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Arnarson, Björn Thor

Published in:
Journal of Economic Behavior & Organization

DOI:
10.1016/j.jebo.2020.06.013

Publication date:
2020

Document version
Early version, also known as pre-print

Citation for published version (APA):
Arnarson, B. T. (2020). The superstar and the followers: Intra-firm product complementarity in international trade. *Journal of Economic Behavior & Organization*, *117*, 277-304. https://doi.org/10.1016/j.jebo.2020.06.013

The Superstar and the Followers:
Intra-Firm Product Complementarity in International Trade

Björn Thor Arnarson†

University of Copenhagen

June 9, 2020

Abstract

Export sales of multi-product firms are known to be skewed towards their best performing core products. Less is known about the large number of products outside the core that still account for a considerable share of the export value. I use high-quality Swedish firm-registry data to investigate if the exports of core and non-core products are systematically interconnected. Using a novel instrumental variable approach, I find evidence that the exports of non-core products respond to trade of the core. Conversely, the same complementarity is not found using non-core products as placebo-cores. Decomposing the response, I find that over a quarter of the effect can be attributed to price changes of non-core products, suggestive of demand-side explanations. The main contribution of this paper is identifying a new, sizeable, and systematic within-firm *one-way* complementarity between products that can explain non-core product trade flows. Ignoring this pattern of cross-product dependence may lead to an *under-emphasis* on the core and *over-emphasis* on individual trade flows as products should not be viewed in isolation, since the 'superstar' core has (contemporaneous) followers.

JEL classification: F10, F14, F13, L1, L2
Keywords: multi-product firms, product complementarity, intra-firm product dependence, within-destination export variation, product demand, product synergies

†I thank Joakim Gullstrand and Fredrik Sjöholm for their constructive feedback. Additionally, I thank Shon Ferguson, Jakob R. Munch, Peter Hull, Kiril Borusyak, Gianmarco Ottaviano, Peter Neary, Fredrik Heyman, Andreas Moxnes, Wu Xiaokang, Andrew Bernard, Marco Grazzi, Georg Schaur, two anonymous referees, and seminar participants at Lund University, University of Copenhagen, NOITS conference in Oslo, ADI conference in Copenhagen, LETC in Slovenia, the ETSG conference in Paris, and Moscow International Trade seminar, for their helpful comments. The project was partly carried out during funded PhD studies at Lund University. Address: Department of Economics, University of Copenhagen, Øster Farimagsgade 5, Bygning 26, 1353 København K, Denmark, E-mail: bta@econ.ku.dk.

1 Introduction

In the last two decades the focus in international trade has shifted from a broad country level view towards less aggregate firm-level analyses. While the heterogeneity between firms is well acknowledged,[1] an emerging body of literature is looking within the firm. Several theoretical models on multi-product firms have been developed in the past decade to incorporate the wide product scope of multi-product exporters.[2] A central component of these models is that export sales are granular and skewed towards a small number of 'core products'.[3]

The aim of this paper is to investigate and causally identify potential (one-way) product complementarities between core and non-core products of a firm. The significance of studying this relationship, and non-core products in particular, is highlighted by the following four findings. First, using high-quality Swedish micro-data we observe granularity of export sales with around 57% of aggregate trade value being attributed to a single (highest ranked) core product of the firm. Importantly, the flip-side is that 43% of the value is still in the vast variety of other (non-core) products firms export. Hence, due to the broad product scope of firms the combined importance of these products should not be underestimated. Second, Bernard, Redding, and Schott (2011) find that the contribution of heterogeneity *within* and *across* firms are of a comparable magnitude when explaining cross-sectional variation in international trade. Third, traditional measures of firm efficiency/productivity predict better firm destination entry compared to sales variation within a destination.[4] Fourth, Munch and Nguyen (2014) find that these measures perform significantly worse for peripheral compared to core products of the firm.

Variation within the firm is therefore quantitatively important and the potential relationship between core and non-core products has received limited attention in the literature.[5] To fill this

[1] Seminal theoretical contribution from Melitz (2003). Additionally, Bernard, Jensen, Redding, and Schott (2007) and Mayer and Ottaviano (2008) summarised stylised facts on firms engaging in international trade and found that they are, in general, compared to non-exporters, bigger, more productive, sell to a larger number of destinations and account for the largest share of trade value.

[2] See for example, Bernard, Redding, and Schott (2011), Feenstra and Ma (2008), Arkolakis, Muendler, and Ganapati (2015), Eckel and Neary (2010), Mayer, Melitz, and Ottaviano (2014, 2016) and Tintelnot (2017) for multinational multi-product firms.

[3] Amador and Opromolla (2013), Görg, Kneller, and Muraközy (2012) and Fontagné, Secchi, and Tomasi (2018) have for example documented that product exports are skewed towards the most exported core-products of the firm. Goldberg, Khandelwal, Pavcnik, and Topalova (2010) found similar patterns in the production of multi-product firms. Gabaix (2011) used the term granularity to describe how large firms are the "incompressible grains of economic activity".

[4] See Eaton, Kortum, and Kramarz (2011), Munch and Nguyen (2014) and Bernard, Redding, and Schott (2011).

[5] Notable exceptions include Mayer, Melitz, and Ottaviano (2014, 2016) who focus on firm or industry level shocks rather than on a subset of products as in this study.

gap, I suggest and empirically identify a new within firm-destination one-way complementarity which relates the exports of 'core' products of a firm to the more peripheral 'non-core' products.[6] The general intuition for this relationship is that, since the trade value of firms to any particular destination is generally dominated by a single or small set of core products, this 'core' may have a positive effect on the export sales of other products. Hence, the existence of a trade relationship for the core may induce[7] other non-core products to follow along in a contemporaneous transaction, either due to demand-side complementarities or supply-side (cost) advantages.[8]

As the export sales of the core and non-core products to a destination may be jointly determined, I employ a novel instrumental variable approach to overcome the potential simultaneity bias (building on the work of Hummels, Jørgensen, Munch, and Xiang (2014)). The aim is to find an instrument which is correlated with the trade flow of the core but is uncorrelated with other non-core products. I propose using core-destination specific demand variation as an instrument for the export value of the core. As the demand shock is specific to the core-destination pair it should be uncorrelated with other product flows of the firm within the destination.

For the empirical analysis, I use detailed and high-quality Swedish firm-registry data (from 1997 to 2011) which is linked to export flows at the firm-product-destination level. The empirical results show evidence of non-core products being complementary to the core, with an elasticity of 0.28. Hence, a 10% increase in the trade value of the core increases the export value of non-core products by 2.8%. In order to ensure the robustness of the result I use lower-ranked product deciles as placebo-cores and find no significant effects for the nine 'placebo' cores. The complementarity is therefore one-way as *only* the peripheral products are dependent on the core. Hence, the core is not only the core but a 'superstar', as it has (contemporaneous) followers.

The results of this paper therefore suggest that the weight of individual product flows may be over-emphasised if all products are naively considered to be independent stand-alone entities, ignoring the observed systematic cross-product contemporaneous complementarities. In the paper, I show that the complementarity explains around 14% of the change in firm-destination

[6] Note that the terms 'core' and 'core product(s)' are used interchangeably and may refer to more than a single product. See section 3.1 for a formal definition of the core. In our dataset (post pre-sample) we find that around 83% of products are defined as non-core products while they still *jointly* contribute for around a third of the aggregate trade value and on average about 49% of yearly firm export value per destination. See table A1.

[7] The analysis focuses on the intensive margin (the intensity of exports of non-core products).

[8] Example: A firm exports three products to a destination, coffee, cookies and cups. A shock to coffee (core) increases exports of cups (non-core product) while a shock to cups will not induce trade of coffee or cookies (other non-core). See also section 5.3, footnote 54, for an extended version of this example.

export flows which indicates that the share of trade value, explained by the core, is over a quarter larger than what the share of trade value suggests. This calculation highlights that the one-way complementarity explains a considerable part of aggregate variation even though each individual non-core product may have small significance.

In the analysis a number of other robustness checks are performed: first, dropping non-core products that are similar to the core; second, using a balanced panel or product flows with duration over four years; third, excluding observations where the Swedish firm has a significant market share; fourth, altering the definition of the core to include only a single product per destination (regardless of scope); fifth, define the core at the firm level based on product production data or BEC categories. These and other robustness checks do not alter the main findings.

A priori it is unclear empirically if the channel observed is driven by supply or demand factors. In an effort to disentangle the effect, some additional exercises are performed. First, if the observed effect is related to supply side forces we would expect prices of non-core products to decrease as lower costs should be transmitted (at least partially) through lower prices. By decomposing the observed effect on non-core products into a price and quantity response, we can see that both quantities and prices increase, with over a quarter of the total impact being attributed to price increases. This positive relationship between core trade and non-core product prices provides suggestive evidence that the mechanism is related to demand rather than supply forces. Note that the mechanism is stronger for products produced by the firm, indicative of a supply-side complementarity in production. However, such production-side complementarities can only partly explain the mechanism as over 80% of the non-core products exported are produced externally. By further investigating the production data I find that the mechanism is transmitted through prices for *both* produced and non-produced products (Carry-Along-Trade), indicative of demand side explanations.

A second related exercise is to compare firms exporting homogeneous or referenced priced goods to those exporting differentiated products. The underlying idea here is that firms exporting homogeneous (reference priced) core products are engaged in price competition and therefore less able to bundle non-core products with the core compared to those exporting differentiated core products (competing more in terms of quality). Consistent with this explanation I find that firms exporting homogenous core products are unable to bundle in the same manner and increase the quantity of non-core products while the transmission through prices persists. Lastly, other robustness checks are performed which corroborate the earlier findings suggesting that the observed one-way mechanism is related to demand-side complementaries.

In the paper a discussion is provided that relates the findings to both theoretical and empirical work on multi-product exporters. First, this paper relates to the theoretical models developed by Mayer, Melitz, and Ottaviano (2014, 2016) and Arkolakis, Muendler, and Ganapati (2015). Mayer, Melitz, and Ottaviano (2014, 2016) show how tougher competition leads firms to skew their export sales to their best performing products and extend their product range while Arkolakis, Muendler, and Ganapati (2015) build a model allowing for potential economies of scope. In the paper I relate the complementarity to these papers and test for variation based on firm size or product scope and do not find any significant differences.

Second, the paper relates broadly to a literature on complementaries at the firm level.[9] In the trade literature, Bernard, Redding, and Schott (2010) find that some goods are systematically co-produced suggestive of some form of interdependence in production. Bernard, Blanchard, Van Beveren, and Vandenbussche (2018) document the existence of "Carry-Along-Trade" (CAT), which is the export of a product by a firm which does not produce that specific good. They show suggestive evidence that trade in CAT products is related to demand-scope complementaries. Fontagné, Secchi, and Tomasi (2018) document how the product mix of firms is arranged in different product vectors across destinations and find suggestive evidence of (technological) complementaries within a firm. Antràs, Fort, and Tintelnot (2017) highlight the importance of interdependencies/complementarities in the sourcing decisions of firms across markets and Berman, Berthou, and Héricourt (2015) find a complementarity between a firms' exports and domestic sales. Lastly, a paper by Ariu, Mayneris, and Parenti (2016) considers bi-exporters, firms that export both services and goods, and find that providing services boosts the exports of goods.

This paper is also related to several literatures, both theoretical and empirical, investigating the behaviour of exporters, specifically multi-product firms (MPFs). First, it relates to research which has found that MPFs engage in intra-firm product churning (switching) or cannibalisation

[9]Early contributions include Milgrom and Roberts (1990) and Vives (1990) and see Gentzkow (2007) for a more recent application investigating complementarities in the newspaper industry.

which can be a source of expansion or adjustment.[10] Second, it has been shown that product quality, mark-ups, and shipment frequency can be important considerations when examining trade patterns of MPFs.[11] Third, the paper is related to a literature on sunk/fixed costs of exporting and duration of trade flows. Several studies have found that a large proportion of trade flows are temporary and that such products are generally among the least traded.[12] Lastly, it relates to research on the role of demand for exporters, especially in terms of explaining within-destination sales patterns.[13]

The remainder of the paper is organized as follows. Section 2 discusses the data and documents some empirical regularities of product exports. Section 3, discusses the empirical strategy and section 4 presents the main results, section 5 discusses potential channels behind the suggested within-firm-destination complementarity and relates to theory. Section 6 concludes the paper.

2 Data and Descriptive Statistics

In this paper I use Swedish firm-registry data provided by Statistics Sweden from 1997 to 2011. The dataset links firm-level registry data, covering the population of Swedish firms, with information about trade flows at the firm-product-destination level. Around 24% of manufacturing firms are exporters and the final dataset includes an unbalanced panel of 12248 manufacturing firms, 4394 HS-6 products, 90208 firm-destination combinations, and over 2.7 million firm-product-destination observations. The data is provided at the 8-digit level but aggregated and converted to time-consistent HS-6 level codes. See appendix A for information on the sample construction and summary statistics (table A1).

[10]See, for example, Iacovone and Javorcik (2010) who considered product churning, Bernard, Redding, and Schott (2010) for a theoretical model of product switching. Additionally, Timoshenko (2015b) suggested that MPFs may learn from the demand conditions they face in the export market and adjust their product portfolio accordingly. Dhingra (2013) discusses cannibalization within brands. Similarly, Hu, Rodrigue, Tan, and Yu (2017) document the expansive role of demand and product churning in the growth of Chinese firms.

[11]For quality and mark-ups, see for example, Crozet, Head, and Mayer (2012), Kugler and Verhoogen (2012), Baldwin and Harrigan (2011), Khandelwal (2010), Antoniades (2015), Hummels and Klenow (2005) and Traiberman, Warzynski, and Smeets (2014). For shipments, see Eaton, Eslava, Kugler, and Tybout (2008) and Kropf and Sauré (2014).

[12]This has been found both for importing and exporting. See, for example, Besedeš and Prusa (2006a), Besedeš and Prusa (2006b), Görg, Kneller, and Muraközy (2012), Gullstrand and Persson (2014), Békés and Muraközy (2012) and Hess and Persson (2011). See also Geishecker, Schröder, and Sørensen (2018) who study one-off export events.

