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Product Quality, Market Competition and International Trade: Evidence from the Food Industry

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Contents

INTRODUCTION		**7**
CHAPTER 1	**Firm heterogeneity and Quality in International Trade**	**13**
1.1	Introduction	13
1.2	Firma heterogeneity and Quality Sorting Models	21
1.2.1	Empirical evidences	22
1.3	Firm heterogeneity in international trade: the Melitz' Model	25
1.4	Extending Melitz to quality heterogeneity	35
1.4.1	Discussion	40
CHAPTER 2	**Export behavior of Italian food firms: does product quality matter?**	**45**
2.1	Introduction	45
2.2	Data description	47

2.3		Econometric approach	50
	2.3.1	TFP estimation	50
	2.3.2	Export intensity, TFP and product quality	55
2.4		Econometric results	58
	2.4.1	Robustness checks and extension	64
2.5		Discussion	67
CHAPTER 3		**Estimating quality from trade data**	**71**
3.1		Introduction	71
3.2		A nested logit demand approach	74
	3.2.1	The model	74
	3.2.2	Applying the method to trade data	81
3.3		Quality estimates: data, results and application	85
	3.3.1	Data	85
	3.3.2	Results	87
3.4		Conclusions	92
CHAPTER 4		**Quality upgrading, competition and food standards**	**95**
4.1		Introduction	95
4.2		Competition, quality upgrading and distance to the frontier	98
	4.2.1	The model	98
4.3		Quality upgrading and competition: evidence from the EU market	104
	4.3.1	Data and measures	104
	4.3.2	Empirical strategy	105
	4.3.3	Results	107
4.4		Standards, competition and quality upgrading	110
	4.4.1	Data	112
	4.4.2	Empirical strategy	113
	4.4.3	Results	116
4.5		Conclusions	118

CONCLUSIONS **121**

Appendix **129**

REFERENCES **133**

Acknowledgements **145**

Introduction

In the last decades globalization and the increasing international interdependence are characterizing the world economy. The global crisis of 2008 and 2009, where the volume of world trade declined by more than one-quarter, represents a clear example of how the economic fortunes of countries are strictly intertwined. Hence, it is of primary importance understanding what drives foreign trade and how trade affects the economic outcomes (Helpman, 2011).

Features of trade flows have been widely studied over time by the international trade literature relying on different models. The evolution of this literature, consisting of theoretical, empirical and historical studies, has been driven by the aim of understanding important characteristics of the world economy that either changed over time or surfaced as a result of new evidence. Economic, technological and political forces, continuously affect the forms and the degrees to which countries are tied with each other. As a consequence, the study of the international trade patterns has to be continuously refocused, in order to better understand what drives countries to trade with each other.

Earliest works analyzed trade flows in perfect competition at the sectorial level. In the course of development, several new elements, such as intra-industry trade or monopolistic competition, have been gradually introduced in the trade models in order to address new issues. In the last years, the seminal firm heterogeneity model of Melitz (2003) became a standard platform for analyzing several international trade issues at the firm level. So far, international trade flows have been explained according to sector, country or firm characteristics. Several elements have been taken into account as main drivers of trade flows, such as technology, factors endowment, trade costs, GDP per capita and firm productivity. More recently, a large body of literature seems to agree that the quality of exported products can be considered one of the key determinants of the international trade flows. A large body of evidence emphasizes that products quality affects the direction of trade, since richer countries tend to import more from countries producing higher-quality goods (Linder, 1961; Hallak, 2010; Crinò and Epifani, 2012). Moreover, the increase in market competition due to globalization leads the production of higher quality goods to be considered more often a pre-condition for export success (Helpman, 2011; Amiti and Khandekwal, forthcoming). This is an important issue especially for developing countries, since their economic development passes necessarily through a greater presence in the international trade markets. However, the quantification of the role of quality in explaining trade outcomes is often prevent by the lack of direct measures of quality, forcing researchers to use proxies, to make quality measurable (Schott, 2004; Hallak, 2006; Hummels and Klenow, 2005). The most common proxy on which researchers rely to measure the quality of the exported goods is unit values, according to which higher unit values reflect higher-quality products. However, there are several evidences in literature showing that unit values are imprecise measure of quality, because unit values also capture several aspects that are not attributable to quality.

In this context, we analyze the extent to which product quality affects the international trade patterns exploring different issues. *First*, we explore the “measurement issues” inferring product quality relying on alternative methods to the simple use of unit value (price). *Second*, we investigate how product quality affects the "direction of trade" in a sample of Italian food firms, using firm level data. *Third*, we analyze how the increase of the level of competition in the exporting countries (expressed by a tariff reduction) affects the rate of quality upgrading of the exported food products, relying on a "distance to the frontier" approach.

In the first chapter, we present a review of the literature on the role of quality in determining the trade patterns. We focus in particular on the quality sorting models, that represent an extension of the seminal "firm heterogeneity" model proposed by Melitz (2003). In the last section of the chapter, we present the Crinò and Epifani (2012) model, on which it is built the empirical exercise proposed in the second chapter. Such a model extends the heterogeneous-firm's model a la Melitz (2003) by incorporating firms heterogeneity in product quality and non-homothetic preferences. In this setting, it shows that, conditional on export, firm's export intensity monotonically increases in the per-capita income of export destinations and, most importantly, this effect should be largely driven by firms heterogeneity in product quality.

