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Multi-Product Firms in International Economics

Abstract

A striking pattern in transaction-level data is the concentration of international shipments in the hands of a few large firms. One common feature of dominating high-performance firms is that they produce multiple products and ship them to many destinations. Motivated by the emergence of highly detailed data at the firm-product-destination level, a series of theoretical and empirical papers studies the role of multi-product firms (MPFs) in international trade. This survey reviews the evidence on the importance of MPFs in international markets and highlights the key theoretical as well as empirical results that the literature has produced in the last decade.

JEL-Codes: F100, F120, F140.

Keywords: survey, multi-product firms, international economics, theory, empirics.

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1 Introduction

The emergence of a wide range of micro-level datasets has changed the way economists conduct research in international trade. While in traditional trade models, the emphasis is placed on industries and countries, the majority of recent research focuses rather on firms and products. In the mid-1990s, a series of empirical papers based on a first wave of microdata demonstrated that firms are heterogeneous within industries. Beginning with Bernard and Jensen (1995, 1999), this literature documents that even within narrowly defined industries, some firms are much larger and make higher profits than others because they are more productive. The fact that exporting firms are different and more productive than firms that operate only domestically is widely documented and has been proven to be robust to many control variables (see Bernard et al. (2007, 2012)). This survey focuses on one strand of recent research, which was stimulated by the availability of microdata on individual trade transactions within the firm. A striking feature of international trade data is that most of the economic activity is concentrated on a small number of very large firms, which are engaged in multi-product trade. Empirical observations document that firms producing multiple products play a dominant role in both domestic and international businesses and in many cases, their dominance has increased with globalization.

The aim of is survey is to provide an overview over the main results from the theoretical and empirical literature on multi-product firms (MPFs) in international trade. Most articles that are covered in this survey were published in the year 2010 or later. In Section 2, the survey starts by reviewing empirical articles, which document the dominance of MPFs in both domestic as well as international markets. For several datasets, covering both developed and developing countries, the articles provide information on the output (export) share of MPFs, the average export scope as well as the share of firms that produce products in more than one sector. Overall, a clear picture emerges showing that a small share of firms dominates international trade. Motivated by the important role of MPFs in international markets, Section 3 reviews a series of theoretical contributions on this topic. Thereby, the survey focuses on the main modeling assumptions regarding the underlying market structure, the production technology as well as the product mix adjustments in response to external shocks. Starting with the seminal work of Krugman (1979), product variety has played an important role in determining welfare in many trade models. Hence, understanding

the determinants of product scope decisions of MPFs contributes to a recent trend in theoretical research in international trade, which puts a strong emphasis on the aggregate impacts of individual firms' decisions. With respect to overall product variety, this margin of adjustment is of particular importance as Broda and Weinstein (2010) have shown that the majority of product creation and destruction happens within the boundaries of the firm. The final Section 4 focuses on empirical studies that provide evidence for theoretical predictions regarding the endogenous scope decisions of MPFs following external shocks. Moreover, it collects evidence on a substantial heterogeneity across products within firms which is, on the one hand, a key modeling feature of several theoretical contributions and, on the other hand, an important characteristic in the understanding of how firms absorb external shocks. In its final part, this section reviews articles that focus on export dynamics and product switching activities of MPFs.

2 The dominance of multi-product firms

Many empirical studies have documented that exporting activities are relatively rare among firms. Using data from the 2002 U.S. census of manufacturers, Bernard et al. (2007) document an average of 18 percent of firms across all industries that export. This pattern can be explained by firm heterogeneity whereas only the most productive firms can overcome the additional costs of shipping goods to foreign destinations. However, there is even a large heterogeneity among firms in the subset of exporting producers. Trade activities are highly concentrated in a small number of dominant firms. Bernard et al. (2009) document for U.S. data in the year 2000 that the top 1 percent of firms account for 81 percent of U.S. trade flows. Similar results are documented by Mayer and Ottaviano (2008) for European data. Across several European countries, they document that the top 10 percent of exporting firms account for no less than 80 percent of aggregate exports. Freund and Pierola (2015) show for 32 developing countries that the top five exporters make up 30 percent of total exports. Macedoni (2021) uses firm-level data from the Exporter Dynamics Database (EDD), which covers 11 low and middle-income countries in the span from 1993 to 2011. In his dataset, the top one (*five*) percent of firms ship 30 (*59*) percent of total export value.

One key characteristic of firms that helps to rationalize this high concentration is their engagement in multi-product trade. Table 1 documents two interesting insights for U.S. data in 2000.

Firstly, the majority (40.4 percent) of firms export only one product to one destination whereas only 11.9 percent of exporters export more than five products to more than five destinations. Secondly, in terms of economic importance, however, the first group of single-product exporters only accounts for 0.20 percent of total export value while the second group accounts for 92.2 percent of export value.

Table 1: Exporters and Export Value for U.S. manufacturing firms in 2000

Share of Exporting firms (share) and Export value (value)

	Number of countries											
Number of products	1		2		3		4		5		**All**	
	share	*value*	*share*	*value*	*share*	*value*	*share*	*value*	*share*	*value*	*share*	*value*
1	**40.4**	**0.20**	1.2	0.06	0.3	0.02	0.1	0.02	0.2	0.07	42.2	0.4
2	10.1	0.19	4.7	0.12	0.8	0.04	0.3	0.03	0.4	0.15	16.4	0.5
3	4.7	0.19	2.3	0.07	1.3	0.05	0.4	0.03	0.5	0.19	9.3	0.5
4	2.5	0.12	1.3	0.08	1.0	0.08	0.6	0.04	0.7	0.27	6.2	0.6
5	6.0	2.63	3.0	1.23	2.7	1.02	2.3	0.89	**11.9**	**92.2**	25.9	98.0
All	64.0	3.3	12.6	1.5	6.1	1.2	3.6	1.0	13.7	92.9	100	

NOTES: This table combines information from Tables 4 A and B in Bernard et al. (2007) p. 118. Data stems from the 2000 Linked-Longitudinal Firm Trade Transaction Database (LFTTD) covering U.S. manufacturing firms that export.

