MULTI-PRODUCT FIRMS AT HOME AND AWAY*

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Abstract

This paper uses a unique data set on Mexican firms to test a number of hypotheses implied by recent work on multi-product firms in open economies. The findings are consistent with the "flexible manufacturing" view that firms have a "core competence" product, and sell fewer products in their export than their home markets, though with possibly higher sales of core products abroad when the foreign market is larger. The additional costs of serving a larger foreign market thus lead firms to adopt a "leaner and meaner" profile of export sales across the varieties they produce relative to their home sales.

Keywords: flexible manufacturing, multi-product firms, trade liberalization.

JEL Classification: F12

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1 Introduction

Recent years have seen an explosion of interest in the behaviour of individual firms in global markets and especially in their responses to changes in trade policy. Early work in this vein concentrated on adjustments between firms, highlighting the selection effect of trade liberalization.[1] More recently, as richer data sets have become available, attention has turned to adjustments within firms. One particular focus of recent work has been what Eckel and Neary (2006) call the "intra-firm extensive margin," reflecting adjustments in the range of goods produced by multi-product firms. The first large-scale empirical study of multi-product firms by Bernard, Redding and Schott (2006a) showed that in the U.S. they are present in all industries; they account for the vast bulk (91%) of total output though less than half (41%) of the total number of firms; and, crucially, most (89%) of them vary their product mix every five years. Partly stimulated by these empirical findings, a number of theoretical models have been developed which model the endogenous choice of scale and scope by multi-product firms in open economies: see in particular, Ju (2003), Allanson and Montagna (2005), Bernard, Redding and Schott (2006a, 2006b), Eckel and Neary (2006), Feenstra and Ma (2007), and Nocke and Yeaple (2006). While there already exists a large literature on this topic in the theory of industrial organization, these recent trade models are more applicable to the kinds of large-scale firm-level data sets which are increasingly becoming available.[2] These theory papers have in turn coincided with a number of empirical studies using data sets of this kind to address questions related to the behaviour of multi-product firms.

This paper aims to contribute to this emerging literature using an unusually rich data set on Mexican firms. Previous empirical studies of multi-product firms have used data for a single year covering either total production or export sales only.[3] By contrast, the

[1] The classic theoretical treatment is by Melitz (2003). The large and still growing number of empirical studies includes Clerides, Lach and Tybout (1998) and Bernard and Jensen (1999).

[2] Most models of multi-product firms in industrial organization make one or more assumption which makes them harder to apply to large firm-level data sets. In particular, they typically assume that products are vertically rather than horizontally differentiated; and/or that the number of products produced by a firm is fixed, so the key question of interest is where in quality space it will choose to locate; and/or that the number of products produced is relatively small. For examples from a large literature, see Brander and Eaton (1984), Klemperer (1992) and Johnson and Myatt (2003).

[3] The small literature documenting patterns at the establishment-product level focuses either on total

data set we use provides highly disaggregated information on both the home sales and the export sales of all goods produced by a large representative sample of manufacturing firms. Furthermore, the data are available in panel form, and coincide with an important recent episode of trade liberalization: the reduction of trade barriers between Mexico, Canada and the U.S. following the North American Free Trade Agreement (NAFTA), which came into effect on January 1, 1994. (The properties of the data are discussed in detail in Iacovone and Javorcik (2007b) and in Section 3 below.)

This data set allows us to consider a number of issues of interest relating to the behaviour of multi-product firms in open economies. It also allows us to explore the extent to which different competing models are consistent with the data. Ideally, we would like to devise tests which discriminate clearly between different models. In practice, this is not so easy, since the models differ along more than one dimension, both in their assumptions and in their predictions. In any case, formal discriminatory tests would hardly be credible when carried out by the authors of one of the competing models. The approach adopted here is more heuristic. We start with a simplified version of the model of Eckel and Neary (2006) and extend it to allow for variable trade costs. From the predictions of this extended model we deduce a number of features which we would expect the data to exhibit: some of these are common across models, some are special to our own. We then explore to what extent the data exhibit these features.

Our main interest is in how the theoretical models differ in the way they model the demand for and the decision to supply multiple products. The models also differ in other ways which are of less interest in the present application. One type of difference is in the assumptions made about market structure. In particular, most recent models assume that markets can be characterized by monopolistic competition, in which firms produce a large number of products but are themselves infinitesimal relative to the size of the overall market. By contrast, Eckel and Neary (2006) assume in their core model that markets are oligopolistic. In this paper, we know little about the market environment facing individual firms: they compete directly with relatively few other firms in the sample, while we have

production patterns (Bernard et al. 2006a, Goldberg et al. 2008) or solely on exports (Bernard et al. 2006b, Eaton et al. forthcoming).

no information on their foreign competitors. Hence we prefer to remain agnostic on this issue, where possible deriving predictions which will hold at the level of individual firms irrespective of the market structure in which they operate. A further dimension of difference concerns the level of analysis, whether partial or general equilibrium. Many of the trade theory papers, including Eckel and Neary (2006), highlight general equilibrium adjustments working through factor markets as an important channel of transmission of external shocks. However, although the data set we use has information on factor prices at firm level, it is not possible to ascertain how much these are determined by changes in trade policy. Hence, we concentrate on testing implications of the model in partial equilibrium.

Section 2 of the paper presents the model and derives a suite of propositions concerning the behaviour of multi-product firms in home and foreign markets. Section 3 describes the data, and Section 4 documents the extent to which they confirm our theoretical predictions.

2 The Model

As discussed in the introduction, the model extends that of Eckel and Neary (2006) to allow for differences in trade costs across markets. Section 2.1 reviews the earlier model, showing how a firm chooses its total sales and the distribution of sales across varieties in a single market. Section 2.2 examines the effects of differences in trade costs across space and time. Throughout we focus on deriving testable implications of the model.