[13]See Eaton, Kortum, and Kramarz (2011), Munch and Nguyen (2014), Foster, Haltiwanger, and Syverson (2016), Nguyen (2012), Hu, Rodrigue, Tan, and Yu (2017), Bernard, Blanchard, Van Beveren, and Vandenbussche (2018) and Timoshenko (2015a,b).

2.1 Why the Lonely 'Star'?

Before proceeding to the empirical analysis it is helpful to document the within-firm and within-firm-destination patterns of export flows. Firms export many products, but the export value is skewed towards a small set of products. By only counting a single product within each firm, the top-ranked export product to all destinations, we account for around 57% of the aggregate trade value. The value then decreases sharply as one descends the product value ladder. Noting the high value share of the single top product accentuates the large number of products (around 96% of observations) that individually have peripheral trade value but still *jointly* account for the remaining 43% of the aggregate trade value (see table A3 in appendix A). Looking *within* firm-destination pairs, a similar pattern emerges independent of the product scope at the destination. As the firm product scope at a destination increases, the contribution of the largest products declines, but slowly. For firms exporting over 20 (100) products to a destination, still around 55% (45%) of the firm export revenue comes from a single product. This shows that firm exports are granular in nature (see figure A1 in appendix A).

Another important aspect of investigating multi-product exporters is the stability of product rankings across destinations (see table 1). If we look at destinations that a specific firm trades with, then in around 63% of the cases the product with the highest export value at the firm level is also ranked first to a destination. Conditional on the product being exported to a particular destination, then in around 73% of the destinations the most exported product at the firm level is also the most exported product to a destination. Rarely is the product most exported at the firm level ranked lower than third in a destination ($\approx$ 6% of the cases, marked bold in table 1). It is also rare for a low ranked product within the firm to be the highest ranked to a destination: in just under 90% of the firm-product observations the highest ranked product in a destination is among the four highest ranked products within the firm (marked in italics in table 1). Hence these results show that even though the product rankings are correlated across destinations within a firm, the correlation is imperfect. This is in line with results documented in the literature (see for example Mayer, Melitz, and Ottaviano (2014), Nguyen (2012) Manova and Yu (2017) and Fontagné, Secchi, and Tomasi (2018)).

Lastly, I investigate if changes in export values within a firm-destination pair are systematically correlated. More specifically, I want to investigate if yearly changes in export value of a 'core

Table 1: Comparison of product rankings at the firm and destination level (1997-2011) (row/col percentages)

Rank within-firm		Rank of product within-destination 1	2	3	4	5	6	7+	Total
1	Row %	72.7	16.2	5.2	**2.3**	**1.2**	**0.7**	**1.7**	100
	Col %	*63.4*	14.1	5.7	3.0	1.8	1.2	0.2	7.2
2	Row %	23.5	49.4	13.0	5.5	2.9	1.7	4.0	100
	Col %	*16.6*	34.8	11.5	5.8	3.7	2.4	0.4	5.8
3	Row %	12.3	26.2	33.2	11.4	5.8	3.3	7.8	100
	Col %	*6.3*	13.4	21.4	8.9	5.3	3.5	0.5	4.2
4	Row %	8.0	17.7	21.1	25.2	9.0	5.3	13.7	100
	Col %	*3.4*	7.5	11.2	16.2	6.9	4.7	0.8	3.5
5	Row %	5.9	13.6	16.4	16.6	21.0	7.3	19.1	100
	Col %	2.1	5.0	7.5	9.2	13.8	5.6	0.9	3.0
6	Row %	4.3	10.9	14.1	14.3	13.3	19.2	23.9	100
	Col %	1.4	3.6	5.8	7.2	7.9	13.1	1.0	2.7
7+	Row %	0.8	2.4	3.3	3.7	3.8	3.8	82.2	100
	Col %	6.8	21.6	36.9	49.7	60.7	69.4	96.2	73.4
Total	Row %	8.3	8.3	6.6	5.5	4.6	4.0	62.7	100
	Col %	100	100	100	100	100	100	100	100

Data is aggregated over the years 1997-2011. Note: Only firms exporting more than 6 products are used when computing this table. Interpretation of table: 63.4% of the products ranked first at the firm-level are also ranked first within a destination and in 16.6% of cases the product ranked 2 at the firm-level is ranked first in a destination. If the highest ranked product of a firm is exported to a destination, then in 72.7% of the destinations it is ranked first, and 16.2% of cases ranked second in a destination.

product' per destination are correlated with yearly changes in the export value of lower ranked non-core products. Figure 1 shows a clear positive relationship between the (log) yearly changes in exports of a 'single' core product and non-core products. While this correlation gives rise to further investigation it does not give evidence on the direction of causation.

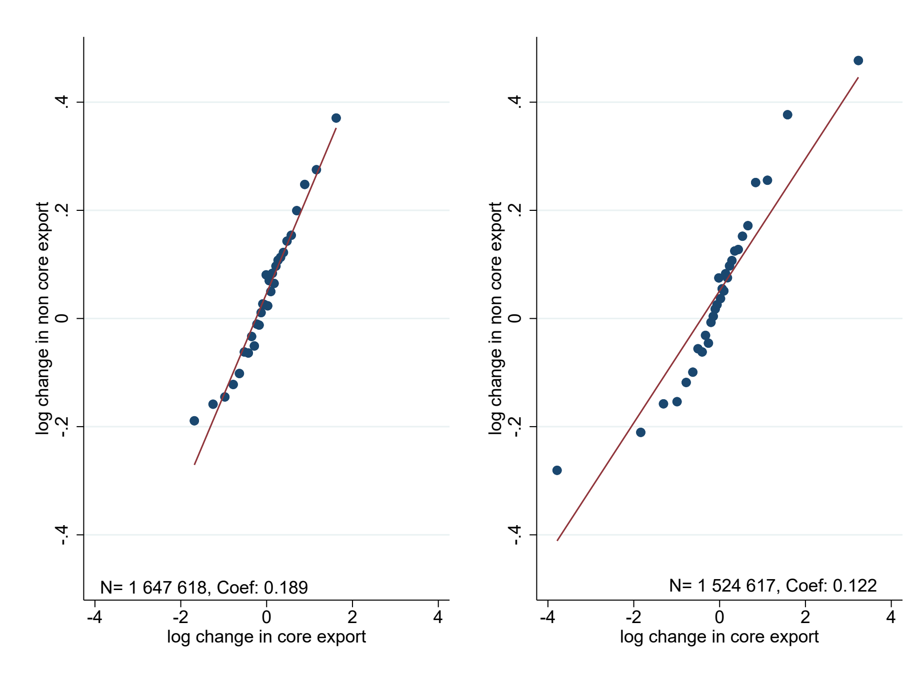

Figure 1: Correlation of yearly log changes in core and non-core product exports 1997-2011 (binned scatter-plot, 30 bins)

The single core-product per firm-destination pair is identified as the most exported product in the first three years a firm is active in a destination (time invariant). The definition used is also discussed in more detail in section 3.1 for both a single product core and the baseline when the core is extended to be allowed to include multiple products. Note that if a product that has been identified as a core product moves dramatically it will impact all non-core products exported to that destination which may therefore create outliers in the binned scatter plot. The left panel limits the sample to exclude such outliers and covers a range (-2 to 2) from roughly 85% reduction to over a six fold increase in export value between years in the core product. The right panel is the full sample. Observations for the core product and missing values for either non-core or core products are not included.

Relying on the preceding discussion, the pattern of firm export sales can be formalised in three[14] stylised facts:

- **Fact 1:** Both firm and firm-destination exports are granular in nature with the economic value concentrated in a few 'core' products.
- **Fact 2:** A limited number of core products are consistently among the highest ranked products across destinations, but need not be exported to all. A large number of products are exported that individually have peripheral trade value relative to the aggregate exports of the firm.

[14]The first two facts are not unique, as discussed above, and have been documented by others. See for example, Görg, Kneller, and Muraközy (2012), Arkolakis and Muendler (2013), Amador and Opromolla (2013), Fontagné, Secchi, and Tomasi (2018) and Bernard, Redding, and Schott (2010).

- **Fact 3:** There is a correlation between the change in export trade value of the core and lower ranked non-core products.

Based on these stylised facts the product mix of firms can be split into two separate groups of products. First, the stable core of products which accounts for a large share of export value. Secondly, a more diffused periphery that jointly constitutes a significant share of the value and contains most product observations. To motivate and guide the empirical analysis, I suggest the following new mechanism in conjecture 1:

Conjecture 1 *I propose that, within each destination, an increase in the export value of the core product(s) of a firm leads to increased exports of peripheral non-core products. The reverse mechanism, from non-core products to other non-core products or the core product(s), should not be found.*

Note that conjecture 1 describes a one-way complementarity or an asymmetric relationship between products, as only the non-core product is dependent on the trade flows of the core. In the following sections I test this proposed systematic relationship empirically.

3 Empirical Strategy and Specification

3.1 Defining the Core

As noted in the stylized facts above, product rankings are found to be imperfectly correlated across destinations. This is emphasized by, for example Mayer, Melitz, and Ottaviano (2014), who find a substantial departure from a steady global product ladder or hierarchy.[15] Choosing a core product that is market specific is also in line with results that product quality varies within firms across markets. A number of papers focusing on product quality and trade have documented variation in product quality both within-firms and across markets, suggestive of market specific taste or preferences for products.[16] We therefore proceed and define the core per destination to account for the irregularities in product rankings across destinations. To take into

[15] Similar imperfect correlations across destinations have been documented by Manova and Yu (2017), Nguyen (2012) and Fontagné, Secchi, and Tomasi (2018).

[16] See Bastos and Silva (2010), Verhoogen (2008), Piveteau and Smagghue (2019) and Manova and Zhang (2012). Other papers have emphasized the importance of high quality intermediate inputs on cross-destination variation in export quality. See Feng, Li, and Swenson (2016), Fan, Li, and Yeaple (2015) and Manova and Yu (2017).

account the wide and varying scope of firms we allow firms with broad scope to have multiple products in their core.[17] The idea being that firms may, for example, export different bundles of products to different buyers.

A product belongs to the 'core', c, of firm i if it is ranked highest or among the top 10% of the most exported products in a pre-sample period.[18] Formally, the core is defined as, $p \in c$ if $p = 1$ or $\frac{p}{P} \leq 0.1$, where p is the product rank identifier and P is the total number of products exported. Both p and P are calculated within a firm-destination pair in the pre-sample. All products outside the core, or not exported in the pre-sample, are by definition non-core products. A hypothetical example of the definition is shown in figure 2. In the baseline sample around 92% of the cores include only a single product, and in just over 2% of cases does the core include more than 4 products (see table A2 in appendix A).

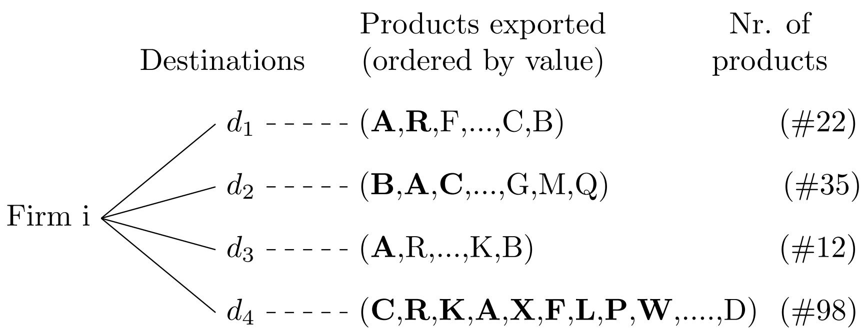

Figure 2: The definition of the core. The products ranked first or in the top decile in the pre-sample period for firm i in a destination are in the core (marked in bold). At destination d_1, products A and R are in the core for firm i in *all* consequent time periods.

The core is defined using a time-invariant pre-sample period. Alternately a time-variant definition of the core could be used to allow the composition of the core and non-core products to change over time. However, changing the identity of the core over time is problematic as it, by construction, leads to product churning as core-trade flows are dropped from the sample.[19]

[17] In the empirical analysis we consider an alternative definition of the core that includes only a single-product per firm-destination pair and discuss why the multi-product core is preferred. In addition, I explore and discuss various other firm (or firm-destination) specific definitions of the core based on product production data or alternative product classifications.

[18] The pre-sample period consists of the first year observed per firm-destination pair and the subsequent two years. The three-year pre-sample is used to ensure that the core is not endogenously determined. The composition of the core is kept constant within each firm-destination pair in all consequent time periods. In a robustness check (table C3) we experiment with alternative definitions of the pre-sample.

[19] In section 4.3, I explore alternative time-variant definitions of the core and the results are similar.

3.2 Empirical Specification

The mechanism presented in conjecture 1 describes a relationship where the export value of the core to a destination explains the trade value of non-core products, which naturally leads to the following baseline specification:

$$ln(Y_{ipdt}) = \beta ln(C_{idt}) + I_{pdt} + \lambda_{ipd} + \eta_{dt} + \gamma_{it} + \zeta_{pt} + \epsilon_{pidt} \tag{1}$$

Y_{ipdt} is the export value of non-core product p by firm i to destination d in year t, where p ranges from the first product outside the core to the last (P) within a firm-destination pair, $c + 1 \leq p \leq P$. All products not exported in the pre-sample are also included as non-core products. In equation 1, the trade in non-core product, Y_{ipdt}, is explained with the export of the core, C_{idt}, by the same firm. The trade value of the core (C_{idt}) is always included, even in cases when none of the core products is exported and the trade value equals zero. All pre-sample observations are dropped in the empirical analysis (see also a discussion in appendix A).

I include a destination-year fixed effect, η_{dt}, to control for country-time specific effects, such as GDP, exchange rate fluctuations, or other country specific effects; a firm-year fixed effect, γ_{it}, which accounts for time variant firm level characteristics such as firm size, productivity and even (broader) industry specific variation; a firm-product-destination fixed effect, λ_{ipd}, which accounts for all time invariant unobserved heterogeneity related to the triad. This could be, for example, product-market information, product characteristics, or quality. By using firm-product-destination fixed effect, λ_{ipd}, the impact of the core on non-core products is identified through the time dimension.