Similar results are documented for other countries. For the year 2000, Arkolakis et al. (2021) report for Brazilian exporter data that 25 percent of all manufacturing exporters ship more than ten products and account for 75 percent of total exports. Fontagné et al. (2018) show patterns for France and Italy where 40 percent and 42 percent of exporters ship more than five HS-6 products. These exporters account for 95 percent and 96 percent of total export flows, respectively. Macedoni and Xu (2021) provide related statistics for Chinese data. In 2006, 40 percent of firms exported more than five HS-8 products. In comparison to the previous study, these firms generated a lower share of total exports of around 74 percent. Moreover, their study reports that 5.7 percent of firms export more than 70 products and account for 31 percent of total exports in China. Damijan et al. (2014) provide similar statistics for Slovenian transaction-level data at a CN 8-digit classification of products. In their data, the top 12 percent of exporters export more than 50 varieties and account for 74 percent of the total export volume. Moreover, their study reports very similar results for

multi-product importers. 20 percent of firms import more than 50 products and account for 83 percent of total imports.

Berthou and Fontagné (2013) show for French firms that the number of exported products is highly skewed. While 50 percent of exporters export two products only, the top five percent of firms export more than 19 products to each destination. Hence, the value of export sales is highly concentrated on those top firms. A related, however, somewhat less skewed pattern also emerges for Chinese data. Using international trade data over the 2003–2005 period, Manova and Zhang (2009) show that 75 percent of all firms transact a product scope, which is lower than the mean. The firms at the 90th percentile, however, transact twice as many products as the average firm. Moreover, they report that 4.4 percent of producers export more than 30 products. These firms contribute to one third of total exports value. Using data from Hungary, Görg et al. (2012) report that the average export scope for firms at the 90th percentile of the productivity distribution increased from 20 in 1992 to 60 in 2003. Bernard et al. (2014) show for Belgian data that 12 percent of firms export more than 20 products and account for 61 percent of total export volume. Their study also reveals another type of heterogeneity with respect to the number of export destinations. The authors report that firms, which export one product, tend to serve on average 1.58 destination countries. The top firms, however, which export more than 50 products, serve more than 23 destinations. All of those results document that the top exporters, which dominate international markets, produce an export scope that is far above the average range of exported products. Table 2 summarizes studies that report the average exported scope for both developed and developing countries. At this point, it is important to notice, that papers differ in the underlying product classification, which makes the reported numbers not always directly comparable.

While all previously cited articles focus on the role of MPFs in international markets, there is also a large literature documenting their dominance in national markets. Using U.S. data for the time-span 1987 to 1997, Bernard et al. (2010) show that 39 percent of producers are classified as MPFs, which are responsible 87 percent of total production. For Indian data, Goldberg et al. (2010) document that 47 percent of firms produce multiple products and account for 80 percent of total output. Table 3 collects empirical studies that document both the share of firms, which are classified as MPFs, as well as their respective share in output. Thereby, the table distinguishes

Table 2: Average export scope in developed and developing countries

Average export product scope				
Article	Country	Period	Classification	Average export scope
Bernard et al. (2009)	U.S.	2000	HS 10-digit	8.9
Manova and Zhang (2009)	China	2003-2005	HS 8-digit	9.3
Iacovone and Javorcik (2010)	Mexico	1994-2003	CMAP 6-digit	2.14
Görg et al. (2012)	Hungary	2003	HS 6-digit	25†
Berthou and Fontagné (2013)	France	1995-2003	HS 6-digit	5.17
Amador and Opromolla (2013)	Portugal	1996-2005	HS 4-digit	4.1
Chatterjee et al. (2013)	Brazil	1997-2006	NCM 8-digit	5.2
Aw and Lee (2017)	Taiwan	1992-2004	SIC 7-digit	1.6
Fontagné et al. (2018)	France/Italy	2000-2007	HS 6-digit	8.5

NOTES: †: The study focuses on large firms with exports above 100 million HUF (approximately 400,000 EUR in 2003).

between international and domestic markets. Comparing the results for various countries, one can conclude that the share of MPFs among exporters is typically higher than in the total population of all firms.

Table 3: MPFs in international and domestic markets

Share of MPFs and share of total exports in **international** markets				
Article	Country	Period	Share of Exporters	Share of Exports
Bernard et al. (2007)	U.S.	2000	58%	99%
Amador and Opromolla (2013)	Portugal	1996-2005	61%	91%
Chatterjee et al. (2013)	Brazil	1997-2006	49%	78%
Bernard et al. (2014)	Belgium	1998-2005	66%	98%
Bee et al. (2017)	France	2003	66%	99%
Macedoni and Xu (2021)	China	2006	77%	94%
Macedoni (2021)	EDD	1993-2011	65%	94%
Share of MPFs and share of total output in **domestic** markets				
Article	Country	Period	Share of Firms	Share of Output
Bernard et al. (2010)	U.S.	1987-1997	39%	87%
Goldberg et al. (2010)	India	1989-2003	47%	80%
Boehm et al. (2016)	India	2000-2008	39%	71%
Caselli et al. (2017)	Mexico	1994-2007	58%	67%
Garcia-Marin and Voigtländer (2017)	Chile	1996-2007	49%	60%

The most dominant and largest producers are diversified in a way that they produce products in different industries or even sectors. In a recent study, Boehm et al. (2021) report results for Indian multi-industry firms for the time-span 2000 to 2009. In their data, firms that were active in more than one industry accounted for 32.2 percent of observations and accounted for 62.2 percent of all sales. In particular, the biggest producers, which span three or more industries (11.2 percent of all observations) still account for more than 41 percent of total sales. Table 4 provides an overview of results that document the prevalence of firms, which are active in more than one sector and displays their output shares as well as the average share of sectors of activity.

Table 4: Prevalence of multi-sector firms

Share of multi-sector firms					
Article	Country	Classification	Share of firms	Share of output	Mean sectors per firm
Goldberg et al. (2010)	India	NIC 2-digit	24%	54%	1.68
Bernard et al. (2010)	U.S.	SIC 2-digit	10%	66%	2.3
Navarro (2012)	Chile	ISIC 2-digit	9%	8%	2.2
Bernard and Okubo (2016)	Japan	JSIC 2-digit	14%	52%	3.2
Boehm et al. (2016)	India	ASIC 2-digit	19%	49%	2.34