2.1 Selling to One Market

Consider a single market in which each one of L consumers maximizes a quadratic sub-utility function defined over a mass δ of differentiated products:

$$u = a\int_0^\delta q(i)\,di - \frac{1}{2}b\left[(1-e)\int_0^\delta q(i)^2\,di + e\left\{\int_0^\delta q(i)\,di\right\}^2\right]. \tag{1}$$

Here e is an inverse measure of product differentiation, assumed to lie strictly between zero and one (which correspond to the extreme cases of independent demands and perfect substitutes respectively). As discussed in the introduction, we remain agnostic in this paper about whether this sub-utility function is embedded in a general or partial equilibrium model: our analysis is compatible with both approaches. All we need assume is that the marginal utility of income can be set equal to one.[4] Maximization of (1) subject to a budget constraint then generates linear demand functions for the typical consumer. These can then be aggregated over all consumers, with market-clearing imposed so $x(i) = Lq(i)$ to give the market demand function faced by the firm:

$$p(i) = a - \tilde{b}\left[(1-e)\,x(i) + eX\right] \qquad \tilde{b} \equiv \frac{b}{L} \qquad X \equiv \int_0^\delta x(i)\,di \tag{2}$$

where $p(i)$ is the price that consumers are willing to pay for an extra unit of variety i, and X is the total volume of output in the market.

Consider next the technology and behaviour of the firm. Throughout we assume that it behaves like a monopolist in this market. (In the next sub-section we compare its behaviour across markets.) As noted in the introduction, with some additional and well-known algebra this can be shown to be consistent either with a single firm competing in a monopolistically competitive sector, or with one among a small group of oligopolistic firms engaging in Cournot competition. In either case its goal is to maximize the operating profits from all the products it sells in the market, taking as given the outputs of other firms (which we do not model explicitly since our data give no information on which firms are close competitors):

$$\pi = \int_0^\delta \left[p(i) - c(i) - t\right] x(i)\,di \tag{3}$$

Here t is a uniform trade cost payable by the firm on all the varieties it sells. The marginal cost function $c(i)$ embodies an assumption which Eckel and Neary (2006) identify as a key aspect of flexible manufacturing: that products can be ranked such that marginal

[4] This is ensured if the sub-utility function (1) is part of a quasi-linear upper tier utility function, with all income effects concentrated on the "numéraire" good. Alternatively, as in Eckel and Neary (2006), (1) can be one of a mass of sub-utility functions without an outside good, with the marginal utility of income set equal to one by choice of numéraire.

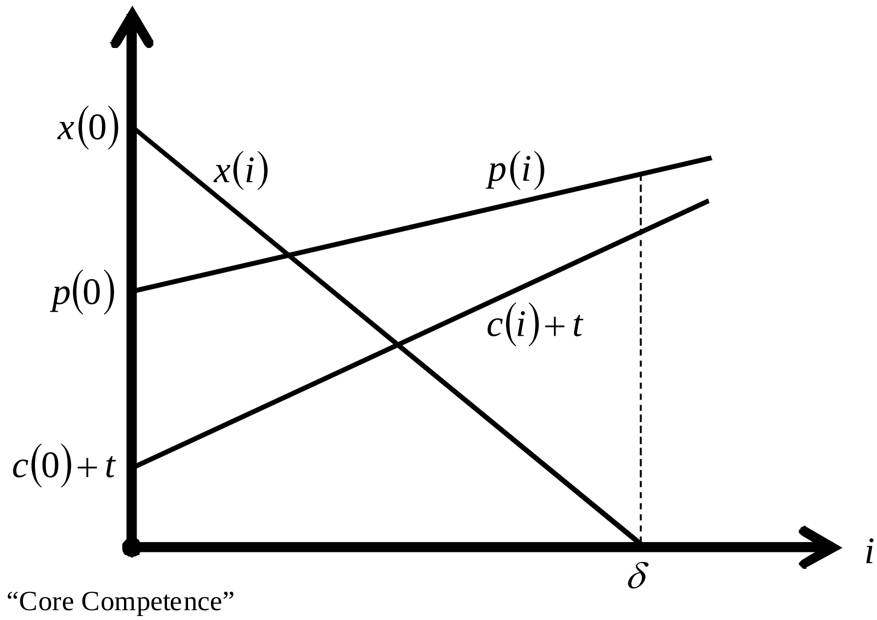

Figure 1: Profiles of Outputs, Prices, and Costs

costs rise as the firm moves away from its "core competence". More specifically, the firm's marginal cost of production for variety i is independent of the amount produced of that variety, is lowest for the core-competence variety indexed "0", and rises monotonically as firms move away from their core competence: $c'(i) > 0$. With trade costs included, this is shown by the upward-sloping locus $c(i) + t$ in Figure 1.[5]

To derive the firm's behaviour, we first consider the optimal choice of output for each variety. The first-order conditions with respect to $x(i)$ are:

$$\frac{\partial \pi}{\partial x(i)} = [p(i) - c(i) - t] - \tilde{b}\,[(1-e)\,x(i) + eX] = 0 \qquad (4)$$

These imply that the net price-cost margin for each variety, $p(i) - c(i) - t$, equals a weighted average of the output of that variety and of total output, where the weights

[5]Figures 1 to 3 are drawn under the assumption that the cost function $c(i)$ is linear in i. Though a convenient special case, this assumption is not needed for any of the results.

depend on the degree of product substitutability. The presence of total output in this expression reflects the "cannibalization effect": an increase in the output of one variety will, from the demand function (2), reduce its sales of *all* varieties. Taking this into account induces the firm to reduce its sales relative to the case of a multi-divisional firm where decisions on the output of each variety were taken independently.[6] Combining the first-order condition with the demand function (2) we can solve for the output of each variety as a function of its own cost and total output:

$$x(i) = \frac{a - c(i) - t - 2\tilde{b}eX}{2\tilde{b}(1-e)}. \tag{5}$$

In addition, the first-order condition with respect to the product range δ implies that the output of the marginal variety $x(\delta)$ is zero. Combining these conditions we can express the output of each variety in terms of the difference between its own cost and that of the marginal variety:

$$x(i) = \frac{c(\delta) - c(i)}{2\tilde{b}(1-e)} \tag{6}$$

Thus the profile of outputs across varieties is the inverse of the profile of costs: outputs fall monotonically as the firm moves further away from its core competence, as shown by the downward-sloping locus $x(i)$ in Figure 1. Since demands are symmetric, the prices which will induce this pattern of demand must be increasing in i. This is confirmed when we substitute for outputs $x(i)$ from (5) into the first-order condition (4):

$$p(i) = \frac{1}{2}[a + c(i) + t] \tag{7}$$

Thus prices increase with costs, though less rapidly, implying that the firm's mark-up is lower on non-core varieties. However it makes a strictly positive mark-up on all varieties: because of the cannibalization effect, it would not be profit-maximizing to set price equal to marginal cost on the marginal variety $x(\delta)$.[7]

[6] Each division of such a firm would independently set $p(i) - c(i) - t$ equal to $\tilde{b}x(i)$, thereby foregoing the gains from internalizing the externality which higher output of one variety imposes on the firm by reducing demand for all others.

