Decomposing Firm-Product Appeal: How important is Consumer Taste?

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Abstract

We develop and structurally estimate a trade model that allows us to decompose export sales at the firm-product-destination level into the contributions of costs, quality and consumer tastes. We find that demand determinants explain most of the firm-product-destination export sales variation. Consumer taste is the most important demand determinant in any destination country and is estimated separately from quality. Productivity (TFPQ) differences between firm-products become more prominent than taste in explaining export success only when the cost elasticity of improving quality is high.

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1 Introduction

Why do some firms export a lot and others do not? What explains the differences in firms export performance when they export the same product to the same destination? These are important questions since aggregate exports are an important component of country-level GDP and the microeconomic determinants of firms performance in exporting affect macroeconomic outcomes (Gabaix (2016); Giovanni and Levchenko (2012)).

When firms export their products abroad, many keys to success are at the firm-product level, such as the productivity with which they are produced and the quality offered.[1] But some critical determinants for success are out of firms' hands such as the likes and dislikes of their consumers that are often related to the destination country's habits, culture or stage of development. For example, the export of pork meat to muslim countries will have low export success due to the religion in the destination, no matter how high the quality of the pork. Similarly, the exports of horse meat to the UK or the US is unlikely to be a success, even when the quality of the horse meat is very high. Likewise, the export of beer to wine drinking countries may prove difficult even for the best quality beers. These examples illustrate that consumer taste for the same product can vary widely across countries and are likely to matter for trade flows. Thus it is rather surprising that so little attention in the literature has been devoted to the identification of taste as a structural demand parameter. While for many products, taste differences for the same product across countries may be less extreme than in the above examples, our aim is to know how important taste is as an empirical determinant of firms export performance, relative to other determinants such as cost and quality.

We first develop a trade model where on the demand side, taste for a firm's product enters consumer preferences in a different way than quality does. This raises issues about how we can

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[1] Antoniades (2015); Khandelwahl (2010); Gervais (2015); Fan, Yi and Yeaple, (2015, 2017); Feenstra and Romalis (2014); Verhoogen (2008); Baldwin and Harrigan (2011) etc.

separate horizontal product differentiation ("taste") from vertical differentiation ("quality") in the utility function, a distinction which, with a few exceptions, has not received much attention in trade theories of monopolistic competition with consumer preferences characterised by love-for-variety.[2] Our definitions by and large follow the IO literature in which vertical differentiation is any demand shifter at firm-product level that raises both the quantity sold and the willingness to pay by all consumers. Horizontal differentiation is any demand shifter that affects the quantity sold, but does not affect price.[3] Such differentiation could arise simply from buyers perceiving a difference that may be less related to physical changes in the product but more based on non-price factors (product appeal, distribution strategy, promotional variables). Taste in our model is what explains remaining differences in firm-product performance by destination, after conditioning on price and quality as well as controlling for destination specific and product market specific effects such as market size, income, markups and competition effects that vary at the destination and product market level.

In developing our structural model we condition on firms' export market participation as earlier work has shown that the main contribution of the demand side lies on the intensive margin.[4][5]

Our choice of the Dixit-Stiglitz, CES demand structure is guided by its prominence in international trade, microeconomics and macroeconomics, tractability and empirical feasibility. But while markups are constant in standard CES models, markups in our model vary by product

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[2] Fajgelbaum, Grossman, Helpman (2011) separate quality from taste using a discrete choice model where consumer consumption is limited to one unit of each product. Di Comité, Thisse and Vandenbussche (2014) separate quality from taste in a "love-for-variety" trade model with quadratic utility.

[3] This distinction between vertical and horizontal differentiation largely follows the industrial economics literature. (Hotelling, 1929); Sutton (1991); Vogel (2008); Recent research in trade has also embraced a distinction between vertical and horizontal differentiation in models of discrete choice Khandelwal (2010); Fajgelbaum, Grossman and Helpman (2011) and in quadratic utility models of monopolistic competition (Di comité, Thisse, Vandenbusche (2014).

[4] Roberts et al. (2016) assess the role of firm-level demand heterogeneity in export participation.

[5] By conditioning on export participation we do not consider fixed entry costs as a source of variation in trade decisions which was studied earlier by Aw, Roberts and Xu (2011).

and destination and can be identified by exploiting the destination specific information of our data. Thus, the model allows multi-product firms with products in different product markets to have different product-level markups. The elasticity of demand differs between varieties within a firm, as well as between varieties supplied by different firms e.g. the demand elasticity is estimated at the product-destination level.

The model assumes that improving quality of exported products raises the marginal cost of production and requires the use of higher quality inputs. Empirically we proxy quality through a polynomial in imported input prices and income levels of destination countries (Kugler and Verhoogen (2008); Hallak (2006)). The model generates the result that both vertical and horizontal differentiation positively affect demand, but while vertical differentiation results in a higher consumers willingness to pay, horizontal differentiation does not. This different effect on price is what allows us to empirically separate the two types of differentiation.

The model further assumes consumer heterogeneity across countries where consumer taste varies by export destination. Every country's representative consumer is assumed to have an innate taste parameter for every product. It is important to note that the model does not impose a correlation between quality and taste and therefore high quality products may or may not be liked in the country of destination. Put differently, while higher quality always shifts out demand in any destination country, taste variation across countries implies that the same quality product can ceteris paribus have very different export revenues across destinations. It is the destination specific information on consumption for each firm-product that allows for identification of the horizontal differentiation determinant in export revenues and distinguish it from income, market size, markups and other destination related effects that may also explain differences in firm-product export sales.

On the supply side of our model, we allow productivity to vary by product within the firm

[6] In our estimation of marginal cost at the firm-product level, we follow Aw and Lee (2017) and account for the multi-product nature of firms in our data. We control for the cost of imported materials and wage costs and allow for economies of scale and for economies of scope in production. We further assume firm-product productivity to follow a Markov-process. By using a Levinsohn-Petrin (2003) control function approach, we obtain a measure of TFPQ at firm-product level.

Our empirical analysis is based on micro-data of exports of Belgian firms at the product-level and by country of destination. After structurally identifying the demand and supply determinants of firm-product export revenue, we then decompose firm-product export revenue into the relative contributions of productivity, quality and tastes in export sales variation of exporting firms. In the decomposition we normalize firm-product-destination export revenue by the average export revenue for all firms supplying the same product to the same destination to account for income, market size and markup effects that are product-destination specific.

Our empirical results point to demand differences being very important for overall firm-product sales variation. On average we find that productivity, quality and tastes explains 40%, 10% and 50% respectively, of the variation in firm-product export revenues. But this decomposition varies a lot depending on the type of goods and on the destination. Taste matters more for consumption goods relative to intermediate goods. Tastes also matters more for goods that are exchanged in markets with reference prices. For goods where the cost elasticity of quality is high, the decomposition shows that firm-product productivity is more important than taste.

The relative importance of demand versus supply factors thus varies substantially by destination. While productivity and quality of the same firm-product is stable across destinations, taste varies with a standard deviation that is up to five times as large. Demand aspects are

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[6] In contrast to Eckel and Neary (2010) and other models, we do not impose a productivity ladder amongst products within the firm, but we simply allow productivity to vary between products of the same firm.

more important in some destinations than in others. We find a significant and positive correlation between the minimum quality shipped and the distance to a destination, a finding that is consistent with Manova and Zhang (2012). Similarly, minimum productivity and tastes are also positively correlated with distance. The results imply that fewer products are shipped to more distant destinations, where only products that represent higher quality, higher productivity and stronger tastes end up.

The empirical correlation between quality and taste also varies by destination. For example, we find the quality of a product to be the most important source of firm-product export sales variation for Chinese consumers, while taste heterogeneity is a larger source for firm-product sales variation for the North-American consumers. Put differently, a high quality product in China will typically sell better than a low quality product, while in North-America higher quality products are less guaranteed to have high sales relative to lower quality products due to stronger taste heterogeneity.

A failure to account for taste as a demand determinant, results in a serious underestimation of the importance of the demand side and an over-estimation of the supply side importance in explaining firm-product export revenues. Ignoring taste in the decomposition almost doubles the variation explained by productivity relative to demand. Including taste as a separate demand determinant, therefore halves the relative importance of productivity in export sales variation relative to demand factors. However, when the cost elasticity of improving quality is high, productivity differences between firm-products become more prominent than taste in explaining export success. The role of quality, while important, is always less important than taste in explaining export revenue except for consumption goods.

2 Literature Review

Existing research has suggested a number of candidate explanations for differences in firm performance, such as differences in technical efficiency in production[7] ; product quality [8] and the multi-product nature of firms [9] .

In much of the literature on firm heterogeneity following Melitz (2003), marginal cost and quality are isomorphic as under CES and monopolistic competition, cost and quality enter equilibrium export revenue in the same way. The role of demand in firm-heterogeneity has been getting increased attention in recent research (Feenstra (2014); Roberts, Xu, Fan, Zhang (2016); De Loecker (2011); Foster, Haltiwanger, Syverson, (2008)). In particular, Hottman, Redding and Weinstein (2016), however show that cost and firm appeal (quality, taste) have different implications on firm export revenue conditional on prices. In that paper marginal cost affects firm revenue through prices, quality affects firm revenue conditional on prices. Thus if two firms charge the same price, but one firm has a more appealing product (e.g; higher quality) then that firm will generate more sales. But in the Hottman, Redding and Weinstein (2016) paper, quality and taste differences are considered isomorphic and are not distinguished from each other.

Our paper contributes to the literature by further decomposing "appeal" into its vertical and horizontal differentiation components. This follows the industrial organization literature indicating that quality and taste can affect demand differently (Hotelling, 1929); Sutton (1991); Vogel (2008); Recent research in trade has also embraced a distinction between vertical and horizontal differentiation in models of discrete choice Khandelwal (2010); Fajgelbaum, Grossman and Helpman (2011) and in quadratic utility models of monopolistic competition (di Comit,

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[7] E.g. Melitz (2003)

[8] E.g. Schott (2008), Khandelwal (2010); Feenstra and Romalis (2015); Roberts, Xu, Fan, Zhang (2012), Aw and Lee (2014, 2017); Di Comit, Thisse and Vandenbussche (2014); de Loecker et al (2016)

[9] E.g. Bernard, Redding and Schott, 2010); Eckel and Neary (2010); Mayer, Melitz, Ottaviano (2014)

Thisse, Vandenbusche (2014). We contribute to the literature by distinguishing between a vertical and horizontal demand shifter in a CES model with monopolistic competition in view of its tractability and the straightforward structural identification of the different demand determinants.

Our paper also contributes to the literature in another important way. Instead of a decomposition at firm-level we pursue one at firm-product level. Most other studies, structurally identify supply versus demand determinants at firm-level, and include product-scope at firm-level to control for the multiple product nature of firms. In this paper we take a different approach by developing and estimating a structural model of heterogenous multiproduct firms that allows us to identify supply and demand determinants at the more disaggregate firm-product level.[10] Taking the firm-product as the unit of observation definitely adds to our understanding of export success. A first indication of that is that in our data, firm-product fixed effects explain almost 50 percent more of the variation. In other words firm-product fixed effects explain 1.5 times the variation in export sales compared to firm-level fixed effects. We take this as a confirmation that we are right in developing and estimating a structural trade model at firm-product destination level.

