# Verti-zontal Differentiation in Export Markets: Micro-foundations*

Francesco Di Comite[†] Jacques-François Thisse[‡] Hylke Vandenbussche[§]

April 16, 2013

Existing trade models identify cost efficiency as the main determinant of firm performance in export markets. To date, the analysis of demand factors has received much less attention. For this purpose, we build on Melitz and Ottaviano (2008) and develop a model in which consumer preferences are asymmetric across countries in terms of quality and consumer taste. Dealing explicitly with vertical and horizontal differentiation generates a new set of predictions. Data patterns observed in Belgian firm-level exports seem to warrant the inclusion of consumer heterogeneity.

*JEL codes:* D43 - F12 - F14 - L16

*Keywords:* Heterogeneous firms - Heterogeneous consumers - Horizontal differentiation - Vertical differentiation - Asymmetric preferences - Monopolistic competition

*We thank seminar participants at Columbia University, Chicago Federal Reserve, Georgia Tech, Emory, Penn State, Syracuse University, UCD Dublin, LSE- London, University of Virginia, the Worldbank and Aarhus for helpful discussions and suggestions. We especially thank Marc Melitz, Jonathan Eaton, Frederic Warzynski, Kala Krishna, Hiau Looi Kee, Gianmarco Ottaviano, Carsten Eckel and Jozef Konings. This research was financially supported by UCLouvain-ARC 09/14-019 and KULeuven-PF 10/003. We thank the National Bank of Belgium for the data provided.

†Department of Economics (IRES), Université Catholique de Louvain, and European Commission, DG Joint Research Centre, Calle Inca Garcilaso 3, 41092 Sevilla, Spain - Email: francesco.di-comite@ec.europa.eu

‡CORE, Université catholique de Louvain (Belgium), NRU Higher School of Economics, Saint Petersburg (Russia) and CEPR. - Email: jacques.thisse@uclouvain.be.

§CORE and IRES, Université Catholique de Louvain; LICOS, KULeuven; and National Bank of Belgium. Email: hylke.vandenbussche@uclouvain.be - Tel: + 32 (0)10 474137

# 1 Introduction

Many existing trade models assume that consumers worldwide share the same preferences. As a result, the demand for any type of good is the same across consumers. This symmetry in demand is imposed on very different products sold within the same country as well as for the same goods sold across different countries. These two assumptions are very restrictive as consumers' taste heterogeneity appears to be a critical ingredient in many applied models of industrial organization, which focus on the working of specific industries.[1] The objective of this paper is to relax these assumptions by allowing consumers to differ in two major respects: demand varies across products within the same country and demand varies for the same product across countries.

Firm heterogeneity in efficiency has empirically been confirmed to be very important in explaining firms' entry into export markets.[2] However, this seems less the case for firm-level sales variation in different markets conditioning upon entry.[3] Several papers analyzing the variability in firm-level prices and sales across a range of export destinations have reached the conclusion that cost factors alone cannot account for all the variation in the data and conclude that demand factors are important too. Our objective is to contribute to the literature by enriching the demand side while continuing to assume supply side heterogeneity in terms of firms' cost.

A specification of preferences that appears very suitable for introducing consumer heterogeneity is the quadratic utility used by Melitz and Ottaviano (2008). We extend their preferences to include consumer heterogeneity along the lines explained above, which results in a new set of predictions, which we briefly summarize. Without consumer heterogeneity, one would expect a strong and negative price-quantity correlation within destination markets as well as a strong correlation of quantities and prices between markets. Allowing for consumer heterogeneity as we do here, yields a strong correlation of the same firm-product prices across markets but in contrast a strong variation of the same firm-product sales across countries. This stems from the fact that consumers in each country are now allowed to have different tastes and evaluate the horizontal attributes of a product differently, hence buying different amounts. Thus, each firm-product faces a specific demand. It is important to point out that varying firm-product-country sales need not result from market size differences, but from asymmetric preferences. Put differently, whereas in Melitz and Ottaviano (2008) firm-product-quantity variation across destinations may result from varying market size or from varying number of competing varieties by destination, the new set of preferences introduced here shows that even when exporting to a country of similar size and competing varieties, quantities may still vary due to consumer taste differences that have not been considered before.[4]

Recall that varieties of the same good are *horizontally* differentiated when there is no common

[1] See, for example, Goldberg and Verboven (2001) on the European car market and Hanson and Xiang (2011) on the cultural industries.

[2] See Melitz (2003), Bernard, Eaton, Jensen and Kortum (2003), and Das, Roberts and Tybout (2007).

[3] See Arkolakis (2010), Eaton, Kortum and Kramarz (2011), Kee and Krishna (2008), and Manova and Zhang (2012).

[4] Our approach is also consistent with the trade literature that focuses on the existence of a home bias in consumers' preferences (Atkin, 2013; Ferreira and Waldfogel, 2013), i.e. domestic products match more closely local taste.

ranking across consumers when varieties are equally priced. In other words, horizontal differentiation reflects consumers' idiosyncratic tastes which will affect how much firms can sell of each variety. By contrast, varieties are *vertically* differentiated when all consumers agree on their ranking and thus quality will affect prices in all destination markets. Because these two types of product differentiation generate very different predictions (Anderson, de Palma and Thisse, 1992; Tirole, 1988), we need a specification of preferences that clearly distinguishes them. This is what we accomplish in this paper by developing a new set of preferences, which we refer to as *verti-zontal* preferences because they include both horizontal and vertical product differentiation in a new way. Clear definitions of horizontal and vertical differentiation until now only existed in models with indivisible varieties and with consumers making mutually exclusive purchases, which characterizes much of the empirical work in industrial economics (Sutton, 2012). But these concepts are largely absent in models guiding empirical work in trade where consumers are typically characterized by "love-for-variety". With the new and richer set of preferences introduced here that distinction can now be made more clearly. The introduction of consumer heterogeneity in quadratic utility results in a number of appealing features of which we single out some of the most important ones.

First, the consumer-specific parameter of horizontal differentiation only affects equilibrium firm-level quantities, but not firm-prices. Thus, horizontal differentiation can be separated from vertical differentiation at the firm-product-country level and can empirically be distinguished by any researcher with access to data on firm characteristics. Since the elasticity of substitution is constant across varieties, horizontal differentiation in CES models cannot explain variation in sales for the same firm-product across countries. To remedy for this, one can introduce a firm-product specific demand shock per country that accounts for sales variation of the same firm-product across countries without affecting prices. Horizontal differentiation between products is then the combination of a constant parameter of substitution and a variable shock at the firm-product level. Because the parameter of substitution also enters the price equation, a clear separation of horizontal and vertical differentiation is difficult to attain with that functional form. In addition, because both quality and taste shift demand, quality differences between varieties may be confounded with taste differences. In this paper we show that taste differences can shift demand without affecting price, while quality differences always imply a price change. A quality measure that is clearly separated from taste opens up possibilities for policy evaluation.[5]

Second, horizontal differentiation in our model is captured by one single parameter that varies across firm-product-countries for which we provide a micro-foundation that goes back to spatial models of product differentiation à la Hotelling (1929). This approach allows us to determine precisely how this parameter affects demand and sales *asymmetrically*.

Third, consumer heterogeneity also implies that consumers recognize quality and have a higher willingness-to pay for high quality varieties than for low quality ones, which is in line with other models that allow products to be vertically differentiated.[6] However, in contrast to most trade models, we do not require any prior relationship between marginal costs and willingness-

[5] Similarly to Amiti and Khandelwal (2009) and Feenstra (1984), who study trade policy effects on quality upgrading.

[6] As in Baldwin and Harrigan (2011), Foster, Haltiwanger and Syverson (2008), Eckel, Iacovone, Javorcik and Neary (2011), Feenstra and Romalis (2012), Kugler and Verhoogen (2012), and Verhoogen (2008).

to-pay. As such we allow for the possibility of quality resulting from fixed investments in research and development or advertising.[7] In the same spirit of many models of monopolistic competition we treat taste, quality and cost as exogenous parameters, but endogenizing these parameters would not overturn our results.

Fourth, consumer heterogeneity in quadratic utility also results in a richer set of country-specific competition effects. Without consumer heterogeneity, competition effects are a sole function of the number of firms in the destination market, which depends on market size. Allowing for consumer heterogeneity generates competition effects that now also depend on the quality of the varieties on offer in the destination market and their interaction with local tastes. Thus, allowing for asymmetric preferences across countries implies that two countries of similar size and GDP can still be subject to varying levels of competition. Even when the quality on offer in these two countries is the same, competition effects can differ because in one country high quality is met with higher local tastes. Without consumer heterogeneity, competition is summarized by the price index only. Allowing for consumer heterogeneity results in several market indices, which together capture the extent of country-specific competition effects, generating market structures ranging from monopoly to perfect competition. As such, the new preferences presented here provide a link to the industrial organization literature where market structure is more central than in standard trade models.

While consumer heterogeneity allows us to derive new equilibrium market outcomes, we do not currently deal with issues of entry and exit. In the absence of consumer heterogeneity, firm productivity is the only source of heterogeneity for which an ex-ante distribution needs to be assumed in order to derive long-term equilibria and to study entry/exit issues, which remains an attractive property of Melitz and Ottaviano (2008). But, with varying demand, deriving longer-term effects would require making assumptions about ex-ante distributions (and cross-distributions) for two additional sources of heterogeneity, which is not pursued here but is an interesting avenue for future research. Given that our main focus lies on the demand side, we disregard issues related to market participation and consider only varieties that are present in all the destination markets in a particular moment in time.