[7] The price-cost margin on the marginal variety is $p(\delta) - c(\delta) - t = \tilde{b}eX > 0$, using (5) and the fact

The relationships illustrated in Figure 1 fully characterize the firm's behaviour across varieties. However, in most typical data sets including the one to be used below, though we can construct data on the real volume of outputs of different varieties, there are no natural units of measurement in which these can be compared across varieties. (By contrast, all the theoretical models assume that every variety affects utility symmetrically.) To bring the models to data it is much more convenient to work with the *value* of sales across varieties. Hence we need to calculate the profile of sales revenue across varieties, which we denote by $r(i)$. From the firm's perspective this equals the f.o.b. ("free on board") price, $p(i) - t$, times the output of each variety:

$$r(i) = [p(i) - t]\, x(i) = \frac{[a + c(i) - t]\,[c(\delta) - c(i)]}{4\tilde{b}(1 - e)} \tag{8}$$

Since price increases but output falls with movements away from the core-competence variety, the implications for sales revenue are not immediately apparent. However, it is easily shown that the output change dominates, so $r(i)$ is decreasing in i, which yields the first testable implication of the model:

Proposition 1 *The profile of sales revenue across varieties in a given market is not uniform.*

Proof. Differentiating (8) and substituting from (5) with $i = \delta$ yields:

$$\frac{dr(i)}{di} = -[\tilde{b}eX + c(i)]\frac{c'(i)}{2\tilde{b}(1-e)} < 0 \tag{9}$$

Representative sales revenue profiles in two different markets (whose detailed properties will be discussed later) are illustrated in Figure 2. ■

The implication that a multi-product firm sells different amounts of each variety it produces in each market it serves is not too remarkable in itself, and follows directly from our assumption that marginal costs rise monotonically for varieties further from the firm's core competence. By contrast, it is inconsistent with models of multi-product

that $x(\delta)$ is zero. For a multi-divisional firm which ignored the cannibalization effect, it would be zero.

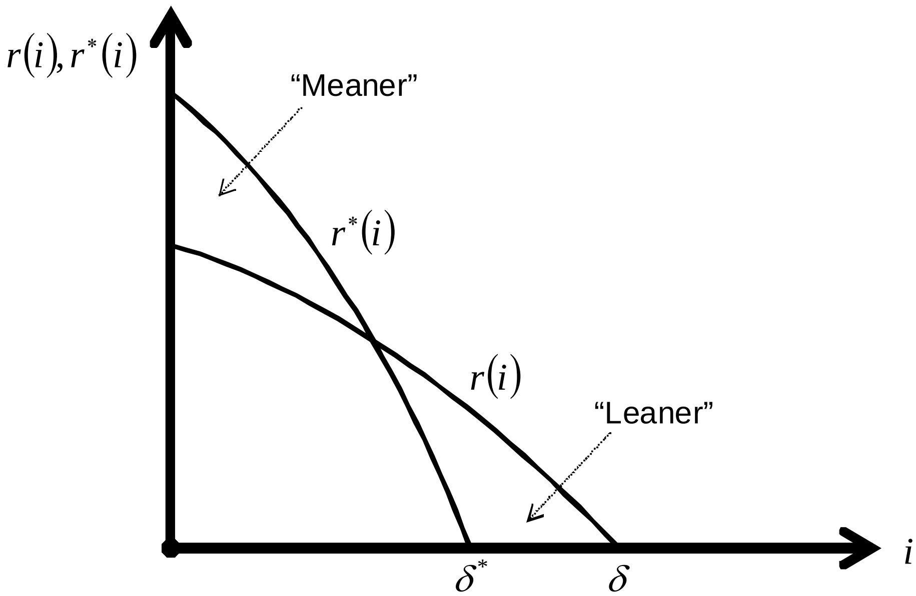

Figure 2: Sales Profiles in the Home and (Larger) Export Markets

firms which assume that varieties are symmetric in both production and demand, such as those of Allanson and Montagna (2005), Feenstra and Ma (2007), and Nocke and Yeaple (2006).[8] It is fully consistent with the model of Bernard, Redding and Schott (2009) notwithstanding the fact that the source of heterogeneity across varieties is different in their model. They assume that each variety has the same productivity and a taste parameter which is an independent stochastic draw from a given distribution, rather than a deterministic function of each variety's distance from the core-competence variety as here, but this difference is immaterial for the observable implications of Proposition 1.[9] However, this difference between models matters for a second property which also follows from equation (9):

[8] Nocke and Yeaple assume that marginal costs rise with the number of varieties as in Eckel and Neary. However, they assume that this reflects diseconomies of scope, so for a given number of varieties the marginal cost and hence the price, output, and sales revenue are the same for all.

[9] Earlier versions of their model, in Bernard, Redding and Schott (2006a, 2006b), assumed that the differences across varieties reflected variety-specific productivity draws.

Proposition 2 *The ranking of sales revenue across varieties is the same in all markets served by the firm.*

Different markets will in general have different values of total output X and of the market-size demand parameter $\tilde{b}$. Nevertheless, equation (9) implies that varieties can be ranked by their distance from the core competence in all markets. This prediction is very different from that of Bernard, Redding and Schott (2006b, 2009) who assume that taste or productivity draws for a given firm-variety pair are independent across markets.