3 Theory of multi-product firms in international trade

Motivated by the empirical evidence on the relevance of MPFs in international markets, a still growing theoretical literature developed various ways of modeling multi-product producers. In contrast to single-product firms, MPFs not only decide on optimal scale per variety but also on optimal scope of the firm. Hence, a main element in many models is an endogenous decision on optimal product scope, which responds to shocks such as *globalization* (see Feenstra and Ma 2008; Eckel and Neary 2010; Qiu and Zhou 2013; Dhingra 2013), changes in *market size* and *geography* (Mayer et al. 2014), *trade liberalization* through lower trade costs (see Baldwin and Gu 2009; Bernard et al. 2011; Nocke and Yeaple 2014; Eckel et al. 2015), *exchange rate shocks* (see Chatterjee et al. 2013; Flach and Irlacher 2018), *demand shocks* in export markets (see Mayer et al. 2021), *deunionization* (see Egger and Koch 2012) and *international taxation* (see Flach et al. 2021). Since product variety plays a central role for welfare in many models of trade, it is crucial to understand

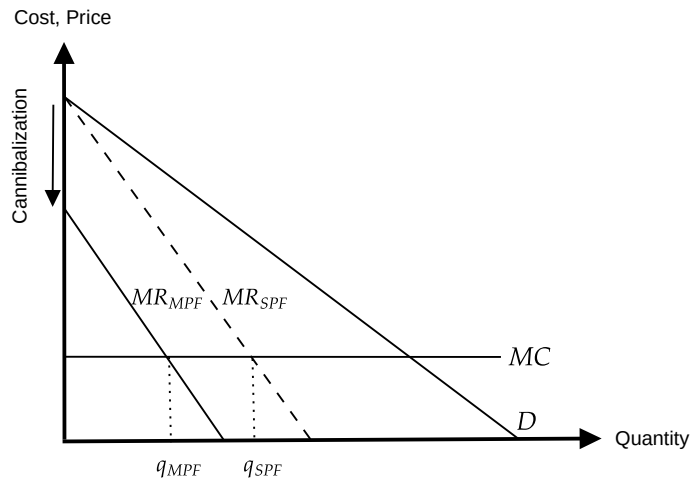
how various shocks affect the scope decision of MPFs. This is particularly important as Broda and Weinstein (2010) show that the majority of product creation and destruction happens within the boundaries of the firm.

In general, the decision on optimal scope at the firm level depends on i) firm-specific demand and supply linkages as well as ii) market-specific characteristics such as trade costs and the degree of competition. Demand and supply linkages are specific to settings with MPFs and constrain the expansion of scope at the firm level. Optimal scope is typically reached when the additional profit of the marginal variety compensates for a potential profit reduction of infra-marginal varieties as well as the additional costs for the marginal product. Firms that produce multiple products may internalize demand linkages, which implies that any additional variety crowds out demand for a firm's initial products. This effect is called the cannibalization effect and is discussed in Section 3.1. Moreover, the cost scheme of the firm may be characterized through diseconomies of scope on the supply side, which will be discussed in detail in Section 3.2. Finally, as already indicated above, optimal scope depends on a variety of determinants that characterize the environment in which the firm operates. Changes in this environment lead to within-firm adjustments and are discussed in Section 3.3.

3.1 Demand linkages: The cannibalization effect

Firms that offer a range of partly substitutable products internalize two effects when adding an additional variety. Firstly, new varieties on the market increase total firm sales. Secondly, this effect may be counteracted as the new variety cannibalizes the sales of the firms' existing varieties. This cannibalization effect is specific to MPFs and generates a distinction in optimal firm behavior in contrast to single-product firms. The difference is visualized in Figure 3.1 where the marginal revenue curve for a MPF is lower than it would be for a single-product firm. In contrast to single-product producers, the marginal revenue curve does not coincide with the inverse demand curve at zero output. Hence, the cannibalization effect provides an additional incentive to restrict output of each variety beyond the own-price effect, which induces MPFs to produce less of every good (all other things being equal). The presence of the latter cannibalization effect, however, crucially depends on the underlying market structure, which is an important distinction in the theoretical

Figure 1: The cannibalization effect



Notes: This figure is inspired by Figure 2 in Eckel and Neary (2010) p. 193.

literature on MPFs in international trade.

A first strand of models is concentrated on monopolistically competitive MPFs. Assuming a continuum of firms implies that firms are implicitly negligible to the market and, therefore, demand linkages among products within the firm are excluded (see for instance Bernard et al. 2011; Nocke and Yeaple 2014; Mayer et al. 2014; Manova and Yu 2017; Arkolakis et al. 2021). Modeling firms of zero mass implies that firms ignore the reduction of own sales when introducing a new variety as they do not realize their influence on price or quantity aggregates. This a standard result in models of monopolistic competition where firms take these aggregates as given. Important exceptions of models that feature the cannibalization effect despite assuming monopolistic competition are Feenstra and Ma (2008) and Dhingra (2013). Feenstra and Ma (2008) rely on CES preferences and monopolistic competition, however, they relax the assumption of a constant aggregate price index. Dhingra (2013) also maintains a monopolistically competitive environment and modifies the preference structure to study cannibalization. In her setting, each firm makes a unique brand of products and consumers have a taste for diversity in brands. Technically, the author uses additive quadratic preferences à la Melitz and Ottaviano (2008) and adds a differentiation parameter across brands into the consumer's utility function. Widening a firm's brand with an additional variety comes at the cost of losing existing market shares as consumers substitute into the brand's new

product.

A second strand of the literature drops the assumption of monopolistic competition and considers firms to attain a finite mass. Eckel and Neary (2010) study the the effects of globalization on the behavior of MPFs in General Oligopolistic Equilibrium (GOLE) where firms are large in their industry and hence, face cannibalization but small in the whole economy. The latter assumption implies that firms have no market power on the economy-wide labor market and take wages as given, which helps to overcome problems of studying oligopoly in general equilibrium. In Eckel et al. (2015), the model is extended to allow for endogenous quality investments in both individual products as well as the brand. Parenti (2018) analyzes a framework in which large and small firms coexist in the same market. In his setting, a small number of large oligopolistic MPFs compete with small single-product producers in a monopolistically competitive fringe whereas the product scope of large firms is constrained by cannibalization. Flach and Irlacher (2018) build on Eckel and Neary (2010) to study industry-specific returns to product and process innovation. In their setting, demand linkages, which are determined by the degree of product differentiation in an industry, affect the returns to product innovation. Consequently, the model predicts more product innovation in highly differentiated industries as the cannibalization effect is lower. Macedoni (2021) studies the welfare implications of endogenous changes in product scope of large MPFs. The author derives a welfare formula in the spirit of Arkolakis et al. (2012) and shows scope for mismeasurement in case of ignoring the cannibalization effect.

