the number of sourcing locations at the brand-model-destination-year level presented in Section 2.1 of Head and Mayer (2019a). In doing so, we also use the *n_sources* Stata do file provided by the authors. Second, we use the *Estimating_sample_sourcing_poisson_anon.dta* data file to calculate the corresponding statistics at the brand-destination-year level. This is the data set that Head and Mayer (2019a) use for the sourcing estimates in their Section 5.1. Third, we use *estimating_sample_brand_tot_anon.dta* data file to obtain information about brand-level market shares across destinations and years.

In all data sets, the following variables have been anonymized: brand, (model), country of assembly, country of sale, country of the headquarter, and year. In addition, several variables have been dropped from the original data. Importantly, *Estimating_sample_sourcing_annual_anon.dta* has been anonymized separately from the other data sets so that it is not possible to link them to each other. The sample restrictions differ slightly. For example, the period of analysis is 2000–2016 for the brand-model-destination-year-level data and 2002–2016 for the brand-destination-year-level data. As a consequence, the number of brand-destination-year observations is smaller in the latter case. This also implies that the frequency distributions of the number of sourcing locations in Figure 2 are calculated from largely overlapping, but not identical samples.

Estimating_sample_sourcing_poisson_anon.dta is organized as a firm-level gravity data set, where the countries of origin are the assembly locations of the brand and the destinations the countries of sale. The data set includes information about the number of car models sourced from origin o that are sold in destination n as well as standard gravity controls. In addition, the data set also

[40] See Head and Mayer (2019a) for a detailed description.

includes gravity-type variables that capture the distance and other bilateral trade frictions between the assembly location and the location of the headquarter. We reorganize the data at the brand-destination-year level such that all trade frictions are between the headquarter location and the destination. In this form, we can merge the data with *estimating_sample_brand_tot_anon.dta*.

B.2.2 The link between productivity and the relative prevalence of exporting and FDI at the firm level

Table 3: Productivity and the share of products served via FDI

Dependent variable	(1) FDI share	(2) FDI (0/1)	(3) FDI share
Log domestic market share	0.084***	0.159***	0.022
	[0.024]	[0.028]	[0.041]
Origin-destination-year FE	Yes	Yes	Yes
Sample	All	All	FDI > 0
Observations	32,868	32,868	22,463

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors (clustered at the brand level) in brackets. The dependent variable is the share of products served via FDI in Columns (1) and (3), and an FDI dummy variable in Column (2). In all cases, FDI comprises both pure horizontal FDI (assembly location in the destination market) and export-platform FDI (assembly location in a third country). All columns exclude observations in the home market of the headquarter. Column (3) restricts attention to observations with positive FDI sales.

According to Proposition 3 *ii)*, for FDI firms, the share of products sold via FDI is constant in firm productivity (whereas the probability of conducting FDI increases in productivity, cf. Proposition 1). We take this prediction to the data by comparing the share of FDI products across brands within the same origin-destination-year. That is, we compare brands from the same headquarter location that serve the same foreign destination market in the same year. We use the log of the domestic market share (in the headquarter location) as a proxy for productivity. We estimate variants of the following regression equation:

$$FDIshare_{bnt} = \gamma \ln market\, share_b^{home} + \nu_{ont} + u_{bnt} \tag{40}$$

where b denotes the brand, n the destination, and t the year. γ is the coefficient of interest, while ν_{ont}

are origin-destination-year fixed effects, which account for all monadic and dyadic terms. Standard errors are clustered at the brand level.

Table 3 presents the regression results. Column (1) shows that there is a positive and statistically significant relationship between the domestic market share and the share of products served via FDI in the foreign destination. However, this is entirely due to the extensive margin of conducting FDI (Column (2)), while, conditional on serving the market via FDI, the relationship between the share of products sold via FDI and the domestic market share is flat (Column (3)), in line with our theoretical prediction.