2.2 Changes in Trade Costs Across Space and Time

So far we have considered the model's predictions that are common to all markets served by the firm. Consider next what it implies for differences between markets, whether across space or time. Starting with cross-section differences, we assume for simplicity, and in accordance with the data available, that firms sell on two markets only, which we label "home"and "foreign".[10] We assume that the costs of accessing the home market are zero, and we normalize its population at one. As for the foreign country, we assume that the cost of accessing it is strictly positive, equal to $t > 0$, and that its population can be denoted by $L \gtreqless 1$. Thus the foreign country can be either larger or smaller than home. Otherwise, variables for the foreign country are indicated by an asterisk. Finally, we assume that the markets are segmented. Combined with the assumption that marginal costs are independent of output, this means that the firm's decisions in each market can be analyzed independently.

The model makes strong predictions about the range of products which the firm will sell in the two markets: their ratio depends only on variable trade costs. In particular:

Proposition 3 *Irrespective of the relative size of the two markets, the firm's product range at home is larger than in its export market.*

Proof. To prove this it is sufficient to show that the firm's product range in its export market is strictly decreasing in the variable trade cost t. To see this, first integrate the

[10] The model is easily extended to allow for a continuum of foreign markets, provided they differ along a small number of dimensions. See for example, Bernard, Redding and Schott (2006b).

expression for the output of a single variety in (6) to get total output for the export market:

$$X^* = \frac{\alpha(\delta^*)}{2b(1-e)}L \quad \text{where:} \quad \alpha(\delta^*) \equiv \delta^* c(\delta^*) - \int_0^{\delta^*} c(i)di \tag{10}$$

This equation in X^* and δ^* can be combined with a second equation in these two variables obtained by evaluating (5) for the marginal variety δ^*:

$$2beX^* = [a - c(\delta^*) - t]L \tag{11}$$

Eliminating X^* from these equations yields a single equation which expresses the product range as an implicit function of exogenous variables:

$$c(\delta^*) + \frac{e}{1-e}\alpha(\delta^*) = a - t \tag{12}$$

Note that the relative market size L cancels in this equation, as the proposition states. Totally differentiating this yields:

$$\frac{d\delta^*}{dt} = -\frac{1-e}{1-e+e\delta^*}\frac{1}{c'(\delta^*)} < 0 \tag{13}$$

which is negative as required. ■

The next result is largely a corollary of Proposition 3, but it is worth stating separately since it requires a different empirical strategy to test it.

Proposition 4 *All products exported by the firm are also sold at home.*

Proof. Proposition 1 implies that $r^*(i) > 0$ for all $i < \delta^*$: all products with indexes lower than δ^* are exported; and, similarly, $r(i) > 0$ for all $i < \delta$: all products with indexes lower than δ are sold on the home market. Moreover, from Proposition 3 we know that $\delta^* < \delta$. Hence the result follows. ■

While the product ranges in the two markets can be ranked unambiguously, the same is not true of sales of core products. In particular:

Proposition 5 *Sales of the core competence product can be larger in the export market.*

Proof. From equation (8), the ratio of export to home sales for a given variety is:

$$\frac{r^*(i)}{r(i)} = \left[\frac{a + c(i) - t}{a + c(i)}\right] \left[\frac{c(\delta^*) - c(i)}{c(\delta) - c(i)}\right] L \tag{14}$$

This shows that export sales tend to be lower than home sales for two distinct reasons, represented respectively by the two terms in square brackets. First, the net price the firm obtains on exports is lower: because markets are segmented, the firm is able to price discriminate by passing on half of the tariff to foreign consumers, but it must absorb the other half itself. Second, the amount sold to an individual foreign consumer is less than that to an individual home consumer.[11] However, equation (14) also shows that both these effects can be offset if the export market is sufficiently larger. In particular:

$$\frac{r^*(i)}{r(i)} > 1 \quad \text{if and only if:} \quad L > \left[\frac{a + c(i)}{a + c(i) - t}\right] \left[\frac{c(\delta) - c(i)}{c(\delta^*) - c(i)}\right] > 1 \tag{15}$$

Thus a sufficiently large export market can lead to higher sales of the core competence product there, and, by continuity, of products close to the core. ■

Propositions 3, 4 and 5 together imply that, if the export market is sufficiently larger than the home one, the profile of export sales must be steeper than that of domestic sales for at least some varieties. The final proposition shows that this property can hold for all varieties:

Proposition 6 *Other things equal, the profile of sales is less steep in the foreign than in the home market. However, it can be steeper at all points if the export market is sufficiently larger.*

Proof. Totally differentiating the slope of the sales profile, equation (9), with respect to the variable trade cost yields:

$$\frac{d^2 r^*(i)}{di dt} = \frac{L c'(i)}{4b(1 - e)} \frac{e\delta^*}{1 - e + e\delta^*} > 0 \tag{16}$$

Bearing in mind that the first derivative $dr^*(i)/di$ is negative, it follows that, for given L,

[11] From (6), the second expression in brackets equals $x^*(i)/[Lx(i)]$.

the slope of the sales profile in the export market, where t is higher, is larger in absolute value throughout, so the profile is less steeply sloped than in the home market. To see the effects of differences in L, compare the slopes in the two markets:

$$\frac{dr^*(i)}{di} > \frac{dr(i)}{di} \quad \text{if and only if:} \quad L > \frac{\frac{e}{1-e}\alpha\left(\delta\right)+2c(i)}{\frac{e}{1-e}\alpha\left(\delta^*\right)+2c(i)} > 1 \tag{17}$$

which proves the proposition: the sales profile in the export market can be more steeply sloped at every point if L is sufficiently large. ■

Propositions 3 to 6 are summarized in Figure 2. Higher trade costs imply from Propositions 3 and 4 that the firm will be "leaner" in the foreign market, selling a proper subset of the varieties that it sells at home. However, Proposition 5 implies that for a sufficiently large foreign market, it will also be "meaner", selling more of core products.