As there may have been contemporaneous non-core product specific demand variation we address this by first, including a non-core product-year fixed effect, ζ_{pt}, which controls for global demand variation for that product (HS6). Secondly, there may have been some *destination* specific contemporaneous changes in the demand for the non-core product which is addressed by adding a non-core product-specific demand control, I_{pdt}. The demand control captures the non-core product-destination-specific element of the change in the export flow. The demand control, I_{pdt}, is defined as the log of the sum of the import value of the non-core product from the world market (except Sweden) to destination d in year t.[20]

[20]Note the similarities between the demand control and the instrument in the next section, as $I_{pdt} = M_{pdt}$ if

3.3 Identification Challenge and Instrument

The identification challenge estimating equation 1, using traditional OLS, stems from two main sources. First, there may be within-firm dependence of product export flows of the core and non-core products. Demand for different products of a firm may be jointly determined, which would cause a simultaneity bias in our estimates. An additional problem with using OLS is the potential for measurement error due to misclassification of the core product(s). If a non-core product is (falsely) defined as an actual core product there will be measurement error in the independent variable (the export value of the actual core), thereby, biasing the OLS results to zero.

To overcome these issues and identify a causal effect, I suggest a novel instrumental variable approach. By using an instrument for the export of the core, I can identify whether changes in the trade of the core explains trade flows of non-core products in a specific destination. The instrument needs to be core-destination specific, correlated with the trade value of the core and uncorrelated with other product trade flows. The instrument used in this paper relates most closely to the instrument used by Hummels, Jørgensen, Munch, and Xiang (2014) but also that in Aghion, Bergeaud, Lequien, and Melitz (2019) and Autor, Dorn, and Hanson (2013). The instrument is defined based on the product-specific import demand to a destination. Formally, the instrument (in logs), z_{idt}, is defined as:

$$z_{idt} = \sum_{p \in c} s_{ipd} M_{pdt} \tag{2}$$

where M_{pdt} is the import of product p from the world market (except Sweden) to destination d in year t. To construct the instrument for the core, each product is weighted by a pre-sample share. The share of each product, s_{ipd}, equals the trade value of product p to destination d divided by total trade value of all products in the core by firm i to that destination in the pre-sample period. Both the shares, s_{ipd}, and set of products included in the core are kept constant over the sample period.[21] As the instrument uses firm-product-destination shares

$c + 1 \leq p \leq P$ (in logs).

[21] To check the stability of the core I calculate the average share of export value of the core of total firm trade value per destination. In 2000, the first year under investigation (excluding pre-sample observations) the firm export value of the core is on average 64% of the total firm trade value to a destination. The share of the core decreases slowly over time and is 43% in the last year (2011) and 51% on average. The share is 59% when including all pre-sample observations, which by construction have the highest share.

the instrument will be firm-destination specific. Data from UN Comtrade (BACI) is used to construct the instrument (and demand control). See appendix A for additional information on the dataset and summary statistics.

3.3.1 Instrument Validity

I argue that the instrument for the core is exogenous to both the firm and export flows of non-core products. First, it is important to note that the unit fixed effect (λ_{ipd}) controls for time-invariant unobservables and isolates the variation in the shocks over time that are used for identification.[22] Hence, it is plausible to assume that the changes in the instrument for the core product(s) is exogenous to the changes in the export of other products of the firm, conditional on the fixed effects used in equation 1. Hence, after absorbing the firm-product-destination, firm-year, destination-year and product(HS6)-year fixed effect, shocks to the instrument, z_{idt}, should explain changes in core trade, C_{idt}, with destination d, but be uncorrelated with the export of other products, Y_{ipdt}, by the firm to that destination. This assumption is reasonable when considering, first, how *dissimilar* the core is to the non-core products of the firm. For example, one can see from the data that around 86% of the non-core products exported are *not* within the same HS4-digit product category as *any* of the products in the core. Even at the HS2 or HS1 digit product level, 55% and 37% of products are not within the same categories as *any* of the core products.[23] Secondly, not only is a large share of the products dissimilar but they are also *not* produced by the firm. I find that around 75% of *all* HS6 digit products exported are not produced by the firm but are rather Carry-Along-Trade (CAT) as discussed by Bernard, Blanchard, Van Beveren, and Vandenbussche (2018). These products account for only 21% of the export value of firms. Considering only non-core products the shares are even higher (84% and 31%). See appendix E for a discussion.

Second, as Sweden is a relatively small country it is reasonable that changes in demand for a small set of products at a destination are not influenced by Swedish firms. Generally, Swedish firms only account for a small share of the of the total value imported from all destinations of a specific product or product groups, indicating that Swedish firms will not have a dominant

[22] Variation does therefore not come from the firm specific weights as noted by Borusyak, Hull, and Jaravel (2018). See also Aghion, Bergeaud, Lequien, and Melitz (2019).

[23] Similarly, when investigating the share of value, products not in the same HS6, HS4, or HS2 categories as *any* of the core products account for 59%, 23% and 12% of the export value.

position and able to influence the inflow of products from other countries. In section 4.3 we experiment dropping observations where Swedish firms have a market share above 1% or 5% and the results are similar.

Third, there is a recent literature that has specifically focused on inference and identification in settings with shift-share instruments as employed in this paper (see Adão, Kolesár, and Morales, 2019, Borusyak, Hull, and Jaravel, 2018 and Goldsmith-Pinkham, Sorkin, and Swift, 2019). Borusyak, Hull, and Jaravel (2018) develop a framework that rests on an exact numerical equivalence between a standard IV shift share regression and one that is estimated at the level of the identifying variation ("shock"). They show that the exclusion restriction can also be interpreted at the level of "shock", rather than at the firm level.[24] In our case we can therefore apply the equivalency and interpret the exclusion restriction in terms of (core) product-destination specific shocks. As noted by Borusyak, Hull, and Jaravel (2018) the underlying assumptions in this setting are that the shocks are many, as-good-as randomly assigned conditional on observables, and each with relatively small exposure. In our micro-data setting there is both a large number of (core) product-destination shocks and given variation in the composition of the core across firms and destinations each shock has naturally a low exposure. Lastly, the shocks should be sufficiently independent conditional on observables. In our setting the yearly shocks are (core) product-destination level specific and one may worry that shocks to the same product, or similar products, are correlated across destinations. In appendix D, I demonstrate, using the single-core product definition, as a special case, that the results are robust to absorbing such global yearly variation specific to the core.

4 Regression Results - The Superstar and the Followers

The objective of this paper is to explain variation in export sales within a market by investigating intra-firm dependence between products that a firm exports. The main identification challenge in our setting is related to simultaneity and measurement error problems which may bias OLS results to zero (see discussion in section 4.1 below). To causally identify the impact of the core on the non-core products, I therefore use an instrumental variable approach to estimate equation

[24]See also Aghion, Antonin, Bunel, and Jaravel (2020) who apply this equivalency in a related context. In appendix D a further discussion is provided.

1,[25] where I instrument for the export of the core. Hence, I perform a first stage regression where actual exports of the core, C_{idt}, are regressed on $ln(z_{idt})$, then the fitted values, $ln(\hat{C}_{idt})$, are used in the second stage equation (instead of $ln(C_{idt})$). In the first stage regression the log export value of the core is regressed on the instrument, z_{idt} (in logs) and the results show a strong positive correlation between the core product's trade value and the instrument, with an F-statistic around 25 (Kleibergen-Paap).

In the second stage regression, equation 1 is estimated using the predicted values for the core exports from the first-stage. The second-stage results show that an increase of 10% in the trade value of the core results in a 2.8% increase in the non-core products to a destination (elasticity of 0.279). See column 1 of table 2 for the baseline results of both stages. This result is consistent with the causal spillover mechanism, suggested in conjecture 1, from the core to non-core products. An alternative to the firm-year and product-year fixed effects included in the baseline is to use firm-product-year fixed effect. The results are similar, see column 2. In the baseline specification, a demand control is included to capture the contemporaneous change specific to that non-core product. An alternative, is to use a product-destination-year fixed effect. This inclusion is demanding on the data as it requires variation across firm exports of the same six-digit product-destination-year combination. The results are similar (see column 3 in table 2).[26]

One way to highlight the overall importance of this complementarity is to perform a back-of-the-envelope calculation for the average firm-destination combination. We can calculate the contribution of the complementarity by using the baseline elasticity in combination with the weight of non-core product exports. For the average firm-destination pair the contribution of the complementarity mechanism is around 14% of the change in exports while the core itself accounts for *half* of the trade value.[27] The total contribution of the core is therefore over a quarter larger than what the share of firm-destination export value suggests. The weight of the core will therefore be underestimated when the (indirect) contribution through the one-way complementarity is ignored.[28]

[25] As there are multiple fixed effects included, I employ the Stata module, `reghdfe`. The module was developed by Correia (2015) and is able to estimate models efficiently that include high-dimensional fixed effects.

[26] The results are also robust to estimation in first differences, see table C4.

[27] For these calculations I use the baseline elasticity and the post-pre sample shares of value provided below table A1.

[28] Mayer, Melitz, and Ottaviano (2016) calculate firm level skewness by using the Theil index. First, they calculate a firm-level measure they then decompose into within and between destination measures of skewness.

Table 2: Baseline results using the multi-product core specification. Dependent variable is non-core product trade flows except for the lower panel which shows the first stage results for each column.

	IV 2-stage			OLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Core trade value	0.279[a]	0.300[a]	0.307[a]	0.0324[a]	0.194[a]	0.221[a]
	(0.0793)	(0.0937)	(0.108)	(0.00129)	(0.00575)	(0.00642)
Product demand control	0.0274[a]	0.0295[a]		0.0312[a]	0.0263[a]	0.0273[a]
	(0.00543)	(0.00577)		(0.00491)	(0.00521)	(0.00522)
	IV 1-stage					
	(1)	(2)	(3)			
Core instrument	0.193[a]	0.180[a]	0.177[a]			
	(0.0382)	(0.0411)	(0.0404)			
Product demand control	0.00835	0.0112				
	(0.00889)	(0.00957)				
Nr. obs.	1663362	1453827	1262784	1663362	1390941	1223363
R^2	0.816	0.850	0.851	0.840	0.847	0.882
# clusters	53291	48050	45793	53291	34419	30887
First stage F stat.	25.59	19.21	19.22			
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	No	Yes	Yes	Yes	No
Prod-year FE	Yes	No	No	Yes	Yes	No
Dest.-year FE	Yes	Yes	No	Yes	Yes	Yes
Firm-prod.-year FE	No	Yes	No	No	No	Yes
Prod.-dest.-year FE	No	No	Yes	No	No	No

Standards errors are clustered on firm-destination level. [c] $p < .10$, [b] $p < .05$, [a] $p < .01$

In the baseline definition of the core in section 3.1 the core is allowed to include multiple products to account for varying product scope. One could also define the core as the *single* highest exported product per destination, regardless of scope. Using the same IV methodology as for the core we explore how this impacts the relationship. By construction, the instrument now becomes $z_{idt} = M_{pdt}$, as it is solely based on the highest ranked product per destination in the pre-sample. The results of this single-product core specification, using otherwise the same IV methodology as for the core, can be found in table B1 in appendix B. The IV results are broadly similar to the multi-product core results above. We can test the assertion that product scope of the exporter may be of significance for the mechanism identified by re-estimating equation 1 using products ranked highly as *potential* core products. The results show indications of a similar contingency of non-core products with the product ranked second in the pre-sample (see table B2 in appendix B). Thereafter, the dependence disappears, underlining that the mechanism is concentrated among a small *set* of high-ranked products of the firm. This result emphasizes the need to expand the definition of the core beyond a single product.

There is a recent discussion of inference when using shift share designs like the one used in this paper.[29] Adão, Kolesár, and Morales (2019) find that standard error are often underestimated in such regressions since the residuals are correlated across observations with similar exposure shares. Borusyak, Hull, and Jaravel (2018) show how valid standard errors can be found by transforming a standard shift share IV regression to the level of the "shock" and derive valid standard errors that are "exposure robust". The standard errors obtained this way are asymptotically equivalent to those suggested by Adão, Kolesár, and Morales (2019). Using the single-core product definition as a special case, I follow the framework proposed by Borusyak, Hull, and Jaravel (2018) and show that the standard errors are minimally impacted (see appendix D).

The existence of the one-way complementarity suggests that we can attribute a share of the non-core trade flows to the core. Such a shift will mechanically increase within-destination skewness while the impact on cross-destination skewness is ambiguous. The combined impact is therefore ambiguous while it is worth noting that Mayer, Melitz, and Ottaviano (2016) point out that cross-destination skewness tends to be small and there is a strong correlation between within-destination and firm level skewness. Hence, this provides indicative evidence that the firm-level skewness measure may be underestimated if the (one-way) complementarity is ignored.

[29] See Adão, Kolesár, and Morales (2019), Borusyak, Hull, and Jaravel (2018) and Goldsmith-Pinkham, Sorkin, and Swift (2019)

4.1 OLS and Zero Trade Flows

One of the main arguments for using the IV estimator is due to the potential for measurement error which would bias the OLS results to zero. In our setting we suspect that the source of attenuation bias is the misclassification of the core product(s) in cases where (by chance) a non-core product is defined as the actual core product(s). If this occurs, we expect these (falsely defined) core products to have considerably shorter trade duration than the an actual core product, and therefore less likely to be traded in consequent periods.[30] Recall that the trade value of the core is always included even in cases where a firms does not have *any* trade of the products defined as their core. Hence, a way to test for this potential misclassification, is dropping observations where the export value of the core equals zero (C_{idt}), which are cases it is suspected that the core may have been incorrectly defined. Using the full sample to estimate equation 1 with traditional OLS, I find that the point estimate is considerably lower than in the IV estimation (see column 4 in table 2). By dropping the small number of observations where the core trade value equals zero (C_{idt}) the elasticity increased sixfold, from 0.03 to 0.19, and is now much closer to the magnitude of the IV estimates. As only cases in which the *entire* core export value equals zero (around 17% of the observations) are dropped, there may still be some measurement error in the core definition, thereby, still biasing the OLS results downward.[31]

4.2 Placebo Test - Only a Superstar has Followers

In conjecture 1 it is suggested that the mechanism from the core to non-core products is only one-way. Recalling that the core is defined to include all products ranked in the top decile in terms of export value, a natural extension to demonstrate that the observed complementarity is indeed one-way, is to use the other nine-deciles of the pre-sample rank as 'placebo-cores'. The instrument is then based on the placebo-cores, otherwise, the methodology is unaltered. Consistent with the suggested *one-way* mechanism in conjecture 1, I do not find any significant effects for the other nine deciles. This is clear from the coefficient plot in figure 3, where each of

[30] This argument is in line with the results of the studies of Békés and Muraközy (2012) and Timoshenko (2015b).