In a similar fashion, Fajgelbaum, Grossman and Helpman (2011) combine horizontal and vertical differentiation within a new framework with idiosyncratic tastes captured through the use of a random term. The functional form they work with is the logit, which is symmetric in nature and as such does not allow for asymmetric preferences as we pursue here (Anderson et al., 1992). However, these authors are able to cope with consumer/income heterogeneity within each country, whereas we can do this only indirectly within our setting.[8] Thus, the approach developed here provides a new theoretical framework to those empirical researchers with access to firm-product-country data that typically have one observation for each product per destination, while being unable to distinguish between the types of consumers within a country.

In this paper we do not pursue a full test of the model since that would require separating consumer heterogeneity from other channels potentially affecting sales variation. The main focus here is to provide micro-foundations for the parameters that capture consumer heterogeneity and

[7] As in Trefler and Sutton (2011)

[8] Other papers dealing with trade, quality and inequality are Goldberg and Pavcnik (2007) and Verhoogen (2008).

to show that indeed this is a possible source of quantity variation of the same firm-products across countries. Our empirical analysis is limited to a cross-sectional analysis of firm-product-country exports data for Belgium to explore whether data patterns are consistent with our theory or reject the need to model consumer taste heterogeneity. For this purpose, we use the most disaggregate trade data available. Our findings do not reject the theory and seem to warrant the inclusion of consumer taste heterogeneity in trade models. However, we do not go as far as to disentangle taste effects from other potential explanations for firm-product-quantity variation across destinations. This is left for future research.

The next section first discusses the standard quadratic utility before introducing the new consumer preferences. Section 3 discusses market equilibria. Section 4 uses firm-product level cross-sectional exports data for Belgium to explore data patterns. Section 5 concludes.

# 2 Consumer preferences

## 2.1 The quadratic utility

Consider a country $i$ with a representative consumer and two goods, a differentiated good and the numéraire. As in Melitz and Ottaviano (2008), the consumer is endowed with the following preferences:

$$U_i = \alpha \int_{S_i} q_{s,i} ds - \frac{\beta}{2} \int_{S_i} q_{s,i}^2 ds - \frac{\gamma}{2} \left( \int_{S_i} q_{s,i} ds \right)^2 + q_0. \tag{1}$$

In this expression, $U_i$ is the utility of the representative consumer in country $i$, which depends on $q_{s,i}$, namely the consumption of variety $s$ belonging to a set $S_i$ of differentiated varieties available in market $i$, and on $q_0$, namely the consumption of the numéraire good. The world can be thought of as consisting of different countries where each country $i$ is considered as a single consumer whose preferences are described in (1). The three demand parameters $\alpha$, $\beta$ and $\gamma$ are positive constants. The parameter $\alpha$ captures the preference for the differentiated good with respect to the numéraire, while $\gamma > 0$ is the degree of substitutability between any pair of varieties in $S_i$: a higher $\gamma$ means that varieties are closer substitutes. The quadratic utility function exhibits a love for variety whose intensity is measured by the value of $\beta$.

An important property of (1) is that the demand parameters are identical for all varieties and for all countries. Thus, (1) makes two implicit assumptions about demand. First, that all varieties face the same demand in country $i$. Second, that any particular variety $s$ faces the same demand no matter which country it is sold in. According to (1) all varieties $s$ enter consumer preferences symmetrically around the world.

Assuming identical demand for all products can best be illustrated with a simple example. Suppose that the set of differentiated varieties $S$ are types of beers. Then, the preferences (1) imply that the demand faced by Heineken is the same as the demand faced by Budweiser in country $i$. In addition, it also assumes that the demand for Heineken and for Budweiser is the same in every country where these beers are sold and compete with a similar set of other beers. These clearly are restrictive assumptions that we want to relax.

It is worth stressing that our model is applicable to any level of product aggregation and market definition, depending on the data availability. Currently available trade datasets often include only firm-product information, which is the level of aggregation we use in Section 4.

## 2.2 The quadratic utility with verti-zontal preferences

Recall that the main purpose of this paper is to present a new set of preferences that allows for demand heterogeneity both across countries for the same variety and within a country between different varieties or firm-products. In other words, we introduce consumer preferences in which Heineken and Budweiser face a different demand in one particular destination market and at the same time Heineken and Budweiser also face a different demand in each country they are sold in. We extend quadratic preferences (1) to allow for this :

$$U_i = \int_{S_i} \alpha_s q_{s,i} ds - \frac{1}{2}\int_{S_i} \beta_{s,i} q_{s,i}^2 ds - \frac{\gamma}{2}\left(\int_{S_i} q_{s,i} ds\right)^2 + q_0. \tag{2}$$

The quadratic utility (2) differs from (1) by the fact that demand parameters $\alpha$ and $\beta$ are now included in the integral and have subscripts $s$ and/or $i$ that indicate that they are variety- and/or country-specific. To justify (2), we find it is important to offer a clear interpretation for the parameters and do so by discussing their micro-foundations in detail below. In particular, we will first argue that $\beta_{s,i}$ can be interpreted as a measure of consumer "taste mismatch" between the variety on offer and its ideal variety. As such, $\beta_{s,i}$ captures horizontal differentiation. Second, we argue that parameter $\alpha_s$ can be interpreted as a variety-specific vertical differentiation indicator, which raises the willingness-to-pay by consumers, and refer to it as "quality." The incorporation of both vertical and a horizontal differentiation in a novel and unprecedented way leads us to refer to the preferences in (2) as verti-zontal preferences.

### 2.2.1 The micro-foundations of taste mismatch

Important for the remainder is to show that $\beta_{s,i}$ can be interpreted as a *taste mismatch* between variety $s$ and country $i$'s consumers. To achieve this goal, we use a spatial metaphor based on the Hotelling (1929) model that has been used extensively in the industrial organization and marketing literature.

In Hotelling's spatial metaphor, consumers are located on a unit line segment with a shop located at each end. The consumer's location on the line determines the distance she has to walk to the shop where she buys one unit of a good. The distance travelled corresponds to the consumer's taste mismatch between her ideal variety, given by the consumer's location and the variety on offer in the shop. In Figure 1, we depict such a setting in which two varieties/shops, indexed $s = 1, 2$, are located at the endpoints 0 and 1. Normalizing the transport rate at 1, $\beta_1$ is the distance between the consumer and shop 1. In other words, a high (low) value of $\beta_1$ amounts to saying that the consumer is far from (close to) shop 1. The further the consumer is from the shop, the lower her utility from consuming the good, due to the disutility of traveling a long distance. Moreover, $\beta_2 = 1 - \beta_1 > 0$ is the distance between our consumer and shop 2. When preferences are symmetric, the consumer is located at $\beta_1 = \beta_2 = 1/2$.

We now show that this distance in the Hotelling spatial model corresponds with the parameter $\beta_{s,i}$ in the quadratic preferences. When preferences exhibit a love for variety as in (2), consumers may visit several shops and can buy several units (see Hart, 1985, and Chen and

Riordan, 2007) of different varieties of a good. To facilitate the analogy between the Hotelling model and the quadratic preferences in (2), we make a simplifying assumption where we limit the number of goods in (2) to two and where we assume that $\alpha_1 = \alpha_2 = \alpha$. Under this assumption, the consumer's willingness-to-pay (WTP) is equal to $\alpha$.

This allows us to draw an analogy between Hotelling's spatial model, where consumers are heterogeneous in one dimension, i.e. their location, and the preferences in (2) in which varieties can differ along several dimensions.

To explain this link we turn to Figure 1 and consider to what the new preferences in (2) correspond to. Assume first that a particular consumer $i$ on the line considers buying variety 1. The consumer located at $\beta_1$ is willing to buy variety 1 if her distance to shop 1 is smaller than $\alpha$. For this to happen, the interval $[1-\alpha, \alpha]$ must be non-empty. In other words, the WTP for the differentiated good must be sufficiently large. When $\beta_1 < \alpha$, the consumer visits shop 1.

While Hotelling's story stops here because consumers make mutually exclusive purchases, this is not the case in love-for- variety preferences. As long as $\alpha$ exceeds $1/2$,[9] there is a segment $[1-\alpha, \alpha]$ in which both $\alpha - \beta_1$ and $\alpha - (1-\beta_1)$ are positive for any $\beta_1 \in [1-\alpha, \alpha]$. Since consumers have a love for variety, consumer $i$ wants to visit both shops if she is located in the segment $[1-\alpha, \alpha]$. However, for this to happen, we must account that the consumer has already acquired one unit of the good so that her WTP is now shifted downward by $\gamma/2$. Therefore, the segment over which both shops are actually visited is narrower than $[1-\alpha, \alpha]$ and given by $[1-\alpha+\gamma/2, \alpha-\gamma/2]$. Consequently, when the consumer is located at $\beta_1 < 1-\alpha+\gamma/2$ ($\beta_1 > \alpha - \gamma/2$ ), she visits shop 1 (2) only, whereas she chooses to visit both shops when her location belongs to $[1-\alpha+\gamma/2, \alpha-\gamma/2]$. For this to be possible, however, this interval must be non-empty, that is, the condition

$$2\alpha > 1 + \gamma$$

must hold. This is so when the desirability of the differentiated good is high, the substitutability between the two varieties is low, or both. Conversely, it is readily verified that, regardless of her location, the consumer acquires a single variety if and only if

$$\gamma > 2\alpha - 1.$$

In other words, when varieties in (2) are very good substitutes, consumers choose to behave like in the Hotelling model: despite their love for variety, they visit a single shop because the utility derived from buying from the second shop is overcome by the cost of visiting this shop.

The foregoing argument shows how the spatial model can cope with consumers buying one or two varieties of the differentiated good and how consumers' decisions to buy one or two varieties are related to the taste mismatch with each variety. While we develop the example for two varieties on offer, this can be extended to any number of varieties. In particular, when consumers' ideal varieties are described by means of $n$-dimensional vectors with $n > 1$, it is readily verified that what we have said above can be extended by considering $n+1$ varieties in

[9] When $\alpha < 1/2$, a consumer located in the central area does not shop at all because both her desirability of the differentiated good is low and her taste mismatch is high. In the standard Hotelling framework, this corresponds to the case in which the price of the good plus the transport cost borne by the consumer exceeds her reservation price.