In the second chapter, we empirically investigate the relationship between product quality and food export performance using an alternative approach to infer product quality. Specifically, it is made use of a (unbalanced) panel of roughly 750 Italian food firms, observed in the period 2001-2006. The main advantage of this dataset is that it allows the construction of a large set of firm-level variables, strictly correlated with product quality, like investment intensity, R&D expenditure, product and process innovations, as well as quality standard certifications. Using this data it has been studied the relationship between Total Factor Productivity (TFP), product quality and firms export across destinations, relying on the theoretical model developed by Crinò and Epifani (2012). Moreover, it is studied the relationship for both the overall food industry and the 'sub-samples' related to firms producing typical 'Made in Italy' and 'Protected Designation of Origin' (PDO) products, in order to investigate if the perceived quality of these two product aggregations really matters for firms export behavior. We found strong support for the key model prediction, namely product quality matters for export performance. Specifically, this work reveals robust evidence that the correlation between export intensity and TFP/quality increases with the per-capita income of foreign destinations. Thus, more efficient firms have higher export performance as they use more expensive and quality inputs to sell higher-quality goods at higher prices. Moreover we also found evidence that firms producing higher quality products export more to more distant markets, a result consistent with the idea that the presence of per unit transaction costs lowers the relative price of high-quality goods, as recently suggested by Hummels and Skiba (2004).

In the third chapter, we deal with the quality measurement issue. After a review over the most common approaches used in the economic literature, we present an innovative method proposed by Khandelwal (2010) to infer product quality using price and quantity information from trade data. Such method embeds preferences for both horizontal and vertical attributes. Quality is the vertical component of the estimated model and captures the mean valuation that consumers attach to an imported product. This methodology, based on the nested logit framework of Berry (1994), requires both import data (unit value and volume) and quantity information (production quantity) and has this straightforward intuition: "conditional on price, imports with higher market shares are assigned higher quality". Relying on such method, we make use of trade data from the Eurostat-Comext database, to infer the quality of the imported agri-food products in the EU 15 countries at the country-product (CN 8-digit) level. We show that, even using different destination countries and focusing on a specific (food) industry, our quality estimate results match the ones of Khandelwal (2010). Moreover, through different exercises and examples, we showed that our quality estimations can be considered reasonable realistic and, thus, particularly useful in assessing the role of product quality in influencing the trade patterns.

In chapter 4, the product quality estimates will be used to analyze to what extent an increase in the level of competition (expressed by a reduction in import tariffs) in the origin country, affects the quality of the exported food products in the EU15. More specifically, using the country-product measure of quality, estimated in Chapter 3, we rely on the approach proposed by Amiti and Khandelwal (forthcoming), by studying the relationship between quality upgrading and competition within a model of 'distance to the frontier' of Aghion et al. (2005; 2009). These authors argued that the relationship between competition and innovation is non-monotonic and conditional to the firm/product distance from the (world) technology frontier. Moreover, we extend this approach studying the extent to which the level of voluntary standards in the EU 15 affects the competitive environment in the exporting market, namely, if standards act as a catalyst (thus increasing the level of competition) or as a barrier to trade.

Main results show that trade liberalization in exporting countries boosts the rate of quality upgrading for varieties close to the quality frontier. These results hold true for both OECD and non-OECD countries, by using alternative measures of the world quality frontier and of the quality upgrading. Moreover, we find, on average, a positive effect of EU standards on the rate of quality upgrading of the exported products, a results that is only marginally affected by the products distance from the world quality frontier.

Chapter 1

Firm heterogeneity and quality in International Trade

1.1 Introduction

The international trade literature agree on the fact that countries largely differ on the quality of the product that they produce and export. However, there is not yet a clear empirical evidence on the direction in which product quality affects international trade. A growing number of recent empirical works have documented that international trade and quality are strictly related. The following literature review is aimed to provide an overview on how product quality has increased its importance in explaining international trade patterns.

Earlier works that investigated the relationship between trade and quality argue that such relation seems to be driven by two main forces: on the supply side by specific transportation costs (generalized Alchian-Allen effect), and on the demand side by the stronger preference for higher quality product in rich countries.

Long ago, Linder (1961) put for the first time product quality at the center stage between the determinants that could affect international trade patterns. He argues that firms in a country produce goods suited to the predominant tastes of their home consumers, and that sell abroad to countries that share their tastes. According to this theory, consumers in high income countries show a preference for high quality products. It follows that high income countries develop a comparative advantage in the production of higher quality goods, leading high income countries to import high quality products from other countries. This is well known as Linder hypothesis.

Some years later, Alchian and Allen (1964), in their "shipping the good apples out", formulate the hypothesis that per unit trade costs lead to a shift in demand toward high-quality goods. In other words, per unit trade costs raise the price of inexpensive goods relatively more compared to the price of high priced goods. As a corollary, goods of high quality (price) take a bigger share in exports. From this work derives the so called "Alchian and Allen conjecture", according to which transportation costs lead firms to ship high quality goods abroad while holding lower quality goods for domestic consumption.

However, albeit these previous works have a straightforward intuition, they just rely on inter-industry trade. Differently, Krugman (1980) and Helpman and Krugman (1985) propose a model of international trade in monopolistic competition, allowing intra-industry trade between countries, under the paradigm of *new trade theory*. They argue that economy of scale, horizontal product differentiation and consumer *love of variety* represent the main drivers of international trade. Such a model assumes that each country specializes in a number of varieties that is proportional to their market size. It predicts that the rate of variety expansion is proportional to the growth in country size while output and prices per variety remain constant. The prediction implies that larger economies export more only on the extensive margin (a greater range of varieties). In this model, trade liberalization leads countries to trade horizontal differentiated products, and the sources of gain from trade are represented by the economy of scale and by a greater variety at disposal of the consumers, that have a *love for variety*. Albeit product quality is not at the central stage in explain trade patterns between countries, these models played a key role in the international trade literature, as an ideal link between the old trade theory and the new generation of international trade literature, that will focus the attention on the intra-industry trade and product differentiation.