[31] A similar exercise can be performed using the alternative single-product core definition. After dropping the zero trade flow observations (around 20% of the total) the elasticities increase by a comparable magnitude. See columns 4-5 of table B1 in appendix B. Large changes in year-to-year exports of the core may also be indicative of misclassification and bias the OLS results. By comparing the two panels of figure 1 we can see a visual indication of such bias related to outliers.

the 10 coefficients from the 10 regressions are shown along with 95% confidence intervals.

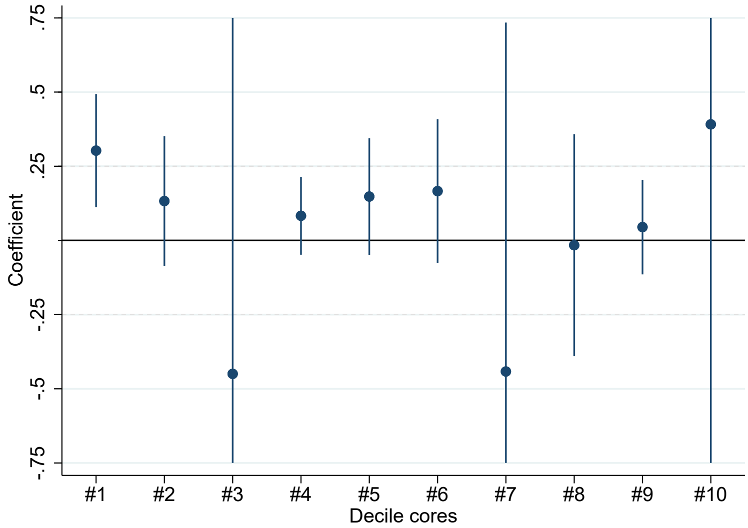

Figure 3: Coefficient plot for placebo test. The plot shows the point estimate and 95% confidence interval for the actual core(#1) and the nine placebo cores based on lower ranked products.

Note: The regressions include the baseline fixed effects. Note to keep the sample constant in all 10 regressions only firms exporting 10 or more products to a destination in the pre-sample are included. The standard errors for (placebo) cores #3, #7, #10 extend beyond the scope of the graph but the full results underlying this figure are available in appendix C (tables C1 and C2).

These results demonstrate that there is a strong mechanism from a set of core products in each destination towards the lower-ranked more peripheral products. I find that the core is more than just a core as other products 'follow' along contemporaneously to complement the trade of the 'superstar core' products of the firm. This mechanism is asymmetric since it is only a *one-way* complementarity of non-core products to the core.[32]

4.3 Robustness Checks - Product Similarities, Duration and Production

One potential concern with the empirical strategy is that non-core products may be similar to the core-products. In that case, the IV strategy may be less applicable as the instrument for the core may be correlated with shocks to other products. As a robustness check addressing this concern, I re-run the regressions after dropping all non-core products belonging to the same 2- or 1-digit product category as *any* of the core-products. The results are similar, see columns 5-6 in table C5. This result is not surprising, considering how dissimilar the non-core products are

[32]For the alternative single-product core I experiment using 'placebo-core' products. The same contingency is generally not found between the placebo single-core products and other products. See discussion and results in appendix B.

generally to the core and most products exported are not produced by the firm (as discussed in section 3.3.1). A related exercise is to base the definition of the core on the BEC classification. The core is then defined as *all* products that fall within the highest ranked BEC digit category. Again the results are broadly similar (see table C4). This shows that the complementarity is broad and not confined within a specific product group.[33]

A second concern is the validity of instrument in cases where a single firm has a large share of the destination market for specific products. Sweden is a relatively small country and a single firm is therefore unlikely, in general, to have a large market share in any specific destination. However, to address this concern I re-run the main regression after dropping observations where the core product(s) constitute a share higher than either 1% or 5% of the import value from the global market (excluding imports from other Swedish firms). The result is similar (see table C5 in appendix C).

A third concern relates to the definition of the core using a pre-sample period or weights. In section 3.1 the core is identified using the first three years a firm enters a destination. The pre-sample is then used to create the firm-destination specific shares for the instrument. A potential concern may be that firms alter their product mix and the core products(s) of the firm may change over time. To address this we introduce time-variant (rolling) one and three year pre-samples that are used to identify the core-products and the firm-specific shares.[34] In this specification the product composition included in the core is allowed to change over time and the last one or three years are always used to define the core and calculate the shares. Using otherwise the same empirical methodology, I find a similar spillover effect as in the baseline results. See table C3 in appendix C.[35]

A fourth robustness check is altering the definition of the core and non-core products. The baseline definition is market specific and does not distinguish between produced and non-produced products. As a robustness check we alter the definition of the core using information on product

[33]This concern is also addressed in the shock level regressions discussed in appendix D.

[34]As discussed above in section 3.1, allowing the composition of the core to change is not preferred in our setting as it creates churning.

[35]A related concern is the potential endogeneity of the pre-sample weights if firms self-select into high growth markets. Using a similar robustness check as Berman, Berthou, and Héricourt (2015) we split the sample by income level and analyse separately high and low income countries. If self-selection is an issue we would expect this to be a larger problem for high-growth countries (e.g. BRICS) rather than countries that share similar characteristics to Sweden. In table C3 we perform three robustness checks based on geography to address this concern and find no significant differences (columns 5-7). Note also that Borusyak, Hull, and Jaravel (2018) show that the shares in shift share IV regressions can be allowed to be endogenous.

production. Using the IVP survey of manufacturing firms in Sweden I am able to identify which products are produced by the firm and those only exported. To identify the core based on production, products are ranked based on production value. Similar to the main definition of the core, products are in the 'production-core' if the product is ranked first or in the first decile in a three year pre-sample period. Note that the identity of the core is now firm, rather than firm-destination specific. By applying the same empirical strategy as before a similar result is found. A further discussion on alternative production based definitions and extensions are provided in appendix E and results in table E1.

5 Exploring the Channels

We have established that non-core products follow along in transactions when the core is traded while the underlying channels have not been explored. In this section I first relate the complementarity to the theoretical literature and test empirically for some of the potential channels.

First, the results of this paper relate to the theoretical model developed by Mayer, Melitz, and Ottaviano (2014) who show how toughness of competition impacts the product mix of exporters. Their model predicts that tougher competition will result in a reallocation effect across products where firms export relatively more of their core products while dropping non-core products that are at the end of the product ladder, leading to increased firm productivity.[36] While Mayer, Melitz, and Ottaviano (2014) use market size (e.g. GDP) as a proxy for competition we could similarly broadly view the demand shocks as indicative of both a larger product market and more import competition from other destinations. Consistent with the results of Mayer, Melitz, and Ottaviano (2014) I find that a positive (demand) shock does lead to increased skewness since the reported elasticity is below one. Note that this result is contingent on keeping the product range fixed as the focus is on the intensive margin.

Second, as the export revenue is skewed towards the best performing products, firms will only overcome entry costs if the core is successful. This is in line with the findings of De Loecker, Goldberg, Khandelwal, and Pavcnik (2016) and the theoretical model of flexible manufacturing of

[36]The main impact on productivity is through the relative reallocation from worse to better performing products but there is also a second order impact through the product extensive margin. In addition, Mayer, Melitz, and Ottaviano (2016) show how a positive demand shock can lead to an extensive margin response as firms broaden their product portfolio in a destination.

Eckel and Neary (2010) that products in the firm's core have higher mark-ups relative to non-core products.[37] The high-markup core, exported in large volume, will thus generate the majority of the firm profits. Firms will therefore base their export decisions on the core product(s) while other non-core products may follow along in the export transaction to complement/supplement the 'main' product for that destination. This could be a result of customers demanding a bundle of core and complementary non-core products.[38]

Third, Békés and Muraközy (2012) showed that over half of firm-product-destination flows last only a single year. Similarly, Timoshenko (2015b) found that, after firms enter a market, they engage in product switching (churning) as they learn about the appeal of their products. She found that continuing exporters derive around 16% of the aggregate revenue from new products and the value of products that are dropped in the next period was found to be the same. This is consistent with an explanation that the duration of core products is longer compared to other products and firms may, as time passes, learn about the market-specific demand conditions for the non-core products. As the bulk of the trade value is in continuously exported (core) products the learning mechanism suggested is mostly active in the lower realm of the product sales distribution. This learning could be in the form of how to bundle products or learn about destination-specific demands/taste (as in Nguyen, 2012). As the focus of this paper is on the intensive margin of non-core product export flows it is important to investigate if product churning (entry/exit) of non-core products is driving the result. First, the sample is restricted to non-core products that have longer duration than four years (at firm-product-destination level) and are still being traded in the last period. Secondly, a balanced panel is created by restricting the analysis further to only firm-destination-product observations (non-core) that are observed in all years. The results are unchanged. See columns 1-2 in table C5.

Lastly, it is important to relate the mechanism of this paper to cannibalization effects documented in the literature among multi-product firms. Cannibalization effects are generally defined as how expanding product scope, adding new varieties, 'cannibalizes' the sales or market shares of exiting products.[39] Instead of investigating how (new) low value products cannibalize

[37] In the model products close to the firm's core-competency (high ranked) are produced at a low cost and should, therefore, be more competitive and have higher mark-ups than non-core products.

[38] This could also be a technical complementarity in product production or 'platforms' as discussed in Baldwin and Woodard (2009). These platforms generally have a set of stable core components with low variety and a complementary set of peripheral components with high variability. These peripheral products are then interrelated as derivative products. This relates also to the work of Dhingra (2013) on within brand cannibalization.

[39] See for example Feenstra and Ma (2008), Dhingra (2013) and Eckel and Neary (2010). While cannibalization

existing (core) products, the focus of this paper is on how non-core products complement and respond to shocks of the core. Hence, compared to cannibalization, the results of this paper highlight a new (intensive margin) mechanism not previously incorporated.

5.1 Demand or Supply?

A priori, it is unclear if the observed one-way complementarity is related to demand and/or supply forces. In the following subsections I try to investigate different explanations for the observed effect that may give indications of the underlying forces and relate them to supply and/or demand side explanations.

5.1.1 Multinationals and Firm Size

Multinational firms account for a large share of global trade flows and Bernard, Jensen, and Schott (2009) find that around a third of US exports (and a half of US imports) come from foreign affiliates of the same multinational.[40] If there are demand or supply linkages then (multi-product) multinationals may react differently to shocks than non-multinationals. If export flows are mostly sales to foreign affiliates within the supply chain then the observed complementarity could, for example, stem from cost-saving efforts in shipping. Multinational firms in particular, may use exiting shipments to export other products within the firm.[41] This could provide a potential supply-side mechanism through cost linkages of products (spread costs across products by 'co-shipping' goods). Kropf and Sauré (2014) found evidence of substantial fixed costs per shipment which ranged between 0.8-5.4% of the export value. As fixed costs per shipment are independent of shipment size/value, they will have a large deterrent effect on the trade of low

can also be thought of as how increases in sales of existing varieties 'cannibalize' the sales of other existing products, this is less used. One important exception is Dhingra (2013) who discusses cannibalization and competition within brands. She distinguishes between process and product innovation and finds that product entry (product innovation) cannibalizes sales of existing products. However, she finds that upgrading the production process of a specific product (process innovation) has no cannibalization effects on the market share of other products. Similarly, the one-way complementarity of this paper suggests that non-core products exported within a firm-destination complement, rather than cannibalize, the sales of the core product(s) (on the intensive margin).

[40] See Antràs and Yeaple (2014) who discuss the impact of horizontal and vertical FDI on the structure of international trade and Tintelnot (2017) for a theoretical model of multi-product multinationals. Earlier work including Baldwin and Ottaviano (2001) construct a model where multinational multi-product firm will have an incentive to engage in vertical FDI and locate production of some products abroad to reduce inter-variety competition. Note that the main mechanism in that model is through the extensive rather than the intensive margin as in this paper.

[41] Blyde and Molina (2015) provide anecdotal evidence and argue that MNE's in particular choose locations that have adequate logistics infrastructure to reduce transportation costs and increase efficiency. In addition, they find empirical evidence that logistic infrastructure positively impacts vertical FDI.

value peripheral products, since they make up a large share of their trade value. This could explain the response of the non-core products as the trade value of the core product increased, as an additional shipment reduces (or removes) the shipping costs for co-shipped non-core products. In the data we can indirectly investigate this potential channel by looking at multinational firms. I identify Swedish multinational firms using firm-specific data and can test if the mechanism varies for multinationals compared to non-multinationals. From table 3 we see that there is no significant difference between multinational firms (MNE) and non-multinationals.[42]

A related potential supply side explanation relates to production constraints and cross-product cost linkages. If firm production is constrained, then alleviating such constrains may spillover to other products of the firm. In our context, increased exports of core products could ease firm-level financial/capacity constraints which could explain the spillover mechanism to (lower markup/higher cost) non-core products. As financial constraints tend to impact smaller and medium size firms more than larger firms[43] we would expect the mechanism to be stronger for relatively smaller firms if such cost-linkages are underlying. By splitting the sample of firms into two size groups we can (indirectly) test for this explanation. The results from table 3 do not show any statistically significant differences based on firm size.