$R^n$.

Another interpretation of $\beta_{s,i}$ is related to the concavity of the variety-specific utility function. As the mismatch between variety $s$ and the consumer $i$'s ideal horizontal characteristics $\beta_{s,i}$ increases, it is natural to expect the consumer's marginal utility to decrease faster.

### 2.2.2 The micro-foundations of variety-specific quality

To better explain how we define vertical differentiation, we now simplify the preferences in (2) by considering again only two varieties whose degree of substitutability is captured by a parameter $\gamma > 0$, where a positive and finite $\gamma$ implies that varieties are imperfect substitutes entering symmetrically into preferences. Consider the example of a market $i$ with two varieties, $s$ and $r$. The utility of variety $s$ in market $i$ is now given by

$$u_{s,i} = \alpha_s q_{s,i} - \frac{\beta_{s,i}}{2} q_{s,i}^2 - \frac{\gamma}{2} q_{s,i} q_{r,i} + q_0 \tag{3}$$

where $q_{r,i}$ is the amount consumed of the other variety.

In this case, $\alpha_s - \gamma q_{r,i}/2$ is the marginal utility derived from consuming an arbitrarily small amount of variety $s$ when $q_{r,i}$ units of variety $r$ are consumed. This marginal utility varies inversely with the total consumption of the other variety because the consumer values less variety $s$ when her consumption of its substitute $r$ is larger. Note that the intercept is positive provided that the desirability of variety $s$ ($\alpha_s$) dominates the negative impact of the consumption of the other variety, $q_{r,i}$, weighted by the degree of substitutability between the two varieties ($\gamma$). As $q_{s,i}$ increases, the WTP of this variety decreases and variety $s$ is consumed as long as its WTP is positive.

The budget constraint is

$$p_{s,i} q_{s,i} + p_{r,i} q_{r,i} + q_0 = y_i$$

where $p_{s,i}$ and $p_{r,i}$ are the prices of varieties $s$ and $r$ respectively, and $y$ is income. Plugging the budget constraint in (3) and differentiating with respect to $q_{s,i}$ yields the inverse demand for variety $s$ in market $i$, the WTP of variety $s$ becomes

$$p_{s,i} = \alpha_s - \frac{\gamma}{2} q_{r,i} - \beta_{s,i} q_{s,i}. \tag{4}$$

Again, the WTP for variety $s$ is shifted downward to account for the fact that the two varieties are substitutes. The value of the shifter increases with the total consumption of the other variety ($q_r$) and the degree of substitutability ($\gamma$).

Following the literature in industrial organization, we now define two varieties as vertically differentiated when all the consumers view the vertical characteristics of variety $s$ as dominating those of variety $r$ (Anderson et al., 1992; Tirole, 1988). Therefore, in line with this definition, we say that varieties $s$ and $r$ are vertically differentiated when all consumers' *WTP for the first marginal unit of variety* $s$ exceeds that of variety $r$, i.e. $\alpha_s > \alpha_r$.

Because a higher $\alpha_s$ implies that the WTP increases regardless of the quantity consumed, $\alpha_s$ can be interpreted as an index of the "quality" of variety $s$. Since the WTP for a variety decreases with its level of consumption, an alternative definition would be to say that varieties $s$ and $r$ are vertically differentiated when $\alpha_s - \beta_{s,i}q > \alpha_r - \beta_{r,i}q$ for all $q > 0$. However, this definition overlaps with the very definition of the WTP that captures more features than vertical attributes. Furthermore, we will see that the equilibrium price of variety $s$ always increases with $\alpha_s$, which we find sufficient to express the idea that a higher quality variety is expected to be priced at a higher level.[10]

We are now equipped to understand how horizontal and vertical differentiation interact to shape consumers' demand. To see it, we return to Figure 1. By increasing $\alpha$, the interval $[1-\alpha+\gamma/2, \alpha-\gamma/2]$ of consumers buying the two varieties widens. Indeed, a variety displaying a higher quality level becomes more attractive to consumers, even those who have a pretty bad taste match with this variety. Conversely, a lower quality incentivizes some consumers not to buy anymore the second variety because the relative weight of horizontal differentiation (the taste parameter) in consumer behavior increases when $\alpha$ decreases.

Summing up, we find it fair to say that the preferences in our example in (3), which is the 2-variety case of (2), encapsulate both vertical ($\alpha_s$) and horizontal ($\beta_{s,i}$) differentiation features. By drawing a neat parallel between the taste parameter $\beta_{s,i}$ and the distance a consumer has to travel to a shop like in the Hotelling setting, we made it clear that a large value of $\beta_{s,i}$ corresponds to a bad match because of the longer distance one has to travel. Stated differently, when $\beta_{s,i}$ is large, the consumer's ideal variety is far from the actual variety. Note that our approach, like most models of monopolistic competition, abstracts from the issue of how product characteristics are determined.

### 2.2.3 The micro-foundations of substitutability between varieties

This brings us to the parameter $\gamma$, which captures the extent of product substitutability between the differentiated varieties in the product-market. The interpretation of $\gamma$ as a parameter of substitution becomes clearer looking at the utility provided by the consumption of a specific variety $s$:

$$u_{s,i} = \alpha_s q_{s,i} - \frac{\beta_{s,i}}{2} q_{s,i}^2 - \frac{\gamma}{2} q_{s,i} \left( \int_{S_i} q_{r,i} ds \right) + q_0.$$

where $\gamma$ measures the direct substitutability between variety $s$ and any other variety $r \neq s$: a higher $\gamma$ means that varieties are closer substitutes, and thus the consumption of other varieties reduces the additional utility of consuming one more unit of variety $s$.

Allowing $\gamma$ to vary across pairs of varieties would require measuring the level of substitutability for each and every pair of varieties in the market, while analytically feasible, is empirically problematic. Therefore we prefer working with a specification in which $\gamma$ is constant and captures product-substitutability common to all varieties in a product-market. Parameter $\beta$, which is variety-specific, then captures the amount of horizontal differentiation that remains after subtracting the substitutability between variety-pairs. Indeed, the specification used in (1) for the quadratic utility differs from earlier versions such as the one used by Ottaviano, Tabuchi and Thisse (2002) in which the parameters $\beta^*$ and $\gamma$ stem from a multi-variety generalization of a

[10]Observe that the approach in (1) implies that quality is intrinsic to a firm, as in Aw, Batra and Roberts (2001) and Foster, Haltiwanger and Syverson (2008). In addition, we allow quality to vary with variety $s$, which corresponds to a firm-product combination.

two-variety quadratic utility:

$$U = \alpha \sum_{i=1}^{n} q_i - \frac{\beta^* - \gamma}{2} \sum_{i=1}^{n} q_i^2 - \frac{\gamma}{2} \left( \sum_{i=1}^{n} q_i \right)^2 + q_0.$$

Therefore the parameter $\beta$ used in Melitz and Ottaviano (2008) is the equivalent of $\beta^* - \gamma$ in Ottaviano et al. where $\beta^* > \gamma$. This implies that the parameter $\beta$ in (1) can be seen as capturing (common or idiosyncratic) horizontal differentiation of varieties net of the substitutability between varieties. Hence, $\beta_s$ is the asymmetric part of variety differences to consumers. Thus, even when products are close substitutes, which pushes demand inwards for each variety, strong local taste for one particular variety offsets this and rotates demand outward but only for the variety with the strong local taste (the home-bias phenomenon, for example).

In terms of our example, this amounts to saying that Heineken and Budweiser are equally good substitute products in every market where both are sold, but allowing Heineken and Budweiser to enter consumer preferences differently in every market they are sold in. The benefits of keeping $\gamma$ constant will became clearer when we will discuss competition effects.

### 2.3 Consumer optimization

Let us now proceed with the maximization of the utility in (2). The corresponding budget constraint is

$$\int_{S_i} q_{s,i} p_{s,i} ds + q_0 = y.$$

Plugging this constraint in (2) and differentiating with respect to $q_{s,i}$ yields the inverse demand for variety $s$:

$$p_{s,i} = \alpha_s - \frac{\gamma}{2} Q_i - \beta_{s,i} q_{s,i} \tag{5}$$

where $Q_i$ is the total consumption in country $i$ of the differentiated good which acts as a demand shifter for an individual variety, and $\alpha_s$ also shifts the intercept of the inverse demand and $\beta_{s,i}$ affects its slope.

Using (5), we readily see that the demand for variety $s$ in country $i$ may be written as follows:[11]

$$q_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta_{s,i}} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \gamma \mathbb{N}_i)} \tag{6}$$

where

$$\mathbb{N}_i \equiv \int_{S_i} \frac{ds}{\beta_{s,i}} \qquad \mathbb{A}_i \equiv \int_{S_i} \frac{\alpha_s}{\beta_{s,i}} ds \qquad \mathbb{P}_i \equiv \int_{S_i} \frac{p_{s,i}}{\beta_{s,i}} ds. \tag{7}$$

Thus, like in most models of monopolistic competition, the demand for a variety (6) depends on a few *market aggregates*, here three (Vives, 2001), which are market-specific. Using the spatial interpretation of $\beta_{s,i}$ given above, it is straightforward to see $1/\beta_{s,i}$ in (7) as a measure of the proximity of variety $s$ to country $i$'s representative consumer's ideal. Consequently, a group of substitute varieties $r$ characterized by small (large) values of $\beta_{r,i}$ have a strong (weak) impact

[11] In a model with a varying number of identical consumers per country, $q_{si}$ equals the per capita consumption times the number of identical consumers.

on the demand for variety $s$ in country $i$ because the representative consumer is (not) willing to buy much of them, as she (dis)likes its horizontal characteristics. This explains why $\beta_{s,i}$ appears in the denominator of the three aggregates, $\mathbb{N}_i$, $\mathbb{A}_i$ and $\mathbb{P}_i$. Note also that (6) does not depend on income. We discuss in the appendix how our model can cope with income differences.