While most papers on multiproduct firms have used Harmonized System (HS) product classification codes, a notable exception is Hottman et al. (2016) who use bar codes from scanner data on consumption goods. In this paper we use the trade data where products are given by the Combined Nomenclature product codes which are similar to the HS codes for the first six digits, but have an additional two digits resulting in eight digit product codes (CN8). By moving to trade data we gain destination specific information about different consumer behaviour, allowing us to identify the role of taste in different countries. But we also loose information as CN8 products are defined at a more aggregate level than in scanner

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[10] This avoids the problem of product scope measurement at firm-level which requires to perform a harmonization procedure of product classifications over time as in Bernard, Van Beveren and Vandenbussche (2014).

data and may hide some underlying heterogeneity in terms of product and quality differences. However, the CN classification does ensure that remaining differences within a product code are smaller than differences across product codes. Destination specific information on export revenue allows us to check for demand determinants varying by (consumer) destination. Thus we can verify whether the same product is liked differently in different destination markets e.g. whether the decomposition of demand versus supply determinants varies by destination. While scanner data from retail chain shopping may also hold information on consumer characteristics, these consumers will tend to belong to the same country, possibly belong to similar income groups in society and may have similar preferences. By using international export data, we track products that are sold to very different consumers, in countries with different levels of development, income and preferences. The larger variation in consumer heterogeneity will help us to identify taste differences between them. Another advantage of using trade data is that CN8 product classifications next to consumer goods also include exports in intermediate goods for which the decomposition of demand versus supply related factors could be very different. In sum we add to the literature by performing a decomposition of export sales at firm-product level rather than at firm-level. The destination aspect of our data allows us to identify horizontal differentiation and to identify taste differences for the same product across countries. Empirically we find the standard deviation of the taste by destination, to be five times larger than the standard deviation of the quality and productivity by destination, which is a first indication of a very strong international variation in taste.[11] And finally, the firm-level trade data that we use, are semi-public data and typically costless, while scanner data are typically collected and distributed by private providers and tend to be costly.[12] The advantage of the trade data is thus that results can be easily replicated and verified by anyone with access

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[11] The taste index is an index that aggregates taste at firm-product-destination level by destination, while the quality and productivity index aggregate quality and productivity estimated at firm-product level by destination

[12] Firm-level trade data are data collected by government agencies, which can give permission to use the data for research purposes.

to exporters trade data.

3 Theoretical Framework

In this section, we start with the demand side of the model. While the theoretical model is essentially static, in the empirical counterpart to theory, we allow for dynamics in the evolution of the productivity and demand parameters.

Consumers in country d face a constant elasticity of substitution (CES) utility function:

$$U_d = \left(\sum_{j=1}^{n} \sum_{i=1}^{k} [\lambda_{id}^{\frac{1}{\sigma_{id}-1}} \delta_{ji}^{\frac{1}{\sigma_{id}-1}} q_{jid}]^{\frac{\sigma_{id}-1}{\sigma_{id}}} \right)^{\frac{\sigma_{id}}{\sigma_{id}-1}} \tag{1}$$

where q_{jid} is the quantity of product i produced by firm j that is consumed in country d and $\sigma_{id} > 1$ is the elasticity of substitution between any pair of varieties within a product market i in country d [13]. λ_{id} is an index of demand reflecting the taste of consumers in country d for product i, δ_{ji} reflects consumers' willingness-to-pay (or product quality) for product i produced by firm j. This specification allows for a product-specific component λ_{id} that is common to all firms that export i, but varies by destination market and year and a firm-product-specific component, δ_{ji} that is common across destination markets [14]. In a standard CES model, the parameter σ typically captures both product differentiation as well as product substitutability. In contrast, the model here separates product differentiation from product substitutability by adding two additional parameters in the utility function. Therefore σ gets a different interpretation than in most CES models since it is now cleaned from horizontal and vertical product differentiation, thus resulting in a finer measure of the elasticity of substitution (σ) compared to other studies.

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[13] Empirically, we estimate the elasticity of substitution σ_{id} by country d and product market i

[14] This corresponds to saying that there is an innate taste for Belgian beer in China which can differ from that of the U.S. Any particular beer (i) sold by a firm (j) is assumed to have the same vertical characteristics, independent of destination

The CES-demand function and corresponding price index can be expressed as:

$$q_{jid} = \frac{E_d}{P_d}\lambda_{id}\delta_{ji}\tilde{p}_{jid}^{-\sigma_{id}}, \quad \text{with } P_d = \sum_{j=1}^{n}\sum_{i=1}^{k}\delta_{ji}\lambda_{id}\tilde{p}_{jid}^{1-\sigma_{id}} \tag{2}$$

where E_d represents total expenditure in country d, P_d is the price index for all varieties in country d, and $\tilde{p}_{jid}$ is the price of product i provided by firm j that consumers in country d face (i.e., the c.i.f. price). Firm level demand in a destination can thus vary due to export prices (inclusive of trade cost), the quality offered (δ) and the local taste (λ) as well as destination specific characteristics like income, local competition and market structure (price index).

Firms are heterogeneous in productivity for each of their product i, ω_{ji}, and product quality, δ_{ji}, and firm j's marginal costs of producing good i, c_{ji}, are decreasing in firm productivity but increasing in product quality so that[15]

$$c_{ji} = W_j\omega_{ji}^{-1}\delta_{ji}^{\gamma}, \quad \gamma > 0 \tag{3}$$

where W_j is the unit price of the bundle of input factors used to produce final output and γ reflects the cost elasticity of consumer valuations of δ_{ji}.[16] c_{ji} thus reflects also the cost of generating higher demand as δ_{ji} is a vertical demand shifter.

Both firm productivity and vertical differentiation affect firms' costs. Under monopolistic

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[15] That is, firms pay extra costs to raise consumers' willingness-to-pay related to higher quality or investments to build a customer base. Eslava et al. (2015) show that producers who are interested in a particular foreign market devote resources to identifying potential buyers there.

[16] Empirically we do not observe output quality (δ) but will proxy it amongst others by input prices of imported material inputs as in Kugler and Verhoogen (2008) and others.

competition, firms set their prices, p_{jid}, and earn revenues, r_{jid}, in country d defined as:

$$\begin{aligned} p_{jid} &= \frac{\sigma_{id}}{\sigma_{id}-1} c_{ji} \tau_{id} \\ r_{jid} &= \frac{E_d}{P_d} \big(\frac{\sigma_{id}}{\sigma_{id}-1}\big)^{1-\sigma_{id}} \lambda_{id} W_j^{1-\sigma_{id}} \omega_{ji}^{\sigma_{id}-1} \delta_{ji}^{1-(\sigma_{id}-1)\gamma} \tau_{id}^{1-\sigma_{id}} \end{aligned} \tag{4}$$

where $\tau_{id} \geq 1$ captures all exchange rate effects, tariffs and shipping costs between Belgium and the destination country d in a particular product market i . The price equation suggests that product quality affects price through costs, while taste (λ) does not affect price and only affects quantity sold (see equation (3)) and hence, revenue. In this way, we are able to separately identify taste from quality as a structural parameter of the model since the taste parameter λ enters the revenue equation but not the price equation. Moreover, we define the destination specific markup as $\sigma_{id}/(\sigma_{id}-1)$.

4 Data

Our data consist of Belgian manufacturing firms for the period 1997-2005 with information on firms exports by product and by destination and firm imports by product and country of origin. The Belgian export data are obtained from the National Bank of Belgiums (NBB) Trade Database, which covers the entire population of recorded trade flows.[17] The trade data are recorded at the year-firm-product-country level, i.e. they provide information on firm-level trade flows by 8-digit Combined Nomenclature (CN8) product and by country.[18]

The NBB trade data are merged with balance sheet data on firm-level characteristics such

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[17] We exclude transactions that do not involve a "transfer of ownership with compensation". This means that we omit transaction flows such as re-exports, the return, replacement and repair of goods and transactions without compensation, e.g. government support, processing or repair transactions, etc.

[18] The CN8-product classification is similar to the HS6 classification for the first 6 digits but offers more product detail in the last two digits. Changes in HS6 and CN8 classifications can affect product code changes as shown in Table A.7.

as wages, material inputs, capital, employment, multi-products and other firm-level characteristics.

During the period of our analysis, the HS6 product classicification altered three times. To address the changes in product classifications over time (Table A.7), we concord the product codes along the lines of Bernard, Van Beveren and Vandenbussche (2012).[19] We then focus our analysis on those product codes that either did not change over the period that we consider or that had a one-to-one product code change. We thus disregard growing and declining product code families. In doing so we lose about 20% of export value in our data, but this ensures that our data are cleaned of product code changes which could otherwise result in misinterpretations on product scope at firm-level. This prevents measurement bias when we construct our measure of firm-product productivity where we allocate raw material inputs over domestic and exported products.

In our analysis we focus on those industries in the top eight of export shares. Export shares by industry range between 15% for “motor vehicles” and 5.7% for “Electrical&Electronic”. Our data comprise both consumption goods such as “Food”, as well as more intermediate products, such as “Chemicals” and “Plastics”. Together the industries that we study represent over 60% of aggregate Belgian exports. Appendix Table A.1. documents the number of observations per industry and per region, where each observation is a firm-product-destination export flow.

5 Empirical Model

In this section we lay out our empirical identification strategy on how to structurally identify the most important parameters from our model. We start with the demand parameters, leaving

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[19] Instructions for concordance of trade classifications over time can be found here: https://www.sites.google.com/site/ilkevanbeveren/Concordances and are explained in Van Beveren, Bernard and Vandenbussche, (2012), “Concording EU Trade and Production data over Time”, NBER working paper series 18604.

the estimation strategy for the cost and productivity parameters for the next subsection. We add an additional subscript t in the notation of the equations to indicate the panel dimension of the data. Following Roberts et al. (2012), we estimate the demand function for all products i at CN8 level belonging to the same product market [20] to get the estimates of consumer tastes, λ_{idt} and product quality, δ_{jit}. Given that our model is based on multi-product firms, the number of varieties i, can differ from the number of firms, j.

5.1 Demand Estimation

Based on the theoretical framework, the CES utility implies that the demand function for variety i of firm j in country d is:

$$\begin{aligned} q_{jidt} &= \frac{E_{dt}}{P_{dt}} \lambda_{idt} \delta_{jit} \tilde{p}_{jidt}^{-\sigma_{id}} exp(\varepsilon_{jidt}), \quad \text{with } \; P_{dt} = \sum_{j=1}^{n} \sum_{i=1}^{k} \delta_{jit} \lambda_{idt} \tilde{p}_{jidt}^{1-\sigma_{id}} \\ q_{jidt} &= \frac{E_{dt}}{P_{dt}} \lambda_{idt} \delta_{jit} p_{jidt}^{-\sigma_{id}} \tau_{dt}^{-\sigma_{id}} exp(\varepsilon_{jidt}) \end{aligned} \tag{5}$$

where $\tilde{p}_{jidt}$ is the c.i.f. price and $p_{jidt} = \frac{\tilde{p}_{jidt}}{\tau_{dt}}$ is the f.o.b. price,[21] ε_{jidt} is the random demand shock. E_{dt} is the total expenditure in the product market in country d and year t and P_{dt} is the aggregate price index. Accordingly, we estimate the demand function as follows:

$$\begin{aligned} \ln q_{jidt} &= \ln E_{dt} - \ln P_{dt} - \sigma_{id}(\ln p_{jidt} + \ln \tau_{dt}) + \ln \delta_{jit} + ln\lambda_{idt} + \varepsilon_{1jidt} + \varepsilon_{2jidt} \\ &= \beta_{gdp} \ln GDP_{dt} + \beta_{\tau} \ln Dist_d - \beta_d \ln p_{jidt} + \ln \delta_{jit} + ln\lambda_{kgt} + \nu_{jidt} + u_{jidt} \\ & \text{where } \; \varepsilon_{jidt} + (ln\lambda_{idt} - ln\lambda_{kgt}) = \nu_{jidt} + u_{jidt}, \; \text{ and } \; i \in k, d \in g \end{aligned} \tag{6}$$

where in the first line ε_{1jidt} accounts for any unobserved demand shock correlated with price

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[20] A product market is defined here at HS2 level to get sufficient observations and variation for estimation

[21] In the data set, we only observe the f.o.b. prices. For simplification, we assume that trade costs do not vary across products to any given destination, that is, $\tau_{id} = \tau_d$ for $i = 1, 2, .., k$.

and ε_{2jidt} is white noise. In the second line, $\ln GDP_{dt}$ captures the income and market size effect on the demand for firm-products in the destination countries and $\ln Dist_d$ is the distance (in log form) between the destination country and Belgium which controls for the trade cost, τ_d. $\beta_d = \sigma_{id}$ reflects the elasticity of substitution across varieties in country d. q_{jidt} is quantity sold of firm j's product i at time t and p_{jidt} is the f.o.b. price that firm j charges for its product i in country d and year t.[22] Product i in our data set is defined as the CN8 level. To simplify the analysis, we group countries(d) into regions(g) and aggregate consumer tastes to 4-digit HS classification(k) and consumers' tastes can be aggregated and represented as $ln\lambda_{kgt}$. The reason is that we do not have enough fiirms to estimate consumer taste at the CN8 level by destination. The deviation of the country-level consumer tastes from the mean consumer tastes in the region $(ln\lambda_{idt} - ln\lambda_{kgt})$ and the unobserved demand shock (ε_{1jidt}) can be put together and decomposed into two components, ν_{jidt} and u_{jidt}, where the first component is observed by the firm before making the price/quantity decisions and the second component is a transitory shock.[23]

Since ν_{jidt} would generally lead firms to change prices i.e., $E(p_{jidt}\nu_{jidt}) \neq 0$, estimation of equation (6) using OLS yields biased coefficients on price because of the endogeneity of prices. Under this setting, two-stage least squares (2SLS) estimation can be used to obtain consistent estimates of the price coefficients. Good instruments for price are variables that shift the short run supply curve of the firm. We instrument for price with the average prices of product i that the firm exports to other countries.[24]

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[22] Because the unit values across different CN8 products are not always comparable, we normalize lnp by taking the deviation of the firm's prices from the average price across all firms selling the same (CN8) product and dividing it by the standard deviation of the prices.