So far, empirical evidence for the cannibalization effect is relatively scarce. Only few papers tried to identify this effect in the data and there is still scope for further research in that direction. Hottman et al. (2016) rely on highly detailed barcode data from U.S. retailing and document sizable cannibalization effects. For the average firm, the authors estimate a cannibalization rate of 50 percent. This implies that half of the sales of an additional variety comes from crowding out own existing varieties whereas the other half comes from the sales of other firms. Moreover, they show that cannibalization rates increase in firm size, which indicates that large firms tend to stronger take into account the negative impact of additional varieties on their existing sales. Using Brazilian data and an exchange rate shock as an exogenous source of variation, Flach and Irlacher (2018) show that exporters in more differentiated industries invested more in new products. The authors rationalize their result by a lower degree of cannibalization in case of highly differentiated varieties.

In general, models featuring oligopolistic MPFs predict a non-monotone, hump-shaped relationship between the scope and the market share of a firm. This non-monotonicity exists as on the one hand, expanding scope increases a firm's market share at the costs of other firms. On the other hand, however, the strength of the cannibalization effect increases in a firm's market share, which reduces optimal scope. Macedoni (2021) finds evidence for this hump-shaped relationship using firm-level data for 11 countries from the Exporter Dynamics Database.

In all previously discussed papers, the cannibalization effect induces a negative demand linkage across varieties. In contrast, Bernard et al. (2019) allow the possibility of positive demand spillovers. In a model of monopolistic competition, heterogeneous MPFs choose optimal scope and whether to make or source a product. Thereby the aim of the authors' approach is to evaluate potential sources of carry-along trade (CAT), which is a prevalent feature in the data and refers to goods, which are sold but not produced by one specific firm. The model assumes a preference structure, which is general enough to capture a demand-complementarity such that demand for a given product increases in total scope. Hence, customers prefer to buy products from firms that offer a wider range of products. As a result and consistent with Belgian data, most productive firms will optimally supply more regularly CAT products to the market. Related to that, Eckel and Riezman (2020) study CAT in an oligopolistic setting and allow products to be substitutes or complements. Hence, there may exist both positive (complementarity) and negative (cannibalization) demand linkages, which are determined by one parameter in the underlying linear demand function. As one result, the authors show that CAT is more profitable in contrast to selling only own goods in case of strong demand linkages (i.e. high substitutability or strong complementarity).

3.2 Supply linkages: Costs and technology of multi-product firms

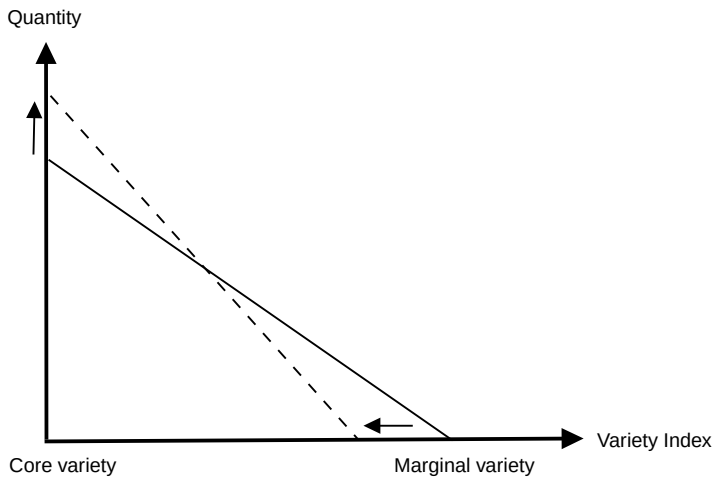
Another dimension, which distinguishes recent theories on MPFs, is the way of modeling the production technology for individual varieties. Papers such as Feenstra and Ma 2008; Baldwin and Gu 2009; Dhingra 2013; Nocke and Yeaple 2014; Parenti 2018; Irlacher 2018; Montinari et al. 2021 assume products of symmetric costs. Hence, there is no heterogeneity in terms of prices and quantities within the product portfolio of a firm and all products are affected identically by external shocks. In their models, adding an additional variety comes along with constant per-product fixed costs. On top of that, Dhingra (2013) allows firms to invest in the production processes of their products.

Process innovation reflects economies of scale, which implies that rising per variety output leads to more investments in better processes. As products are symmetric, each variety receives the same investment. Related to that, Nocke and Yeaple (2014) assume that firms can allocate organizational capital to each of their products, which also reduces marginal costs. As products are homogeneous, each variety gets a symmetric share of the firm's total stock of capital. Montinari et al. (2021) assume homogeneous productivity across firms and products, which however varies over time due to a stochastic innovation process.

Pioneered by Eckel and Neary (2010), another strand of models assumes that firms are characterized by a core competency as well as a flexible manufacturing technology. In Eckel and Neary (2010) firms are modeled as homogeneous and the focus lies on product heterogeneity within the firm. The product with the lowest marginal cost within the portfolio is defined as the core competence. Adding additional varieties comes at zero fixed costs but increasing marginal costs when moving away from the core variety. A similar approach is taken in Mayer et al. (2014) who model a competence ladder with geometrically increasing customization costs. They further consider firm heterogeneity whereas the productivity draw by a firm from a Pareto distribution determines the productivity of a firm's core product. Qiu and Zhou (2013) assume a flexible manufacturing technology as well as fixed costs of introducing additional varieties, which rise in product scope and hence, are not constant. Flach and Irlacher (2018) combine the approaches from Eckel and Neary (2010) and Dhingra (2013) to allow for both flexible manufacturing as well as product-specific fixed costs for product innovation. Moreover, their cost structure allows for spillover effects of process innovation across varieties, which are larger in magnitude when products are more similar. Timoshenko (2015) and Arkolakis et al. (2021) model incremental fixed (market access) costs, which may increase or decrease in scope. While total fixed costs increase with the number of products, the models are flexible enough to allow for either economies or diseconomies of scope.

A direct implication of the underlying technology in Eckel and Neary (2010) and Mayer et al. (2014) is that firms are characterized by a "cost-based competence", which implies that the output of the core variety is the highest as it is sold for the lowest price. Since both settings abstract from per-variety fixed costs, the output of the marginal variety is equal to zero. Hence, the output schedule is characterized by asymmetries across varieties and is illustrated by the solid curve in Figure 3.2. In Section 4.2, this survey reviews empirical evidence on product asymmetries within

Figure 2: Output schedule across varieties



Notes: This graph is inspired by Figure 4 in Eckel and Neary (2010) p. 199. It is drawn for a continuum of products and linearly increasing marginal costs. The underlying technology in Mayer et al. (2014) would lead to a falling step function with similar properties.

the firm. The underlying rationale behind this output schedule is that product prices are increasing in distance to the core competency. However, there is empirical evidence that contradicts the result of increasing prices in distance to the core product. Eckel et al. (2015) and Manova and Yu (2017) provide evidence for a "quality-based competence", which implies that sales as well as prices are the highest for a firm's core product. To rationalize these findings, the papers introduce a quality choice into their models where firms allocate the highest quality towards their core varieties.