Each variety is weighted by the inverse of its taste mismatch $\beta_{s,i}$ to determine the *effective* mass of varieties, given by $\mathbb{N}_i$. It is $\mathbb{N}_i$, and not the unweighted mass of varieties $N_i$, which affects the consumers' demand for a given variety. Indeed, adding or deleting varieties with bad taste matches does not affect much the demand for the others, whereas the opposite holds when the match is good. Note also that the effective mass of varieties $\mathbb{N}_i$ may be larger or smaller than the unweighted mass of varieties $N_i$ in the product market, according to the distribution of taste mismatches. Similarly, the quality and price of a variety are weighted by the inverse of its taste mismatch to determine the effective quality index $\mathbb{A}_i$ and the effective price index $\mathbb{P}_i$. In particular, varieties displaying the same quality (or price) may have very different impact on the demand for other varieties according to their taste mismatches. The three aggregate indices in (7) show that taste heterogeneity affects demand and, therefore, the market outcome. In addition, two different markets are typically associated with two different $\beta$-distributions. The nature and intensity of competition may then vary significantly from one market/country to another, even when the same range of varieties is supplied to both and market/country sizes are the same.

This clearly offers new insights into competition effects. Based on the standard quadratic utility given in (1), country size determines the number of varieties and, therefore, the competition effects. Allowing for consumer heterogeneity and asymmetric preferences across countries, as we do here, adds another dimension of competitiveness, especially taste mismatch and quality. In Melitz and Ottaviano's (2008) type of models two countries of similar size and GDP would have competition effects that are identical. Under the system of preferences we present here, this will not be the case, i.e., it will also depend on the quality of the varieties on offer and on their interaction with local preferences. Even with the same market size, the same number of firms, and the same quality on offer, this could still result in two different competition effects because in one country one set of varieties match better local taste than the others.

The above discussion shows that it is possible to introduce consumer heterogeneity across varieties in demand. This new set of preferences can potentially generate a large array of new effects. The demand for a variety $s$ now depends on its own horizontal and vertical attributes, but also on the effective mass of competing varieties present in market $i$ ($\mathbb{N}_i$), on the aggregate effective quality present in market $i$ ($\mathbb{A}_i$) as well as on the effective price index in $i$ ($\mathbb{P}_i$). The interplay between these three aggregate indices determine how a particular firm meets the competition in a particular country $i$.

Note, finally, that (6) implies that the total mass of varieties consumed in country $i$ is given by

$$Q_i = \frac{\mathbb{A}_i - \mathbb{P}_i}{1 + \gamma \mathbb{N}_i} \tag{8}$$

which shows once more how the utility of a variety depends on the distribution of the taste parameter $\beta_{s,i}$ since all the aggregate indicators enter into $Q_i$ which can be seen from (8). Incidentally, note that the definition of $Q_i$ corresponds to the second term in the right-hand side of (6), where is weighted by the ratio $\gamma/\beta_{s,i}$. Thus, the larger $Q_i$, the stronger the competition that each variety $s$ faces and the smaller its individual demand. For example, competition effects in a market are stronger whenever the aggregate quality $\mathbb{A}_i$ in the destination market is higher. As a result, if the aggregate quality in market $i$ goes up this will reduce the demand for each variety exported to that market. This may lower the willingness-to-pay for a particular variety by so much that the choke price of this variety falls below its costs, thus driving the variety out of this market. This channel of firm-product exit was hitherto missing in models where the level of quality in a market was not included in the competition effects and, therefore, could not affect the exit of products.

Standard definitions of horizontal and vertical differentiation exist only for indivisible varieties and with consumers making mutually exclusive choices, which characterizes models guiding much of the empirical work in industrial economics (Sutton, 2012). But these concepts until now were largely absent in models guiding empirical work in trade. Therefore, we consider the verti-zontal preferences particularly useful for those researchers who are interested in measuring and distinguishing horizontal (taste) from vertical (quality) attributes in trade. In contrast, in the standard quadratic utility, the common $\beta$ assigned to all the varieties affects both price and quantity sold of each variety, which makes it difficult to interpret it as a true parameter of horizontal differentiation. With the new and richer set of preferences introduced here, that distinction can now be made more clearly.

The utility being quasi-linear, the above expressions do not involve any income effects. However, this does not mean that income effects can not be dealt with. In the Appendix we show how income differences across markets can be incorporated. Whereas the approach we follow here can deal with income differences across markets, it cannot deal with income inequality within a market.

# 3 Firm optimization and market outcome

In this section, we consider the profits of firms selling a particular variety $s$ to market $i$. The costs of producing each variety are heterogeneous and so are their vertical and horizontal attributes. Firms in the model can be thought of as exporters of a particular country of origin shipping products to destination countries indexed by $i$. Each of these destination markets is characterized by a different set of market aggregates ($\mathbb{N}_i$, $\mathbb{A}_i$ and $\mathbb{P}_i$), which are all weighted by the destination-specific taste distribution.

## 3.1 Profit maximization

The operating profits earned from any variety $s$ can be written as follows:[12]

$$\Pi_{s,i} = (p_{s,i} - c_s)q_{s,i}$$

[12]Since our model deals with heterogeneity at a firm-product level, firms can be either single product or multi-product. As in Bernard, Redding and Schott (2011), we assume that each firm-product has a different marginal cost which is constant but independent of each other. We leave more complex multi-product issues such as cannibalization and core competencies, as in Eckel and Neary (2010) and Mayer, Melitz and Ottaviano (2012) respectively, for future research.

where the parameter $c_s$ is the marginal production cost of variety $s$, whereas $q_{s,i}$ is given by (6). Note that in this model $q_{s,i}$ and $p_{s,i}$ differ according to the destination country the firm exports its variety to. Differentiating the profit expression with respect to $p_{s,i}$ yields:

$$p^*_{s,i}(\mathbb{P}_i) = \frac{\alpha_s + c_s}{2} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{2(1+\gamma\mathbb{N}_i)} \tag{9}$$

where for simplicity transport costs are not introduced, but the argument can be easily extended to include such costs without affecting our results. The natural interpretation of (9) is that it represents firm $s$' best-reply to the market conditions. These conditions are defined by the aggregate behavior of all producers, which is summarized here by the price index $\mathbb{P}_i$. The best-reply function is upward sloping because varieties are substitutable: a rise in the effective price index $\mathbb{P}_i$ relaxes price competition and enables each firm to sell its variety at a higher price. Even though the price index is endogenous, $\mathbb{P}_i$ is accurately treated parametrically by firms because each variety is negligible to the market. In contrast, $\mathbb{A}_i$ and $\mathbb{N}_i$ are exogenously determined by the distributions of quality and tastes over $S_i$. In particular, by shifting the best reply downward, a larger effective mass $\mathbb{N}_i$ of firms makes competition tougher and reduces prices. Similarly, when the quality index $\mathbb{A}_i$ rises, each firm faces varieties having in the aggregate a higher quality, thus making the market penetration of its variety harder. Thus, through market aggregates determined by the asymmetric distribution of varieties, we manage to reconcile weak interactions under monopolistic competition with several of the main features of Hotelling-like models of product differentiation.

Integrating (9) over $S_i$ shows that the equilibrium price index can be expressed in terms of three aggregate market indices, $\mathbb{N}_i$, $\mathbb{A}_i$ and $\mathbb{C}_i$:

$$\mathbb{P}^*_i = \mathbb{C}_i + \frac{\mathbb{A}_i - \mathbb{C}_i}{2+\gamma\mathbb{N}_i} \tag{10}$$

where the cost index $\mathbb{C}_i$ is defined as follows:

$$\mathbb{C}_i \equiv \int_{S_i} \frac{c_s}{\beta_{s,i}} ds.$$

Hence, as in the other market indices, varieties' costs are weighted by the taste distribution in the country of destination. The interpretation is that efficiently produced varieties may have a low impact on the cost index when they have a bad match with this consumer's ideal. Note also that $\mathbb{A}_i$ affects prices positively, even though it affects each individual variety's price negatively. In words, this implies that an increase in aggregate quality in a market raises price levels, but makes it harder for an individual variety to survive.