[23] In the empirical model, we present consumer tastes (λ_{kgt}) as product-destination specific dummy variable (D_{kgt}). This is consistent with Bernard, Redding and Schott (2010) in which firms produce horizontally differentiated products, and the strength of consumer tastes is represented by a firm-product-country shock in the demand function. They do not consider quality. Our goal is to separately identify taste from quality to assess their relative importance.

[24] We assume that the unobserved demand shocks on product i of the firm are independent across destination countries to make sure that our instrument is uncorrelated to the error term.

Firm-product quality ($ln\delta_{jit}$) is intrinsic to a product but unobserved in the data.[25] If the unobserved firm-product quality is correlated with output price (lnp_{jidt}) then an OLS estimation of equation (6) generates inconsistent parameters. To deal with this issue we apply the insights in Levinsohn and Petrin (2003) by replacing the unobserved $ln\delta_{jit}$ with observed input costs of quality and the income level of the destination country by using respecitvely firm import prices and per capita GDP of the destination country both of which are correlated with product quality. Firms are likely to export high-quality products to high-income countries.[26] Moreover, producing high-quality products may require high-quality inputs.[27] If high-quality inputs cost more, the imported prices of a firm are a proxy variable for product quality.[28]The other proxy for product quality is GDP per capita of the destination countries, a variable that is highly correlated with the consumption of high quality products.[29] Since a firm-product pair can be exported to several destinations, we use the sales share of the product exported to country d over the total export of the firm-product pair as the weight to construct the firm-product weighted per capita GDP. That is, $PCGDP_{jit} = \sum_d s_{jidt} \times PCGDP_{dt}$ where s_{jidt} is the ratio

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[25] While prices of products vary by destination, their quality ranking appears very stable as shown by di Comite, Thisse and Vandenbussche (2014). Using the same Belgian exporters data, they find that price rankings of products across destinations are very stable. Bilateral correlations of price rankings of a set of similar products are close to 90%, suggesting that firms ship similar quality around the world. See also *The Economist*, July 1 2017, p. 25, arguing that firms ship similar quality around the globe

[26] Schott (2004) finds a positive relationship between the unit value of U.S. imported products and the per capita GDP of exporters. Hallak (2006) uses bilateral trade data for differentiated products among 60 countries in 1995 and finds that rich countries tend to import relatively more from countries that produce high quality goods. Finally, Bils and Klenow (2001) show that "...high income countries consume larger proportions of high quality goods." These results support the Linder hypothesis where countries with high income per capita spend a larger fraction of their income on high-quality goods.

[27] Kugler and Verhoogen (2012) using data from Columbia find that firms that charge a high output price also purchase high-price (high-quality) inputs. Fan, Yao and Yeaple (2015) finds that a reduction in tariffs on imported inputs in China encourages firms to use high quality foreign inputs and raise the prices and quality of Chinese exports.

[28] De Loecker et al. (2016) use output prices in the control function of quality when estimating productivity, but we prefer input prices in the control function as we are estimating demand which already has output prices in there seprarately

[29] This is consistent with the Linder-hypothesis in trade in which rich countries have a comparative advantage in the production and export of high quality products. In addition Bils and Klenow (2001) and Hallak (2006) show that "...high income countries consume larger proportions of high quality goods."

of firm j's sales revenue on product i that is exported to country d over firm j's total export sales on product i, and $PCGDP_{dt}$ is country d's per capita GDP in year t. Similarly, we construct a firm-level import price index by calculating the weighted sum of import price of each imported product within a firm.[30] Therefore, $ln\delta_{jit}$ can be represented by a function of weighted per capita GDP and firm import price, $f(\ln PCGDP_{jit}, \ln IMP_{jt})$. By proxying $ln\delta_{jit}$ as a second-order polynomial approximation, equation (6) can be re-written as:[31]

$$\begin{aligned} \ln q_{jidt} = \beta_{gdp}\ln GDP_{dt} + \beta_{\tau}\ln Dist_d - \beta_d \ln p_{jidt} + D_{kgt} + \big[a_1\ln PCGDP_{jit} + a_2\ln IMP_{jt} \\ + a_3(\ln PCGDP_{jit})^2 + a_4(\ln IMP_{jt})^2 + a_5(\ln PCGDP_{jit} \times \ln IMP_{jt})\big] + \nu_{jidt} + u_{jidt} \quad (7) \end{aligned}$$

where j denotes firm, i denotes CN8-products, d denotes destination countries, t denotes year, k denotes (HS4)product categories, and g denotes regions. D_{kgt} is a set of dummy variables representing the combination of (HS4)product-region-year to measure taste (λ_{kgt}) [32]

By using 2SLS, the estimation of the demand function in equation (7) allows us to empirically identify three important parameters e.g. the elasticity of demand , $\hat{\sigma}_{id} = \beta_d$, [33] , the (HS4)product-region consumers' taste[34] $ln\hat{\lambda}_{kgt} = \hat{D}_{kgt}$ and the firm-product quality index

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[30] Here $IMP_{jt} = \sum_l \sum_d s_{jzot} \times IMP_{jzot}$ where s_{jzot} is the import share of firm j's total imports that come from good z imported from country o and IMP_{jzot} is the import price of good z coming from country o.

[31] An often used approach in the literature to estimate quality at product-level is a Khandelwahl (2010). However, in our framework this would confound quality with taste as it rests on the premises that quality goods are those that "conditioning on price, have higher sales". Therefore we apply a different approach.

[32] We do not include additional fixed effects (country or product FE) in (7) since our measure of consumer taste λ, would then be measured as an index relative to a base group, rendering the interpretation very difficult and not useful for the decomposition later on.

[33] note that $\hat{\sigma}$ is estimated at the HS2 level and at regional level and is constant over time. Hence markups vary at the HS2-region level within firms. Thus, markups within the multiproduct firm can vary by HS2 and by destination (region)

[34] The estimated consumers' taste $(ln\hat{\lambda}_{kgt})$ may still capture some market size effect (after controlling for GDP in its estimation). This will be controlled for in section 6.1 where we perform a normalization in which we further "clean" λ by normalizing each firm-product-destination export revenue flow by the average firm export revenue in the same product-destination market to control for markups, market size and competition effects at the product market level. The advantage is that in the decomposition we then do not need to control for

$ln\hat{\delta}_{jit}$ by

$$ln\hat{\delta}_{jit} = \hat{a}_1 \ln PCGDP_{jit} + \hat{a}_2 \ln IMP_{jt} + \hat{a}_3(\ln PCGDP_{jit})^2 + \hat{a}_4(\ln IMP_{jt})^2 + \hat{a}_5(\ln PCGDP_{jit} \times \ln IMP_{jt})$$

5.2 Cost and Revenue Estimation

We start by defining firm j's short run marginal costs (in log form) of product i in year t as:

$$lnc_{jit} = \gamma_w lnW_{jt} + \gamma_{pm} lnIMP_{jt} + \gamma_k lnk_{jt} + \gamma_q lnq_{j-it} + \gamma_\delta ln\hat{\delta}_{jit} + \gamma_t D_t - \omega_{jit} + \varepsilon_{jit} \qquad (8)$$

where W_{jt}, IMP_{jt} and k_{jt} are the wage rates, firm-level import price index[35] and capital stock for firm j in year t, respectively, $q_{j-it} = \sum_{l \neq i, j \in \Omega_{jt}} q_{jlt}$ represents the total sales[36] of all of the firm's products except product i, ω_{jit} represents firm j's productivity in the production of product i in year t, D_t is a set of year dummy variables and ε_{jit} is an i.i.d. cost shock. Since the manufacture of products with higher product quality involves higher marginal costs, we allow the firm's marginal costs to be a function of product quality, $\hat{\delta}_{jit}$ which is partly based on import prices of material inputs. Note that $\hat{\delta}_{jit}$ has been estimated in the previous stage when estimating the demand (7)[37]. We include lnq_{j-it} in the marginal cost equation to capture the magnitude of production complementarities or technological distance between the firm's product pairs. If firms engage in joint-production of products[38], where they share the same inputs

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market size and markups additionally.

[35] The correlation between wages and the imported input price index does not exceed 0.27, which is the one in the "iron and steel industry"

[36] Total sales is measured as value of sales rather than physical output since different products have different units of quantity.

[37] The correlation between IMP and $\hat{\delta}$ is 0.6. While this does not affect the estimated values of $\hat{\delta}$, it may affect the estimation of ω which is why for robustness we also run (8) without inclusion of IMP. Excluding imported input price does not have a significant influences on the ω estimation e.g. the scale of productivity changes but the correlation between the original ω and the new ω measures is around one

[38] For instance, the processing of crude oil as an input simultaneously yields both gasoline and lubricants.

across multiple products, an increase in the production of one product provides free inputs for the other product (economies of scope) . Consequently, multi-product firms face lower marginal costs of each product at any given level of output relative to single-product firms and thus we expect the coefficient on lnq_{j-it} to be negative.[39] Note that while for the estimation of the demand for each product of the multiproduct firm, information on value and quantity of sales is available at the product level. This is not the case here for the estimation of the cost where the data on input usages is aggregated across all products of the firm. Next we work towards an empirical specification for the estimation of the revenue function and for the estimation of TFPQ at firm-product level to take to the data. In addition to $\hat{\delta}_{jit}$ and $\hat{\lambda}_{idt}$ retrieved in based on the earlier section, we still need to structurally identify ω_{ijt} in order to perform a decomposition of firm-product export revenue into its determinants including productivity, quality and taste. Assuming that firms face a monopolistically competitive market, firm j's optimal price of product i in country d and year t is

$$ln\tilde{p}_{jidt} = ln(\frac{\sigma_{id}}{\sigma_{id}-1}) + lnc_{jit} + ln\tau_{dt}.$$

Using the demand and pricing equations, we can express the log of the firm's revenue as:

$$\begin{aligned} lnr_{jidt} &= ln(\frac{E_{dt}}{P_{dt}}) + ln\hat{\delta}_{jit} + ln\hat{\lambda}_{kgt} + (1-\sigma_{id})ln\tilde{p}_{jidt} \\ &= ln(\frac{E_{dt}}{P_{dt}}) + ln\hat{\delta}_{jit} + (1-\sigma_{id})\bigg[ln(\frac{\sigma_{id}}{\sigma_{id}-1}) + \gamma_w lnW_{jt} + \gamma_{pm} lnIMP_{jt} + \gamma_k lnk_{jt} \\ &\quad + \gamma_q lnq_{j-it} + \gamma_\delta ln\hat{\delta}_{jit} + \gamma_t D_t - \omega_{jit} + \ln\tau_{dt} + \varepsilon_{jit}\bigg] + \ln\hat{\lambda}_{kgt} \qquad (9) \end{aligned}$$

The firm's revenue will depend on the observable cost factors, lnW_{jt} and lnk_{jt}, characteristics of multi-product firms, q_{j-it}, firm demand index, $ln\hat{\delta}_{jit}$, and productivity shocks, ω_{jit}. Rearranging

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[39] Dhyne, Petrin, Warzynski (2014) apply a similar approach to estimating firm-product level marginal cost for multi-product firms.