However, the *new trade theory* predictions could be applied just for horizontal intra-industry trade, while in the literature was emerging increasing evidences that bilateral trade flows involved (also) exchanges of different qualities of the same good (vertical product differentiation). Flam and Helpman (1987) provide the first seminal model of intra-industry trade in quality-differentiated products, where consumers show non-homothetic preferences. In this model differences in the technology applied and in the human capital endowment between North and South countries, lead products to be vertical-differentiated.

Differently, analyzing again the supply side, Falvey and Kierzowski (1987) offer a Heckscher-Ohlin based explanation for differentiated quality production, where countries will specialize in production of goods which require to use their abundant factors intensively. Since high quality goods require higher capital intensity, capital rich countries are more likely to export them, while, labor abundant countries are more likely to specialize in the export of low quality goods.

Despite this theoretical evidences, the lack of well-defined empirical tools for the measurement of quality hindered the empirical quantification of the role of quality as determinant of the international trade patterns. Nevertheless, the earlier empirical works tried to overcame this problem sharing a common approach, that is the measure of product quality with the unit values of export, assuming a positive relation between prices and quality. In particular, these works investigate how the countries' endowment affects the demand (or the supply) of quality goods, with the aim of find the determinants of vertical comparative advantage of countries.

On the supply side, Schott (2004) points out that within very detailed product categories, unit value of U.S. manufacturing imports varies widely. He shows that imports unit value is systematically higher for varieties exported by capital and skill abundant countries compared to those from labor-abundant exporting countries, and that prices are affect by more capital intensive techniques. He finds also evidence that, over time, the same capital and skill abundant countries experience an increase in unit values greater than the countries that they leave behind. Hummels and Klenow (2005) extend Schott's finding to a larger sample of 126 exporting countries and 59 import markets using 1995 trade data. They study the relationship between country size, variety and quality patterns, using a decomposition between extensive and intensive components. They find a large degree of heterogeneity among exporters countries in their extensive and intensive margins. In particular larger countries seem to export more as they export more varieties. It follows that the extensive margin is more important in larger economies' export patterns. Thus, there appears that country size has a greater impact on the quantity component than on the price (quality) component of the intensive margin, although prices are positively affected by exporter size and income too. These findings imply that larger and richer countries export more units of the same varieties at higher prices (equivalent to higher quality exports). Kaplinsky and Santos Paulino (2005) study the evolution of import unit values into the European Union countries in a selected number of disaggregated manufacturing sectors, finding evidence that unit-price trends vary with the type of economy exporting into the European Union and the type of product being exported. They show that, considering the period 1998-2002, low income countries reduced their export prices for the European Union market, as they are characterized by an intense competition. The analysis at the sectorial level point out that higher technological content appears to be a protection against falling export prices in the European Union.

So far, the considered literature relied mainly on the supply side mechanisms, aimed to find out differences across countries, in technology and or/relative abundance of factors, to explain vertical comparative advantage of them. However, more recently, the international trade literature increases the attention on the demand side on such a relation. Interestingly, some of these works, make a step back, trying to find empirical evidence for the earlier theoretical models, i.e. the Linder hypothesis and the Alchian-Allen effect. Hallak (2010) builds a theoretical framework that captures the main components of the Linder's theory, showing that the Linder hypothesis should be formulated at the sector level. Thus, this sectorial Linder hypothesis is tested and confirmed empirically. Moreover, he shows that the aggregation across sectors induces a systematic bias.

Hummels and Skiba (2004) find evidence about an increasing of the average FOB price with the freight cost to the destination market, interpreting this as a confirmation of the Alchian-Allen effect, according to witch, as said before, exported goods present a higher average unit value with respect to products sold in the domestic market.

More recently, Lugovskyy and Skiba (2011) build up a theoretical framework that generalizes, together, the Linder hypothesis and the Alchian-Allen effect. They study how the geographic position of a country affect the quality choice of its firms, in a multi-country model with arbitrary distribution of country-specific preferences for quality and of transportation cost (ad-valorem or specific). They find empirical evidence that the quality of a country's exporter is positive affected by the proximity to richer export destinations, due to a stronger preference for quality from these destinations, giving support to the Linder hypothesis. They also find that a large market share in a distant country, encourages the production of higher quality goods, due to the smaller impact of the transportation cost on the delivered price for higher quality products, supporting the Alchian-Allen conjecture.

The strand of literature related to the demand-based determinants of the quality component of import, increasingly focuses the attention on the relation between product quality and income distribution. Hallak (2006) tests the effect of quality on bilateral trade flows relating export quality and importer income per capita using a price index based on cross-country variation in export unit values. The results lead to the conclusion that rich countries tend to import relatively more from countries that produce higher quality goods. Choi et al. (2009) find that countries with similar income distribution, tend to show similar distribution of import prices. Bekkers et al. (2012), using the Atkinson index as proxy for income inequality, find that unit values of trade decline in income inequality of the importer country. Moreover, at the firm level, Crinò and Epifani (2012) shows that more productive firms export higher quality product and thus concentrate their exports on high income countries.