### 3.2 Market equilibrium

Plugging (10) into (9), we obtain the (absolute) markup of variety $s$:

$$p^*_{s,i} - c_s = \frac{\alpha_s - c_s}{2} - \mathcal{T}_i \frac{\tilde{a}_i - \tilde{c}_i}{2} \tag{11}$$

where $\tilde{a}_i$ is the average effective quality in country $i$ of varieties present in this country and $\tilde{c}_i$ is the average effective marginal production cost of the varieties present in market $i$, be they domestically produced or imported:

$$\tilde{a}_i \equiv \mathbb{A}_i/\mathbb{N}_i \qquad \tilde{c}_i \equiv \mathbb{C}_i/\mathbb{N}_i$$

where

$$\mathcal{T}_i \equiv \frac{\gamma \mathbb{N}_i}{2 + \gamma \mathbb{N}_i} \in [0, 1] .$$

The parameter $\mathcal{T}_i$ reflects the toughness of competition in country $i$, which can make the equilibrium price range from perfect competition to pure monopoly. This is an important additional feature of the preferences presented in this paper: it offers the possibility of studying market structures with varying levels of toughness of competition in trade models. To see this, consider the following example. When $\gamma N_i$ is arbitrarily small, which means that variety $s$ has only poor substitutes in country $i$, each variety is supplied at its monopoly price because $\mathcal{T}_i \to 0$. On the other hand, when $\mathcal{T}_i \to 1$, the market is crowded with many good substitutes, which means that market outcome converges toward perfect competition. The benefits of assuming that $\gamma$ is the same between any pair of varieties are reaped by capturing the intensity of competition on a particular market through $\mathcal{T}_i$. In addition, the toughness of competition may vary from one country to another because $\mathcal{T}_i$ depends on the effective mass of competing varieties in each country, which depends itself on the country-specific taste distribution.[13]

Furthermore, as expected, the markup (11) increases (decreases) with $\alpha_s$ ($c_s$). More importantly, it also increases (decreases) with $\tilde{a}_i$ ($\tilde{c}_i$). Hence, when varieties available in country $i$ have a high quality and a good match with country $i$'s consumer tastes, the price at which variety $s$ can sold in country $i$ is very low. By contrast, when the same varieties have a bad match, variety $s$ can be sold at a high price. The same holds for the marginal production costs. Therefore, quality is not enough for a variety to be successful on a specific market. What (11) tells us is that the markup of a specific variety is strongly affected by the way competing varieties meet consumers' tastes in country $i$.[14]

Last, suppose that the average effective quality $\mathbb{A}_i/\mathbb{N}_i$ increases by $\Delta > 0$. Then, if the quality upgrade $\Delta_s$ of variety $s$ is such that

$$\Delta_s > \mathcal{T}_i \Delta$$

then its price will increase, even though the quality upgrade $\Delta_s$ may be lower than $\Delta$. In contrast, if the quality upgrade of variety $s$ is smaller than $\mathcal{T}_i\Delta$, then its markup and price will decrease, even though the quality upgrade $\Delta_s$ is positive. Thus, what matters for the "competitiveness" of a firm is its relative quality at the level of the product market.

[13]This parameter can be nicely related to the existence of different price ranges across sectors observed by Khandelwal (2010). Noting that each variety is characterized by an idiosyncratic quality and cost parameter, we can show that, paraphrasing Khandelwal, it is *the length of the markup ladder* that varies across sectors in our model: the tougher the competition, the shorter the ladder.

[14]A model with varying markups at firm-product level and incomplete pass-through seems warranted, given the strong empirical evidence on this as in De Loecker, Goldberg, Khandelwal and Pavcnik (2012).

From (11) we can obtain the price equation:

$$p_{s,i}^* = \frac{\alpha_s + c_s}{2} - \mathcal{T}_i \frac{\tilde{a}_i - \tilde{c}_i}{2} \tag{12}$$

Note from (12) that higher quality results in higher prices, but the opposite need not hold. Prices can rise for other reasons such as higher costs or lower competition. This points at the need to complement unit values with cost controls to properly measure quality at the product level, which is not always possible without access to firm-level information.[15]

Note also that the first term of (12) is variety-specific (the parameters are all indexed $s$). These variety-specific determinants of prices and per-capita quantities, such as cost and quality, do not vary by destination market and influence prices and quantities in a similar way in all countries. However, the second term in (12) is not variety-specific but depends on market aggregates that are identical for all the varieties sold in a particular market $i$. Since these indices are country-specific variables (all indexed $i$) we refer to the second term in (12) as a *market effect*.

Using the properties of linear demand functions, we readily verify that the equilibrium output of each variety is given by

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} \left( \frac{\alpha_s - c_s}{2} - \mathcal{T}_i \frac{\tilde{a}_i - \tilde{c}_i}{2} \right). \tag{13}$$

The first term in parentheses on the right-hand side of (13) is variety-specific, whereas the second term shows that quantities shipped can differ across geographical markets due to a market effect (variables indexed by $i$) that is common to all the varieties present in $i$. But notice that the entire expression in brackets is weighted by the taste parameter $\beta_{s,i}$, which is variety and country specific turning (13) into a non-linear expression. The equilibrium quantity equation (13) can be rewritten as a function of its price:

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} (p_{s,i}^* - c_s).$$

Combining (12) and (13) provide us with a description of the market outcomes predicted by our model in terms of the export price and quantity of a variety shipped by a firm to the destination market $i$. The quantity exported $q_{s,i}^*$ differs depending on the characteristics of the destination market, which are captured here by a series of effective market aggregated indices. Important to realize is that even when markets are identical in terms of their size and the number of varieties sold, they can still have very different demand for a firm's product due to the taste differences (distribution of $\beta_{s,i}$) of heterogeneous consumers in different countries.

The market effect implies that fob prices can differ depending on destination markets through the $\beta$-weighted market aggregates. However, $\beta_{s,i}$ does not enter the price equation (12) directly, whereas it does enter directly in the equilibrium quantity equation (13).[16] This is important for

[15] Several country-product level studies use unit values without cost controls as a measure of quality as in Hallak (2006) and Hallak and Schott (2011).

[16] The parameter $\beta$ does not enter prices because firms in their profit maximization trade-off setting a higher price when taste is strong and having smaller sales, to setting a price independent of taste but getting a large

several reasons. First, it offers an opportunity for the identification of parameters $\alpha_s$ and $\beta_{s,i}$ based on the fact that taste affects directly quantities but not prices. Second, it confirms the interpretation of the parameter $\beta_{s,i}$ as capturing horizontal differentiation. Also, where the price equation (12) is a linear and separable equation, the quantity equation (13) is not. The reason is that $\beta_{s,i}$ is both market- and variety-specific. This difference offers an easy way to contrast the predictions of the standard quadratic utility with the ones arising here, which is what we will pursue in the empirical section.

Note that the equilibrium price of variety $s$ is independent of $\beta_{s,i}$ because the price elasticity is independent of this parameter:

$$\epsilon_{s,i} = -\frac{p_{s,i}}{\alpha_s - \gamma Q_i - p_{s,i}}.$$

The elasticity ranges from 0, when $p_{s,i} = 0$, to $-\infty$, when prices equal the intercept of the inverse demand function, $\alpha_s - \gamma Q$. Since $\beta_{s,i}$ does not affect $\epsilon_{s,i}$ , it has no impact on $p_{s,i}$. However, the whole $\beta$-distribution matters because it influences the equilibrium value of $Q_i$.

We summarize those results as follows.

**Proposition 1** *Equilibrium* ***prices*** *depend on variety-specific cost and quality as well as on the market-specific degree of competitiveness. Market effects, which can be captured by taste-weighted price, quality and cost indices as well as by the effective mass of competitors, vary with the destination country, but are common to all varieties exported there. Thus, export prices of the same variety across countries only vary through market-specific effects.*

**Proposition 2** *Equilibrium* ***quantities*** *(sales) depend on market-specific and variety-specific tastes. Thus, export quantities of the same variety across countries shows additional variability, as compared to prices, because of idiosyncratic tastes.*

These propositions imply that export prices are explained by a combination of firm characteristics ($s$) and market characteristics ($i$), whereas we expect this to be less the case for quantities (sales). On the one hand, variety (firm-product) characteristics are the same no matter where a variety is exported to, so they should not account for the variability in prices of the same variety across markets, but they should account for differences between varieties exported to the same market. On the other hand, market characteristics should account for most of the variability of prices of the same variety sold into different markets. When considering several varieties jointly, we would expect the combination of firm-product characteristics, which account for variety heterogeneity in costs and quality, and market characteristics to be important and to give a high goodness-of-fit for prices, but a much lower goodness-of-fit for quantities (sales). This is what we will explore in the next section.

We assume that transport costs are the same for any variety of a product exported from the same country of origin to the same destination, which seems plausible. Empirically, transports costs will be captured by product-destination specific dummies. This property is useful for

market share when taste is strong.

researchers with firm-product-country data from one country of origin, as we do for Belgium.[17]

# 4 Evidence on consumer heterogeneity

Our purpose is not to test the model, but to engage in a first exploration of the data to see if the facts are congruent with the theory. More precisely, we are interested to see whether the data are more supportive of the standard quadratic utility or seem to warrant the inclusion of consumer heterogeneity. A distinctive feature of standard quadratic utility is the linearity of the equilibrium price and quantity expressions. However, this is no longer the case when allowing for verti-zontal preferences. Introducing consumer heterogeneity in quadratic utility results in a non-linear expression for quantities, driven by the presence of variety-country specific idiosyncratic taste, which can be seen from (13). This is not the case for the price equation where the taste parameter does not enter directly. Thus a simple test where we approximate firm-product variation and country variation through a set of dummies for each is expected to perform very well in the case of standard quadratic utility, but is expected to show much less explanatory power in the case of verti-zontal preferences in explaining quantity variation across countries.

Notice that with the data at hand we can combine a product category at 8-digit level, say beer, with a firm- identifier such that beers can be distinguished from one another by the firm they are exported by. These firm-product varieties then enter consumer preferences differently. One limitation trade researchers face is that even when using very detailed product classifications as we do in this section, we cannot exclude the possibility that there may still be heterogeneity within the product category that cannot be observed. While most 8-digit products have a precise description, for some products this is less the case. But what is important to keep in mind is that by linking the product to a firm, in what follows, consumer preferences are now allowed to differ between the various firm-product combinations available on the market.

## 4.1 Data

We use a unique dataset on trade flows of Belgian exporters. The data is composed of fob (free on board) export prices and quantities by destination market at the firm-product level, which are obtained by dividing values by quantities expressed in kilograms. This allows us to compare prices and quantities of the same firm-products across destination markets as well as prices and quantities of different firm-products within the same destination market. The Belgian export data are obtained from the National Bank of Belgium's Trade Database and are a cross-section of the entire population of recorded annualized trade flows at the firm level by product and destination. Exactly which trade flows are recorded (i.e. whether firms are required to report their trade transactions) depends on their value and destination. For extra-EU trade, (trade partner outside the EU borders), all transactions with a minimum value of 1,000 euros or weight of more than 1,000 kg have to be reported. For intra-EU trade, (trade partner inside the EU borders) firms are only required to report their export flows if their total annual intra-EU export

[17]Variation in fob export prices under verti-zontal preferences is attributed to varying competition effects in the countries of destination. With standard CES preferences, fob export prices only vary by distance, if specific transport costs are assumed, as shown by Hummels and Klenow (2005) and Martin (2012).

value is higher than 250,000 euros. The products are recorded at 8-digit Combined Nomenclature (CN8).