the revenue equation and recycling the estimated parameters from the demand equation in (7), to control for quality ($\hat{\delta}_{jit}$), taste ($\hat{\lambda}_{kgt}$) and markups ($\sigma_{id}/(\sigma_{id}-1)$) we obtain

$$\begin{aligned}
\frac{1}{1-\hat{\sigma}_{id}} lnr_{jidt} &= \gamma_{gt} + ln(\frac{\hat{\sigma}_{id}}{\hat{\sigma}_{id}-1}) + \frac{1}{1-\hat{\sigma}_{id}} ln(\frac{E_{dt}}{P_{dt}}) + \gamma_w lnW_{jt} + \gamma_{pm} lnIMP_{jt} + \ln\tau_{dt} + \gamma_k lnk_{jt} + \gamma_q lnq_{j-it} \\
&+ (\frac{1}{1-\hat{\sigma}_{id}} + \gamma_\delta) ln\hat{\delta}_{jit} - \omega_{jit} + \frac{1}{1-\hat{\sigma}_{id}} \ln\hat{\lambda}_{kgt} + e_{jidt} \\
\frac{1}{1-\hat{\sigma}_{id}}(lnr_{jidt} - ln\hat{\lambda}_{kgt}) - ln(\frac{\hat{\sigma}_{id}}{\hat{\sigma}_{id}-1}) &= \gamma_{gt} + \gamma_{gdp} lnGDP_{dt} + \gamma_w lnW_{jt} + \gamma_{pm} lnIMP_{jt} + \gamma_\tau \ln Dist_d + \gamma_k lnk_{jt} + \gamma_q lnq_{j-it} \\
&+ (\frac{1}{1-\hat{\sigma}_{id}} + \gamma_\delta) ln\hat{\delta}_{jit} - \omega_{jit} + e_{jidt} \\
\frac{1}{1-\hat{\sigma_{id}}}(lnr_{jidt} - ln\hat{\lambda}_{kgt}) - ln(\frac{\hat{\sigma}_{id}}{\hat{\sigma}_{id}-1}) &= \gamma_{gt} + \gamma_{gdp} lnGDP_{dt} + \gamma_w lnW_{jt} + \gamma_{pm} lnIMP_{jt} + \gamma_\tau \ln Dist_d + \gamma_k lnk_{jt} + \gamma_q lnq_{j-it} \\
&+ (\frac{1}{1-\hat{\sigma}_{id}} + \gamma_\delta) ln\hat{\delta}_{jit} - \omega_{jit} + e_{jidt} \qquad (10)
\end{aligned}$$

where $\gamma_{gt} = \gamma_g D_g + \gamma_t D_t$ is a set of region and time dummy variables capturing all region and time-varying variables on the demand and supply sides. If the unobservable firm productivity (ω_{jit}) is correlated with the observable cost factors (W_{jt} and IMP_{jt}) and firm quality index (δ) then OLS of equation (10) estimation generates inconsistent parameters. To deal with this issue we utilize the insights in Levinsohn and Petrin (2003) by replacing the unobserved ω_{jit} with a control function, $f(lnm_{jit}, lnk_{jit})$,[40] in material usage and capital stock respectively .

In the first stage, we estimate the revenue function:

$$\begin{aligned}
\frac{1}{1-\hat{\sigma_{id}}} lnr_{jidt} - \frac{1}{1-\hat{\sigma_{id}}} ln\hat{\lambda}_{kgt} - ln\Big(\frac{\hat{\sigma}_{id}}{\hat{\sigma}_{id}-1}\Big) &= \gamma_{gt} + \gamma_{gdp} lnGDP_{dt} + \gamma_w lnW_{jt} + \gamma_{pm} lnIMP_{jt} + \gamma_\tau \ln Dist_d \\
&+ \gamma_q lnq_{j-it} + (\frac{1}{1-\hat{\sigma_{id}}} + \gamma_\delta) ln\hat{\delta}_{jit} \\
&+ \phi(lnk_{jit}, lnm_{jit}, lnk_{jt}) + e_{jidt} \qquad (11)
\end{aligned}$$

where $\phi(lnk_{jit}, lnm_{jit}, lnk_{jt}) = \gamma_k lnk_{jt} - \omega_{jit}(lnk_{jit}, lnm_{jit})$ comprises of lnk and firm-product productivity in the revenue function. By treating ϕ as a polynomial we can estimate this

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[40] The data on input usage is only available at the firm level. Following Foster et al. (2008), we assign the inputs across the outputs according to the product's revenue share in the firm.

equation using ordinary least squares and construct the fitted value $\hat{\phi}_{jit}$. In the second stage, we can then separately recover the productivity shocks and marginal cost components based on the productivity evolution equation:

$$\omega_{jit} = h(\omega_{jit-1}) + \epsilon_{jit}$$

where ϵ_{jit} is an i.i.d. shock. Rearranging the productivity evolution equation, we get

$$\begin{aligned}\hat{\phi}_{jit} &= \gamma_k lnk_{jt} - h(\omega_{jit-1}) + \epsilon_{jit} \\ &= \gamma_k lnk_{jt} - h(\gamma_k lnk_{jt-1} - \hat{\phi}_{jit-1}) + \epsilon_{jit}\end{aligned}$$

By assuming a functional form for the h function, we can estimate the equation using nonlinear least squares and recover the parameters γ_k and the parameters of the productivity evolution function h. Given these estimates, the productivity shock for each firm-product and year can be retrieved as:

$$\hat{\omega}_{jit} = \hat{\gamma}_k lnk_{jt} - \hat{\phi}_{jit} \tag{12}$$

The firm-product productivity obtained from (12) can be regarded as a TFPQ measure of firm-product productivity since it is not contaminated by price effects.

6 Decomposition of Firm-Product Export Revenue

6.1 Decomposition by Product

While in the previous section our aim was to structurally identify quality (δ_{ijt}), taste (λ_{kgt}) and TFPQ (ω_{ijt}), in this section, our purpose is to assess the relative importance of demand versus supply determinants in export revenue. We are interested in the contributions of firm productivity, product quality and consumer tastes to the export revenue at firm-product level.[41] In particular, we want to know how important taste is as a distinct and separate determinant of export flows.

Rewriting equation (9), we get firm j's export revenues on product i in destination country d and year t is:

$$\begin{aligned} r_{jidt} &= (\frac{E_{dt}}{P_{dt}})\delta_{jit}\lambda_{kgt}\left[(\frac{\sigma_d}{\sigma_{id}-1})c_{jit}\tau_{dt}\right]^{1-\sigma_d} \\ &= (\frac{E_{dt}}{P_{dt}})(\frac{\sigma_d}{\sigma_{id}-1})^{1-\sigma_{id}}\tau_{dt}^{1-\sigma_{id}}\delta_{jit}\lambda_{kgt}\left[\underbrace{W_{jt}^{\gamma_w}k_{jt}^{\gamma_k}q_{j-it}^{\gamma_q}\delta_{jit}^{\gamma_\delta}\omega_{jit}^{-1}}_{c_{jit}}\right]^{1-\sigma_{id}} \end{aligned}$$

Since market size may have a significant influence on firm export revenue, we normalize the export revenue to the mean level in each destination to account for any product market size effect. The normalized export revenue then becomes:

$$\begin{aligned} \tilde{r}_{jidt} &= r_{jidt} - \bar{r}_{idt} \\ &= \delta_{jit}\lambda_{kgt}\left[\underbrace{W_{jt}^{\gamma_w}k_{jt}^{\gamma_k}q_{j-it}^{\gamma_q}\delta_{jit}^{\gamma_\delta}\omega_{jit}^{-1}}_{c_{jit}}\right]^{1-\sigma_{id}} = \delta_{jit}^{(1+(1-\sigma_{id})\gamma_\delta)}\lambda_{kgt}\left[W_{jt}^{\gamma_w}k_{jt}^{\gamma_k}q_{j-it}^{\gamma_q}\omega_{jit}^{-1}\right]^{1-\sigma_{id}} \end{aligned} \tag{13}$$

where $\bar{r}_{idt}$ is the average export revenue across firms in destination d and year t for at the product-level.[42] Through the normalization, we subtract average taste across all firms shipping the same product to the same destination from the estimated consumer taste $\hat{\lambda}$, which accounts for the remaining destination and product market effects that can affect $\hat{\lambda}$. Through the normalization, we also difference out markup effects. Since markups are estimated at the

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[41] In this section we look at data at firm-product level so we reduce the data by one dimension e.g. we do not consider the destination specific information here.

[42] This normalization ensures that we control for product market effects such as markups and remaining market competition effects that may explain revenue differences.

product-destination level, they will be identical for the same products shipped to the same destination. Equation (13) thus ensures that variation in destination specific firm export revenues account for markup differences. The normalization then ensures that we then do have to include market size and markups as additional components in the decompostition. In the decomposition below, we isolate the contributions of cost, quality and taste as determinants of firm export revenues across destination markets for each product.

Equation (13) indicates that σ_{id} affects the contributions of the firm-product quality, productivity and input prices to export revenue even though for any given firm-product pair, all these variables do not vary across destinations. For instance, when the cost of quality improvement increases or productivity decreases, marginal costs rise leading to product price increases. An increase in prices reduces the quantity sold in each export market and thus decreases the export revenue in each market as long as $\sigma_{id} > 1$. The elasticity of export revenue with respect to any cost increment will vary across markets with firms facing a large reduction in the export revenue in the high-σ markets and a relatively small loss in export revenue in the low-σ markets when firms' production costs increase.

In order to construct each component on the right-hand side of equation (13) at the firm-product level we rewrite equation (13):

$$\tilde{r}_{jidt}^{\frac{1}{1-\sigma_{id}}} = \delta_{jit}^{(\frac{1}{1-\sigma_{id}}+\gamma_\delta)} \lambda_{kgt}^{\frac{1}{1-\sigma_{id}}} \omega_{jit}^{-1} W_{jt}^{\gamma_w} k_{jt}^{\gamma_k} q_{j-it}^{\gamma_q} \tag{14}$$

It is clear from equation (14) that in aggregating export revenues across destination markets, it is necessary to construct firm-product level quality and tastes indices ($\tilde{\delta}$ and $\tilde{\lambda}$ in below) that controls for the variance in quality and tastes across regions.

Rearranging equation (14), firm j's total export revenues on product i across all destination countries can be expressed as:

$$
\begin{aligned}
r_{jit} \equiv \sum_d \tilde{r}_{jidt}^{\frac{1}{1-\sigma_{id}}} &= \sum_d \delta_{jit}^{(\frac{1}{1-\sigma_{id}}+\gamma_\delta)} \lambda_{kgt}^{\frac{1}{1-\sigma_{id}}} \omega_{jit}^{-1} W_{jt}^{\gamma_w} k_{jt}^{\gamma_k} q_{j-it}^{\gamma_q} \\
&= \left[\frac{1}{N^d_{jit}} \sum_d \left(\frac{\delta_{jit}^{(\frac{1}{1-\sigma_{id}}+\gamma_\delta)}}{\widetilde{\delta_{jit}}}\right)\left(\frac{\lambda_{kgt}^{\frac{1}{1-\sigma_{id}}}}{\widetilde{\lambda_{jit}}}\right)\right] N^d_{jit}\widetilde{\delta_{jit}}\widetilde{\lambda_{jit}}\omega_{jit}^{-1} W_{jt}^{\gamma_w} k_{jt}^{\gamma_k} q_{j-it}^{\gamma_q} \qquad (15)
\end{aligned}
$$

where $\widetilde{\lambda_{jit}} = \left(\Pi_{k,g \in D^d_{ijt}} \lambda_{kgt}^{\frac{1}{1-\sigma_{id}}}\right)^{1/N^d_{jit}}$ is the geometric mean of consumer tastes across all destinations that a firm-product pair exports [43] and D^d_{ijt} [44] represents the set of (HS4)product-region pairs that firm j export product i to country d in year t and N^d_{jit} is the number of destination countries that the firm-product pair exported to. $\widetilde{\delta_{jit}} = \left(\Pi_d \delta_{jit}^{\frac{1}{1-\sigma_{id}}+\gamma_\delta}\right)^{1/N^d_{jit}}$ is the geometric mean of firm-product quality weighted by the elasticity of demand across all destinations.