Modeling product heterogeneity in terms of a cost-based competence generates important implications for a firm's overall productivity. Any shock that increases optimal scope reduces firm productivity as marginal varieties come along with higher marginal costs. On the other hand, any shock that reduces product scope or induces firms to skew sales towards their core varieties increases firm productivity. These within-firm adjustments are discussed in more detail in the following Section 3.3.

The cost scheme of MPFs has also been shown to determine their decisions to undertake foreign direct investments (FDI). Focusing on vertical FDI, Eckel and Irlacher (2017) study the relocation of entire production lines to a foreign low wage destination: "multi-product offshoring". Firms are

characterized by a core competence and flexible manufacturing whereas the opportunity to relocate production abroad particularly benefits a firm's high cost varieties. Hence, firms relocate high-cost varieties abroad as savings on factor costs are the highest for them. Baumgarten et al. (2021) study optimal modes of market access at the firm-product level. Extending the setting of Helpman et al. (2004) to MPFs, they show that the most productive firms engage in horizontal FDI for their core varieties and export varieties of an intermediate productivity level.

Bernard et al. (2011) propose an alternative modeling approach to generate product heterogeneity. In contrast to a supply-side formulation, they introduce a parameter for product attributes on the demand side of their model. Those attributes reflect consumer tastes, which vary across varieties and occur as idiosyncratic shocks to individual products. It turns out, however, that in their formulation of the model with CES preferences and monopolistic competition a product-specific productivity parameter and a taste parameter enter equilibrium firm revenue in exactly the same way. Related to that Arkolakis et al. (2021) add a stochastic demand component at the firm-product-destination level. This extension of the Bernard et al. (2011) model allows to capturing variation in sales ranks of a firm's products across export destinations. Related to that Montinari et al. (2021) assume identical taste shocks for products across countries in combination with heterogeneous fixed entry costs across markets. The latter implies that top-selling products will be shipped to more destinations.

3.3 Product mix responses to shocks

The question of how globalization affects the optimal product mix of firms is central to many recent theoretical contributions. One key result in the literature is that trade liberalization induces firms to concentrate more on their better-performing core varieties. Eckel and Neary (2010) show that core varieties expand due to the market-size effect of globalization while marginal varieties are dropped because of the increase in competition. This result can be visualized by the rotation of the dashed line in Figure 3.2. Similar results are found in Mayer et al. (2014) who focus on the skewness of sales across varieties of different productivity levels. They find that tougher competition in export markets induces a firm to skew its export sales towards better performing varieties. Moreover, they demonstrate how this reallocation of sales towards core varieties improves firm productivity even for a constant product range (i.e. without dropping low-performing products). While the two previous

papers derived their results for a specific (linear) demand system, Mayer et al. (2021) rely on a general demand structure and provide conditions that are needed to generate these product-mix reallocations. Thereby, the result that firms skew their sales towards better-performing varieties for a given set of products in markets with a higher degree of competition crucially hinges on an endogenous price elasticity. Hence, it can be generated in models that rely on quadratic preferences but not in a standard CES-utility framework. The result that firms reduce their product scope in response to trade liberalization, however, is not specific to a setting with endogenous price elasticities. Bernard et al. (2011) rely on CES preferences and monopolistic competition to show that trade liberalization causes firms to drop their least-successful products. Ma et al. (2014) extend the framework of Bernard et al. (2011) to a two-factor model with both capital and labor as factors of production. Firms produce a continuum of products, which differ in their capital intensities. The authors show that firms from a labor-abundant country will specialize on their labor-intensive varieties (their core products) when they start to trade with capital-abundant countries. Hence, these firms become more labor-intensive by increasing the sales of labor-intensive products or by adding addition labor-intensive products to their portfolio.

A common feature in the previously cited papers is that *all* exporting firms drop least-productive products following a globalization shock. The mechanism behind this result is similar to frameworks with heterogeneous single-product firms where the least-productive producers are forced to exit in response to a globalization shock. While empirical support for this prediction will be discussed in detail in Section 4.1, the following theoretical contributions provide frameworks that allow for heterogeneous responses in product scope across firms. In Qiu and Zhou (2013), heterogeneous MPFs are differentially affected by shocks in terms of their scope adjustments. They show that the most productive firms may expand their product scope in response to globalization while less productive firm have to reduce their scope. To derive this result, the authors require that product fixed costs are steeply increasing in product scope. Dhingra (2013) allows for the cannibalization effect as well as innovations in new products and production processes. Her model shows that following a bilateral tariff reduction, product and process innovation move in the same direction for large exporters but in opposite directions for non-exporters. Hence, product and process innovations turn out to be complements for large firms. These firms benefit from a larger market size, which increases their investments in better processes. As they are able to capture larger market shares, which leads to

economies of scale, they can overcome the cannibalization effect and invest in additional product lines to increase their scope in contrast to less productive exporters as well as domestic firms. Nocke and Yeaple (2014) provide a related result for scope responses after a bilateral trade liberalization. While continuing exporters increase their scope, new exporters as well as domestic firms have to drop products as a response to the shock.

While the previous papers analyzed shocks that where directly related to globalization, there are further papers that investigate different types of shocks in an international context. Chatterjee et al. (2013) study the effect of exchange rate shocks on the export behavior of MPFs. In particular, they study the response of prices, quantities as well as product scope to an exchange rate depreciation. Similar to previous studies, a MPF is characterized by a core competence and rising marginal costs for additional varieties. As a specificity of the model, firm have to pay local per-unit distribution cost. The latter feature implies varying markups of varieties across the product ladder, despite the fact that the framework relies on CES preferences. Similar to a setting with linear demand, the model implies the highest markups for a firm's core product. The authors show that a depreciation leads to price increases, which are most pronounced for core products. Moreover, firms increase their product range, and their sales distribution across different products becomes less skewed. Hence, in contrast to many previously discussed papers, an exchange rate devaluation induces firms to put more emphasis on non-core varieties. A similar result has been found in Flach and Irlacher (2018) who show that firms invest more in new products following an exchange rate depreciation. Flach et al. (2021) study the effects of changes in the foreign corporate tax rate on the export behavior of MPFs to that destination. As producers face tougher competition in export markets with lower corporate tax rates, they reduce the number of exported products to that destination and skew their export sales towards the better performing varieties.