Propositions 3 to 6 are phrased in terms of a cross-section comparison between home and foreign markets, but they can also be restated in terms of a time-series comparison between the sales in a given market before and after a reduction in trade costs. Specifically:

Proposition 7 *A reduction in trade costs raises the range of products exported, increases export volume, and leads to a steeper profile of export sales across varieties.*

In this case the market size is unchanged, so the implications of a fall in trade costs for the sales profile are very clear, as shown in Figure 3. The product range sold increases, so the firm expands at the extensive margin, but sales revenue rises by more for core products, so the firm also expands at the intensive margin, and the latter is likely to dominate.

3 The Data

We turn next to review the data set.[12] A unique characteristic of our data is the availability of plant-product level information on the value and the quantity of sales for *both*

[12] For a more complete account, see Iacovone and Javorcik (2007b).

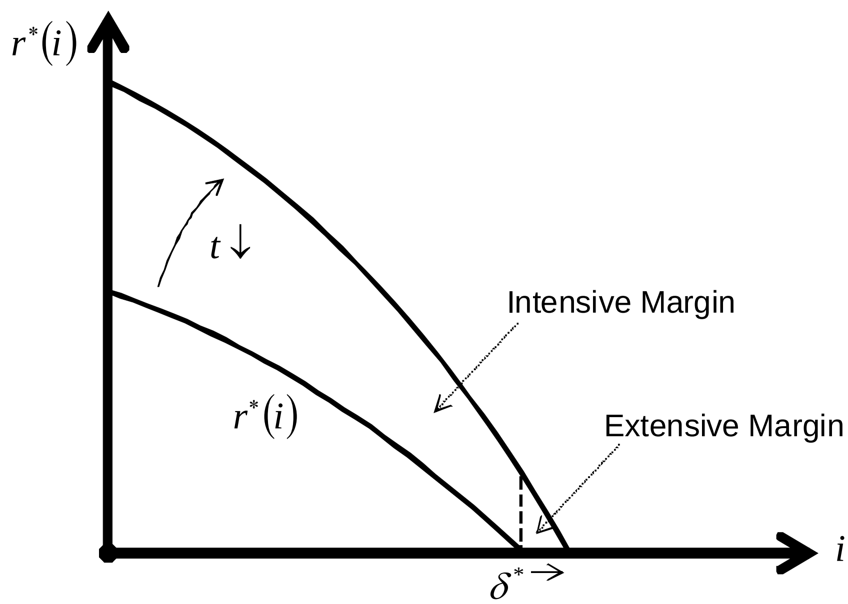

Figure 3: Effects of a Fall in Trade Costs on Export Sales

domestic and export markets. Our data source is the *Encuesta Industrial Mensual* (EIM) administered by the *Instituto Nacional de Estadística Geografía e Informática* (INEGI) in Mexico. The EIM is a monthly survey conducted to monitor short-term trends and dynamics in the manufacturing sector. As we are not primarily interested in short-term fluctuations, we aggregate monthly EIM data into annual observations. The survey covers about 85% of Mexican industrial output, with the exception of "maquiladoras." It includes information on 2,555 unique products produced by over 6,000 plants.[13] Plants are asked to report both values and quantities of total production, total sales, and export sales for each product produced, making the data set particularly valuable for our purposes.

Products in the survey are grouped into 205 *clases*, or activity classes, corresponding to the 6-digit level CMAP (Mexican System of Classification for Productive Activities)

[13]For comparison, the pioneering study by Bernard et al. (2006a) using US data at the five-digit SIC code level is based on approximately 1,800 product codes.

classification. Each *clase* contains a list of possible products, which was developed in 1993 and remained unchanged during the entire period under observation. For instance, the *clase* of *distilled alcoholic beverages* (identified by the CMAP code 313014) lists 13 products: gin, vodka, whisky, other distilled alcoholic beverages, coffee liqueurs, "habanero" liqueurs, "rompope", prepared cocktails, hydroalcoholic extract, and other alcoholic beverages prepared from either agave, brandy, rum, or table wine. The *clase* of *small electrical appliances* contains 29 products, including vacuum cleaners, coffee makers, toasters, toaster oven, 110 volt heaters, and 220 volt heaters; within each group of heaters the classification distinguishes between heaters of different sizes: less than 25 liters, 25-60 liters, 60-120 liters, and more than 120 liters. These examples illustrate the narrowness of the product definitions and the richness of the micro-level information available in our dataset.

Table 1 shows that the number of plants in the sample varies from 6,291 in 1994 to 4,424 in 2004. Between 1,579 and 2,137 plants were engaged in exporting.[14] The decline in the number of establishments during the period under analysis is due to exit.[15] In this paper, we refer to each plant-product combination as a product variety. The number of varieties sold ranges from 19,154 in 1994 to 12,887 in 2004, while the number of varieties exported rose from 2,844 in 1994 to 3,118 in 2004, reaching a peak of 4,193 in 1998.

Notwithstanding the many advantages of our data set, two drawbacks should be mentioned. First, we can only identify which plants were owned by the same firm for the final year in our sample, 2004. This poses a dilemma: on the one hand, treating plants as the unit of observation risks ignoring the interdependence of decision-making within multi-plant firms; on the other hand, the pattern of plant ownership in 2004 is unlikely to be typical of previous years because of plant sales and divestitures as well as mergers and acquisitions. In practice, we present results for plant-level data, but we have checked that the findings are robust when we group together in all years the information

[14]We exclude a very small number of plant-year observations (23 in total) which reported positive exports but no production: see Table 1.

[15]The objective of the survey was to provide an accurate picture of the evolution of Mexican manufacturing industry. Plants that exited after 1994 were not automatically replaced, though new firms were added in an effort to ensure that larger firms were represented throughout.

on plants owned by the same firm in 2004. Second, while our data set is unique in providing information at the same level of disaggregation on both home and export sales, we cannot distinguish between different export destinations. Fortunately, this problem is much less severe in the case of Mexico, since the U.S. is by far the dominant market for most Mexican manufacturing exports. Our work is thus complementary to those of Arkolakis and Muendler (2009), Berthou and Fontagné (2009), and Mayer, Melitz and Ottaviano (2009), who apply models of multi-product firms to data sets for Brazil, Chile, and France. They are able to examine how the profile of exports varies across export destinations, but they do not have information on home sales.[16]

4 Do the Data Support the Theoretical Predictions?

Armed with this rich data set, we now consider whether the patterns it exhibits are consistent with the predictions derived in Section 2, with the numbering of sub-sections that follow matching the propositions stated there.