Taking logs of equation (15), we get

$$
\begin{aligned}
lnr_{jit} = & \underbrace{ln\left[\frac{1}{N^d_{jit}} \sum_d \left(\frac{\delta_{jit}^{(\frac{1}{1-\sigma_{id}}+\gamma_\delta)}}{\widetilde{\delta_{jit}}}\right)\left(\frac{\lambda_{kgt}^{\frac{1}{1-\sigma_{id}}}}{\widetilde{\lambda_{jit}}}\right)\right]}_{B_{jit}} + lnN^d_{jit} + ln\widetilde{\delta_{jit}} + ln\widetilde{\lambda_{jit}} - ln\omega_{jit} \\
& + \gamma_w lnW_{jt} + \gamma_k lnk_{jt} + \gamma_q lnq_{j-it} \qquad (16)
\end{aligned}
$$

where term B_{jit} captures the variation of weigthed product quality and consumer tastes across all destinations that the firm-product exports to which includes two components: the variation in weighted product quality $\left(\frac{\delta_{jit}^{(\frac{1}{1-\sigma_{id}}+\gamma_\delta)}}{\widetilde{\delta_{jit}}}\right)$ and the consumer tastes variation across (HS4)product and regions within a firm-product pair ji $\left(\frac{\lambda_{kgt}^{\frac{1}{1-\sigma_{id}}}}{\widetilde{\lambda_{jit}}}\right)$.

We are now ready to perform a decomposition of export revenue similar to the one proposed

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[43] the data forces us to structurally identify λ at a more aggregate product-level and destination e.g. HS4-region. These values are then used to construct a lambda (taste) parameter at the more disagggregate firm-CN8 level

[44] Two firms selling same CN8 will have different taste values assigned to them, provided they differ in their set of export destinations

by Hottman et al. (2016) and that is consistent with our theoretical model. While Hottman et al (2016) decompose firm-level sales, we decompose firm-product level export sales into its separate components to assess their relative importance. According to equation (16), firm-product export revenue can be decomposed into eight components: the variation of product quality and consumer tastes across all destinations (B_{jit}), the number of destinations that the product exported to (N^d_{jit}), firm-level wages (W_{jt}), total export sales of all of the firm's products except product i (q_{j-it}), firm capital stock (K_{jt}), firm-product productivity (ω_{jit}), firm-product quality ($\tilde{\delta}_{jit}$) and destination and product specific consumer tastes ($\tilde{\lambda}_{jit}$).

Following Hottman et al. (2016), we regress each component of the right-hand side of equation (16) on lnr_{jit} to get the contribution of each component of firm-product export revenue on firm-product export revenues. This results in eight separate regressions as listed below:

$$\begin{aligned}
lnB_{jit} &= \beta_B lnr_{jit} + \varepsilon^b_{jit} \\
lnN^d_{jit} &= \beta_N lnr_{jit} + \varepsilon^n_{jit} \\
\gamma_w lnW_{jt} &= \beta_W lnr_{jit} + \varepsilon^W_{jit} \\
\gamma_k lnk_{jt} &= \beta_k lnr_{jit} + \varepsilon^k_{jit} \\
\gamma_q lnq_{j-it} &= \beta_q lnr_{jit} + \varepsilon^q_{jit} \\
ln\widetilde{\lambda_{jit}} &= \beta_\lambda lnr_{jit} + \varepsilon^\lambda_{jit} \\
ln\widetilde{\delta_{jit}} &= \beta_\delta lnr_{jit} + \varepsilon^\delta_{jit} \\
-ln\omega_{jit} &= \beta_\omega lnr_{jit} + \varepsilon^\omega_{jit} \qquad (17)
\end{aligned}$$

The above decomposition has the advantage that we can simply compare the estimated β coefficients of each regression to assess the relative importance of each component in explaining the variation in firm-product export revenue. Thus, each regression coefficients on the separate components in the decomposition exercise gives the percentage variation that is explained of the firm-product revenue. Our main interest here lies in the β's on ω, δ and λ and we less on all the other individual control variables in the decomposition. For convenience, we sum all the control variables in one variable T and report the regression coefficient on the term $lnT_{jit} = lnB_{jit} + lnN^d_{jit} + \gamma_w lnW_{jt} + \gamma_q lnq_{j-it} + \gamma_k lnk_{jt}$ such that the regression coefficient on the summed term T corresponds to the sum of the regression coefficients on the control variables :

$$\beta_T = \beta_B + \beta_N + \beta_W + \beta_q + \beta_k$$

and since β's sum to one:

$$\beta_\omega + \beta_\delta + \beta_\lambda + \beta_T = 1$$

we can read of the contribution of productivity ω, quality δ and taste λ and other controls as determinants of normalized export revenue variation as percentages.[45]

6.2 Decomposing by Region

In this section, we aim to analyze the contribution of product quality, consumer tastes and productivity to the variation in export revenue at the firm-product-region level. Based on equation (16), we can calculate firm *j*' export revenues on product *i* across markets within

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[45] In the regressions of the decomposition (17) we use the predicted values of the revenues which accounts for the remaining firm-product specific markups and firm-product specific tastes affecting actual revenues. This ensures that the coefficients of each determinant in the decomposition can be interpreted as the percentage of the variation explained by the determinant. This is different from the approach in Hottman et al (2016) where the decomposition also includes the demand side residuals. Because our taste and quality measure do not include the residuals from the demand side, we turn to this alternative approach to have a simple interpretation of the regression coefficients.

region g as:

$$\begin{aligned} lnr_{jigt} = {} & lnN^{d}_{jigt} + \big(\frac{1}{1-\sigma_{id}} + \gamma_{\delta}\big)ln\delta_{jit} + \big(\frac{1}{1-\sigma_{id}}\big)ln\lambda_{kgt} - ln\omega_{jit} \\ & + \gamma_{w}lnW_{jt} + \gamma_{k}lnk_{jt} + \gamma_{q}lnq_{j-it} \end{aligned} \tag{18}$$

where $lnr_{jigt} \equiv \sum_{d\in g} ln\tilde{r}_{jidt}$ is the aggregated export revenue across all destination countries within region g for firm j's product i and N^{d}_{jigt} is the number of destination countries that the firm-product pair export to in region g. Since the demand elasticity (σ_{id}) and consumer tastes (λ_{kgt}) are constant within the firm-product-region-year combination, we do not need to construct the aggregated index for product quality and consumer tastes.

Following Hottman et al. (2016), we regress each component of the right-hand side of equation (18) on lnr_{jigt} to get the contribution of each component of firm-product-region export revenue on firm-product-destination export revenues. The 'decomposition by region' below differs from the 'decomposition by product' in the sense that we now no longer need term B_{jit}. Since the data are now at firm-product-region level, the decomposition by region no longer needs to consider the variation of demand parameters across destinations. The decomposition therefore now consists of seven determinants instead of eight.

$$\begin{aligned}
lnN^{d}_{jigt} &= \alpha_N lnr_{jigt} + \varepsilon^{n}_{jigt} \\
\gamma_w lnW_{jt} &= \alpha_W lnr_{jigt} + \varepsilon^{W}_{jigt} \\
\gamma_k lnk_{jt} &= \alpha_k lnr_{jigt} + \varepsilon^{k}_{jigt} \\
\gamma_q lnq_{j-it} &= \alpha_q lnr_{jigt} + \varepsilon^{q}_{jigt} \\
(\frac{1}{1-\sigma_{id}}) ln\lambda_{kgt} &= \alpha_\lambda lnr_{jigt} + \varepsilon^{\lambda}_{jigt} \\
(\frac{1}{1-\sigma_{id}} + \gamma_\delta) ln\delta_{jit} &= \alpha_\delta lnr_{jigt} + \varepsilon^{\delta}_{jigt} \\
-ln\omega_{jit} &= \alpha_\omega lnr_{jigt} + \varepsilon^{\omega}_{jigt}
\end{aligned}$$

and given that α's sum to one, we get

$$\alpha_\omega + \alpha_\delta + \alpha_\lambda + \alpha_T = 1$$

where $\alpha_T \equiv \alpha_N + \alpha_W + \alpha_q + \alpha_k$ and when we take the decomposition to the data, every regression coefficient α allows us to read of the percentage contribution of each determinant in the decomposition to the firm-product export revenues across destinations.

7 Results

7.1 Summary Statistics and level of Aggregation

Earlier studies using similar type of trade data, have structurally identified supply versus demand determinants but at firm-level and without a decomposition of horizontal and vertical differentiation in demand. In this paper we take a different approach by developing and estimating a structural model at the more disaggregate firm-product level. A first look at the data can tell us whether this more disaggregated level of analysis is relevant. Our data consist of 51,449 firm-product observations and 112,066 firm-product-destination observations. Table A.1. in the appendix shows the total firm-product observations by industry and by region. In Table 1, we run a simple OLS regression of export prices and quantities on firm-FE which explains 52% of data variation on export prices and 41% of data variation in export quantities. Thus while firm-level factors are important, it misses more than half of the data variation.

Next we run an alternative OLS regression with firm-product (CN8) fixed effects. Firm-product FE seem to explain more of the data variation e.g. 75% of the variation in export prices and 59% of the variation in export quantities. Thus, moving from firm FE to firm-product FE explains substantially more of the data variation than firm-FE or product FE in isolation. Empirically, the importance of the product-destination factors also becomes apparent from Table 1. Product-country FE by themselves explain 50% of export price variation and around 37% of export quantity variation in the data. We thus conclude from Table 1 that the level of aggregation at which the structural model has been developed e.g. in terms of firm-product productivity and firm-product quality and product-country taste appears more appropriate to explain the data variation than if all variables were defined at firm-level. The panel dimension of the data appears less important which can be seen from the low R-squares when only inserting year fixed effects as shown by the last row in Table 1. Consequently, we mainly focus on the cross-sectional variation in the data, even though are structural parameters are estimated in a time-varying way.

7.2 Estimation of Demand

Table 2 reports the estimated elasticity of demand(σ_{id}) for each (HS2) industry and region. The elasticity of demand varies across industries where the food industry has the lowest average elasticity of 1.71 and the iron&steel industry has the highest demand elasticity (4.78). The last two columns of Table 2 report the mean value and standard deviation of the elasticities of demand across industries within each region. Western Europe(WE) and China(CN) has the highest elasticities of demand for Belgian export products with the average elasticities 3.93 and 3.73, respectively. North America(NA) and South America(SA) have the low average elasticities of demand across the ten regions. Regions with high average elasticities of demand are likely to have high standard deviations in σ_{id} which reflects the high dispersions in demand elasticities across industries within one region.

7.3 Estimation of Productivity, Quality and Taste

Table 3 averages the structurally estimated ω , δ and λ by region (in logs). While average productivity and quality of exported products are stable and robust across destinations, the average consumer taste for exported Belgian products varies substantially by destination. This confirms the notion that productivity and quality are firm-product level variables, chosen by the firm but that these product attributes do not vary much across destinations. Taste, however is destination specific and the last column in Table 3 indicates that taste of consumers for exported Belgian products varies substantially. This can also be seen from Figure 1 where the mean indices of productivity, quality and taste are visualised in a bar chart per region. The taste for Belgian export products varies substantially by destination. While the taste (λs) parameter is always positive for any firm-product-destination flow as long as a product is present in a market.[46] The magnitude of the taste parameter that we estimates is so high such that measurement error is unlikely to be driving the estimates. Moreover, if measurement error would determine our taste parameter, then there is no reason why it would vary by destination,

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[46] But note that the mean indices are expressed in logs which is why the taste index takes on a negative value in some regions.

unless it was really taste differences. From Table 3 it can be noted that the average taste for Belgian products in China is higher than that in North America (NA).

The standard deviations of productivity and quality of Belgian products shipped to the different regions is small, whereas the standard deviation of the taste index is very large and about five times as high, which can be seen in Figure 2 and confirms the more idiosyncratic nature of taste e.g. products with the same productivity and quality may not be liked in every destination to the same extent. These standard variations will prove useful in order to understand decomposition results by region which we discuss later.

In our data, the correlations between productivity, quality and taste are not very high. This can be seen from Table 4. The correlation between productivity and quality is positive but as small as 0.06. Based on our theory, that is also what we would expect, but this is very different from other quality models. Most existing models, endogenize the quality choice by firms which results in a strong correlation between productivity and quality e.g. only the most productive firms can invest in quality.[47] The novelty of our model is that we introduce taste, which breaks the strong correlation between productivity and quality. In our model, strong taste can compensate for low productivity such that it is still profitable to purchase high priced inputs and to engage in quality investment.

Consider the extreme case of a traditional trade model where only productivity varies between firms, but without quality and taste demand shifters. In such a model the more productive firms always make most profits. Introducing quality as a demand shifter, without allowing for taste demand shifters, then generates the prediction that only the more productive firms will produce high quality goods, because their production is more costly. Introducing both quality and taste as separate demand shifters, as we do in our model, then generates the prediction that even low productivity firms but with high taste for their products can have high profits.