Fajgelbaum et al. (2011) provide a seminal works on the relation between income distribution, product quality and international trade. They build up a model where heterogeneous consumers with non-homothetic preferences face a consumption choice over varieties of a horizontally and vertically differentiated goods. Such a model allows trade patterns to depends on the distributions of income in trade partners, with different welfare consequences across income groups in any country. This model provides different predictions on the trade pattern based on country size, income distribution and quality differentiated product. Indeed, with sufficiently high trade costs, there exists a unique trade equilibrium in which each country produces both high and low-quality differentiated products. In this setting, a greater income leads a country to have a greater home market for higher quality goods.

On the other hand, a fall in the trade costs facilitates entry of new producers, which expands the range of available varieties and so the probability that a consumer will find the once he likes.

However, a reduction in trade cost has a different effect on consumers: an expansion of higher quality goods relative to the low quality goods, leads to a benefit for who are more likely to consume a high-quality product but harms those who are more likely to consume the low-quality one. Thus, the likelihood of consuming a high-quality goods rises with income.

Latzer and Mayneris (2012), using an extension of the Fajgelbaum et al. (2011) model, provide empirical evidences on the role of income distribution on the vertical comparative advantage on a sample of EU 25 countries. Using unit value as a proxy for product quality, the results show a positive impact of average income distribution on the production of higher quality goods and a heterogeneous impact of the country's inequality on export unit value. In particular, the results suggest that a poor country seeking to climb the quality ladder should not immediately favor the formation of a new rich class through an increase in inequality. The intuition behind leads to the conclusion that, a small and relative wealthy group of consumers shouldn't leads high quality firms to produce in the country, since the (greater) poor majority of consumer still cannot afford high quality goods. Thus, as policy implication, a poor country should have to develop policies that lead to increase income of the whole population, since the average income is high enough to develop a domestic market for high quality products.

More recently, the main research efforts have focused on developing new methodology to measure product quality, in order to purge all the elements that make unit values an imprecise proxy for product quality. Hallak and Schott (2011) estimated a Price Index from trade data as proxy for quality, based on the intuition that, among countries with the same export price, the country with the higher trade balance is revealed to possess higher product quality. They use this new proxy for quality to estimate the quality of exports to the United States from 43 countries between the years 1989 and 2003. They provide evidences that the quality of exports is positively correlated with the export per capita income, and, they show also that during the considered period, the quality levels of different countries' exports converged, while their income per capita did not.

Khandelwal (2010), develops a new methodology to infer product quality that derives from a nested logit demand system, based on Berry (1994), that captures the mean valuation that consumers attach to an imported product. He makes use of both unit values and production data to infer quality and has a straightforward intuition: conditional on price, imports with higher market share are assigned higher quality. He finds empirical evidence that developed countries export higher quality products relative to developing countries. He measures also the market scope for quality differentiation with the *quality ladder*, that represents the range of the quality measures within the same product market. Moreover, he argues that markets with a large scope for quality differentiation have long quality ladder, while, markets with a narrow range of estimated quality have a short quality ladder. He makes use of this new proxy for quality to study the impact of low wage competition on U.S. industries. He finds evidence that such impact varies with the industry quality ladders. Moreover, he shows that in long-ladder markets, developed countries can defend themselves from the developing countries competition, by using their comparative advantage factors, such as skill, capital/ or technology, to specialize atop the quality ladder. However, in short-ladder markets, developed countries are directly exposed to the developing countries competition, due to a infeasible quality upgrading.

Finally, Amiti and Khandelwal (forthcoming), using the Khandelwal's method to infer quality on U.S. import data, empirically investigate the possible non-monotonic relationship between quality upgrading and competition, relying on the distance to the frontier model, developed by Aghion and Howitt (2005), Aghion et al. (2005, 2009)

The intuition behind this model is that the effect of competition on quality upgrading depends on firms' proximity to the world frontier, defined as the highest quality exported product to United States within a product category in a given year. They measure the competition faced by the exporting countries as the level of import tariff that they impose in their home market. They find evidences that, products that face a relatively high degree of competition in their home market exhibit relatively slower quality upgrading when they are distant from the world frontier. In contrast, for products close to the world frontier, a competitive home market is associated with faster quality upgrading. All these results are consistent with the non-monotonic relationship between competition and quality upgrading found in the frontier model.

1.2 Firm Heterogeneity and Quality Sorting Models

In the last years, the empirical challenges faced by the new trade theory with the use of micro-data have led to the development of theories of firm heterogeneity and international trade. The seminal study of Melitz (2003) introduces firm heterogeneity in the Krugman's (1980) intra-industry trade model, becoming in few years a standard platform for analyzing several international trade issues at the firm level. The so called *firm heterogeneity* models share the assumption that, in monopolistic competition, firms can be ranked by an exogenous attribute, productivity, according to which depends their export status, pricing, profits and revenues. In this setting, the more productive firms perform better and all firms with productivity above a certain threshold level become exporter. Firms produce horizontally differentiated varieties under monopolistic competition and, due to the absence of quality differentiation across products, all producer are assumed to use identical inputs to produce symmetric outputs, but more productive firms have a lower marginal cost and charge lower prices.