4.1 Is the profile of sales revenue uniform?

We start by examining the models' predictions with respect to the revenue profile. To do so, we rank all products within each establishment in terms of their sales revenue. Then we divide the revenue from sales of the second most important product by the revenue associated with the core product. We repeat the exercise for the third, fourth, most important product, etc., and we do this for both total and export sales in Tables 2 and 3 respectively.

The top panel of Table 2 presents the distribution of these ratios for total sales, and the results clearly indicate that the revenue profile is not uniform across products, thus supporting the predictions of Eckel and Neary (2006) and Bernard, Redding and Schott (2006a) and contradicting the assumption of symmetric products made by other authors. On average, the revenues from sales of the second product are 40.8% of the revenues

[16] In other respects these papers are comparable to ours. In particular, they assume a flexible manufacturing specification of technology.

brought by the core product. For the third and fourth products the corresponding figures are 23.4% and 16.2%, respectively. The magnitudes decline as we move away from the core variety. Interestingly, the same pattern is found when we consider the median or other percentiles of the distribution.

One may be concerned that the above figures are based on different number of plants (as different plants produce a different number of products), so we repeat the exercise restricting the sample to establishments with exactly five products (middle panel) and establishments with exactly three products (bottom panel). In both cases, the pattern described above is confirmed. Finally, Table 3 shows that the revenue profile is also non-uniform across products in the case of exports.

4.2 Is the ranking of varieties by sales revenue the same in both markets?

Next, we focus on whether the ranking of sales across varieties sold by a multi-product producer is the same at home and abroad. Indeed, this turns out to be the case. The squared correlation coefficient between the product rank based on domestic sales and the product rank based on export sales is 0.58 This high correlation is confirmed by the simple regressions shown in Table 4, where the product rank based on domestic sales is regressed on the product rank based on export sales. The coefficient on the export rank is 0.874 and is statistically significant at the one percent level. Controlling for establishment fixed effects slightly lowers the magnitude of the coefficient to 0.665, but does not affect its significance level.

4.3 Do firms sell more products in their home market?

Another prediction of the model that finds support in the data is that a multi-product producer sells a wider range of products in its home market than abroad. As can be seen in Table 5, an average exporting establishment in our dataset produces three products, two of which are exported. An exporting establishment at the 90th percentile of the distribution produces six products, four of which are exported. Empirical support for this proposition is also clearly visible in Figure 4 which depicts the distribution of the ratio of the number of exported to total products at the establishment level.

4.4 Are all exported products also sold at home?

Our theoretical framework predicts that all export products are also sold at home. This prediction is again consistent with the Mexican data. We find that only in 1,851 of 39,272 cases (plant-product-year observations), is an export product not sold domestically. These cases constitute a mere 5% of all observations pertaining to exported products. Similarly, Table 6 shows that 85% of export products sold by producers entering foreign markets for the first time were sold domestically in the previous period. In the case of export products introduced by established exporters, this figure is somewhat lower but still very high (70%).

4.5 Are export sales higher than home sales?

The model is ambiguous on whether the value of domestic or export sales will be higher, the relative magnitudes being determined by the market sizes. Table 7 shows that, for a large majority of producers, export sales are much smaller than domestic sales. For producers at the median of the distribution, exports of the top three products are only about 15% or 19% of the value of domestic sales. However, for producers at the 90th percentile, the corresponding figures are between 298% and 357%, confirming that for some firms the effect of a larger foreign market offsets the trade costs which must be incurred in serving it.

4.6 Is the profile of sales revenue steeper in the export market?

The model predicts that the profile of sales across varieties will be steeper in the export market than in the home market if the export market is larger. Since the bulk of Mexican exports are shipped to the U.S., there is a presumption that this is the relevant case for our sample, and this prediction is confirmed by the data. As can be seen in Table 7 and Figure 5, the ratio of export sales to domestic sales is higher for core products than for non-core varieties. The same pattern is found at most of the percentiles of the distribution (with the exception of the 75th).

4.7 Do similar results follow a reduction in trade costs?

So far we have considered only the cross-section predictions of the model. However, as Section 2 showed, it has implications for time-series comparisons too. A nice feature of our data is that they cover the period immediately following the introduction of NAFTA and the aftermath of the Peso crisis of 1994. This means that we are focusing on the period during which Mexico enjoyed a substantial reduction in the cost of trading with its North American partners. According to the model, this would imply that we should observe an increase in the number of exported products. And indeed this is exactly what we observe: the number of exported products increases from 2,844 in 1994 to 4,193 in 1998. (See Table 1.) Although there is a slight decline in the number of exported varieties in subsequent years, this is mostly due to plant exit.

A different time-series prediction of the model is that exports of core products should expand more than exports of peripheral varieties following a reduction in trade costs. Table 8 provides support for this prediction. The transition matrix shows that the most important export variety (in terms of export value) in a given year is in 51% of cases also the variety with the largest increase in export value in the following year. For the second most important variety, this proportion is only 40%, while for the fifth largest variety it falls to 14%. Nonetheless, there is a clear association between the importance of a given product in a firm's export profile and its subsequent export growth.

In Table 9, we illustrate the same point by regressing the change in log exports on the product rank (defined with reference to domestic sales). We do so using the full sample, a subsample of plants with three products, and a subsample of plants with five products. In all three cases, the coefficient on the product rank is negative suggesting that peripheral products see a smaller expansion in exports than those nearer the core. The coefficient is statistically significant in two of the three regressions.

5 Conclusion

This paper uses a unique data set on Mexican firms to test a number of hypotheses implied by recent work on multi-product firms in open economies. The great advantage of this data set relative to others which have been used in this literature is that it gives detailed information on both home and foreign sales, allowing us to test theoretical predictions about their relative profiles. The findings are consistent with the “flexible manufacturing” view that firms have a “core competence” product, sell fewer products in their export than in their home markets, though with possibly higher sales of core products abroad when the foreign market is larger. The additional costs of serving a larger foreign market thus lead firms to adopt a “leaner and meaner” profile of export sales across the varieties they produce relative to their home sales. A similar pattern appears in the response of firms to the liberalization of trade with the U.S. and Canada following NAFTA, with exports of core products expanding much more rapidly than those of peripheral ones.