4 Empirics of multi-product firms in international trade

The aim of this section is to review some main results from empirical studies on MPFs in international economics, which complement the theoretical assumptions and predictions in Section 3. The recent availability of transaction-based micro data allows the study of MPFs and enables a detailed decomposition of exports, which was not possible in more aggregated datasets. Export data is

available at the firm-product-destination level and allows researchers to test theoretical predictions with respect to within-firm adjustments of MPFs. While Section 4.1 provides empirical evidence on the response of MPFs to external shocks, Section 4.2 collects insights on the product hierarchy within the firm. Finally, Section 4.3 focuses on studies, which analyze product switching as well as export dynamics at the product level.

4.1 Product mix responses to shocks

A key interest of researchers is how MPFs respond in terms of scale and scope to shocks related to globalization. Many theoretical contributions (see Section 3.3) predict that globalization induces firms to focus on core varieties and drop peripheral products. Bernard et al. (2011) rely on U.S. data in the period 1992 through 2004 and observe export products at the HS-10 level. They exploit the Canada U.S. Free Trade Agreement (CUSFTA) as a natural experiment to investigate the effect of trade costs on a firm's export scope. As trade cost reductions were symmetric between U.S. and Canadian exporters this event resembles a bilateral trade liberalization in theoretical models. The authors allow for variation in the size of tariff reductions across industries and generate firm-specific measures of exposure to tariff reductions. To derive the results, the study makes use of a diff-in-diff specification that compares the number of products before and after CUSFTA for U.S. firms experiencing above- versus below-median Canadian tariff reductions. By doing so, the authors find that firms experiencing above-median Canadian tariff reductions reduce the number of products relative to firms experiencing below-median Canadian tariff reductions. Baldwin and Gu (2009) also investigate the effects of CUSFTA but make use of survey and administrative data for Canadian manufacturing firms over the period 1973 to 1997. Their study predicts differential effects of tariff changes between exporting and non-exporting firms. While Canadian non-exporters experienced a drop in product scope, the effect of a tariff reduction on Canadian exporting firms is not statistically significant. Another study that exploits the effects of CUSFTA on product scope is Lopresti (2016). Focusing on the response of U.S. firms, the paper makes use of Bayesian econometric techniques to investigate whether the shock led to differential effects among heterogeneous firms. The author documents differential product-level responses across firms that were determined by their share of sales in international markets. While firms with a low share of international sales decrease scope, more foreign-oriented firms tend to increase their diversification in products.

Iacovone and Javorcik (2010) rely on Mexican survey data covering the period 1994 through 2003 with product-level information on a 6-digit classification (CMAP). In one exercise, the authors regress an indicator variable, which measures whether a firm continues a product or not, on the importance of that variety to total firm sales. Controlling for firm age as well as NAFTA tariffs for that specific product, they find that varieties further from the core product are more likely to be discontinued. Iacovone et al. (2013) rely on the same data set to study the impact of Chinese competition on Mexican MPFs. By doing so, they focus on the scale and scope of Mexican firms in both their home market as well as in their main export destination – the U.S. market. Using the emerge of China as a quasi-natural experiment, the authors find evidence of product reallocations within plants such that they focus more on their core competencies. Their analysis documents that larger firms and core products seem to be relatively shielded from Chinese competition. Similar results are found in Liu (2010) who uses Compustat data in the period 1984 to 1999 for firms incorporated in the U.S.. The paper relies on relatively aggregated product-categories at the 4-digit SIC level to empirically examine the effect of import competition on core versus peripheral products. Relying on probit estimates, the author finds a relatively higher probability of product exit for peripheral products in the face of rising import competition. More specifically, the paper reports that following a 10 percent increase in imports the exit probability of peripheral (*core*) products rises (*decreases*) by 5.2 (*6.7*) percent. In Liu and Rosell (2013) the Compustat database is linked to the NBER patent database to demonstrate a negative relationship between firm exposure to imports and the basic nature of firm patents. The authors find evidence, that firms, which restrict their product scope following an increase in import competition, produce less fundamental inventions.

Theoretical contributions have emphasized that a reallocation of resources towards core varieties and the associated relative increase in their sales may contribute to an increase in productivity at the firm level. Mayer et al. (2014) study the skewness of sales for French exporters across destinations of varying degrees of competition. They use French customs data in 2003 that includes export sales at the 8-digit CN classification. To investigate the effects on relative exports, the authors construct the sales ratio between products as well as skewness statistics such as the standard deviation of log export sales, a Herfindhal index, and a Theil index. The aim of their analysis is to uncover variation in the skewness of sales for a given firm over destinations. Overall, the authors find that French firms

skew their export sales towards better performing products in large destinations as well as in markets characterized by many competitors from all over the world. Related to that, Flach et al. (2021) use data from the World Bank Exporter Dynamics Database and evaluate changes in the corporate tax rates in destination countries. The authors find that a lower corporate tax rate in the destination country increases the within-firm skewness of export sales to this market. The underlying rationale for this result is that exporters experience tougher competition from local incumbent firms, which have to pay lower corporate taxes. Mayer et al. (2021) use French customs data in the period 1995 through 2005 to investigate the effects of demand shocks in destination markets on the product mix of French exporters. Moreover, the authors aim to relate those reallocations to changes in firm-level productivity. The study relies on several measures of demand shocks in the export destination i) at the country level (changes in GDP), ii) at the industry level (total imports to the destination), as well as iii) at the firm level (total imports to the destination at the product level). For all measures, the authors find a significant increase in the skewness of firm export sales to a destination as a response to more intense competition. As a main contribution of the paper, the authors further investigate the relation between the demand shocks and labor productivity at the firm level. The study documents a highly significant effect of demand shocks on firm productivity indicating an elasticity of labor productivity to the shock between 5 and 11 percent.