Based on this seminal model, the relation between product quality and international trade was studied re-interpreting this framework to allow firms to produce vertical differentiated product by choosing input of different quality. In the so called *quality heterogeneous-firms models*, quality enters in much the same mathematical way as exogenous productivity. Given the possibility to rank firms according to their product quality, the quality heterogeneity models are also called "Quality Sorting Model". The introduction of product quality in firm heterogeneity model is aimed to reconcile some apparent contradictory facts that emerged in empirical works. Indeed, the traditional firm heterogeneity literature argued that more productive firms are larger, more likely to export, serve more, and distant, markets and charge lower prices (see Melitz, 2003; Bernard et al. 2007; Melitz and Ottaviano, 2008; Bernard et al., 2009).[1] However, several recent stylized facts are at odds with this interpretation, as larger exporters are more skill intensive, use more expensive inputs, and charge higher, not lower, prices (Verhoogen, 2008; Manova and Zhang, 2011). In this contest, empirical works based on quality sorting model, tend to show that more efficient firms have higher export performance as they use more expensive and better quality inputs to sell higher-quality goods at higher prices (Baldwin and Harrigan, 2011; Verhoogen, 2008; Crozet et al. 2011; Crinò and Epifani, 2012).

1.2.1 Empirical evidences

As explained above, there are several empirical works built on quality heterogeneity models that provide new predictions on the international trade patterns. Differently from all the empirical works considered so far, all these works make use of firm level data and, basically, they introduce firm level variables that allow to interpret the international trade patterns in a dimension never considered before. Moreover, the use of firm level variable allows also to use some innovative proxy for measure product quality,

[1] Similar patterns have been found for food and beverage firms (see Chevassus-Lozza and Latouche, 2011; Gullstrand, 2011). Specifically, Chevassus-Lozza and Latouche (2011), using a micro-dataset for 2004, studied the accessibility of European markets to French firms. Differently, Gullstrand (2011) investigated the importance of sunk export costs, using a very detailed dataset of Swedish food and beverage sector in the 1997-2002 period.

different than unit value (e.g ISO 9000 quality certification, R&D activity, etc.). In the following short review of empirical works built on quality heterogeneity model, on one hand it will be explored how firms' features affect the production and export of quality goods and, on the other hand, how product quality affects the firms' exporting patterns and performances.

Verhoogen (2008), using certification standard as a measure of quality, analyzes a sample of Mexican manufacturing firms finding empirical evidences that more productive firms produce higher quality products and pay higher wages in order to maintain a higher quality workforce. He finds also that quality difference among exporters and non-exporters is driven by the U.S. consumers' preference for quality and not by the nature of the transportation costs.

Hallak and Sivadasan (2009), using firm level data from India, U.S., Chile and Colombia, argued that conditional on size, exporters produce and sell higher quality products at higher prices and pay higher wages and use capital more intensively. For the Indian firms sample, as in Verhoogen (2008), they use ISO 9000 quality certification as proxy for the production of higher quality goods.

Baldwin and Hurrigan (2011), use U.S. bilateral trade flow firm level data, and find that firms that supply the lowest priced goods are not necessarily the most competitive. In such a model, firms' competitiveness depends upon their quality-adjusted price and, in equilibrium, higher quality goods are more costly, more profitable, and better able to penetrate distant markets.

Manova and Zhang (2011) using Chinese trade transaction microdata, find a number of systematic features of export and import, linked to firms, products and destinations that are consistent with the quality sorting model. They find evidences across firms selling a given product that firms that charge higher export prices, have higher profits in each destinations, and a greater extensive and intensive margin across markets. They find also that within a product, firms set higher price in rich, larger and more distant countries. They find evidence also that exporting firms source inputs from more countries and pay a wider range of input prices. All these facts are consistent with the quality sorting model where more successful exporters use higher-quality inputs to produce higher quality goods and where exporting firms vary the quality of their product based on the destination market. Similarly, Bastos and Silva (2009) using Portuguese microdata find that exporting firms set higher prices in bigger, richer and more distant countries.

Kugler and Verhoogen (2011) using Colombian microdata, analyze the relation between firm export and import decision, providing evidences of the fact that larger firms charge more for their outputs and pay more for their inputs than smaller firms, and the same evidences emerge considering exporting and non-exporting firms. As in the Melitz (2003) model, firms endogenously choose both input and output quality and there is a complementary between the quality of inputs and outputs.

Kneller and Yu (2008) argue that firms with higher marginal costs produce higher quality. They find also evidences that better-quality firms set higher prices not only because of they have higher costs, but also because they can charge a bigger mark-up. They also argue that if their mark-up grow fast, higher quality firms will get higher market share.

Crozet et al. (2011) use wine guidebooks rating as a proxy for quality, find evidence that highly-ranked French wine producers export to more markets, charge higher prices, and sell more in each market. They also argue that Quality sorting can explain the fact that the more difficult a market is to serve, the better on average will be the firms that serve it.

Crinò and Epifani (2012), make use to infer quality of firm level variables that according to the literature are likely to be associated with product quality, such as R&D and ICT investments, skill labor, product or process innovations. They show that, conditional to export, firm's export intensity monotonically increases in the per-capita income of foreign destinations and, most importantly, this effect should be largely driven by firms heterogeneity in product quality.