Due to its hierarchical nature, all products expressed as CN8 are also classified as products at more aggregated levels. For firms with primary activity in manufacturing, the data includes over 5,000 exporters and over 7,000 different CN8 products, resulting in more than 60,000 firm-product varieties (firm-product combinations at the CN8 level) exported to 220 destination markets in a total of almost 250,000 observations in one year. We use cross-sectional export data for the year 2005 from manufacturing firms and for which both values and weights are reported.

### 4.2 Goodness-of-fit

From the price equation in (12) it arises that in equilibrium firm-product quality and cost affect prices in a similar and linear way. So, even without identifying quality and without disentangling quality and cost, a simple OLS regression of export prices on firm-product dummies is expected to capture this variation and to explain an important part of the price data. Since cost and quality are variety-specific, firm-product dummies should account for that. According to our model, the other determinants of export prices are all market effects indexed by $i$ in (12) that affect all varieties (firm-CN8) competing in the same product market (country-CN8) in the same way and also enter the price equation in a linear way. Hence, based on the theory, the joint inclusion of firm-product and country-product dummies is expected to yield a good fit in a regression on individual firm-product prices.

But the same set of variables is expected to perform less well in explaining variation of per capita quantities across markets.[18] This becomes apparent from equation (13). Quantities are not just a function of firm-product cost and quality and country-level competition effects, but are also determined by idiosyncratic taste ($\beta_{s,i}$) that makes the quantity equation in (13) a non-linear one.

Therefore, based on the model we would expect a substantially lower goodness-of-fit when regressing variety-specific dummies and destination market-specific dummies on individual firm-product prices then on quantities ($y_{s,i}$) as in the following:

$$y_{s,i} = \delta_0 + \delta_1 Firm\_Product_s + \delta_2 Country\_Product_i + \epsilon_{s,i} \tag{14}$$

In the regressions we use alternatively price ($p_{s,i}$) and quantity ($q_{s,i}$) level data as dependent variables. In the data we include the most important destination markets for Belgian exports that guarantee a sufficiently high number of varieties present in all markets. This is shown in Table 1, where we list the destination countries and the number of Belgian varieties exported to each.[19] To deal with outliers we drop the one percentage tails of both the price and quantity

[18] We use per capita quantities in order is to get rid of market size effects. We divide quantities exported by the population size of each destination country.

[19] We rule out selection issues by only considering overlapping markets, i.e., markets in which all the varieties considered are simultaneously present, which allows us to compare prices and quantities in these markets. While this significantly limits the number of observations, it avoids selection issues side-stepped in the theory.

distributions. In the year 2005, this results in 5,616 cross-sectional observations.

INSERT TABLE 1 HERE.

Before discussing the results, the question can be raised how our predictions differ from those of models using standard quadratic utility preferences. Without consumer heterogeneity, demand is identical and costs are the only firm-specific component affecting prices and quantities. In such a framework, both the price and the quantity expressions are directly influenced by the same set of parameters, including $\beta$, which affects equally all the varieties. The prediction arising from a model without consumer heterogeneity is that both the prices and the quantity regression would give an *equally similar* goodness-of-fit.

With consumer heterogeneity, prices are not affected by taste differences, but quantities are affected in a non-linear way. Thus, with consumer heterogeneity, we expect a linear OLS regression on a specification as in (14) to give *a much lower* goodness-of-fit for the quantity equation than for the price equation. This seems to be confirmed by the results reported in Table 2.

Results show that in all specifications considered, the price regressions have a systematically higher $R^2$ than the one associated with the corresponding quantity regressions. The goodness-of-fit in the price regressions averages around 70 percent while for the quantity regressions the average is closer to 40 percent. While there is no systematic test statistic for differences in $R^2$, Table 2 reports results for many different specifications, does seem to suggest a consistently lower goodness-of-fit for quantities.

The specifications listed in Table 2 differ from each other depending on the size of the product-market that we consider (CN8, CN6, CN4, CN2). It is however important to note that in each specification, varieties are defined as firm-CN8 combinations. The narrowest product market definition is at the CN8 level. In this case the right-hand side variables in (14) consist of firm-product (CN8) dummies as well as country-product (CN8) dummies. The most broadly defined product market in our analysis is at the CN2 level. In that case we consider all firm-CN8 combinations belonging to the same CN2 product category as one product market. The right-hand side variables in (14) then become firm-product (CN8) dummies together with country-product (CN2) dummies. We also perform a similar type of analysis at CN6 and CN4 level.

The specifications listed in Table 2 also differ depending on whether we consider quality and cost to vary mostly at firm, firm-product or at product-level. In the theory we assumed that quality and unit cost are intrinsic to a variety, which corresponds to assuming that most of the heterogeneity in them is at the firm-product level. This was convenient since it allowed us to make predictions independent of the single or multiple product nature of firms. Empirically, however, this needs to be verified.

We start by including firm-fixed effects (column 1) to see how much data variation in prices and quantities is explained by firm heterogeneity. Put differently, including firm-fixed effects is consistent to assuming that cost and quality differences are small between products of the same firm, but are large between products of different firms. But results in column (1) do not confirm this assumption. The inclusion of firm-fixed effects alone explains less than half of the variation for prices and quantities (column 1).

If instead, we include firm-CN8 fixed effects, as we do in column 3, the explained variability substantially increases for prices, which are not subject to idiosyncratic variability. This allows for at least two important inferences. First that in multi-product firms, quality and unit cost of individual varieties differ quite a lot, which justifies a theoretical approach that allows demand to vary by firm-product, rather than by firm. Second, the inclusion of parallel demand shifters at firm-product level significantly raises the explained variation in fob export prices across destinations but much less so of quantities. This is in line with what we would expect based on the theory. In linear demand, prices are affected by cost and intercept shifters but not by slope shifters, while quantities are additionally affected by slope shifters not captured by firm-product dummies.

Similarly, the inclusion of a product fixed effect (column 2) instead of a firm-product one (column 3) also results in much lower variability explained in both the price and quantity regressions. This confirms that firm heterogeneity in quality and cost is important and that firm-characteristics explain much of the variation in price and quantity of the same product (CN8) across markets.

Therefore our preferred specifications account for the variety-specific components in prices and quantities through firm-product fixed effects. To additionally account for market effects, in columns (4) to (7) we complement firm-product dummies with country-product dummies for varying levels of product-market aggregation. The finer the product-market definition, the better the goodness-of-fit. For example, in column (4) where we include country-CN2 dummies, the variability in prices explained is 71 percent while that in quantities is 53 percent. In column (7) where country-CN8 dummies account for the market effect, the variability explained for prices is 87 percent while that of quantities is 76 percent.

INSERT TABLE 2 HERE.

### 4.3 Does geography matter?

A legitimate concern is whether our results are not driven by the fact that the most important trading partners included in our analysis thus far are European, which may have a dampening effect on price differences. If the high goodness-of-fit in the price regressions is the result of arbitrage or lack of border controls, this would drive the results. Therefore, as a consistency check, we investigate whether a country selection allowing for more heterogeneity could affect our results. We do so by looking at pairwise price and quantity correlations in a set of heterogeneous and remote countries (Australia, Brazil, Canada, China, India, Japan, South Africa, Turkey, and US)[20] together with the three main trading partners of Belgium (France, Netherlands and Germany). For this exercise, we consider only pairwise correlations instead of a fully-fledged regression because not enough varieties are exported to all the markets considered, so the $R^2$

[20]The criteria for choosing these countries included a maximum distance from Belgium, including as many different continents as possible and conditioning on the fact that countries received the same set of varieties exported from Belgium.

would be inflated by the presence of many dummies capturing individual observations. To make the price correlations and the quantity correlations meaningful and to avoid potential selection issues we consider varieties that are shipped to all the countries considered. This results in 87 varieties and 1,044 observations.[21]

In Figure 2 we illustrate the results of the pairwise correlations graphically by plotting rank-correlation pairs for the exported varieties both for prices and quantities, sorting them by decreasing quantity rank correlation. The square dots refer to bilateral price rank correlations between any pair of destination markets for the same set of firm-product varieties exported from Belgium to both destinations. It can be noted that these pairwise correlations all lie around 90 percent which is the average of all the bilateral price rank correlations considered and is indicated by the solid line at the top of Figure 2. This again confirms Proposition 1 according to which destination market competition effects result in varying fob export price-levels per firm-product. Competition effects act as a demand shifter for all varieties shipped to the same destination (the second term on right-hand side of (12)) but will not affect will not affect the price rankings of varieties within destination markets, which is confirmed by the high price correlation that we find. Prices are also determined by firm-product specific factors such as cost and quality that are intrinsic to the product and do not vary by destination market (the first term on RHS in (12)). Therefore, we would expect stable price rankings amongst a set of varieties exported even when the destination markets are remote and heterogeneous compared to the country of origin.

In contrast, the bilateral quantity ranking correlations given by the triangle dots in Figure 2, can be as low as 50 percent as indicated by the dashed horizontal line segment, which is what we expect on the basis of Proposition 2. The four most correlated country pairs in terms of quantity ranks correspond to the three EU member states considered (France, Netherlands and Germany) and Turkey, a candidate EU member country. All the other quantity correlations are lower than price correlations in a statistically significant way at a 1 percent confidence level. Of all the countries included, the ones with the highest pairwise quantity rank correlations are the three European countries. Given that the regressions in (14) include exclusively European destinations, this may have underestimated the real difference between price and quantity regularity across markets yielding results which go against our modeling choices. This can clearly be seen from Figure 2 where EU countries are circled. Figure 2 thus suggests that taste differences are smallest in the three EU countries included, which seems quite plausible given their proximity. As such, the evidence in Figure 2 also refutes an alternative explanation in which measurement error in quantities would be the sole driver of stronger quantity variability. Based on such an explanation, there would be no reason to expect a difference in quantity based on countries' geographical location or distance from the country of origin. Whereas based on the theory we put forward here, stronger quantity correlation in nearby countries can easily be attributed to stronger taste similarity, which seems a more plausible explanation.