In contrast to the previously discussed scenarios of trade liberalization, another set of studies investigates the effects of antidumping policies on Chinese multi-product exporters. Antidumping policies target specific products and cause a potential increase in trade costs for affected varieties. Lu et al. (2018) use Chinese transaction-level data containing information on export products at the HS 8-digit level in the period 2000–2006 as well as World Bank data on antidumping cases from the Global Antidumping Database (GAD). The two datasets are then combined at the HS 6-digit product level. The authors find that exporters, which are affected by U.S. antidumping measures, reduce their overall export scope in response to the U.S. antidumping policy. More specifically, the authors document product churning as affected producers drop peripheral products but simultaneously introduce additional export varieties in their main export industry. Thereby, the overall export value remains unchanged. Meng et al. (2020) analyze Chinese transaction data at the firm-product-country level for the period 2000–2014. Products are classified at the HS 6-digit level and antidumping cases are retrieved from GAD. In line with the previous study, they

find that MPFs shift sales towards their core varieties when they are confronted with anitdumping measures. The main interest of their study, however, lies on within-firm adjustments in product quality, which are induced by antidumping policies. Their empirical findings document that firms upgrade the quality of their exports for targeted products in affected destinations. This effect is more pronounced for producers, which were initially characterized by high quality products before the policy intervention. Moreover, firms focus on quality upgrades for those products, which are closer to their core competence. Vandenbussche and Viegelahn (2018) focus on Indian antidumping cases on inputs to investigate resource allocations within MPFs. As a data source for firm-level inputs, the study relies on a private database *Prowess*, which contains information on the import value of raw materials as well as the main industry of a firm at the NIC 5-digit level for the period 1989–2007. Antidumping cases are again inferred from GAD. In order to identify outputs produced with protected inputs, the authors construct an input-output correspondence at the level of the firm. The results show that firms skew their input usage away from protected inputs, which results in output losses due to misallocation effects within the firm. Moreover, firm-level sales are skewed towards products, which are made of unprotected inputs.

A final set of studies investigates how MPFs respond to exchange rate shocks. Chatterjee et al. (2013) use Brazilian customs data (SECEX) from 1997 to 2006 and exploit a series of currency fluctuations in that period. The data provides information for exported goods at the 8-digit level (NCM). Their main interest lies on how producer prices of core versus peripheral products respond to a real exchange rate depreciation. Overall, the authors report an estimated producer price elasticity of 0.23, which corresponds to an exchange rate pass-through of 0.77. To identify the effect on varieties within the firm, the authors interact the exchange rate fluctuations with the rank of the product within the firm. This exercise shows that the price increases are more pronounced for varieties close to the core competence of the firm. Related to that, Xu et al. (2016) investigate the effects of a real appreciation of the RMB on Chinese multi-product exporters. To do so, their study relies on HS 8-digit transaction-level data over the period 2000 to 2007 as well as China's Annual Survey of Industrial Firms (CASIF). Following a real appreciation, the authors find that MPFs narrow their export scope and skew their export sales towards the best-performing products. Moreover, the study reports, that a real appreciation of the RMB lengthens (*reduces*) the export duration of core products (*peripheral products*). Bernard et al. (2014) use panel data from Belgium

in the period 1998 to 2005, which allows them to study within-firm adjustments of intensive and extensive margins over time. The study also exploits variation of exchange rates, which vary by country as well as year and relates them to firm-level responses of Belgian exporters. Their results show that a one percent depreciation of the Euro is associated with a 0.35 percent increase in Belgian exports. The effect is both driven by changes at the extensive and the intensive margin. Thereby, the rise in exports is evenly split between an increase in the number of firms and products as well as rising average exports at the firm-product dimension. Relying on Brazilian data, Flach and Irlacher (2018) investigate the effects of a major exchange rate devaluation in January 1999 on product as well as process innovations of MPFs. Next to customs data by SECEX, the authors rely on the PINTEC survey, which includes detailed information on firm-level innovation investments. Using industry-specific exchange rate fluctuations, the paper shows that incentives to innovate in new products and processes increase following the devaluation. As the main interest of the paper lies on differential effects across industries, the exchange rate shock is interacted with various measures of product differentiation. Thereby, the authors show that firms in differentiated industries focus more on product innovation, while firms in more homogeneous industries focus more on process innovation.

4.2 Product asymmetries within multi-product firms

As described in Section 3.2, a series of theoretical contributions stresses the heterogeneity of products within firms. Indeed, several empirical contributions relying on product-level data reveal the existence of core as well as peripheral varieties, which holds both for domestic as well as export markets. For several datasets, there is evidence that the distribution of output is highly skewed. Bernard et al. (2010) report for U.S. firms that the average share of the core product in sales ranges from 80 percent for firms producing two products to 46 percent for firms that produce ten varieties. Table 5 reports further results for various countries that document this skewness in sales. The share that is attributable to the core product decreases in firm scope but remains relatively high even for firms with a large product range.

Similar results are also found when the focus is only on export sales. Bernard et al. (2011) provide results for U.S. firms that export ten products. Their study reports that core product

Table 5: Share of core product sales for firms of different scope

Share of core product sales											
			Number of products produced by the firm								
Article	Country	Classification	2	3	4	5	6	7	8	9	10
Bernard et al. (2010)	U.S.	SIC 5-digit	80	70	63	58	54	52	50	48	46
Goldberg et al. (2010)	India	NIC 4-digit	86	75	70	65	63	62	64	53	46
Liu (2010)	U.S.	SIC 4-digit	77	65	58	50	46	39	43	38	24
Boehm et al. (2016)	India	ASIC 4-digt	87	78	72	62	57	54	51	46	44
Dhyne et al. (2017)	Belgium	Prodcom 8-digit	78	70	64	58	49†	-	-	-	-

NOTES: †: Average share of core product for firms producing 5+ products.

exports account for 49 percent of export sales. The second best product generates less than half of the core variety's sales and makes 18.6 percent of total export value. Finally, the product of rank ten only generates 1.1 percent of total export value. For Brazilian data, Chatterjee et al. (2013) report that the export value of the core product is 2.7 times higher than for the second best product of the firm. Moreover, it is 1.9 times higher than the total export value of all remaining export products. Eckel et al. (2016) and Caselli et al. (2017) find similar numbers for Mexican exports. They show that export sales of the core product are 2.5 times larger than for the second best product and 5.3 times higher than the export sales of the median product. This type of product heterogeneity is also confirmed for Portuguese data in a study by Amador and Opromolla (2013). They report a share of 86.6 percent of core variety export sales for firms exporting two products, which goes down to 48 percent for firms that export more than 50 products. Figure 2 in Arkolakis et al. (2021) illustrates Brazilian export sales to Argentina for exporters of different scope. They document that wide-scope exporters sell large (small) amounts for their core (marginal) products. Studies by Bernard et al. (2010, 2011) and Amador and Opromolla (2013) report that a Pareto distribution provides a reasonable approximation to the data, however, the tails are somewhat thinner than a Pareto distribution would predict.