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[47] Eckel and Neary (2010); Baldwin and Harrigan (2011) etc.

Therefore, based on our model, conditioning on the productivity level of the firm, you would expect that high taste firms would invest in high quality goods while low taste firms would not. This explains why our model does not predict a strong correlation between quality and productivity or between productivity and taste. The data seem to confirm this.

The correlation between quality and taste in the data is even negative and around -0.16.[48] This suggests that firm-products with high tastes can be exported even when their product quality is not high.

7.4 Decomposition of firm-product Export Revenue

7.4.1 Consumer versus Intermediate Goods

In Table 5 column 1, we show the regression coefficients on each of the components in the decomposition exercise. The regressions are at firm-product export revenue and each regression coefficient gives the percentage variation that is explained of the firm-product revenue. Since we are mainly interested in a decomposition of firm-product appeal, we focus on the coefficients on ω, δ and λ. The demand side factors ($\delta + \lambda$) play an important role in explaining the variations in firm-product export revenues. Excluding the demand side determinants of export, more than 50% of firm-product export revenues will be lost. It is also clear from column 1 that including taste as a separate demand determinant in the decomposition, results in productivity explaining 35% of the variation in export sales relative to demand ($\beta_\omega/(\beta_\omega + \beta_\delta + \beta_\lambda)$. Ignoring taste in the decomposition more than doubles the variation explained by productivity relative to demand to 79% ($\beta_\omega/(\beta_\omega + \beta_\delta)$.

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[48] Since quality is measured at firm-product level and consumer taste is at product-destination level, in order to check the correlation among them we construct a firm-product level index for consumer tastes by simply calculating the average tastes across all destination countries that the firm-product pair exported to. Also each parameter is then normalized to their industry(HS2) mean to control the heterogeneity in these indices across industries.

In column 2, for consumption goods [49], the demand side factors explain more of the variation than for intermediate goods. Demand side factors ($\beta_\delta + \beta_\lambda$) in consumption goods explain over 50% of the variation in firm-product export revenues. For intermediate goods (column 3), the demand side determinants ($\beta_\delta + \beta_\lambda$) account for less than 50% of the variation in firm-product export revenue across firm-product pairs but demand related factors still capture almost twice the variation explained by productivity (β_ω) which equals 28%. Within the demand side determinants of export, consumer tastes β_λ is the more important demand factor. Taste accounts for more than 80% of the contributions of demand side factors to firm-product export revenues in both consumption goods and intermediate goods ($\beta_\lambda/(\beta_\delta + \beta_\lambda)$).

The overwhelming importance of consumer taste in explaining firm export success is a new finding and its magnitude suggests that its importance cannot be overlooked. We defined consumer taste as a residual source of variation in the data after controlling for productivity and quality at firm-product level, but also controlling for market size and income of the destination, markups and competition effects that also vary by destination. Therefore, the estimated taste parameter is cleaned of all the usual suspects that offer alternative explanations for the variation in firm export revenue at the product level across destinations.

In the Appendix Table A.2. we show the full decomposition where we document the separate the regression coefficients underlying β_{Tijt} but it is clear that the individual importance of these terms in the decomposition on consumption and intermediate goods in columns (2) and (3) tend to be small.

7.4.2 Goods with and without a Reference Prices

In Table 5, we also distinguish between goods that are exchanged on a market and have a reference price and those goods that are not and results of the decomposition are shown in

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[49] To identify consumption goods and intermediate goods in the data we use the BEC goods classification

columns (4) and (5) respectively. This classification is the one by Rauch (1999) to distinguish between homogeneous goods that are commonly traded on market exchanges and those that are too differentiated to have a reference price. Since we are mainly interested in a decomposition of firm-product appeal, we focus on the regression coefficients on ω, δ and λ. From the last row we observe that taste is a very important explanatory factor in explaining firm-product export revenue for both types of goods. Even for goods with a reference price ("homogeneous" goods), taste in the destination explains over 50% of the data variation in sales. For goods without a reference price ("differentiate" goods), taste is also the most important determinant in explaining firm-product export revenue.

In Rauch's classification, the "goods without a reference price" are typically considered to be the group of differentiated products, but the classification does not distinguish between the type of product differentiation. Put differently, Rauch does not distinguish between vertical and horizontal differentiation of goods. Our decomposition allows us to distinguish the two such that we can say that even for goods without a reference price, it is horizontal differentiation that seems to matter most in explaining export performance variation between products which we believe is a novel and interesting result.

Looking at results in the last two columns of Table 5 differently, we can also say that firm specific factors ($\omega_{jit} + \delta_{jit}$) explain around 50% of variation in firm-product export revenue for goods without a reference price, while firm heterogeneity ($\omega_{jit} + \delta_{jit}$)) is relatively small in explaining the variation of export revenue for goods with a reference price (32%). These results suggest that while firm heterogeneity, is the main factor determining the export revenue variations across firm-product pairs in goods without a reference price. For homogeneous goods, products have high degrees of substitutability and firm heterogeneity is less important for consumers and consumer tastes on product varieties are the main factors in explaining firm-product export revenue variations.

In the Appendix Table A.3. we combine the BEC and the Rauch classification, which does not alter the results.

7.4.3 Cost Elasticity of Quality

Since producing high-quality goods are costly, the magnitudes of the cost elasticities of product quality (γ in equation (3)) may also affect the roles of productivity, quality and tastes in explaining the variations of firm-product export revenue. Equation (4) indicates that the contribution of product quality (δ) to the export revenue depends on the scale of the cost elasticity of quality improvement. In the case of small cost elasticity of quality improvement (i.e., $\gamma < \frac{1}{\sigma_{id}-1}$), high-quality products have high export revenue relative to low-quality goods. If the costs of producing high-quality goods are high ($\gamma > \frac{1}{\sigma_{id}-1}$), firms producing high-quality incur high marginal costs and thus charge prices. High prices reduce the quantity demanded and thus decrease the export revenue that the firm have. We next separate firm-product pairs based on the scale of cost elasticity of quality improvement[50] and examine the roles of productivity, quality and tastes in explaining the variations of firm-product export revenue. In particular, firm-product pairs with $\gamma < \frac{1}{\sigma-1}$ are classified as low cost on quality improvement (low-γ) and firm-product pairs with $\gamma > \frac{1}{\sigma-1}$ are classified as high cost on quality improvement (high-γ).

Results in Table 6 show that ω_{ijt} is the most important determinant in explaining the variation of export sales of goods for which the cost of quality is high, while for those with a low cost of quality, taste is a more important explanation.

In Table A.4 and A.5 for completeness we document results of a decomposition of firm-product export revenue where we combine the BEC, Rauch and the magnitude of cost elasticity of quality improvement. In general productivity differences between firm-products become more prominent than taste in explaining export revenue variations for firm-product pairs with high

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[50] Since σ_{id} varies across destinations, we use the weighted average σ that a firm-product pair face where σ_{id} is weighted by the share of export revenue in country d over total export revenue of a firm-product pair.

cost elasticity of quality improvement. In contrast, quality is more important in the decomposition of export sales for firm-product pairs with low cost elasticity of quality improvement. For products without a reference price, quality variations account for 14% in explaining firm-product export revenue variations while productivity variations play a smaller role (11%) than quality.

7.5 Decomposition by Destination

Table 7 shows that firm-product appeal does not just vary by product type but also by destination. The results by destination lead us to conclude that the relative importance of demand versus supply components in export success, is destination-specific. While China displays a high average taste index for Belgian products (Table 3), the decomposition by destination shows that mainly quality differences between products is what explains export success in China. Despite high levels of taste for Belgian products, taste heterogeneity explains 31% ($\alpha_{\lambda_{ijt}}$ in Table 7) while quality explains 59% ($\alpha_{\delta_{ijt}}$) of variation in export revenues of firms in China. The relatively low taste heterogeneity suggests that Chinese consumers on average seem to have a high "taste for quality" and that their tastes are aligned on high quality goods. This is very different for North-America where in the decomposition the taste regression coefficient is larger, referring to the fact that America consumers appear less "aligned" in their tastes and like both high and low quality goods e.g. both high and low quality goods sell well and tastes are more idiosyncratic. In all regions we find quality and taste to be negatively correlated but in some more than in others as shown in Table 8. For example, in China we find a correlation of -0.07 and for North America the correlation is -0.19. This suggests that quality and taste are stronger substitutes in North-America than in China.

7.6 Robustness Checks

Table 9 shows a positive correlation between distance to destination and the minimum product quality present in a destination. We also find a positive correlation between distance and the minimum productivity at firm-product level. The positive correlations between distance to destination and the quality(productivity) threshold also hold if the 1 percentile of quality(productivity) index is used instead of the minimum level of quality(productivity) indices across firms within one destination. These results suggest that the threshold for quality and productivity rises with distance.[51]. Finally, in column (5) of Table 9, we examine the correlation between the distance to destination and the minimum tastes index.[52] The positive correlation between distance and taste index suggests that firms are able to enter a destination far away from Belgium if consumers in that destination have a strong preference for Belgium products.

The patterns observed in Table 9 imply that product composition varies across destinations and that fewer products are shipped to more distant destinations, where only products that represent higher quality, higher productivity and stronger tastes are shipped. The structural model that we developed above conditions on firms being present in a market and aims to explain differences in firm export revenues on the intensive margin but does not explicitly study entry into export markets. The results in Table 9 however suggest that when we decompose cost, quality and taste determinants, as we do in the previous section, the results may be affected by a different product composition being present in each destination. Therefore in we will verify results obtained in an unbalanced panel to results in a balanced panel where we constrain the data to the same exported products being present in every market.

We start by showing results in for the decomposition by product. It can be verified that

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[51] Baldwin and Harrigan (2011), Manova and Zhang (2012) find similar results

[52] Since consumer tastes indices are at region-(HS4)product level, we calculate the average distance across countries within one region and then compare the correlation between the tastes indices with regional average distance.

the results in Table 10 in a balanced panel are very similar to the ones in Table 5 where we included all observations. Therefore our earlier conclusions on the importance of taste versus other determinants in consumption versus intermediate type of goods are qualitatively the same which can be seen from the first two columns of Table 10. Also the results on the Rauch classification goods do not change in a balanced panel which can be seen from the last two columns in Table 10. Taste still remains a very important determinant in the decomposition of export revenue for both goods with and without a reference price. For goods without a reference price, horizontal differentiation remains the more important of the two demand variables ($\beta_\lambda > \beta_\delta$).

The decomposition by region results for a balanced panel are shown in Table 11. So while demand as opposed to productivity determines the majority of the variation in export success in every region, the relative importance of demand factors vary by destination. The results that we obtain on the decomposition by destination, do not seem to depend on the product composition since we obtain similar results in a balanced panel in Table 11 as in the unbalanced panel in Table 7. For completeness we show in Appendix Table A.6. the full set of results on the decomposition by region in a balanced panel, including the control variables (N, W, q_{j-i}, k) which are the variables whose effect is now captured in Table 11 by α_{Tijt}. It can be observed that these remaining variables explain relatively little of the total variation in export sales, confirming that productivity, quality and taste are the most important determinants of firm export success.

8 Conclusion

Recent research identifies firm appeal (quality or tastes) as the single demand-side factor that explains the bulk of firm success. Our unique contribution lies in our ability to identify consumer tastes as a demand-side factor that is separate from the effect of product quality in explaining the export performance of firms. Consumer heterogeneity in tastes is reflected in the destination-specific information of Belgian exports in the data. It is this destination-specific information on consumption for each firm-product that allows for identification of the horizontal differentiation determinant in export revenues and distinguish it from income, market size, markups and other destination related effects that may also explain differences in firm-product export sales. Empirically we find that consumer heterogeneity in taste across countries is very large. The standard deviations in average taste across products sold by destination is up to five times as large as the standard deviations of the average quality and productivity of products present in a destination.

Our results indicate that a failure to account for taste as a demand determinant of firm-product export revenues, results in a serious underestimation of the importance of the demand side and an over-estimation of the supply side importance. We perform a decomposition of firm-product appeal in the spirit of Hotttman, Redding and Weinstein (2016) and find that ignoring taste in the decomposition almost doubles the variation explained by productivity relative to demand. Including taste as a separate demand determinant, halves the relative importance of productivity in export sales variation relative to demand factors. When the cost elasticity of improving quality is high, productivity differences between firm-products become more prominent than taste in explaining export success. The role of quality, while important, is always less important than taste in explaining export revenue except for consumption goods.