[21] For correlation results on a much broader set of countries and products, we refer to Di Comite, Thisse and Vandenbussche (2011). There we demonstrate that the lower quantity correlation is independent of which set of countries or products is taken.

# 5 Conclusions

This paper departs from standard specifications of preferences used in trade models by enriching the demand side. We deviate from the assumption that all substitute varieties within a differentiated product market face the same demand, and instead we allow for two important aspects of consumer heterogeneity. First, substitute varieties sold in the same geographical market are allowed to be vertically differentiated as well as to have a different match with local consumers' tastes. Second, the same variety sold in different destination markets is allowed to face a different demand depending on the interactions between local tastes and competition effects. The combination of these two dimensions of consumer heterogeneity results in a tractable framework in which taste heterogeneity interacts with cost heterogeneity and vertical differentiation. We call it a verti-zontal model to stress its vertical and horizontal attributes.

An important prediction arising from consumer heterogeneity is that firm-product-country exports can be idiosyncratic and display additional variability even after controlling for firm-product specific productivity and parallel demand shifters. Detailed firm-product-country data for Belgian exporting firms confirm this prediction, which the model rationalizes as the outcome of taste differences unrelated to market size or aggregate income. This missing source of variation cannot be rationalized by Melitz and Ottaviano (2008) nor any other type of preferences used in models based on productive efficiency but can be captured by the new set of preferences we propose here. When empirically controlling for market size differences, we still find quantity variation, which the theory we put forward rationalizes as taste differences.

However, we do not claim that taste heterogeneity is the only possible explanation for the firm-product sales variation across countries. For that we would have to distinguish consumer taste from other potential sources of quantity variability which is not pursued here. Future research should be aimed at disentangling taste effects from other explanations put forward recently such as variation in distribution networks (Arkolakis, 2010) or demand build-up over time (Foster, Haltiwanger, Svyerson, 2012), which calls for a more dynamic analysis using panel data. This may however prove difficult as these alternative explanations may be highly correlated with taste factors, which are less directly observable. All that we claim here is that consumer heterogeneity can rationalize the data as a potential source of quantity variation.

An evident next step is the empirical identification of demand parameters involved in the verti-zontal model such as the identification of the quality and taste parameters. This calls for an external validation similar to the approach in Crozet, Head and Mayer (2012). They use an external quality classification of champagne to calibrate the productivity and quality parameters using CES preferences.

The advantage of deriving quality and taste measures from the model is that such measures would then become available for a much wider set of product markets including those for which external quality indicators do not exist. Empirical identification of quality measures can also be used to strip price indices from quality changes and to get better estimates of GDP growth indicators as currently also pursued by Feenstra and Romalis (2012) using a different model.

Note, finally, that we are not the first to point out the importance of demand effects. Based on French firm-level evidence, Eaton, Kortum and Kramarz (2011) report variation in the sales performance of the same firms in different markets, thus suggesting the existence of an additional source of variability on the demand side. This implies that firm efficiency, while important, is not the only determinant of sales variation across countries. Brooks (2006), using Colombian export data, makes a similar point. Also, Kee and Krishna (2008) find that the correlation between firm-level sales of Bangladeshi firms in different destination markets is close to zero. While other explanations may be congruent with these findings, taste differences offers a plausible and additional explanation for an empirical regularity hitherto not well understood and should be further examined to clean it from other effects at work.

Figure 1: The spatial metaphor of verti-zontal preferences

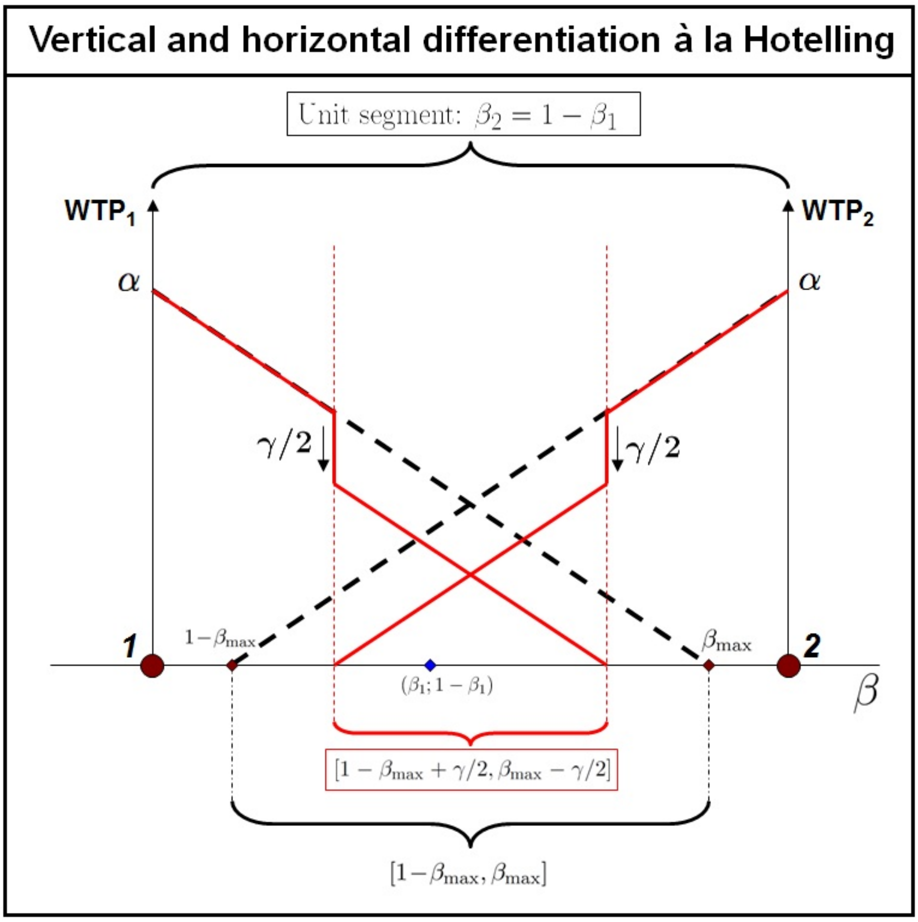
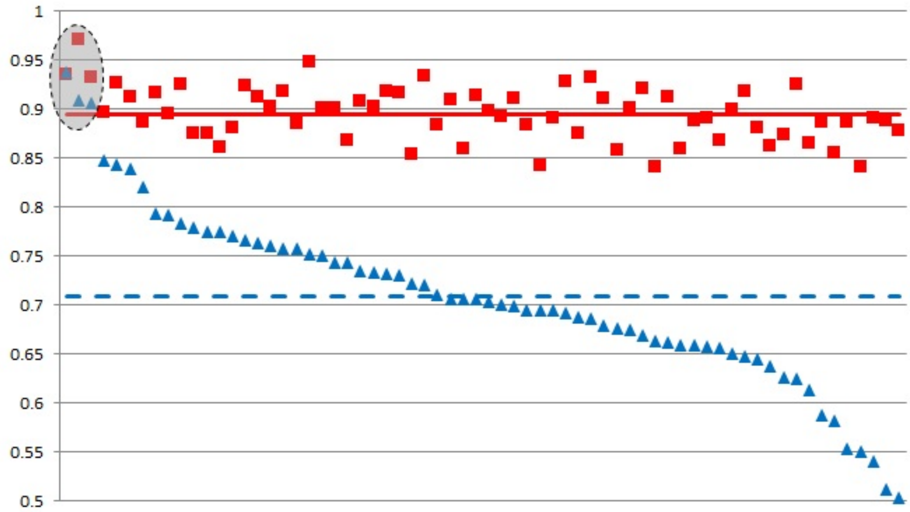


Figure 2: Pairwise rank correlations for a sample of the 12 relevant export markets selected from across the globe




**Notes:** The countries considered are: France, Netherlands, Germany, US, Canada, Brasil, South Africa, Australia, Turkey, China, India, Japan. The square dots indicate price rank correlations for all the 66 country pair combinations, triangle dots indicate pairwise quantity rank correlations. The horizontal line segments refer to the averages: the solid one refers to prices, the dashed one to quantities. Note that for illustrative purposes country pairs have been sorted in decreasing quantity rank correlation order. The shaded area covers the three most correlated country pairs in terms of quantity ranks: France-Netherlands; Germany-France; Germany-Netherlands.

Table 1: Number of varieties exported by destination markets.

| **Markets** | **Exported varieties** |
|---|---|
| France | 24,608 |
| Netherlands | 24,177 |
| Germany | 17,905 |
| UK | 11,951 |
| Spain | 8,796 |
| Italy | 8,865 |
| Denmark | 5,538 |
| Sweden | 5,528 |
| Poland | 6,223 |

**Notes:** In the table is reported, for each destination market, the total number of exported varieties. We include only varieties from the nine Belgian export markets whose combination yields the highest number of varieties simultaneously exported to all of them, resulting in the 5,616 used for the regressions in the next table.