Similarly Arkolakis, Muendler, and Ganapati (2015) document that firms with broad scope sell minor amounts of their lowest selling products and build a model that allows for potential economies of scope. They show that products further from the core are produced at a higher cost while there are economics of scope in market entry costs. The fall in market entry costs, enabling firms to have broader scope, is particularly found in nearby destinations and those with lower non-tariff barriers. A natural extension is therefore to investigate two related aspects. First, if product scope in general influences the mechanism identified, and secondly, if the mechanism differs when investigating the (nearby) common EU market with low non-tariff barriers. I find no significant difference between wide and narrow scope firms (see table 3) or when investigating only the common EU market (see column 7 in table C3).

[42] As the MNE indicators used are firm, rather than firm-destination specific, there could still be a destination specific effect that is not observed.

[43] See for example Forbes (2007), Beck, Demirguc-Kunt, Laeven, and Levine (2008) and Aterido, Hallward-Driemeier, and Pages (2011).

Table 3: Robustness results using different measures of firm size, product scope and MNE. Dependent variable is non-superstar product trade flows.

	Size		Scope		MNE		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Core trade value	0.297[a]	0.300[a]	0.429[b]	0.274[a]	0.266[a]	0.285[a]	0.268[a]
	(0.0864)	(0.0859)	(0.176)	(0.0680)	(0.0827)	(0.0813)	(0.0828)
Product demand	0.0278[a]	0.0277[a]	0.0259[a]	0.0274[a]	0.0273[a]	0.0277[a]	0.0273[a]
control	(0.00538)	(0.00535)	(0.00617)	(0.00540)	(0.00545)	(0.00543)	(0.00544)
Size ×	-0.0791	-0.107					
Core trade value	(0.0743)	(0.0729)					
Scope ×			-0.284	0.0157			
Core trade value			(0.280)	(0.142)			
MNE ×					0.0313	-0.0957	0.0268
Core trade value					(0.0246)	(0.0777)	(0.0239)
Nr. obs.	1663362	1663362	1663362	1663362	1663362	1663362	1663362
R^2	0.822	0.824	0.783	0.817	0.815	0.816	0.815
# clusters	53291	53291	53291	53291	53291	53291	53291
First stage F stat.	10.60	10.97	3.162	12.11	12.93	12.92	13.03
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The sample is split by median employment (col. 1), median firm sales (col. 2), median product scope in the pre-sample (col. 3) or over 50 products (col. 4). Median product scope in the pre-sample is 18 products. In columns 1-4 a interaction equals 1 (0 otherwise) if the size/scope is above the median (or 50 in col. 4). The data on MNE is firm specific and the interaction equals 1 (0 otherwise) if the firm is part of a Swedish MNE (col. 5), part of a foreign MNE (col. 6) or either part of a Swedish or a foreign MNE (col. 7). Note that the data on MNE status is firm, rather than firm-destination specific, and we cant therefore compare destinations where a MNE has affiliates to others. Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

5.2 Prices and Product Quality

Another exercise to uncover the underlying channel is to decompose the impact on non-core product trade value (Y_{ipdt}) into two separate effects on product price (p_{ipdt}) and quantity (q_{ipdt}). The elementary decomposition follows in equation 3:

$$Y_{ipdt} = p_{ipdt} * q_{ipdt}, \quad or \quad ln(Y_{ipdt}) = ln(p_{ipdt}) + ln(q_{ipdt}) \tag{3}$$

To quantify the effect on each part in the decomposition we now include the log of quantity and log price of non-core products as dependent variables in equation 1. The results are presented in table 4, see columns 1-3 (or columns 4-6 using firm-product-year fixed effect). Using the same IV strategy as before, I find that increased core trade value leads to increases in non-core quantity exported which is consistent with either a supply or demand channel. If the mechanism from the core to non-core products is related to supply forces we would expect a negative relationship between increased core trade value and non-core export prices.[44] Supply side forces would tend to lower marginal costs and prices through, for example, increased productivity or economics of scale in distribution. A positive supply shock should therefore be passed on (at least partially) to the buyer via lower prices.[45] We would therefore expect prices to decrease, or stay unchanged in the extreme case of no cost pass-through, if supply forces are underlying the mechanism. However, decomposing the results I find that *over a quarter* (28% to 32%) of the total impact on non-core trade value is transmitted through price *increases* suggesting that the mechanism is related to demand.

Prices are often used as a proxy for product quality[46] and one may therefore think that the observed price variation of non-core product stems from variation in product quality. That could also provide a possible explanation for the mechanism in conjecture 1 by considering

[44]This is similar to Bernard, Blanchard, Van Beveren, and Vandenbussche (2018) who try to uncover if demand or supply forces underlie the existence of CAT products. They find evidence that CAT is driven by a demand-scope complementarity as prices are systematically higher with broader scope. Similarly they argue that this evidence is inconsistent with a supply side mechanism which would, all else equal, suggest that increased scope leads to lower prices.

[45]Cost saving could include co-shipping of goods as discussed by Kropf and Sauré (2014) who find and evaluate fixed costs per shipment. De Loecker, Goldberg, Khandelwal, and Pavcnik (2016) found that prices decreased following tariff reductions but the cost pass-through was incomplete to lower prices (i.e. firms increased their product-mark-ups).

[46]See Kugler and Verhoogen (2012), Manova and Zhang (2012), Verhoogen (2008). Piveteau and Smagghue (2019) find the same correlation but note that prices can be a misleading proxy for quality when investigating the extensive margins (new product or destinations) which is not a focus of this paper. Antoniades (2015) and Khandelwal (2010) show that for some industries/countries the measure may perform worse.

jointly product quality and mark-ups. Eckel, Iacovone, Javorcik, and Neary (2015) found that in the flexible manufacturing framework of Eckel and Neary (2010), products close to the core-competence of the firm can be produced at a low cost and sold with a high margin. They argued that firms producing differentiated goods are competing in terms of quality rather than cost. Thus, there is an incentive for firms to invest in the (perceived) quality of their core products which have the highest mark-ups and sales. One way to achieve higher perceived quality would be to bundle the high-quality high-mark-up core product with complementary non-core. Alternatively, the firm may use marketing to increase the (perceived) quality of the firm/product which could have a positive spillover on other products.

In a recent article Piveteau and Smagghue (2019) construct a firm-product-destination-year specific measure of quality. They find that a *time-invariant* firm-product-destination fixed effect captures a high share of the variation in quality (78%) while a firm or firm-product specific effect captures a much smaller share (20% and 52%). This suggests that market specific taste is important and once a firm enters a market with a product there is relatively little variation in quality. Hence, the inclusion of firm-product-destination fixed effects will account for most of the variation in quality. In addition, the inclusion of firm-year or firm-product-year fixed effects will account for variation in quality over time that is not destination specific. If firms jointly increase quality and prices by destination, the impact through prices could be an indication that product quality plays some role in the mechanism.[47]

Another way to investigate quality is to split the sample of products into homogenous and differentiated products as the latter have a much broader scope for quality differentiation.[48] In this exercise I use the Rauch (1999) product classification to separate between homogeneous and differentiated products. As in Rauch (1999), a buyer of homogeneous (or referenced priced) products can easily compare prices and faces therefore lower search costs to find a new seller,

[47] Similarly, a supply shock could lead to quality upgrading, resulting in both higher quantity and prices. If time variant supply side factors are underlying the results we would *not* expect the mechanism to be destination specific, but rather, related to the firm-year or firm-product-year combinations. The inclusion of firm-year or firm-product-year fixed effects will account for such time varying firm-level supply side variations (e.g. quality, product production cost, efficiency) of non-core products or other unobserved heterogeneity related to the firm-product-year combination. The inclusion of these fixed effects may therefore potentially downplay supply side explanations. Note however that replacing the firm-year fixed effect with an industry-year or industry-product-year fixed effect does not impact the size of the overall result, suggesting that such supply factors are not mainly underlying the observed mechanism. See table C4, columns 5-6.

[48] Kugler and Verhoogen (2012) note that when studying homogenous sectors the correlation of quality and price may be negative. Piveteau and Smagghue (2019) find that prices are less informative for more homogenous markets. Similar results are found by Khandelwal (2010) and Manova and Zhang (2012).

Table 4: Identifying the channel: Dependent variable is non-core product trade flows(Y), export price(p) or quantity (q).

	Dependent variable			Dependent variable		
	y	p	q	y	p	q
Core trade value	0.277^{a}	0.0900^{b}	0.188^{a}	0.295^{a}	0.0833^{c}	0.212^{b}
	(0.0851)	(0.0415)	(0.0702)	(0.101)	(0.0474)	(0.0836)
Product demand control	0.0293^{a}	-0.00311	0.0325^{a}	0.0309^{a}	-0.00169	0.0326^{a}
	(0.00555)	(0.00282)	(0.00527)	(0.00593)	(0.00287)	(0.00551)
Nr. obs.	1588389	1588389	1588389	1381958	1381958	1381958
R^2	0.815	0.856	0.872	0.850	0.881	0.897
# clusters	52955	52955	52955	47719	47719	47719
First stage F stat.	22.93	22.93	22.93	16.97	16.97	16.97
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm -year FE	Yes	Yes	Yes	No	No	No
Firm-prod-year FE	No	No	No	Yes	Yes	Yes
Prod.-year FE	Yes	Yes	Yes	No	No	No

Dependent variable is log value of non-core trade flows in columns 1 and 4. In columns 2 and 5 the dependent variable is the log of the unit price and log of quantity+1 of non-core products in columns 3 and 6. The empirical strategy is otherwise unchanged from the baseline estimations. Note: observations that have missing information on quantities are dropped which explains why the result in column 1 is not identical to the baseline result in table 2 (col. 1). Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

relative to a buyer comparing differentiated products from several sellers. The idea here being that firms exporting a homogeneous core are competing in terms of price rather than quality. To investigate this an interaction dummy term is added if the entire core is homogeneous or reference priced, 0 otherwise.[49] I find that the interaction is negative and of similar size as the main effect. See column 1 in table 5. Hence, if a firm is predominantly selling products where prices are easily observed (lower cost of switching suppliers), then no causal link is found between the core and non-core products of the firm.[50] However, employing the same decomposition as in equation 3 we can see that firms exporting homogenous core products are still able to charge higher prices for their non-core products while they are unable to increase quantities. See columns 4-5 in table 5. This suggests that these firms are unable to co-export or bundle goods in the same manner as firms selling differentiated products while the fact that these firms are still able to increase prices provides suggestive evidence that the mechanism is related to

[49] As with the definition based on production data discussed in appendix E, using a firm-year fixed effect removes most of the variation in this case as the core is frequently firm-year specific. Instead industry-year fixed effects are used while the results including firm-year fixed effects are shown in column 2 of table 5. In the data, the most common homogeneous or referenced priced core products are (in order of frequency, within HS2 categories): (1) paper and paper-board articles, (2) articles of iron and steel, (3) plastics and articles thereof, (4) iron and steel.

[50] This is indicative of a form of 'cannibalization' as the lack of dependence implies that the share of the (homogenous) core increases without a response (in quantities) of non-core products.

demand rather than supply factors.

Table 5: Identifying the channel - homogenous/differentiated products: Dependent variable is non-core product trade flows(Y), export price(p) or quantity (q).

	Dependent variable				Dependent variable		
	y	y	p	q	y	p	q
Core trade value	0.336^{a}	0.377^{a}	0.0616^{b}	0.258^{a}	0.270^{a}	0.0922^{b}	0.167^{b}
	(0.0780)	(0.121)	(0.0313)	(0.0689)	(0.0818)	(0.0424)	(0.0686)
Product demand control	0.0263^{a}	0.0228^{a}	-0.00255	0.0305^{a}	0.0279^{a}	-0.00331	0.0332^{a}
	(0.00558)	(0.00643)	(0.00276)	(0.00550)	(0.00550)	(0.00282)	(0.00531)
Homog. core $\times$ core trade value	-0.309^{a}	-0.605^{c}	-0.00833	-0.265^{b}			
	(0.110)	(0.364)	(0.0406)	(0.110)			
Homog. non-core product $\times$ core trade value					0.0592	-0.0390	0.0814
					(0.0663)	(0.0272)	(0.0619)
Nr. obs.	1680868	1663362	1605832	1605832	1663362	1588414	1588414
R^2	0.791	0.797	0.854	0.854	0.816	0.857	0.873
# clusters	56310	53291	55955	55955	53291	52956	52956
First stage F stat.	10.35	1.105	10.49	10.49	12.73	11.85	11.85
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	No	Yes	Yes	No	No	No
Prod.-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	No	Yes	No	No	Yes	Yes	Yes

Products are classified as homogeneous, referenced priced or differentiated according to the liberal Rauch(1999) classification system. Column 1-4 and adds an interaction equal to 1 the entire core is homogeneous or referenced priced, 0 otherwise. In columns 4-6 the interaction equals 1 if the non-core products are homogeneous/referenced priced products, 0 otherwise. In columns 3-4, and 6-7 we decompose the impact on non-core products by log price (p) and log quantity (q) instead of log value (y) as in columns 1-2 and 5. Observations with missing values for quantities are dropped from columns 3-4 and 6-7. Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

A further exercise is to investigate if product characteristics of *non-core* products influence the mechanism. Using an interaction dummy for homogeneous (or referenced priced) non-core products I do not find any significant differences between homogeneous and differentiated *non-core* products, see table 5. This is reasonable considering that there may be buyer-seller relation specific fixed costs, as in Bernard, Moxnes, and Ulltveit-Moe (2018), and therefore optimal to purchase additional products from the seller regardless of their type/characteristics.[51] We can also decompose the impact, as above, by price and quantity for homogenous/differentiated

[51] This relates to the work on the number of buyers in a destination by Bernard, Moxnes, and Ulltveit-Moe (2018), Carballo, Ottaviano, and Volpe Martincus (2018) and Bernard, Moxnes, and Saito (2019). As firm sales are skewed towards a limited number of products, potential buyers are more likely to have knowledge of the core (due to, for example, marketing) rather than non-core products. A new buyer is therefore more likely to demand the core than other products. This would result in the mechanism in conjecture 1 if the new buyer also demands some non-core products.

non-core products. In table 5 we do not find a statistically significant difference based on non-core product type.

Piveteau and Smagghue (2019) find evidence that firms jointly increase prices and quality and the correlation is stronger for markets with larger potential for product differentiation. From the results above however, we do *not* find a difference in the transmission through prices regardless of whether the core (or non-core) products are homogenous or differentiated. This suggests that variation over time in quality is not the main underlying channel of the complementarity.