1.3 Firm heterogeneity in international trade: the Melitz' Model

Considering its fundamental contribution given to the international trade literature it is now presented a stylized version of the Melitz (2003) model. The importance of understanding the main predictions of such model, is given by the fact that all the following quality sorting models have heavily relied on the structure of this seminal contribution.
Consider a CES utility function of a representative consumer:

$$U = \left[_{v \in V} \int c(v)^{\rho} \, dv\right]^{1/\rho} \; 0 < \rho < 1 \qquad (1.1)$$

where V is a continuous set of varieties indexed by v, and $c(v)$ is the consumption of each. The demand function associated with (1.1) is:

$$c_v = \frac{p(v)^{-\sigma} R}{P^{1-\sigma}}$$

where $p(v)$ is the price of a variety v, $\sigma = \frac{1}{1-\rho} > 1$ is the constant elasticity of substitution between any two varieties, R is income (equal total revenue and expenditure), and P is the ideal price index associated to (1.1)

$$P = \left[_{v \in V} \int p(v)^{1-\sigma} \, dv\right]^{1/1-\sigma} \qquad (1.2)$$

In this setting, each firm chooses to produce a different variety v. Production requires just one factor, labor, L. Technology is represented by the following total cost function:

$$TC(v) = f + \frac{1}{\theta} q \, ,$$

where $1/\theta$ represents the marginal cost, f is the fixed cost (both are in terms of labor), and where θ represents firms' productivity.

The profit maximizing price is a constant markup $\left(\frac{\sigma}{\sigma-1}=\frac{1}{\rho}\right)$ over marginal cost:

$$p(\theta)=\frac{1}{\rho\theta}\,. \tag{1.3}$$

The revenue of a firm with productivity θ is then:

$$r(\theta)=p(\theta)q(\theta)=p(\theta)^{1-\sigma}RP^{\sigma-1}=R(P\rho\theta)^{\sigma-1}.$$

It is important to underline that the relative revenue of two firms with productivities θ' and θ'' depends solely on relative productivity:

$$\frac{r(\theta')}{r(\theta'')}=\left(\frac{\theta'}{\theta''}\right)^{\sigma-1}\rightarrow r(\theta')=\left(\frac{\theta'}{\theta''}\right)^{\sigma-1}r(\theta'')\,. \tag{1.4}$$

This is important because, expressing a firm revenue only in term of exogenous variables, it allows to write any other firms revenue in terms of relative productivity and parameters. Thus, consider two firms with productivity $\tilde{\theta}$ and θ^{*}, we have:

$$r(\tilde{\theta})=\left(\frac{\tilde{\theta}}{\theta^{*}}\right)^{\sigma-1}r(\theta^{*}) \tag{1.5}$$

Profit can be expressed as a function of firms' revenue:

$$\begin{aligned}\pi(\theta)&=r(\theta)-\frac{1}{\theta}q(\theta)-f=r(\theta)-\rho p(\theta)q(\theta)-f=\\&=(1-\rho)r(\theta)-f=\frac{1}{\sigma}r(\theta)-f\end{aligned} \tag{1.6}$$

Considering again the two firms with different productivities $\tilde{\theta}$ and θ^{*}, from (1.5) we have:

$$\pi(\tilde{\theta})=\left(\frac{\tilde{\theta}}{\theta^{*}}\right)^{\sigma-1}\frac{r(\theta^{*})}{\sigma}-f \tag{1.7}$$

The equilibrium is characterized by a mass M of firms and a distribution $\mu(\theta)$ of productivity levels and thus, in equilibrium, there will be $M\mu(\theta)$ firms with productivity θ. In such an equilibrium, firms with the same productivity charge the same price, then the aggregate price in given by:

$$P = \left[\int_0^\infty p(\theta)^{1-\sigma} M\mu(\theta)d\theta\right]^{\frac{1}{1-\sigma}} \quad (1.8)$$

This can be written also as $P = M^{\frac{1}{1-\sigma}}p(\tilde{\theta})$, where $p(\tilde{\theta})$ is the price charged by a firm with productivity $\tilde{\theta}$, given by:

$$\tilde{\theta} = \left[\int_0^\infty \theta^{\sigma-1}\mu(\theta)d\theta\right]^{\frac{1}{\sigma-1}} \quad (1.9)$$

Where $\tilde{\theta}$ is a weighted average of the firm productivity levels and is independent of the number of firms, *M*.

Thus, $\tilde{\theta}$ also represents aggregate productivity because it completely summarizes the information in the distribution productivity level, $\mu(\theta)$, relevant for all aggregate variables.

Given the aggregate variables price $P = M^{\frac{1}{1-\sigma}}p(\tilde{\theta})$ and quantity $Q = M^{1/\rho}q(\tilde{\theta})$, the aggregate revenue will be $R = PQ = Mr(\tilde{\theta})$ and the aggregate profit will be $\Pi = M\pi(\tilde{\theta})$.

Further, note that $\bar{r} = R/M = r(\tilde{\theta})$ and $\bar{\pi} = \Pi/M = \pi(\tilde{\theta})$, namely that average revenue and profit equals the revenue and the profit of a firm with productivity, $\tilde{\theta}$.

Consider now a zero-productivity cutoff, denoted by θ^*, that is the productivity level associated with zero profits. Equation 1.6 implies:

$$r(\theta^*) = \sigma f \quad (1.10)$$

Thus, firms with productivity $\theta \geq \theta^*$ make positive profits and firms with $\theta < \theta^*$ would make negative profits and therefore exit from the market. Thus, only firms with a productivity $\theta \geq \theta^*$ will be observed. It follows that active firms make positive profits in equilibrium. This is compatible with the free entry assumption, that implies that whenever expected profits are positive, new firms are willing to enter. Hence, an equilibrium with free entry must be associated with zero expected profits. This is possible only if entry is costly.

Now assume that there is a large (unlimited) number of identical potential entrance firms. These firms, prior to entry must make an irreversible fixed investment f_e (measured in unit of labor), thereafter *sunk cost*, in order to learn its type θ, which is drawn independently from a common distribution, $g(\theta)$. $g(\theta)$ has positive support over (0; ∞) and has a continuous cumulative distribution $G(\theta)$.