Our model predicts a weak correlation between productivity and quality. This is very different from other quality models. Most existing models, endogenize the quality choice by firms which results in a strong correlation between productivity and quality e.g. only the most productive firms can invest in quality. The novelty of our model is that we introduce taste, which breaks the strong correlation between productivity and quality. In our model, strong taste can compensate for low productivity to make it still profitable to purchase high priced inputs and to engage in quality investment. Conditioning on productivity, we would therefore expect high taste firms to invest in high quality goods while low taste firms would not. Our main conclusion that taste is a very important determinant of export success, underlines the importance for firms to learn about the demand in their destination markets. These insights contribute to the recent literature on the importance of “learning about demand” as suggested by Eslava et al. (2015). Cost efficiency and productivity while important do not appear to be the main determinant of export sales. Knowledge about consumer tastes seems just as important in most destinations.

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Table 1: Export Price and Quantity Variation: goodness-of-fit (R-squared)

	All Industries	
	lnp	**lnq**
Firm FE	0.519	0.415
Firm-Product	0.747	0.594
Product FE	0.429	0.286
Product-Country	0.502	0.372
Product - Region	0.434	0.290
Product Category - Country	0.366	0.240
Region	0.017	0.013
Year	0.002	0.001

Table 2: Demand Elasticity by Region and Industry

	Food	**Chemicals**	**Chemical Product**	**Plastic**	**Iron& Steel**	**Machinery**	**Electrical &Electronic**	**Vehicle**	**Mean**	**S.D.**
AU	1.838	4.694	1.605	2.396	4.052	3.179	2.974	3.585	3.040	1.069
CN	1.678	3.405	2.216	1.580	5.424	4.005	7.835	3.684	3.728	2.105
EA	1.409	3.639	2.111	1.903	3.723	3.086	4.044	2.717	2.829	0.956
EE	1.903	3.837	2.613	2.627	5.056	4.489	4.778	2.940	3.530	1.168
ME	1.794	3.985	2.581	2.737	4.999	3.714	5.582	3.038	3.554	1.276
NA	1.698	2.520	1.845	1.836	3.854	3.418	3.123	2.077	2.546	0.823
SA	0.647	3.162	2.692	1.629	5.559	3.285	1.714	4.281	2.871	1.573
SAM	1.664	3.222	2.290	2.601	4.623	3.412	5.490	4.723	3.503	1.333
SSA	2.014	3.361	2.369	3.052	4.355	4.110	1.873	1.967	2.888	0.986
WE	2.435	3.745	2.888	2.600	6.195	4.184	5.235	4.131	3.926	1.313
Mean	1.708	3.557	2.321	2.296	4.784	3.688	4.265	3.314	3.242	
S.D.	0.460	0.577	0.396	0.516	0.807	0.483	1.898	0.926	0.461	

Table 3: Summary of Index in Productivity, Quality and Tastes

	mean($ln\omega$)	mean($ln\delta$)	mean($ln\lambda$)
AU	3.860	4.793	0.575
CN	3.269	4.898	2.112
EA	3.411	4.496	0.424
EE	3.323	4.574	-0.193
ME	3.332	4.550	0.381
NA	3.535	4.426	0.648
SA	3.210	5.163	-0.952
SAM	3.328	4.666	0.538
SSA	3.434	4.616	0.570
WE	2.870	4.414	-0.629

Table 4: Correlation Matrix among Quality, Productivity and Tastes Indices

	$ln\delta$	$ln\omega$	$ln\lambda$
$ln\delta$	1		
$ln\omega$	0.0625	1	
$ln\lambda$	-0.1648	0.2191	1

Note: All variables are normalized to their (HS2)industry mean levels.

Consumer tastes are constructed at firm-product level where firm-product consumer tastes are the mean of consumer tastes across destinations that the firm-product export to.

Table 5: Decomposition of Firm-Product Revenue (BEC and Rauch classification)

	BEC			Rauch	
	Overall	**Consumption goods**	**Intermediates**	**reference price**	**no reference price**
β_{Tijt}	0.1414***	-0.0600***	0.2097***	0.0914***	0.1463***
	(0.004)	(0.009)	(0.005)	(0.007)	(0.005)
$\beta_{\omega ijt}$	0.3011***	0.4318***	0.2882***	0.2498***	0.3636***
	(0.003)	(0.006)	(0.004)	(0.005)	(0.004)
$\beta_{\delta ijt}$	0.0803***	0.0975***	0.0879***	0.0690***	0.0942***
	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)
$\beta_{\lambda ijt}$	0.4772***	0.5307***	0.4142***	0.5898***	0.3960***
	(0.003)	(0.007)	(0.004)	(0.006)	(0.004)
no.(obs)	51,449	11,139	25,535	17,391	28,436

Note: We use the BEC classification to identify consumption and intermediate goods in our data.

Table 6: Decomposition of Firm-Product Revenue, by cost of quality improvement

	Low cost on quality improvement	**High cost on quality improvement**	**Overall**
β_{Tijt}	0.2462***	0.0876***	0.1414***
	(0.007)	(0.005)	(0.004)
$\beta_{\omega ijt}$	0.0815***	0.4724***	0.3011***
	(0.003)	(0.004)	(0.003)
$\beta_{\delta ijt}$	0.1022***	0.0534***	0.0803***
	(0.002)	(0.002)	(0.001)
$\beta_{\lambda ijt}$	0.5701***	0.3867***	0.4772***
	(0.005)	(0.004)	(0.003)
no.(obs)	22,293	29,156	51,449

Note:: Low cost of quality improvement: Firm-(CN8)product pairs with $1-(\bar{\sigma}-1)\times\gamma \geq 0$, where $\bar{\sigma}$ is the average sigma across all destinations that the firm's product export to. High cost of quality improvement: Firm-(CN8)product pairs with $1-(\bar{\sigma}-1)\times\gamma < 0$.

Table 7: Decomposition of Firm-Product-Region Revenue, by Region

	Australasia (AU)	China (CN)	East Asia (EA)	East Europe (EE)	Middle East (ME)
α_{Tijt}	0.0140***	0.0043*	0.0116***	0.1449***	0.1593***
	(0.002)	(0.002)	(0.001)	(0.004)	(0.004)
$\alpha_{\omega ijt}$	0.0861***	0.0854***	0.0280***	0.2509***	0.1707***
	(0.004)	(0.004)	(0.002)	(0.004)	(0.004)
$\alpha_{\delta ijt}$	0.8575***	0.5982***	0.3038***	0.1506***	0.1838***
	(0.011)	(0.010)	(0.002)	(0.003)	(0.004)
$\alpha_{\lambda ijt}$	0.0423***	0.3121***	0.6566***	0.4536***	0.4862***
	(0.010)	(0.010)	(0.003)	(0.004)	(0.005)
no.(obs)	3,287	2,182	8,295	16,759	10,597
	North America (NA)	**South Asia (SA)**	**South America (SAM)**	**Africa (SSA)**	**West Europe (WE)**
α_{Tijt}	0.0133***	0.0384***	0.0640***	0.0514***	0.0884***
	(0.002)	(0.004)	(0.004)	(0.004)	(0.002)
$\alpha_{\omega ijt}$	0.1369***	0.0758***	0.1027***	0.0593***	0.2841***
	(0.003)	(0.005)	(0.004)	(0.005)	(0.002)
$\alpha_{\delta ijt}$	0.1879***	0.7472***	0.1683***	0.2868***	0.2233***
	(0.007)	(0.013)	(0.003)	(0.006)	(0.001)
$\alpha_{\lambda ijt}$	0.6619***	0.1386***	0.6650***	0.6026***	0.4042***
	(0.008)	(0.013)	(0.005)	(0.007)	(0.002)
no.(obs)	7,594	2,569	6,402	5,214	49,167

Table 8: Correlation between Quality and Tastes indices, by Region

	Corr(Quality, Tastes)
AU	-0.1307
CN	-0.0766
EA	-0.1753
EE	-0.1922
ME	-0.1899
NA	-0.1912
SA	-0.1000
SAM	-0.1400
SSA	-0.2115
WE	-0.1908

Table 9: Minimum quality(productivity) in each country v.s. Distance from Belgium

	Minimum Quality Index	**Quality Index at 1%**	**Minimum Productivity Index**	**Productivity Index at 1%**	**Minimum Tastes Index**
ln(Distance)	0.224	0.369	0.513	0.606	0.89
	(0.010)***	(0.010)***	(0.010)***	(0.011)***	(0.094)***
Year dummy	yes	yes	yes	yes	yes
(HS2)Industry Dummy	yes	yes	yes	yes	yes
no.(obs.)	8,452	8,452	8,451	8,451	640

Table 10: Decomposition of Firm-Product Revenue (BEC and Rauch classification)

	Balanced Panel			
	BEC		Rauch	
	Consumption goods	**Intermediates**	**reference price**	**no reference price**
β_{Tijt}	-0.1044***	0.2194***	0.1801***	0.0744***
	(0.017)	(0.012)	(0.015)	(0.012)
$\beta_{\omega ijt}$	0.3879***	0.3273***	0.1520***	0.4787***
	(0.014)	(0.009)	(0.010)	(0.009)
$\beta_{\delta ijt}$	0.1499***	0.1588***	0.1145***	0.1716***
	(0.009)	(0.005)	(0.006)	(0.006)
$\beta_{\lambda ijt}$	0.5666***	0.2946***	0.5534***	0.2753***
	(0.014)	(0.007)	(0.010)	(0.007)
no.(obs)	2,351	6,655	3,917	6,602

Table 11: Decomposition of Firm-Product-Region Revenue, by Region on Balanced Panel

	Australalasia (AU)	China (CN)	East Asia (EA)	East Europe (EE)	Middle East (ME)
α_Tijt	0.0204***	0.0016	0.0178***	0.1573***	0.2398***
	(0.003)	(0.003)	(0.003)	(0.008)	(0.010)
$\alpha\_\omega ijt$	0.0898***	0.0828***	0.0348***	0.2776***	0.2949***
	(0.005)	(0.005)	(0.004)	(0.008)	(0.010)
$\alpha\_\delta ijt$	0.8606***	0.6419***	0.3226***	0.0719***	0.0458***
	(0.012)	(0.011)	(0.004)	(0.005)	(0.008)
$\alpha\_\lambda ijt$	0.0292***	0.2736**	0.6249***	0.4932***	0.4195***
	(0.011)	(0.011)	(0.005)	(0.008)	(0.010)
no.(obs)	1,810	1,444	3,217	5,169	3,726

	North America (NA)	South Asia (SA)	South America (SAM)	Africa (SSA)	West Europe (WE)
α_Tijt	0.0184***	0.0248***	0.0989***	0.0585***	0.0834***
	(0.004)	(0.005)	(0.009)	(0.008)	(0.004)
$\alpha\_\omega ijt$	0.1842***	0.0989***	0.1785***	0.1204***	0.2736***
	(0.007)	(0.008)	(0.009)	(0.009)	(0.005)
$\alpha\_\delta ijt$	0.1936***	0.8100***	0.1602***	0.2757***	0.2307***
	(0.013)	(0.019)	(0.007)	(0.011)	(0.003)
$\alpha\_\lambda ijt$	0.6037***	0.0663***	0.5625***	0.5454***	0.4122***
	(0.016)	(0.018)	(0.010)	(0.011)	(0.004)
no.(obs)	2,975	1,376	2,573	2,212	10,838

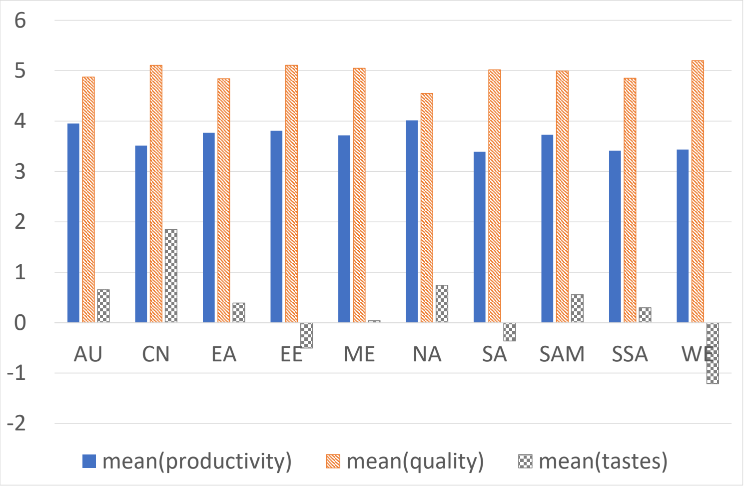

Figure 1: Averages of Productivity, Quality and Taste by Region (in logs)