This paper provides evidence of the importance of the “intra-firm extensive margin” in the responses of firms to differences in trade costs across space and time. Of course, it would be desirable to explore how these responses vary with firm productivity, and we hope to address this issue in future work.

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Table 1. Number of plants and products

Year	Number of plants					Number of products	
	Total	Owned by multi-plant firms[1]	Other	Exporters		Produced	Exported
				Total	Adjusted[2]		
1994	6,291	1,259	5,032	1,582	1,579	19,154	2,844
1995	6,011	1,245	4,766	1,844	1,842	18,568	3,406
1996	5,747	1,256	4,491	2,024	2,023	17,662	3,881
1997	5,538	1,256	4,282	2,138	2,137	16,938	4,092
1998	5,380	1,268	4,112	2,095	2,094	16,419	4,193
1999	5,230	1,279	3,951	1,951	1,950	15,885	3,889
2000	5,100	1,280	3,820	1,901	1,899	15,279	3,737
2001	4,927	1,258	3,669	1,770	1,766	14,714	3,509
2002	4,765	1,237	3,528	1,686	1,684	14,182	3,321
2003	4,603	1,193	3,410	1,678	1,675	13,507	3,282
2004	4,424	1,159	3,265	1,602	1,599	12,887	3,118
Total	58,016	13,690	44,326	20,271	20,248	175,195	39,272

1. Information on the number of plants owned by a single firm is available for 2004 only.

2. The adjusted data exclude plants not reporting production in the year in question.

Table 2. Products are unequal: Ratio of the ith product sales to the sales of the core product

Sold products (value of sales)	mean	10th pctile	25th pctile	50th pctile	75th pctile	90th pctile	No. of plants
Ratio of 2nd to top	0.408	0.041	0.140	0.365	0.649	0.857	36,059
Ratio of 3nd to top	0.234	0.015	0.053	0.166	0.360	0.569	24,119
Ratio of 4th to top	0.162	0.008	0.030	0.102	0.239	0.409	16,405
Ratio of 5th to top	0.125	0.005	0.022	0.075	0.180	0.321	11,476
Ratio of 6th to top	0.100	0.004	0.018	0.057	0.141	0.253	8,318
Ratio of 7th to top	0.078	0.003	0.014	0.042	0.106	0.198	6,192
Only plants with 5 products							
Ratio of 2nd to top	0.475	0.108	0.230	0.460	0.708	0.889	3,157
Ratio of 3nd to top	0.241	0.035	0.081	0.185	0.352	0.533	3,157
Ratio of 4th to top	0.119	0.007	0.023	0.071	0.170	0.301	3,157
Ratio of 5th to top	0.052	0.001	0.004	0.019	0.066	0.135	3,157
Only plants with 3 products							
Ratio of 2nd to top	0.392	0.051	0.142	0.336	0.616	0.833	7,697
Ratio of 3nd to top	0.132	0.004	0.016	0.057	0.182	0.376	7,697

Note: products which tied in terms of their rank were excluded from the bottom two panels of the table

Table 3. Products are unequal: Ratio of the ith product export sales to the export sales of the core product

Exported products (value of exports)	mean	10th pctile	25th pctile	50th pctile	75th pctile	90th pctile	No. of plants
Ratio of 2nd to top	0.374	0.031	0.110	0.313	0.603	0.826	7,915
Ratio of 3nd to top	0.204	0.011	0.043	0.137	0.305	0.501	4,280
Ratio of 4th to top	0.137	0.006	0.023	0.08	0.199	0.359	2,438
Ratio of 5th to top	0.094	0.004	0.016	0.055	0.133	0.249	1,478
Ratio of 6th to top	0.069	0.002	0.009	0.036	0.097	0.187	974
Ratio of 7th to top	0.052	0.002	0.008	0.026	0.064	0.136	631
Only plants with 5 products							
Ratio of 2nd to top	0.500	0.135	0.268	0.488	0.756	0.881	502
Ratio of 3nd to top	0.266	0.039	0.097	0.225	0.365	0.587	502
Ratio of 4th to top	0.137	0.012	0.031	0.082	0.176	0.346	502
Ratio of 5th to top	0.057	0.001	0.005	0.019	0.065	0.166	502
Only plants with 3 products							
Ratio of 2nd to top	0.384	0.046	0.133	0.323	0.617	0.814	1,836
Ratio of 3nd to top	0.134	0.004	0.018	0.067	0.181	0.365	1,836

Note: products which tied in terms of their rank were excluded from the bottom two panels of the table

Table 4. Core domestic products are also core export products

Dependent variable: product rank in terms of domestic sales		
Product rank in terms of export sales	0.874***	0.665***
	(0.01)	(0.01)
Intercept	0.540***	1.010***
	(0.01)	(0.03)
No. of obs.	37312	37312
R-squared	0.58	0.67
Plant fixed effects	no	yes

Note: robust standard errors are reported in parentheses

*** denotes statistical significance at the one percent level

Table 5. Fewer products are exported than sold domestically

	Number of exported products	Total number of products
10th percentile	1	1
25th percentile	1	1
50th percentile	1	2
75th percentile	2	4
90th percentile	4	6
mean	2.0	2.9

Note: Sample of only exporting plants

Figure 4. Ratio of the number of exported products to the total number of products