5.3 Product Production and Carry Along Trade

Bernard, Redding, and Schott (2010) document that some products are either systematically co-produced by the same firm or systematically produced by separate firms suggestive of some form of interdependence in production. Similarly, Fontagné, Secchi, and Tomasi (2018) find that core products may not always be well defined by (strict) product hierarchies suggestive of some other product complementarities.[52] If products are a part of the core-competency of the firm and there are technical (supply side) complementarities we would expect the products driving the mechanism also to be produced by the firm. It is therefore natural to investigate this channel by using data on firm product production.

Firms export a large number of products while they need not produce all. Instead, products are rather part of Carry-Along-Trade (CAT), which is the export of products the firms themselves do not produce. Bernard, Blanchard, Van Beveren, and Vandenbussche (2018) document that around 30% of the export value and three quarters of products are CAT products.[53] They created a model emphasising sourcing of products and suggested that a demand-scope complementarity of produced and non-produced products could explain the existence of CAT products.[54] This type of demand-side product bundling may provide one explanation of conjecture 1. Hence, if core and non-core products are demanded in conjunction and are bundled, a positive shock to the

[52] Note that Fontagné, Secchi, and Tomasi (2018) do not observe firm level product production and are hence unable to identify if products are produced or only exported.

[53] A similar pattern is found in Sweden, see appendix E.

[54] Bernard, Blanchard, Van Beveren, and Vandenbussche (2018) provide some anecdotal evidence of demand-scope complementaries. They interviewed Belgian and US firms on their sales strategies and reported that firms often export non-produced products with produced products as the customer demands a bundle of goods. An example they use is a coffee exporter who will bundle his produced good (coffee) with non-produced goods (coffee cups and/or cookies) which are then sold to the foreign market. In our setting, a shock to coffee (the core product) will impact exports of cups (the non-core product) while a shock to cups will not induce trade of coffee or cookies (other non-core).

core will induce trade in non-core products. Conversely, a positive shock to non-core products should not induce trade of core products (or other non-core products), as these products are individually of minimal importance for the exporter.

Table 6: Identifying the channel - CAT products: Dependent variable is non-core product trade flows(y), export price(p) or quantity (q).

	HS4			HS6		
	y	p	q	y	p	q
Core trade value	0.293^a	0.0883^b	0.192^a	0.297^a	0.0890^b	0.195^a
	(0.0820)	(0.0414)	(0.0682)	(0.0823)	(0.0415)	(0.0685)
Product demand control	0.0269^a	-0.00339	0.0328^a	0.0268^a	-0.00341	0.0327^a
	(0.00564)	(0.00293)	(0.00542)	(0.00565)	(0.00293)	(0.00543)
CAT ×						
Core trade value	-0.0204^a	0.00260^a	-0.0227^a	-0.0227^a	0.00130^c	-0.0235^a
	(0.00155)	(0.000752)	(0.00158)	(0.00164)	(0.000750)	(0.00165)
Nr. obs.	1508969	1438320	1438320	1508969	1438320	1438320
R^2	0.817	0.853	0.874	0.817	0.853	0.874
# clusters	43573	43305	43305	43573	43305	43305
First stage F stat.	12.01	11.26	11.26	12.00	11.26	11.26
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Prod.-year FE	Yes	Yes	Yes	Yes	Yes	Yes

In all regressions an interaction variable is added that equals 1 if the product is identified as a CAT product (0 otherwise). Note that in columns 1-3 (4-6) a CAT product is *identified* based on 4 (6) HS digit aggregation of the data from the IVP survey while the data is always at the 6-digit level. The dependent variables is non-core trade flow in columns 1 and 4, log unit price in columns 3 and 5 and log quantity in column 4 and 6. Observations with missing values for quantities are dropped from columns 2-3 and 5-6. Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

After identifying CAT[55] products in the data, I investigate if the one-way complementarity observed differs for CAT products compared to produced non-core products. I find that the mechanism is present for both produced and CAT products, while the elasticity is lower for CAT products. That the complementarity mechanism is weaker for CAT products rather than produced non-core products, provides indicative evidence of some supply side effects. See appendix E for a discussion of the underlying production data and the results in table 6.

To further uncover the channel, I use the decomposition from equation 3 and investigate if the mechanism is transmitted more strongly through prices than quantities for CAT products.

[55] A related test is to analyse if the observed mechanism depends on the concept of product space introduced by Hidalgo, Klinger, Barabasi, and Hausmann (2007). In their work they measure product relatedness by a measure they call product proximity. This measure is intended to identify opportunities for product expansion (at country level). I find no indications of differences based on the distance in the product space (results available on request). This need not be surprising as the product space concept is intended to explain or predict product entry (extensive margin) rather than the intensive margin which is the focus of this study.

From table 6 we can see that a larger fraction of the mechanism is transmitted through prices for CAT products and less through quantities consistent with a demand driven channel. This is similar to Bernard, Blanchard, Van Beveren, and Vandenbussche (2018) who documented that prices are systematically higher with broader scope which they interpreted as evidence of a demand driven channel behind CAT products.

The fact that the channel is stronger for produced products lends some support that there may be underlying co-production (supply-side) complementarities. However, co-production complementarities can only explain a small part of the mechanism as over 80% of the non-core products(HS6) are not produced by the firm (see appendix E). In addition, even though the transmission through prices is stronger for CAT products it is still found among co-produced products.[56] Again, this suggests that even if supply side co-production may partly contribute to the mechanism the main channel is through demand.

Together, these results on export product prices and different product types, suggest that demand factors, rather than supply, are mainly underlying the observed mechanism. These results add to a growing literature that have found demand factors to be important drivers of firm export expansion and adjustment.[57]

6 Conclusion

Export sales of multi-product firms are skewed towards the core, still, non-core products account for the wide variety of exported products and a significant share of the value. Despite their sizeable *joint* weight, relatively little is known about what causes these peripheral products to be traded. This article contributes to the literature by looking within the firm and uncovers systematic cross-product complementarities that enhance the understanding of firm exporting patterns.

In this paper I suggest an asymmetric relationship between these two groups of core and the non-core products that is brought to the data. This complementarity is investigated using high-quality Swedish firm registry data that is matched with export flows at the firm-HS6

[56]If co-production complementarities are the mechanism then we would not expect prices to increase as discussed above.

[57]See for example Bernard, Blanchard, Van Beveren, and Vandenbussche (2018), Coşar, Grieco, Li, and Tintelnot (2018), De Loecker, Goldberg, Khandelwal, and Pavcnik (2016), Hu, Rodrigue, Tan, and Yu (2017) and Foster, Haltiwanger, and Syverson (2016).

product-destination level. Using a novel instrumental variable approach, I find that a 10% increase in trade value of the core leads to a 2.8% increase in export value of non-core products. I therefore find a causal relationship that shows how the core products of the firm explain trade in more peripheral products. In the estimations, we control for unobserved heterogeneity by including firm-product-destination, firm-year and destination-year fixed effects. Furthermore, to ensure that the complementarity is not driven by non-core product specific variation we use both a product-year fixed effect and a product-destination-year demand control.

To investigate if the mechanism is asymmetric, I use lower ranked products as placebo cores to verify if they are also able to explain the trade value of other products within the destination. In line with the suggested one-way mechanism, the same type of complementarity is not found for these placebo-cores. The results therefore show evidence of a *one-way* causal mechanism where the non-core products complement the core. Hence, the 'superstar' core has products that 'follow along' in the a contemporaneous transaction while the periphery does not.

Exploring the underlying channel we examine if the mechanism is related to demand or supply forces. We see that increased trade of the core is transmitted both as an increase in the quantity and price of non-core products. I find that *over a quarter* of the increase in non-core product trade can be attributed to prices. If supply forces are underlying the mechanism we would however expect prices to *decrease* rather than increase as we observe. Hence, this positive relationship between core product exports and non-core product prices is suggestive of demand forces underlying the mechanism. While I find some evidence that supply-side co-production may account for a part of the mechanism it can only explain a small share as most non-core products exported are produced externally. Several other exercises are performed which also support the conclusion that demand plays a fundamental role.

The implications of these results are twofold. First, ignoring the observed pattern of cross-product dependence may over-emphasize individual trade flows as products should not be viewed in isolation. Hence, even if one acknowledges the high value share of the core, one misses the full impact of the core products due to product complementarities. In the paper I show that after accounting for the one-way complementarity the weight of trade value explained by the core is over a *quarter* larger than the share of value directly attributed to the core. Similarly, evaluating (at the product level) a change in foreign product demand (or policy) the true impact may be under- or overestimated due to differences in firm product sales composition. I show in addition that this mechanism is especially relevant for firms exporting differentiated, rather than homogenous, core products. Second, the causal mechanism provides an explanation for observed export trade variation that is not directly incorporated in current theoretical models of multi-product exporters. The models often incorporate the concept of core competency/products of a firm but the 'superstar' core is an addition thereto, as it has (contemporaneous) followers. Hence, future theoretical research on multi-product exporters should incorporate this within-firm one-way (demand) dependence of product exports.

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7 APPENDICES

A About the Dataset and Descriptive Statistics

The datasets used in this paper are provided by Statistics Sweden (SCB) and include firm registry, trade and multinational firm data. The combined dataset is at the firm-(origin)-product-destination level using HS eight-digit level product codes. The data is first aggregated to the six-digit HS level and then converted to time-consistent product codes (HS 2012) using a correspondence table from Eurostat (RAMON). The BACI version of Comtrade (Gaulier and Zignago, 2010) is used to construct the instrument (in thousands current USD). The industry classification used is the Swedish SNI industry codes (5-digit) that builds on the EU's NACE Rev.2 classification system.

A product in the analysis refers to a specific HS 6-digit product unless explicitly stated otherwise. All observations with zero trade values and/or missing values are dropped (e.g. missing product codes, trade partners, trade values, product demand control). Only firms which have an aggregate trade value above a threshold are required to report their intra-EU trade to SCB. The firm-level threshold ranges from 2.5 to 4.5 million krona depending on the year. All firms are included in the regression dataset regardless of this threshold. Deleting all firms with a minimum trade value below 4.5 million krona in any year does not change the results of the paper. Since we are interested in mostly large multi-product exporters, this is not surprising.

In section 3.1 the core of the firm is defined based on a three year pre-sample. As the core product(s) need not be exported to a destination in any of the following years there may be a problem of zero trade flows of the core. To avoid dropping all years when the core product(s) is not exported all non-core firm-product-destination observations are merged with the data on the core instrument regardless of whether the core is exported that year or not. Hence, practically in the regression analysis, the trade value of the core is *always* included, even in cases where no trade is observed as we add 1 to the export value of the core (ln(export value + 1)). Similar adjustment is performed is performed for the instrument to avoid missing values for the instrument. Pre-sample and core observations are dropped in the regressions. All products outside the core in the pre-sample or products only observed post pre-sample are defined as non-core products. A few negligible countries are dropped from the dataset, as they are either very small or their names were altered during the sample period (examples: Virgin Islands, Serbia/Montenegro, Myanmar/Burma). Some descriptive statistics on the dataset can be found in table A1. Pre-sample observations are included in the descriptive statistics unless otherwise stated.

Table A1: Summary statistics for the baseline multi-product core dataset (in logs if not specified as #).

	Mean	St. dev.	Min	Max	Obs.
Non-core prod. trade value	9.74	2.82	0.69	22.98	2734123
Product demand control	9.80	2.29	0.69	18.41	2734123
Core trade value	9.28	6.55	0.00	23.62	535890
Instrument	10.06	2.21	0.03	18.41	535890
# non-core products exported to dest.	5.1	14.38	1	428	535890
# firms	12248				
# products	4394				
# firm - dest. combinations	90208				

Data for years 1997-2011 is used to compute this table. Note that firms only active in the pre-sample, single-product firms or those only exporting core products are dropped. Non-core products account for 83% of the observations in the post pre-sample data and 33% of the aggregate export value. At the firm destination level non-core products account for on average 49% of the export value. Including pre-sample observations the equivalent shares (same order) are 80%, 30% and 41%.

Table A2: Number of products in the core. Column 1-3 shows the number, percentages and cumulative percentages for the baseline regression sample and columns 4-6 restricted to larger multi-product exporters(all years).

	Baseline			10+ only		
	#	%	cuml. %	#	%	cuml. %
1	38160	91.5	91.5	4013	53.2	53.2
2	1487	3.6	95.1	1487	19.7	72.9
3	697	1.7	96.8	697	9.2	82.2
4	363	0.9	97.6	363	4.8	87.0
5	631	1.5	99.2	631	8.4	95.4
10	240	0.6	99.7	240	3.2	98.5
21	110	0.3	100	110	1.5	100
Total	41688	100		7541	100	

The maximum number of products in a core is 45. Columns 3-5 (labelled 10+) restrict the sample to multi-product exporters that exported 10 or more products to a destination in the pre-sample period. This sample is used for some of the robustness checks.

Table A3: Rank of products within firm and destination. Table shows percentage of trade value and percentage of observations (parenthesis) in each cell (aggregated over 1997-2011)

	Nr. of destinations					
Product Rank	1	2	3	4-10	11+	Total
1	0.4 (2)	0.3 (0.4)	0.3 (0.2)	3.2 (0.5)	53.2 (0.8)	57.4 (3.9)
2	0.1 (2.2)	0.1 (0.4)	0.1 (0.2)	1.1 (0.4)	16.8 (0.5)	18.2 (3.7)
3	0.2 (2.2)	0.1 (0.3)	0.1 (0.2)	0.5 (0.3)	7.1 (0.4)	8 (3.4)
4-10	0.2 (10.5)	0.2 (1.6)	0.1 (0.6)	0.8 (1.4)	10.7 (1.1)	12 (15.2)
11+	0.2 (52.1)	0.1 (8.8)	0.1 (3.6)	0.4 (5.9)	3.8 (3.5)	4.6 (73.9)
Total	1.1 (69)	0.8 (11.5)	0.7 (4.8)	6 (8.5)	91.6 (6.3)	100 (100)

Number of firm-product observations: 332568.