Table 2: Export prices ($p_{s,i}$) and quantities ($q_{s,i}$). Regressions: goodness-of-fit.

| | $y = p, q$ (1) | $y = p, q$ (2) | $y = p, q$ (3) | $y = p, q$ (4) | $y = p, q$ (5) | $y = p, q$ (6) | $y = p, q$ (7) |
|---|---|---|---|---|---|---|---|
| Firm FE | YES | | | | | | |
| Product (CN8) FE | | YES | | | | | |
| Variety FE (firm-CN8) | | | YES | YES | YES | YES | YES |
| Market FE (country-CN2) | | | | YES | | | |
| Market FE (country-CN4) | | | | | YES | | |
| Market FE (country-CN6) | | | | | | YES | |
| Market FE (country-CN8) | | | | | | | YES |
| Price regression R-squared | 40.2% | 56.1% | 71.1% | 71.7% | 80.3% | 82.6% | 87.1% |
| Quantity regression R-squared | 34.4% | 26.7% | 38.5% | 53.0% | 67.2% | 73.5% | 76.4% |
| Observations | 5616 | 5616 | 5616 | 5616 | 5616 | 5616 | 5616 |

**Notes:** The results shown in this table cover only varieties for which exported weight, in kilograms, is available. Quantities are considered in per capita terms. Outliers have been dealt with by dropping the tails of the distribution and keeping the observations between the 1% and the 99% of the distibution of prices and per capita quantities. Varieties exported to the 9 markets reported in Table 1 are considered.

## Appendix: How income matters

In the foregoing, income had no impact on the demand for the differentiated good. Yet, it is reasonable to expect consumers with different incomes to have different WTP. When the product under consideration accounts for a small share of their total consumption and the numéraire is interpreted as a Hicksian composite good representing a bundle of all the other products, we may capture this effect by slightly modifying the utility function $u_{s,i}$ of consumer $i = 1, .., n$. Specifically, consumer $i$'s utility of variety $s$ is now given by

$$u_{s,i} = \alpha_s q_s - \frac{\beta_{s,i}}{2} q_s^2 + q_{0,i}$$

where $q_{0,i} = \delta_i q_0$ and $\beta_{s,i}$ is consumer's taste mismatch, which may be interpreted as in the foregoing. In this reformulation, $\delta_i > 0$ measures the consumer's marginal utility of income. Because this typically decreases with the consumer's income, we may rank consumers by decreasing order of income, and thus $\delta_1 < \delta_2 < ... < \delta_n$ where $\delta_1 = 1$ and $q_{0,1} = q_0$ by normalization.

Consumer $i$'s WTP for variety $s$ becomes

$$p_{s,i} = \max \left\{ \frac{\alpha_s - \beta_{s,i} q_s}{\delta_i}, 0 \right\}$$

where $p_{s,i}$ is expressed in terms of the numéraire of the richest consumer: the lower $\delta$, the higher the WTP for the differentiated good. Thus, we indirectly capture the impact of income on demand. Therefore, though we find it convenient to refer to $\alpha_s$ as the quality of variety $s$, we acknowledge that this parameter interacts with some other variables, such as income. It is readily verified that such variables generate market effects akin to what we call quality. Hence what we show is that a quasi-linear model like ours can deal with income differences across countries but cannot deal with income inequality within countries. Still, to work with a representative consumer model seems a reasonable assumption in view of the current data availability. Most available trade data, like ours, only have one observation per firm-product-country which does not allow analysis of consumer differences within countries.

### References


Amiti, M. and Khandelwal A. (2009). Import Competition and Quality Upgrading. NBER working paper 15503, National Bureau of Economic Research.

Anderson, S., de Palma, A. and Thisse, J. (1992). *Discrete Choice Theory of Product Differentiation.* Cambridge, MA: MIT Press.

Arkolakis, C. (2010). Market penetration costs and the new consumers' margin in international trade. *Journal of Political Economy* 118: 1151-1199.

Atkin, D. (2013). Trade, tastes and nutrition in India. *American Economic Review*, forthcoming.

Baldwin, R. and Harrigan, J. (2011). Zeros, quality, and space: trade theory and trade evidence. *American Economic Journal: Microeconomics* 3: 60-88.

Bernard, A.B., Eaton, J., Jensen, J.B. and Kortum, S. (2003). Plants and productivity in international trade. *American Economic Review* 93: 1268-1290.

Bernard, A.B., Redding, S. and Schott, P. (2011). Multi-Product firms and Trade liberalization. *The Quarterly Journal of Economics* 126: 1271-1318.

Brooks, E.L. (2006). Why don't firms export more? Product quality and Colombian plants. *Journal of Development Economics* 80: 160-178.

Chen, Y. and Riordan, M.H. (2007) Price and variety in the spokes model. *Economic Journal* 117: 897-921.

Crozet, M., Head, K. and Mayer, T. (2012). Quality sorting and trade: firm-level evidence for French wine. *Review of Economic Studies* 79: 609-644.

Das, S., Roberts, M.J. and Tybout, J.R. (2007). Market entry costs, producer heterogeneity and Export Dynamics. *Econometrica* 75: 837-873.

De Loecker, P., Goldberg, A., Khandelwal A. and Pavcnik N. (2012). Prices, Markups and Trade Reform. NBER working paper 17925, National Bureau of Economic Research.

Di Comite, F., Thisse, J.-F. and Vandenbussche, H. (2011). Verti-zontal differentiation in monopolistic competition. CEPR Discussion Papers 8752, Centre for Economic Policy Research.

Eaton, J., Kortum, S. and Kramarz, F. (2011). An anatomy of international trade: evidence from French firms. *Econometrica* 79: 1453-1498.

Eckel, C., Iacovone, L., Javorcik, B. and Neary, J.P. (2011). Multi-product firms at home and away: cost- versus quality-based competence. CEPR Discussion Papers 8186, Centre for Economic Policy Research.

Eckel , C. and Neary J.P. (2010). Mutli-Product Firms and Flexible Manufacturing in the Global Economy. *Review of Economic Studies* 77: 188-217.

Fajgelbaum, P., Grossman, G.M. and Helpman, E. (2011). Income distribution, product quality, and international trade. *Journal of Political Economy* 119: 721-765.

Feenstra, R.C. and Romalis, J. (2012). International prices and endogenous quality. NBER Working Paper 18314, National Bureau of Economic Research.

Feenstra, R.C. (1984). Voluntary Export Restraints in the U.S. Autos, 1980-1981: Quality, Employment ande Welfare Effects, in *The Structure and Evolution of Recent U.S. Trade Policy*, ed. by Baldwin R. and Krueger A., University of Chicago Press.

Ferreira, F. and J. Waldfogel (2013). Pop internationalism: has a half century of world music trade displaced local culture? *Economic Journal*, forthcoming.

Foster, L., Haltiwanger, J.C. and Syverson, C. (2008). Reallocation, firm turnover, and efficiency: selection on productivity or profitability? *American Economic Review* 98: 394-425.

Foster, L., Haltiwanger, J.C. and Syverson, C. (2012). The slow growth of new plants: learning about demand? NBER Working Papers 17853, National Bureau of Economic Research.

Goldberg, P.K. and Pavcnik N. (2007). Distributional Effects of Globalization in Developing Countries. *Journal of Economic Literature* 45: 39-82.

Goldberg, P.K. and Verboven, F. (2001). The evolution of price dispersion in the European can market. *Review of Economic Studies* 68: 811-848.

Hallak, J. C. (2006). Product quality and the direction of trade. *Journal of International Economics* 68: 238-265.

Hallak, J. C. and Schott, P. K. (2011). Estimating cross-country differences in product quality. *Quarterly Journal of Economics* 126: 417-474.

Hanson, G. and Xiang, C. (2011). Trade barriers and trade flows with product heterogeneity: an application to US motion picture exports. *Journal of International Economics* 83: 14-26.
Hart, O.D. (1985). Monopolistic competition in the spirit of Chamberlin: a general model. *Review of Economic Studies* 52: 529-546.
Hotelling, H. (1929). Stability in competition. *Economic Journal* 39: 41-57.
Hummels, D. and Klenow, P.J. (2005). The variety and quality of a nation's exports. *American Economic Review* 95: 704-723.
Katayama, H., Lu, S. and Tybout, J.R. (2009). Firm-level productivity studies: illusions and a solution. *International Journal of Industrial Organization* 27: 403-413.
Kee, H.L. and Krishna, K. (2008). Firm-level heterogeneous productivity and demand shocks: evidence from Bangladesh. *American Economic Review* 98: 457-462.
Khandelwal, A. (2010). The long and short (of) quality ladders. *Review of Economic Studies* 77: 1450-1476.
Kugler, M. and Verhoogen, E. (2012). Prices, Plant Size and Product Quality. *Review of Economic Studies* 79: 307-339.
Manova, K. and Zhang, Z. (2012). Export prices across firms and destinations. *Quarterly Journal of Economics* 127: 379-436.
Martin, J. (2012). Markups, quality, and transport costs. *European Economic Review* 56: 777-791.
Mayer, T., Melitz M.J. and Ottaviano G.I.P. (2011). Market Size, Competition and the Product Mix of Exporters. CEPR discussion paper 8349, Centre for Economic Policy Research.
Melitz, M.J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica* 71: 1695-1725.
Melitz, M.J. and Ottaviano, G.I.P. (2008). Market size, trade, and productivity. *Review of Economic Studies* 75: 295-316.
Ottaviano, G.I.P., Tabuchi, T. and Thisse J.-F. (2002). Agglomeration and trade revisited. *International Economic Review* 43: 409-436.
Sutton, J. (2012). *Competing in Capabilities. The Globalization Process.* Clarendon Lectures in Economics, Oxford University Press.
Tirole, J. (1988). *The Theory of Industrial Organization.* Cambridge, MA: MIT Press.
Trefler D., and Sutton, J. (2011). Deductions from the export basket: capabilities, wealth and trade. NBER Working Papers 16834, National Bureau of Economic Research.
Verhoogen, E. (2008). Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector. *Quarterly Journal of Economics* 132: 489-530.
Vives, X. (2001). *Oligopoly Pricing: Old Ideas and New Tools.* Cambridge, MA: MIT Press.