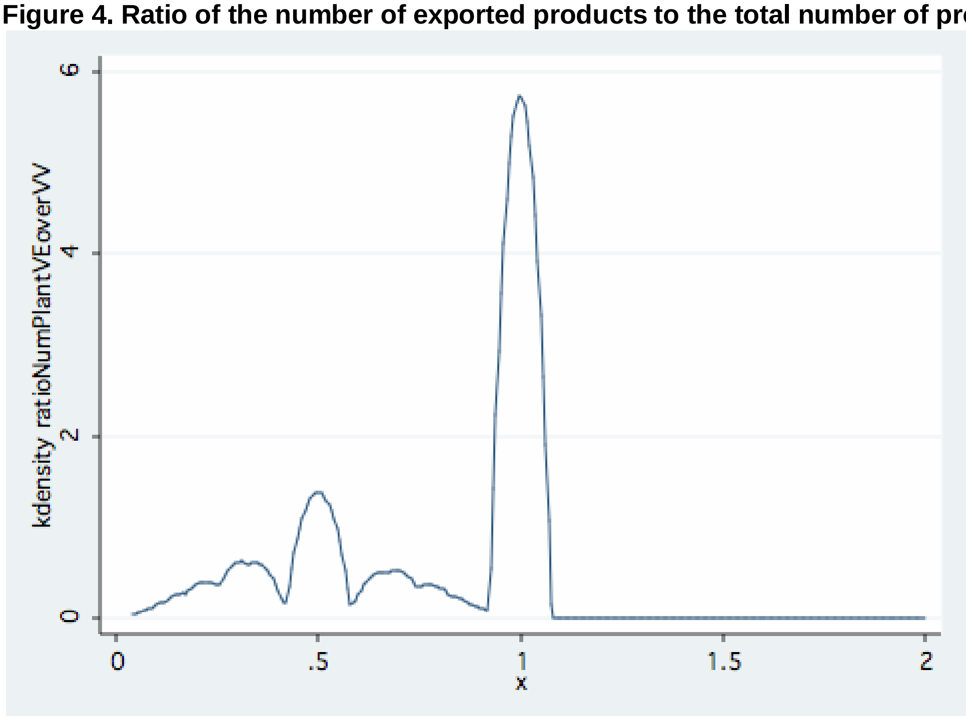

Table 6. Products tend to be sold at home before they are introduced in export markets

	No. of new export products	of which products previously sold domestically	%
Introduced by new exporters	2,437	2,065	84.7
Introduced by established exporters	3,170	2,202	69.5

Table 7. Ratio of export sales to domestic sales

No. of plants	10th pctile	25th pctile	50th pctile	75th pctile	90th pctile
Top product					
18,054	0.0114	0.048	0.194	0.814	3.571
Second most important product					
7,535	0.0106	0.047	0.188	0.834	3.528
Third most important product					
4,205	0.0097	0.039	0.153	0.708	2.975

Note: ranking of products is based on total sales

Only exported products are included

Figure 5. Ratio of export sales to domestic sales by type of product

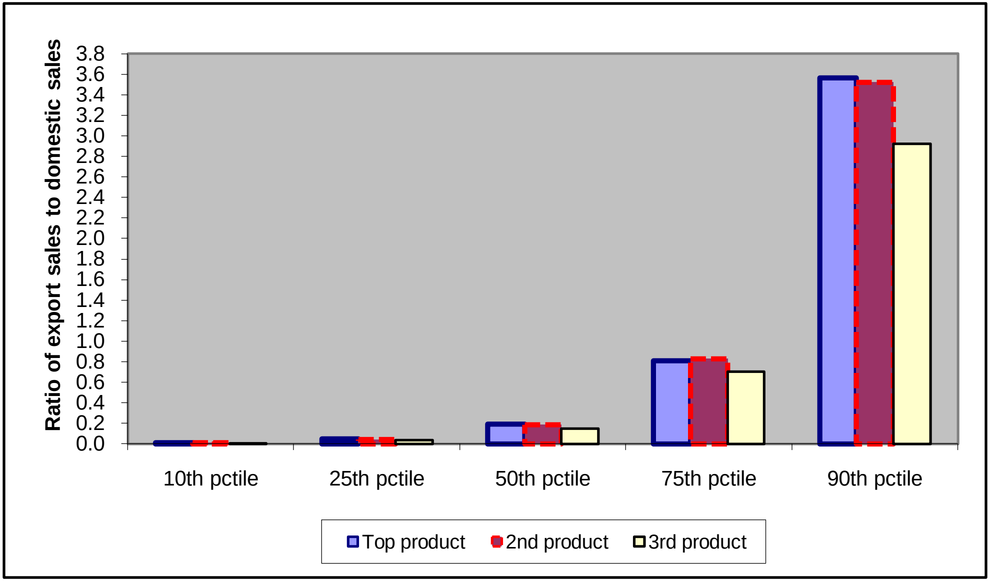

Table 8. Exports of core products tend to see the largest expansion

Rank expansion	Number of Products					Percentages				
	Top product	2nd product	3rd product	4th product	5th product	Top product	2nd product	3rd product	4th product	5th product
1	**3,360**	2,208	716	292	132	**51.2**	37.5	22.7	16.3	12.4
2	1,781	**2,339**	960	417	177	27.2	**39.7**	30.4	23.3	16.6
3	700	667	**846**	436	235	10.7	11.3	**26.8**	24.4	22.1
4	285	317	292	**347**	195	4.3	5.4	9.3	**19.4**	18.3
5	185	124	142	114	**153**	2.8	2.1	4.5	6.4	**14.4**
6	91	93	63	81	83	1.4	1.6	2.0	4.5	7.8
7	67	56	60	46	31	1.0	1.0	1.9	2.6	2.9
8	33	32	29	22	20	0.5	0.5	0.9	1.2	1.9
9	20	21	15	10	16	0.3	0.4	0.5	0.6	1.5
10	15	7	10	8	6	0.2	0.1	0.3	0.5	0.6
10+	23	22	21	17	16	0.4	0.4	0.7	1.0	1.5
Total	6,560	5,886	3,154	1,790	1,064	100	100	100	100	100

Note: Only plants exporting more than one product are included

Note: 51.2 = 51.2% of the top export products experienced the largest expansion in export volume next period

Table 9. Link between export growth and product rank

	All plants	Plants with 3 domestic products	Plants with 5 domestic products
Dependent variable = change in log exports			
Rank based on domestic sales (lagged)	-0.032***	-0.054	-0.079**
	(0.01)	(0.05)	(0.03)
N. Obs	24593	3410	2760
R-squared	0.15	0.30	0.21

Note: plant and year fixed effects are included in all models.