The free entry condition implies that the expected profits must equal the sunk cost of entry. Formally, the sunk costs equals the average profit conditional on successful entry, $\bar{\pi}$, times the probability of drawing a productivity level greater than θ^*. Thus f_e equals $1 - G(\theta^*)$, where $G(\theta^*) = \Pr(\theta < \theta^*) = \int_0^{\theta^*} g(\theta)d\theta$.

Thus we have:

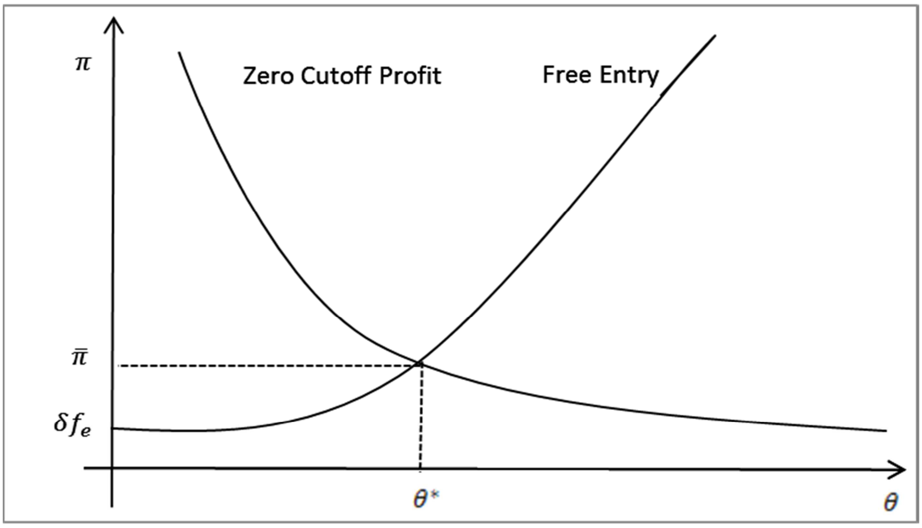
$$(1 - G(\theta^*))\,\bar{\pi} = f_e \tag{1.11}$$

The free entry condition also implies a positive relationship between the average profit $\bar{\pi}$ and the productivity cutoff θ^*. This is because a rise in $\bar{\pi}$, leads to a fall in the likelihood of successful entry in order to discourage entry in equilibrium. Thus, using $r(\theta^*) = \sigma f$, we can express $\bar{\pi}$ as:

$$\bar{\pi} = \pi(\tilde{\theta}) = f\left[\left(\frac{\tilde{\theta}}{\theta^*}\right)^{\sigma-1} - 1\right] \tag{1.12}$$

As shown in Figure 1.1, in (θ, π) space, the free entry curve is increasing and is cut by the Zero Cutoff Profitt curve only once from above. This ensures the existence and uniqueness of the equilibrium defined by $\bar{\pi}$ and θ^*.

Figure 1.1 Determinant of the equilibrium cutoff θ^* and average profit π



Source: Melitz (2003)

Now it is important to better explain the difference between the ex-ante productivity distribution, $g(\theta)$ and the ex-post $\mu(\theta)$. $g(\theta)$ is exogenous and represents the probability of drawing any given productivity level upon entry. $\mu(\theta)$ is endogenous and is an equilibrium outcome and given that, firms with productivity $\theta < \theta^*$ do not produce. Hence, the ex-post equilibrium productivity distribution $\mu(\theta)$ is zero for $\theta < \theta^*$. Thus we have:

$$\mu(\theta) = \begin{cases} 0 & \text{if } \theta<\theta^* \\ \frac{g(\theta)}{1-G(\theta^*)} & \text{if } \theta>\theta^* \end{cases} \tag{1.13}$$

Using (1.13) it is possible to define the aggregate productivity level $\tilde{\theta}$ as a function of the cutoff level θ^*:

$$\tilde{\theta} = \left[\frac{1}{1-G(\theta^*)}\int_{\theta^*}^{\infty}\theta^{\sigma-1}g(\theta)d\theta\right]^{\frac{1}{\sigma-1}} \tag{1.14}$$

This implies that average productivity is increasing in the productivity cutoff.

Using (1.14), it is possible to write (1.12) as follows:

$$\bar{\pi} = f\left[\frac{1}{1-G(\theta^*)}\int_{\theta^*}^{\infty}\left(\frac{\theta}{\theta^*}\right)^{\sigma-1} g(\theta)d\theta - 1\right] = \left[\left(\frac{\theta}{\theta^*}\right)^{\sigma-1} - 1\right] g(\theta)d\theta \quad (1.15)$$

Finally, using (1.15) into the free entry condition (1.11) yields:

$$f\int_{\theta^*}^{\infty}\left[\left(\frac{\theta}{\theta^*}\right)^{\sigma-1} - 1\right] g(\theta)d\theta = f_e \quad (1.16)$$

From (1.16) it emerges that the left hand side of such a relation, represents the expected value of entry and is monotonically decreasing in θ^*, because an increasing in the zero-productivity cutoff reduces the probability of successful entry. Thus, (1.16) uniquely individuates θ^* as a function of the model parameters, with θ^* decreasing in f_e. In this setting, an increase in the entry cost, reduces entry and therefore allows less productive firms to survive. However, θ^* is increasing in the fixed production cost, f. In this case, the intuition is that the average profit is proportional to the revenue of the marginal firm, which is increasing in f and θ^*. Thus, a higher fixed production cost therefore requires a higher productivity for the marginal firm to break even.