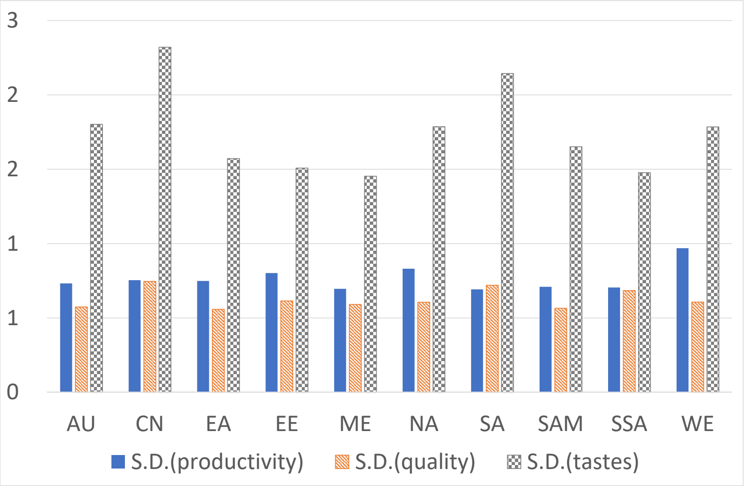

Figure 2: Standard Deviation of Productivity, Quality and Taste (average indices) by Region

Appendix

Table A-1: Number of firm-product-region observations in the subsamples

1. By HS2-Industry				
	Not export to all regions	Exported to all regions	Total	Share of no.(firm-product-region) exporting to all regions
Food	15,826	5,156	20,982	24.57
Chemicals	11,971	7,072	19,043	37.14
Chemical Product	9,623	9,010	18,633	48.36
Plastic	9,149	7,293	16,442	44.36
Iron&Steel	9,957	2,483	12,440	19.96
Machinery	11,681	2,776	14,457	19.20
Electricals&Electronics	5,833	438	6,271	6.98
Vehicle	2,686	1,112	3,798	29.28
Total	76,726	35,340	112,066	31.53
2. By Region				
	Not export to all regions	Exported to all regions	Total	Share of no.(firm-product-region) exporting to all regions
AU	1,477	1,810	3,287	55.07
CN	738	1,444	2,182	66.18
EA	5,078	3,217	8,295	38.78
EE	11,590	5,169	16,759	30.84
ME	6,871	3,726	10,597	35.16
NA	4,619	2,975	7,594	39.18
SA	1,193	1,376	2,569	53.56
SAM	3,829	2,573	6,402	40.19
SSA	3,002	2,212	5,214	42.42
WE	38,329	10,838	49,167	22.04
Total	76,726	35,340	112,066	31.53

Table A-2: Decomposition of Firm-Product Revenue in eight Determinants

	Unbalanced Panel		
	Overall	**Consumption goods**	**Intermediates**
β_B	-0.0432***	-0.1017***	-0.0166***
	(0.002)	(0.006)	(0.002)
β_N	0.1624***	0.0228***	0.1968***
	(0.003)	(0.005)	(0.004)
β_W	0.0019	0.0209***	-0.0063***
	(0.002)	(0.003)	(0.002)
β_q	0.0157***	-0.0065	0.0320***
	(0.002)	(0.005)	(0.002)
β_k	0.0045***	0.0045***	0.0039***
	(0.000)	(0.001)	(0.001)
β_ω	0.3011***	0.4318***	0.2882***
	(0.003)	(0.006)	(0.004)
β_δ	0.0803***	0.0975***	0.0879***
	(0.001)	(0.003)	(0.002)
β_λ	0.4772***	0.5307***	0.4142***
	(0.003)	(0.007)	(0.004)
no.(obs)	51,449	11,139	25,535

Table A-3: Decomposition of Firm-Product Revenue, by product category(BEC & Rauch (liberal) classification)

	Balanced Panel			
	Consumption goods		**Intermediates**	
	reference price	**no reference price**	**reference price**	**no reference price**
β_B	-0.1808***	-0.1201***	-0.0399***	-0.0880***
	(0.038)	(0.011)	(0.005)	(0.006)
β_N	0.0400*	-0.0116	0.3158***	0.1250***
	(0.023)	(0.014)	(0.016)	(0.014)
β_W	-0.0268*	0.0228***	-0.0022	-0.0044
	(0.015)	(0.008)	(0.005)	(0.007)
β_q	0.0618***	0.0668***	-0.0009	0.0488***
	(0.020)	(0.011)	(0.005)	(0.007)
β_k	0.0012	0.0012	-0.0061***	-0.0003
	(0.002)	(0.001)	(0.003)	(0.002)
β_ω	0.1695***	0.6494***	0.1425***	0.4994***
	(0.030)	(0.016)	(0.014)	(0.013)
β_δ	0.1091***	0.2266***	0.1587***	0.1804***
	(0.015)	(0.012)	(0.008)	(0.008)
β_λ	0.8270***	0.1648***	0.4320***	0.2392***
	(0.034)	(0.010)	(0.012)	(0.009)
no.(obs)	417	1,934	2,320	3,690

Table A-4: Decomposition of Firm-Product Revenue, by cost of quality improvement & (BEC)

	Consumption goods		**Intermediates**	
	Low cost on quality improvement	**High cost on quality improvement**	**Low cost on quality improvement**	**High cost on quality improvement**
β_B	-0.0932***	0.0198***	-0.0157***	-0.0187***
	(0.012)	(0.003)	(0.004)	(0.002)
β_N	0.1111***	0.0572***	0.3278***	0.0925***
	(0.008)	(0.005)	(0.006)	(0.006)
β_W	0.0037	0.0276***	0.0009	-0.0118***
	(0.006)	(0.005)	(0.002)	(0.003)
β_q	0.0035	-0.0126**	0.0017	0.0559***
	(0.008)	(0.006)	(0.002)	(0.003)
β_k	0.0013*	0.0048***	0.0103***	-0.0011
	(0.001)	(0.001)	(0.001)	(0.001)
β_ω	0.1719***	0.5815***	0.0265***	0.4969***
	(0.010)	(0.007)	(0.004)	(0.006)
β_δ	0.1013***	0.0473***	0.1236***	0.0609***
	(0.007)	(0.003)	(0.003)	(0.003)
β_λ	0.7003***	0.2743***	0.5249***	0.3255***
	(0.014)	(0.006)	(0.006)	(0.005)
no.(obs)	3,585	7,554	11,465	14,070

Table A-5: Decomposition of Firm-Product Revenue, by cost of quality improvement, combined with Rauch-classification

	reference price		no reference price		Overall	
	Low cost on quality improvement	**High cost on quality improvement**	**Low cost on quality improvement**	**High cost on quality improvement**	**Low cost on quality improvement**	**High cost on quality improvement**
β_B	-0.0815***	-0.0598***	-0.0212***	-0.0232***	-0.0427***	-0.0256***
	(0.006)	(0.003)	(0.006)	(0.002)	(0.004)	(0.002)
β_N	0.2501***	0.0091	0.2567***	0.1068***	0.2747***	0.0853***
	(0.007)	(0.007)	(0.007)	(0.005)	(0.004)	(0.004)
β_W	-0.0021	0.0234***	-0.0112***	0.0035	-0.0057***	0.0060***
	(0.003)	(0.005)	(0.003)	(0.003)	(0.002)	(0.002)
β_q	0.0105***	-0.0217***	0.0148***	0.0358***	0.0128***	0.0198***
	(0.003)	(0.006)	(0.004)	(0.003)	(0.002)	(0.003)
β_k	0.0131***	0.0065***	0.0001	0.0003	0.0071***	0.0021***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
β_ω	0.0731***	0.4887***	0.1082***	0.4957***	0.0815***	0.4724***
	(0.005)	(0.008)	(0.006)	(0.005)	(0.003)	(0.004)
β_δ	0.0797***	0.0547***	0.1395***	0.0596***	0.1022***	0.0534***
	(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)
β_λ	0.6570***	0.4992***	0.5131***	0.3214***	0.5701***	0.3867***
	(0.008)	(0.008)	(0.007)	(0.004)	(0.005)	(0.004)
no.(obs)	10,003	7,388	8,865	19,571	22,293	29,156

Table A-6: Decomposition of Firm-Product-Region Revenue, by Region on Balanced Panel

	Australasia (AU)	China (CN)	East Asia (EA)	East Europe (EE)	Middle East (ME)
α_N	0.0016		0.0099***	0.1286***	0.1444***
	(0.001)		(0.001)	(0.003)	(0.004)
α_W	0.0335***	0.0065**	-0.0044***	-0.0099***	-0.0211***
	(0.003)	(0.003)	(0.001)	(0.002)	(0.003)
α_q	-0.0257***	-0.0045	0.0061***	0.0227***	0.0341***
	(0.004)	(0.003)	(0.001)	(0.003)	(0.003)
α_k	0.0046***	0.0023***	0.0001	0.0035***	0.0019**
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
α_ω	0.0861***	0.0854***	0.0280***	0.2509***	0.1707***
	(0.004)	(0.004)	(0.002)	(0.004)	(0.004)
α_δ	0.8575***	0.5982***	0.3038***	0.1506***	0.1838***
	(0.011)	(0.010)	(0.002)	(0.003)	(0.004)
α_λ	0.0423***	0.3121***	0.6566***	0.4536***	0.4862***
	(0.010)	(0.010)	(0.003)	(0.004)	(0.005)
no.(obs)	3,287	2,182	8,295	16,759	10,597
	North America (NA)	South Asia (SA)	South America (SAM)	Africa (SSA)	West Europe (WE)
α_N	0.0032***	0.0158***	0.0604***	0.0464***	0.0731***
	(0.001)	(0.003)	(0.004)	(0.004)	(0.002)
α_W	0.0075***	-0.0299***	-0.0108***	-0.0214***	0.0088***
	(0.002)	(0.004)	(0.003)	(0.003)	(0.001)
α_q	-0.0023	0.0464***	0.0152***	0.0272***	0.0024*
	(0.003)	(0.004)	(0.003)	(0.004)	(0.001)
α_k	0.0049***	0.0061***	-0.0008	-0.0007	0.0041***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
α_ω	0.1369***	0.0758***	0.1027***	0.0593***	0.2841***
	(0.003)	(0.005)	(0.004)	(0.005)	(0.002)
α_δ	0.1879***	0.7472***	0.1683***	0.2868***	0.2233***
	(0.007)	(0.013)	(0.003)	(0.006)	(0.001)
α_λ	0.6619***	0.1386***	0.6650***	0.6026***	0.4042***
	(0.008)	(0.013)	(0.005)	(0.007)	(0.002)
no.(obs)	7,594	2,569	6,402	5,214	49,167

Table A-7: Structure of the Combined Nomenclature (CN8) Classification

Combined Nomenclature 8-digit (CN8)		Harmonized System 6-digit (HS6)
Year	no. of CN8 products	
1988	9506	HS6 1988 (no. HS6 = 5019)
1989	9579	
1990	9695	
1991	9743	
1992	9837	HS6 1992 (no. HS6 = 5018)
1993	9906	
1994	10108	
1995	10448	
1996	10495	HS6 1996 (no. HS6 = 5113)
1997	10606	
1998	10587	
1999	10428	
2000	10314	
2001	10274	
2002	9837	HS6 2002 (no. HS6 = 5224)
2003	9906	
2004	10108	
2005	10448	
2006	9841	
2007	9720	HS6 2007 (no. HS6 = 5051)
2008	9699	
2009	9569	
2010	9443	

Notes: All classification files are obtained from the Eurostat Ramon server, with the exception of the files for 1988-1994, which were provided by Eurostat on request.

Table A-8: Structural Parameters of Interest Identified in the Model

Parameters Identified	In the Theory varies at	In the Empirics varies at
σ_{id}	product i, destination d level	HS2-Region level
λ_{idt}	product i, destination d level and year t	HS4-Region-year level
δ_{jit}	firm(j)-product(i) and year t	firm-CN8-year level
ω_{jit}	firm(j)-product(i) and year t	firm-CN8-year level