B.2.3 The link between distance and the relative prevalence of exporting and FDI at the firm level

According to Proposition 3 *iii)*, the share of products sold via FDI increases in fixed as well as variable trade costs. We take this prediction to the data by analyzing the share of FDI products within the same brand-year across destinations. We focus on the distance between the headquarter location and the destination as a generic proxy for trade costs. In particular, we estimate the following regression equation:

$$FDIshare_{bnt} = \delta \ln dist_{o(b)n} + \mu_{bt} + \eta_{nt} + e_{bnt} \tag{41}$$

where b denotes the brand, n the destination, t the year, and $o(b)$ the headquarter location of the brand. δ is the coefficient of interest, while μ_{bt} and η_{nt} are brand-year and destination-year fixed effects, respectively. Standard errors are clustered at the origin-destination level.

Table 4 presents the regression results and Figure 6 shows the corresponding binscatter plot.[41] There is a positive and statistically significant relationship between distance and the share of products served via FDI, in line with our theoretical prediction.

[41] The number of observations differs between Tables 3 and 4. This is for two reasons. First, rgressions in Table 3 only include brands that serve the domestic market (and hence have a positive market share). Second, singleton observations, which are dropped from the estimation, differ between the two specifications, as the latter include different types of fixed effects.

Table 4: The share of products served via FDI against distance: gravity estimates

	(1)	(2)
Log distance	0.017***	0.028***
	[0.005]	[0.007]
Brand-year FE	Yes	Yes
Destination-year FE	Yes	Yes
Sample	All	FDI > 0
Observations	37,699	26,082

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors (clustered at the origin-destination level) in brackets. The dependent variable is the share of products served via FDI at the brand-destination-year level, where FDI comprises both pure horizontal FDI (assembly location in the destination market) and export-platform FDI (assembly location in a third country). Both columns exclude observations in the home market of the headquarter. Column (2) restricts attention to observations with positive FDI sales.

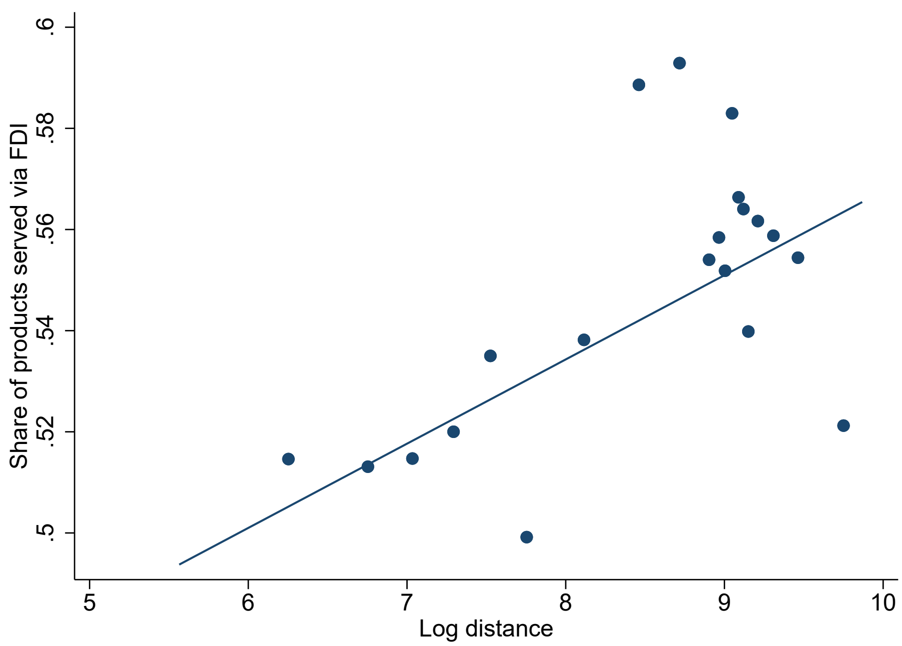

Figure 6: The share of products served via FDI against distance

Notes: The graph shows the binscatter plot and the linear fit line of the share of products served via FDI at the brand-destination-year level against distance, accounting for brand-year and destination-year fixed effects.