Within firms, core varieties can be characterized either as the most efficient product or as the product with the highest quality. A series of empirical studies provides evidence for a "quality-based competence". Eckel et al. (2015) rely on Mexican survey data with product information at the 6-digit CMAP level. They document a price premium for the core variety of 9.1 (*16.1*) percent relative to the average price of peripheral products within the firm in the home (*export*) market.

Focusing only on non-differentiated varieties, however, the authors find that firms rather compete on costs than on quality. Manova and Yu (2017) exploit Chinese data at the Chinese 8-digit HS classification. They document that core products are of superior quality due to better inputs and hence, are sold at higher prices. Due to quality differentiation, exporters earn higher revenues from their more expensive products, which can therefore be characterized as their core varieties. Related to that and also for Chinese customs data, Yin et al. (2021) show that additionally added export products are of lower quality compared to the existing products that a firm sold in a specific destination. Moreover, the authors confirm the result that product quality decreases in distance to the core product of the firm.

4.3 Export market entry and product dynamics

Firms frequently add and drop products, which turned out to be influential for both firm as well as aggregate outcomes. Bernard et al. (2010) report that 54 percent of U.S. firms change their product mix within five-year spells whereas half of them add and drop products at the same time (product churning). While the latter figures include all firms, the percentage of product-switching firms among exporters (62 percent) and MPFs (80 percent) is even higher. While Liu (2010) confirms a high percentage of MPFs altering their product mix in a five-year window for U.S. data (73 percent), Goldberg et al. (2010) report a slightly different picture for Indian firms. In their study, only 28 percent of firms report changes in the product mix over a period of five years. As these firms account for 43 percent of total output, they can be considered as rather large producers. While the latter numbers reflect product dynamics for domestic markets, the remainder of this final section focuses on articles that empirically investigate the dynamics of the export product mix and the entry patterns of products in foreign markets.

Görg et al. (2012) investigate data for Hungarian exporters to determine the factors of success of export products. For the year 2000, they report that 87 (*92*) percent of exporters added (*dropped*) at least one product from their export mix. Their empirical model relates the hazard of dropping a variety to product, firm, and industry characteristics. It turns out that products of more productive exporters survive longer in international markets. With respect to product characteristics, the authors document that a larger per-variety scale as well as longer product tenure are important determinants of product survival. The role of tenure on an export variety's survival rate is also

documented in Iacovone and Javorcik (2010) who show that survival rates are lowest in the first period and increase to almost 90 percent between the second and third year of exporting. Navarro (2012) investigates product switching for Chilean exports. The study reports that 90 percent of multi-product exporters changed their export product mix between 1996 and 2003. Thereby, most changes in the set of exported products included both adding and dropping of products. Related to previous studies, the author finds evidence that the probability of dropping a product is decreasing in product size and tenure.

Ma et al. (2014) show for Chinese transaction-level data that new exporters added on average ten HS-6 products in the time-span 2002–2006. In the same period, they dropped six products and continued on average five products after their first year of exporting. Moreover, the authors investigate the capital-intensities of products that were added or dropped. Thereby, they find that added (*dropped*) products are more (*less*) labor-intensive than the existing exported varieties. The latter pattern of product churning is more pronounced when the destination market is a more capital-abundant country. Timoshenko (2015) investigates product-switching behavior of Brazilian exporters. In her data, 72 percent of exporters are engaged in product adding and dropping in their export markets and these firms account for 83 percent of aggregate Brazilian exports. She documents that 40 percent of annual growth rates of Brazilian exports are caused by changes in sales of added and dropped products. The author further reports that the average surviving exporter that added at least one product in a given year derives 29 percent of its total export sales from added products. This number is significantly higher for firms with only two years of export experience, which derive 51 percent of their total sales from added products. For more experienced exporters, the importance of the product-switching margin in total sales goes down.

For Mexican firm-product level data, Iacovone and Javorcik (2010) investigate export dynamics in the aftermath of NAFTA. They find that new exporters start with a low number of exported varieties sold at a low volume in new destination markets. On average, new exporters sell 1.5 export varieties, which slightly rises to about 2 varieties two years after starting to export. Moreover, the authors document that firms start by exporting varieties, which have been previously sold on the domestic market. 85 percent of new export varieties were sold in the domestic market before starting to export. More experienced exporters, however, also introduce more frequently new varieties to their export destinations. In case of established exporters, only 69 percent of export varieties are

also sold on their home market. Relying on the same dataset, Eckel et al. (2016) report that the sales ranking across varieties for Mexican firms is very similar in domestic and foreign markets. They show that 75 percent of products ranked first in home sales are also the top products in export sales. In a regression analysis, they further relate the product rank based on domestic sales on the product rank based on export sales and find a highly significant positive coefficient.

Arkolakis et al. (2021) use firm-product-destination data from Brazil to characterize market access costs at the firm-product level. The authors use a simulated method of moments estimator as their underlying model features three stochastic elements (firm-level productivity, firm-level market access costs, and local product appeal shocks). Their estimations uncover economies of scope in market access costs, which can explain why wide-scope exporters are able to sell their marginal varieties at a very low scale. Additional products benefit from falling export costs at destination-specific rates whereas they decrease faster in nearby destinations as well as in regions characterized by lower nontariff measures. In particular, the authors report a reduction in the elasticity of market access costs with respect to additional products in nearby destinations by one-third.

5 Conclusion

Over the last decade, a still growing body of theoretical and empirical research has investigated the important role of MPFs in international trade. Evidence from transaction-level data for many countries has shown that international trade flows are typically concentrated in the hands of a few large multi-product exporters. Over time, this concentration has even increased. Motivated by this empirical evidence, theoretical research has examined how firms determine the range of products for their domestic as well as export markets. New modeling techniques on product asymmetries within the firm allow researchers to open the black box of within-firm adjustments in response to external shocks such as globalization. Asymmetries among products not only determine how individual varieties are affected by the chances and threats of globalization but also affect the breath of countries to which they are exported. Research has shown that firms frequently vary their product mix across export destinations depending on trade costs as well as the degree of competition in each market. Newly available transaction data containing information at the firm-product-destination level made it possible to confront a new set of predictions specific to MPFs

with the data. Many new insights on the behavior of MPFs were gained, which contribute to our understanding of how individual firms' decisions affect even aggregate outcomes such as product variety and productivity.

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