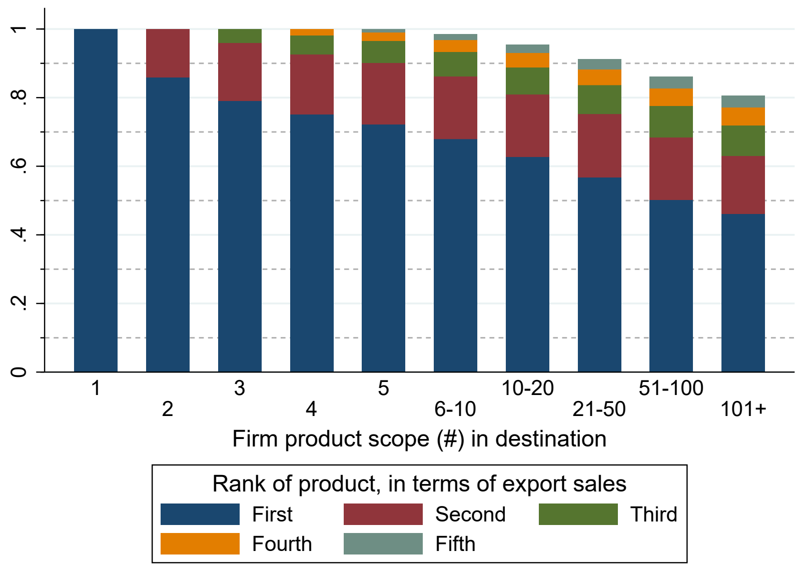

Figure A1: Share of export value of products ranked first to fifth within a firm-destination pair. Calculated as the export value of the product divided by the total export value to the destination (aggregated over all years from 1997-2011).

B Single Product Core - Results and Robustness

As a robustness check for the alternative *single-product* core specification, I re-estimate the regressions using low-ranked products (per destination) in the pre-sample as placebo-core products. I define a placebo-core product for each decile of the pre-sample. The highest ranked product in each decile is the placebo-core product for that decile. The instrument is now based on the placebo-core product but otherwise the identification method and sample construction is unchanged. The products used as placebo core products are found using the relative rank of products in a pre-sample period to a destination. The specific product used is the first product that has a rank ratio strictly above each rank ratio threshold decile. The rank ratio is defined as the rank of product(p) divided by the lowest ranked product (P), $p \in c$ if $\frac{p}{P}$. Example: A firm exports 25 products in the first three years in the dataset. The product ranked third will then be used as the 10% threshold placebo product as it is the first product to have a ratio higher than 0.1 (since 3/25=0.12). The product ranked sixth is used as the 20% (6/24=0.24) placebo product. This method of choosing the placebo products is used to ensure that the placebo products have a similar relative ranking within the firm regardless of product scope to the destination. To ensure that the sample is consistent in the placebo tests the sample is restricted to firms exporting 10 or more products in the pre-sample. Consistent with conjecture 1, I generally do not find the same contingency between the placebo core products and other products. See tables B3 and B4.

Table B1: Robustness results using a single core-product per firm-destination pair. Dependent variable is non-core product trade flows except for the lower panel which shows the first stage results for each column.

	IV 2-stage			OLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Core trade value	0.259^a	0.291^b	0.266^b	0.0243^a	0.145^a	0.164^a
	(0.0983)	(0.125)	(0.134)	(0.00132)	(0.00653)	(0.00727)
Product demand control	0.0304^a	0.0329^a		0.0315^a	0.0302^a	0.0325^a
	(0.00563)	(0.00604)		(0.00504)	(0.00551)	(0.00545)
	IV 1-stage					
	(1)	(2)	(3)			
Core instrument	0.209^a	0.194^a	0.196^b			
	(0.0679)	(0.0732)	(0.0791)			
Product demand control	-0.00298	0.00143				
	(0.0119)	(0.0130)				
Nr. obs.	1660191	1456392	1265403	1660191	1336791	1180220
R^2	0.818	0.845	0.855	0.849	0.859	0.892
# clusters	50617	45626	43318	50617	32269	28986
First stage F stat.	9.481	7.033	6.139			
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	No	Yes	Yes	Yes	No
Prod-year FE	Yes	No	No	Yes	Yes	No
Dest.-year FE	Yes	Yes	No	Yes	Yes	Yes
Firm-prod.-year FE	No	Yes	No	No	No	Yes
Prod.-dest.-year FE	No	No	Yes	No	No	No

Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table B2: Robustness results using products, ranked #2 to #6 as alternative core products. Dependent variable is non-core product trade flows.

	Rank of product within destination				
	#2	#3	#4	#5	#6
Placebo core-product trade value	0.115^c	-0.0996	0.0353	-0.319	0.0687
	(0.0600)	(0.125)	(0.0429)	(0.677)	(0.0511)
Product demand control	0.0293^a	0.0289^a	0.0323^a	0.0297^a	0.0313^a
	(0.00625)	(0.00648)	(0.00633)	(0.00808)	(0.00619)
Nr. obs.	1095089	1085572	1091568	1086986	1098508
R^2	0.861	0.860	0.868	0.806	0.869
# clusters	8928	8835	8863	8917	8903
First stage F stat.	15.97	4.466	14.07	0.217	11.33
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes

Only firms with 10 or more products in the pre-sample are included to keep the sample consistent in the placebo regressions. Standards errors in parentheses are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table B3: Robustness results comparing the (actual) single core-product and placebo-core products from lower deciles in the pre-sample rank. Dependent variable is non-core product trade flows.

	Rank	Rank ratio thresholds			
	#1	10%	20%	30%	40%
Placebo-core product trade value	0.291^b	0.0647	-0.0880	0.0823^c	0.0454
	(0.131)	(0.0479)	(0.117)	(0.0432)	(0.0607)
Product demand control	0.0322^a	0.0329^a	0.0331^a	0.0310^a	0.0326^a
	(0.00715)	(0.00627)	(0.00671)	(0.00635)	(0.00625)
Nr. obs.	1076602	1059485	1078854	1077272	1088363
R^2	0.826	0.867	0.861	0.869	0.870
# clusters	8778	8853	8852	8853	8910
First stage F stat.	6.291	19.30	3.687	11.34	9.494
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes

See section B for information on how the rank ratio thresholds are constructed. Only firms with 10 or more products in the pre-sample are included to keep the sample consistent in the placebo regressions. Standards errors in parentheses are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table B4: Robustness results using placebo-core products from lower deciles in the pre-sample rank. Dependent variable is non-core product trade flows.

	Rank ratio thresholds					
	50%	60%	70%	80%	90%	Last
Placebo-core product trade value	0.121	-0.104	0.372	-0.420	0.176	0.215^c
	(0.133)	(1.453)	(0.550)	(1.205)	(0.118)	(0.124)
Product demand control	0.0319^a	0.0355^a	0.0341^a	0.0384	0.0318^a	0.0325^a
	(0.00646)	(0.00925)	(0.00842)	(0.0235)	(0.00658)	(0.00678)
Nr. obs.	1097465	1101553	1092722	1085832	1092583	1089638
R^2	0.866	0.861	0.813	0.783	0.860	0.857
# clusters	8916	8945	8926	8914	8893	8833
First stage F stat.	1.684	0.0351	0.617	0.130	4.850	5.751
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes

See section B for information on how the rank ratio thresholds are constructed. Only firms with 10 or more products in the pre-sample are included to keep the sample consistent in the placebo regressions. Standards errors in parentheses are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

C Baseline Definition of Core - Robustness

Table C1: Robustness results. Comparison of the baseline core (#1) to placebo cores (based on products in the #2 to #5th deciles). Dependent variable is non-core product export flows.

	Deciles				
	#1	#2	#3	#4	#5
Placebo core trade value	0.303[a]	0.133	-0.450	0.0831	0.148
	(0.0973)	(0.112)	(1.266)	(0.0669)	(0.100)
Product demand control	0.0264[a]	0.0322[a]	0.0306[b]	0.0306[a]	0.0325[a]
	(0.00621)	(0.00622)	(0.0133)	(0.00624)	(0.00661)
Nr. obs.	1070885	1090311	1112424	1124611	1140174
R^2	0.828	0.867	0.798	0.873	0.869
# clusters	10051	10275	10255	10329	10401
First stage F stat.	20.01	10.19	0.235	13.88	8.779
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes

Deciles are created using pre-sample rank of products. Only firms with 10 or more products in the pre-sample are included to keep the sample consistent in the placebo regressions. Standards errors in parentheses are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table C2: Robustness results. Results using placebo cores (based on products in the #6 to #10th deciles). Dependent variable is non-core product export flows.

	Deciles				
	#6	#7	#8	#9	#10
Placebo core trade value	0.166	-0.442	-0.0160	0.0450	0.391
	(0.124)	(0.600)	(0.191)	(0.0813)	(0.597)
Product demand control	0.0339[a]	0.0340[a]	0.0366[a]	0.0320[a]	0.0353[a]
	(0.00618)	(0.00854)	(0.00758)	(0.00599)	(0.00752)
Nr. obs.	1151723	1160981	1169514	1179487	1191626
R^2	0.865	0.778	0.868	0.869	0.812
# clusters	10293	10346	10333	10318	10538
First stage F stat.	5.197	1.044	1.554	8.470	0.488
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes

Deciles are created using pre-sample rank of products. Only firms with 10 or more products in the pre-sample are included to keep the sample consistent in the placebo regressions. Standards errors in parentheses are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table C3: Robustness results using time variant pre-samples (col. 1-4) and specific geographic regions (col. 5-7). Dependent variable is non-core product trade flows.

	3 yeas PS		1 year PS		Geography		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Core trade value	0.273^b	0.368^b	0.190^b	0.327^a	0.278^a	0.333^a	0.235^a
	(0.134)	(0.177)	(0.0950)	(0.115)	(0.0796)	(0.101)	(0.0811)
Product demand control	0.0225^a	0.0385^a	0.0321^a	0.0397^a	0.0249^a	0.0284^a	0.0276^a
	(0.00661)	(0.00617)	(0.00540)	(0.00549)	(0.00550)	(0.00547)	(0.00546)
Low income × core trade value						-0.109	
						(0.104)	
EU × core trade value							0.120
							(0.105)
Nr. obs.	866334	1307359	1315551	1962157	1573709	1662652	1662652
R^2	0.865	0.882	0.853	0.879	0.819	0.812	0.811
# clusters	29043	61619	40173	86215	50291	53264	53264
First stage F stat.	21.00	12.43	35.32	22.56	20.15	11.94	8.836
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Alternative definitions of the core using time variant pre-samples (PS): For each year in the data a pre-sample period consisting of the last 3 (or 1) years is used to define the core. Example: Using a 3- year window then the years 2002-2004 are used to identify the core for 2005. The core is then found for that year using the methodology described in section 3.1. The products in the core are then dropped from the dataset in 2005. Similarly, for 2006 the years 2003-2005 are used to identify the core and dropped in 2006. Hence, instead of using a single pre-sample period the same method is used for each year always dropping the core in the year of interest. The composition of the core can therefore change over time but is always based on historical trade flows. The first one/three years in the data are dropped as the identity of the core is unknown. The instrument for the core is constructed for *each* pre-sample period as described in section 3.3. As the core is allowed to change over time this can be problematic when investigating the intensive margin. Products in the core may change and since the core is dropped from the regressions the trade flows will not be observed. An alternative is including the core- product flows in the regression and these results are shown in columns 2 and 4 respectively. In column 5 the BRIC countries are excluded, columns 6 and 7 add interactions for low income countries (col. 6) and EU-27 or EFTA countries (col. 7). Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table C4: Robustness results (IV) using information about BEC classification to identify the core and non-core products, alternative fixed effects or results using first differences. Dependent variable is non-core product trade flows.

	BEC		FD		Alt FE.	
	(1)	(2)	(3)	(4)	(5)	(6)
Core trade value	0.503^a	0.562^c	0.250^b	0.280^b	0.291^a	0.310^a
	(0.184)	(0.295)	(0.101)	(0.114)	(0.0672)	(0.0726)
Product demand control	0.0254^a	0.0220^a	0.0174^a	0.0199^a	0.0283^a	0.0291^a
	(0.00725)	(0.00777)	(0.00557)	(0.00596)	(0.00549)	(0.00568)
Nr. obs.	1150125	1133505	1121224	1004214	1680868	1585602
R^2	0.742	0.746	-0.0101	0.0906	0.795	0.821
# clusters	41914	38767	49543	44675	56310	54512
First stage F stat.	8.095	3.786	7.527	6.855	34.99	32.89
Firm-prod.-dest. FE	Yes	Yes	No	No	Yes	Yes
Firm-year FE	No	Yes	Yes	No	No	No
Prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry.-year FE	Yes	No	No	No	Yes	No
Ind.-prod-year FE	No	No	No	No	No	Yes
Firm-prod-year FE	No	No	No	Yes	No	No

BEC: In practice, a very similar methodology is used as in figure 3.1. I calculate for each of the eighteen BEC categories the export value by destination of all products in that category. The BEC category with the highest trade value in the pre-sample will be defined as the core category to that destination. All products that are included in that category will automatically belong to the core regardless of export value. The shares are calculated based on the pre-sample export flows. There are only 18 different 3-digit BEC categories in the regression data and roughly 70% of both observations and value come from only three different BEC categories; processed industrial supplies (220), parts and accessories of capital goods (420) and capital goods (410). Hence, similar to the production core discussed in appendix E, using BEC categories to define the core and firm-year fixed effects removes much of the intra-firm cross destination variation needed for identification. I therefore replace the firm-year fixed effect with a five digit industry-year fixed effect. The main BEC result is shown in column 1 of table C4 while the result using firm-year fixed effect is shown in column 2. Standards errors in parentheses are clustered on firm-destination level. FD: log first difference results. Alt FE: Shows results when the firm-year fixed effect is replaced with either a (five digit) industry-year or industry-prod-year fixed effect. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table C5: Various robustness checks. Dependent variable is non-core product trade flows.

	Duration		Share		Excluded prod. groups	
	Spell>4y	BP	1%	5%	HS1	HS2
Core trade value	0.239^a	0.280^a	0.183^a	0.175^a	0.423^c	0.360^b
	(0.0841)	(0.0959)	(0.0576)	(0.0476)	(0.221)	(0.150)
Product demand control	0.0439^a	0.0246^c	0.0267^a	0.0250^a	0.0169	0.0163^b
	(0.00893)	(0.0142)	(0.00686)	(0.00567)	(0.0108)	(0.00779)
Nr. obs.	517959	230124	1035365	1380340	554482	867165
R^2	0.856	0.860	0.835	0.833	0.784	0.797
# clusters	14266	4974	44310	49628	28072	34366
First stage F stat.	22.25	34.35	53.75	69.01	4.630	8.627
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Prod.-year FE	Yes	Yes	Yes	Yes	Yes	Yes

Column 1 includes only firm-product-destination flows that have a duration above 4 years and trade in the last year. In column 2 we use a balanced panel (BP) of firm-product-destination flows. In column 3-4 the results are shown after excluding observations where the exports of the core of a firm are higher than 1% or 5% of the imports of the same product(s) to destination from the world market (excluding other Swedish trade flows). In columns 5-6 products within the same one or two digit HS product category as *any* of the core products are dropped. Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

D Robustness: Shock Level Regressions

Adão, Kolesár, and Morales (2019) find that in shift share regressions standard errors are often underestimated and the problem stems from the regression residuals being correlated across observations that have similar exposure shares. Borusyak, Hull, and Jaravel (2018) develop a novel framework that addresses this issue and provides valid standard errors. In this section, I describe and implement their framework and discuss identification. Borusyak, Hull, and Jaravel (2018) show that there is a numerical equivalence between a standard shift share IV regression coefficients and one that has been transformed and estimated at the level of the "shock". In this transformed regression they show that the standard errors are valid ("exposure robust") and asymptotically equivalent to those suggested by Adão, Kolesár, and Morales (2019).

In this appendix I focus on the specification that uses a single-core product per firm-destination. Using the single core specification for this exercise is applicable since, if anything, the problem discussed by Adão, Kolesár, and Morales (2019) should be exacerbated by this definition of the core. This stems from the fact that all firms that are exposed to the same shock will have identical exposure shares (since $s_{ipd} = 1$ for all observations) while the shares vary in the baseline multi-product core definition.

To apply the framework of Borusyak, Hull, and Jaravel (2018) the single-core product regression data is transformed from the firm-product-destination-time ($ipdt$) level to the shock level, i.e. (core) product-destination-year level (denoted cdt). In this transformation, the firm-product-destination-time level variables are residualized by the control variable and each fixed effect (firm-product-destination, firm-year, product-year, destination-year) prior to aggregation.[58] After the transformation the original "raw shocks"[59] are added to the transformed data and used as an instrument. Note that outcomes or instruments need not generally be observed at the shock level for this approach to be valid. Hence, now we run the following weighted transformed regression:

$$ln(Y_{cdt})^T = \beta ln(C_{cdt})^T + \lambda_{cd} + \eta_{dt} + \epsilon_{cdt} \tag{4}$$

Analogously to section 3.2, I perform a first stage regression but now the transformed core, $ln(C_{cdt})^T$, is regressed on the shocks, M_{pdt} (when $p = c$), then the fitted values, $ln(\hat{C_{cdt}})^T$, are used in the second stage equation (instead of $ln(C_{cdt})^T$). Borusyak, Hull, and Jaravel (2018) suggest that with panel data, fixed exposure shares and unit fixed effects (firm-product-destination) in the original regression one should apply unit fixed effects in the transformed regression (core-destination fixed effects, λ_{cd}). Since the shocks, by definition, vary across destinations I include a destination-year fixed effect (η_{dt}) in the transformed regression to avoid omitted variables bias (see Borusyak, Hull, and Jaravel (2018)). As shown by the equivalence result of Borusyak, Hull, and Jaravel (2018) the point estimates from the transformed regression are identical to the result in the full regression while the standard errors are valid ("exposure robust") and asymptotically equivalent to those suggested by Adão, Kolesár, and Morales (2019). The errors are clustered at 6 digit (core) product-destination level.[60] Comparing the "exposure robust" standard error of the shock level regressions (see col. 1 in table D1) to those in the full regression the difference is minimal (see the comparable full results in table B1, column 1) suggesting that the underestimate is small.

The broad underlying assumptions needed for identification in this setting are that the shocks

[58]This transformation is performed using the Stata package `ssaggregate` developed by Borusyak, Hull, and Jaravel (2019) which also produces the importance weights (called s_{nt} by Borusyak, Hull, and Jaravel (2018)) that are used to weight observations in the transformed regression. A version of `ssaggregate` that handles high-dimensional fixed effects was kindly provided by Peter Hull and Kiril Borusyak.

[59]Note that when $s_{idpt} = 1$ and the core includes a single product then $z_{idt} = M_{pdt}$ as can bee seen from equation 2.

[60]Clustering at HS 4 or 2 digit product group level has minimal influence on the standard errors, see columns 2 and 3 in table D1.

are as-good-as randomly assigned conditional on observables and there are "*many sufficiently independent shocks, each with sufficiently small average exposure*" (see Borusyak, Hull, and Jaravel, 2018). In our setting we both have a large number of shocks (over 200 thousand) and each shock has a very low average exposure with the single highest importance weight (s_{nt}) under 0.0004. Lastly to fulfil the exclusion restriction of the equivalent shock level regression the shocks should be sufficiently independent. In our setting the shocks are (core) product-destination-year specific and we may still worry that shocks to the same HS6 core product are correlated globally. Using the single-product core specification we can address this concern directly by including a (core) product-year specific fixed effect in the regression and absorb such yearly global product specific variation. The results are very similar, see table D2. Alternatively, if we expect the yearly shocks to be correlated globally for similar product groups we can account for such variation by including a fixed effect that is common to the HS2 or HS4 category of the core product (interacted with year). Again the results are very similar to before.

A priori, we may expect the single product specification to be particularly sensitive to the insights outlined by Adão, Kolesár, and Morales (2019) as the exposure shares are identical. The results of this appendix show however that applying the framework developed by Borusyak, Hull, and Jaravel (2018), accounting for the potential underestimate of standard errors, has minimal impact. Note that these robustness checks are non-trivial in the baseline multi-product core case due to the unique and complex product combinations of each core. For that same reason the multi-product core results should be even less sensitive than the single product core to a potential underestimation of standard errors.

Table D1: Shock level regressions. Dependent variable is the non-superstar product trade flows(transformed).

	HS6	HS4	HS2
	(1)	(2)	(3)
Core trade value	0.259^{b}	0.259^{b}	0.259^{b}
	(0.109)	(0.109)	(0.112)
Nr. obs.	211677	211677	211677
# clusters	29136	18094	4301
First stage F stat.	8.070	8.102	9.207
Core-prod.-dest. FE	Yes	Yes	Yes
Dest.-year FE	Yes	Yes	Yes

Standards errors are clustered on (core) product-destination level. Level of product clustering shown in header. Observations are at the (core) product-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

Table D2: Robustness - Inclusion of (core) product-year fixed effects using the single-product core definition. Dependent variable is the non-superstar product trade flows.

	HS6		HS4		HS2	
	Full	Shock	Full	Shock	Full	Shock
Core trade value	0.318^{b}	0.318^{b}	0.356^{b}	0.356^{b}	0.280^{b}	0.280^{b}
	(0.142)	(0.148)	(0.163)	(0.168)	(0.110)	(0.114)
Product demand control	0.0285^{a}		0.0286^{a}		0.0303^{a}	
	(0.00574)		(0.00603)		(0.00571)	
Nr. obs.	1657323	205461	1659426	209981	1660155	211621
# clusters	50161	28268	50501	28912	50612	29131
First stage F stat.	5.801	5.241	5.445	5.104	8.444	7.835

In the shock level regressions (columns 2, 4, 6) the observations are at the core-destination level and the standards errors are clustered on core product-destination level. The shock level regressions are performed as described above except I add a (core) product-year fixed effect (either HS6-year, HS4-year or HS2-year, see header) to the original transformation and to the transformed shock level regression. In the full regressions the observations are at firm-product-destination level (columns 1, 3, 5) and the standards errors are clustered at firm-destination level. In the full regression I add a (core) product-year fixed effect (either HS6-year, HS4-year or HS2-year, see header). ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$

E Production Data and Related Robustness Checks

An alternative method to identify the core activity of the firm is to use data on production. As a robustness check, I use data from the Industrins varuproduktion (IVP) survey to identify products that are produced by the firm. The IVP database includes information on the production of products by manufacturing firms with more than 20 employees (10 in some cases). The production data is based on the same eight-digit[61] product nomenclature as the trade data.

Using the IVP survey of firm production I can redefine the core of the firm based on production. To identify the production core the products are ranked by production value at the firm level. The products that are ranked first or in the top decile in terms of production value in a three year pre-sample are included in the 'production-core'. Similarly to the baseline definition of the core based on exports the 'production core', $\bar{c}$, is defined as $p \in \bar{c}$ if $\bar{p} = 1$ or $\frac{\bar{p}}{\bar{P}} \leq 0.1$, where p is the original product rank identifier, $\bar{p}$ is the rank based on production value and $\bar{P}$ is the total number of produced products in the pre-sample. Note that production rankings are firm specific, rather than firm-destination as before, and the composition of the core will therefore be the same across destinations and time. The firm specific shares are created using either; a) the share of production, b) or alternatively equals the export value of the product p to all destinations divided by total export value of all products in the core by firm i to all destinations. This resembles the definition used in section 3.3 except the share is at the firm level (rather than firm-destination).

Defining a firm-specific core and using firm-year fixed effect eliminates a considerable part of the intra-firm variation needed for identification.[62] I therefore use a five-digit industry-year fixed effect instead of firm-year fixed effect as in the baseline regressions. Note that the empirical strategy is in other aspects unchanged as the main difference is how the core is identified. The results are shown in columns 1 (using production shares) and 2 (export shares) of table E1.

We can see that the point estimate is somewhat lower than the baseline results (table 2) but still highly significant. As there may be destination market-specific demand conditions (taste), this specification may be less appropriate and more noise present. Hence, a product may for example never be exported to a country due to destination-specific taste or demand but still

[61] There is one difference between the two; the IVP data uses, when applicable, an additional letter as a ninth digit in the code. As the data is aggregated to the six-digit level this has no impact.

[62] This can be seen from comparing the results in columns 1 and 3 of table E1.

included in the firm-specific core. This can be seen from table 1 on the comparison of firm-level to within firm-destination rankings of products. To partly accommodate this concern we can, define a *single* product production core per destination. The product is identified as the highest exported product in the pre-sample (conditional on it being produced). The share naturally equals 1 as in the single core product case. The results are shown in column 4 of table E1. Recall that in section 4 the same contingency is found among high ranking *potential* core products (results in table B2). Given that finding, a possible concern is that the single-produced-product core per destination will not capture the full scope of the core.

A possible issue using the IVP survey is the potential for firms to aggregate (group) the production of similar products to a single product code when reporting their production values. The nature of international trade may however limit the scope for such aggregation of exported products as these databases have different collection methods; the trade statistics are collected on a monthly basis while the IVP data is based on an end-of-year survey. As a robustness check for this production-core definition we experiment by *identifying* the core based on HS4-digit production data. After identifying the core product categories we classify all HS6 digit products within those categories as core products (regardless of whether they are reported to be produced in the IVP). After identifying the core based on HS4-digit production data we can now construct an instrument for the production-core at the 4-digit level using he same methodology as above (either use production or exports to construct shares). Note that the non-production-core products (dependent variables) are still at the 6-digit level. By definition all products within any of the 4-digit HS categories are now a part of the core and hence not included. See results in columns 5 (production shares) and 6 (export shares) of table E1. Again the results are similar.

Using the IVP survey we can also identify Cary-Along-Trade (CAT) as we observe which products are only exported but not produced by the firm. Following Bernard, Blanchard, Van Beveren, and Vandenbussche (2018), a product which is exported by the firm but produced by another is called a Cary-Along-Trade (CAT) product. In the data, there is a high share of (pure) CAT products. Using only firms included in the IVP survey, we find that around 75% of the 6-digit observations (firm-product-destination) are products not produced by the firm exporting them(including the core). Notably, these observations account for only 21% of the trade value of firms. Note that if the data is aggregated to the 4-digit or even the very broad 2-digit level the results are similar (to account for potential issues of firms aggregating similar products in the IVP survey). At the 4-digit (2-digit) level around 72% (63%) products are CAT and account for around 16% (11%) of the trade value. Excluding the core, the shares are naturally higher (HS6: 84% and 31%, HS4: 82% and 27%, HS2: 76% and 21%).

Table E1: Robustness results (IV) using information about production of products from IVP database. Dependent variable is non-superstar product trade flows.

	HS6				HS4	
	(1)	(2)	(3)	(4)	(5)	(6)
Produced-core product trade value	0.120^{a}	0.138^{a}	0.133^{c}	0.151^{a}	0.127^{b}	0.142^{b}
	(0.0451)	(0.0513)	(0.0741)	(0.0474)	(0.0571)	(0.0606)
Product demand control	0.0308^{a}	0.0304^{a}	0.0291^{a}	0.0303^{a}	0.0268^{a}	0.0264^{a}
	(0.00506)	(0.00513)	(0.00520)	(0.00535)	(0.00544)	(0.00547)
Nr. obs.	1650559	1650559	1646746	1531884	1411969	1411969
R^2	0.843	0.841	0.850	0.839	0.838	0.837
# clusters	54344	54344	53740	41046	41276	41276
First stage F stat.	23.47	19.20	7.573	25.37	25.55	19.88
Firm-prod.-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	No	Yes	Yes	Yes
Firm-year FE	No	No	Yes	No	No	No
Prod.-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-dest. FE	Yes	Yes	Yes	Yes	Yes	Yes

Production shares used in columns 1,3 and 5 and export shares in columns 2 and 6. See discussion in appendix E on the shares and each regression. Standards errors are clustered on firm-destination level. ^{c} $p < .10$, ^{b} $p < .05$, ^{a} $p < .01$