Free Trade Equilibrium

From (1.16) emerges that the free entry condition is independent of market size. It follows that the productivity cutoff, θ^*, and therefore also average productivity and average profits, are independent of L. The main implication of this, is that as in the Krugman's model, moving from autarky to free trade, which is isomorphic to a rise of country size, leads all firms to export and to a welfare rises due to increase choice only (because V is increasing in L). In this case, heterogeneity doesn't play any role, because trade liberalization increases the size of the market and the number of firms in the same proportion, thereby leaving revenue unaffected for all firms. In particular (as shown earlier) we have:

$$r(\theta) = R(P\rho\theta)^{\sigma-1} = L\left(M^{\frac{1}{1-\sigma}}p(\tilde{\theta})\rho\theta\right)^{\sigma-1} =$$

$$= \frac{L}{M}\left(\frac{\theta}{\tilde{\theta}}\right)^{\sigma-1} = r(\tilde{\theta})\left(\frac{\theta}{\tilde{\theta}}\right)^{\sigma-1}$$

Hence, the only way in which trade liberalization leads to different effects for heterogeneous firms, is that trade must have asymmetric effects on firms revenue. This may be the case under costly trade.

Assume that exporting firms incur a variable trade cost of the iceberg type $\tau > 1$, and fixed cost of exporting, f_x, due to the cost of setting up shop abroad. It follows that τ/θ is the marginal cost of an exported unit and revenue in the foreign market, $r_x(\theta)$, is therefore reduced by $\tau^{(1-\sigma)}$ relative to domestic revenue, $r_d(\theta)$:

$$r_d(\theta) = R(P\rho\theta)^{\sigma-1}$$

$$r_x(\theta) = R\left(P\rho\frac{\theta}{\tau}\right)^{\sigma-1} = \tau^{1-\sigma}r_d(\theta)$$

Thus, the combined revenue for a firm, $r(\theta)$, depends on its export status:

$$r(\theta) = \begin{cases} r_d(\theta) & \text{if a firm does not export} \\ r_d(\theta) + (1+\tau^{1-\sigma}) & \text{if a firm export} \end{cases}$$

The productivity cutoff for exporters, θ_x^*, that is the productivity level which makes a firm indifferent between exporting and non-exporting, is defined by the following condition:

$$\pi_x(\theta_x^*) = \frac{r_x(\theta_x^*)}{\sigma} - f_x = \frac{\tau^{1-\sigma}r_d(\theta_x^*)}{\sigma} - f_x = 0 \rightarrow r_d(\theta_x^*) = \sigma f_x \tau^{1-\sigma}$$

Using (1.4) we can write:

$$r_d(\theta_x^*) = \left(\frac{\theta_x^*}{\theta^*}\right)^{\sigma-1} r_d(\theta^*) \rightarrow \sigma f_x \tau^{\sigma-1} = \left(\frac{\theta_x^*}{\theta^*}\right)^{\sigma-1} \sigma f \rightarrow$$

$$\rightarrow \theta_x^* = \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} \tau\theta^* \tag{1.17}$$

Note that the exporting cutoff is greater than the zero-productivity cutoff, thus, formally $f_x\tau^{\sigma-1} > f \rightarrow \theta_x^* > \theta^*$. It follows that only the most productive firms can profitably break into the foreign market. In this setting, all the firms with productivity below the cutoff level only serve domestic market. From (1.17) emerges that a partitioning of firms into exporters and non-exporters is possible only in the presence of fixed costs of exporting, and is more likely the higher the fixed and variable costs of exporting are.
Thus, the average profit, $\bar{\pi}$, of active firms under costly trade, will be equal the average profit from the domestic sale $\bar{\pi}_d$, plus the average profit from exporters, $\bar{\pi}_x$, times the probability of exporting conditional on successful entry, p_x:

$$\bar{\pi} = \bar{\pi}_d + p_x\bar{\pi}_x \tag{1.18}$$

Where:

$$p_x = \frac{1 - G(\theta_x^*)}{1 - G(\theta^*)}$$

$$\bar{\pi}_d = \frac{f}{1 - G(\theta^*)} \int_{\theta^*}^{\infty} \left[\left(\frac{\theta}{\theta^*}\right)^{\sigma-1} - 1\right] g(\theta)d\theta = f\left[\left(\frac{\tilde{\theta}}{\theta^*}\right)^{\sigma-1} - 1\right]$$

$$\tilde{\theta} = \left[\frac{1}{1 - G(\theta^*)}\int_{\theta^*}^{\infty} \theta^{\sigma-1} g(\theta)d\theta\right]^{\frac{1}{\sigma-1}}$$

$$\bar{\pi}_x = \bar{\pi}_x(\tilde{\theta}_x) = \frac{f}{1 - G(\theta_x^*)} \int_{\theta_x^*}^{\infty} \left[\left(\frac{\theta}{\theta_x^*}\right)^{\sigma-1} - 1\right] g(\theta)d\theta = f\left[\left(\frac{\tilde{\theta}}{\theta_x^*}\right)^{\sigma-1} - 1\right]$$

$$\tilde{\theta}_x = \left[\frac{1}{1 - G(\theta_x^*)}\int_{\theta^*}^{\infty} \theta^{\sigma-1} g(\theta)d\theta\right]^{\frac{1}{\sigma-1}}$$

Substituting into (1.18) yields

$$\bar{\pi} = \left[\left(\frac{\tilde{\theta}}{\theta^*}\right)^{\sigma-1} - 1\right] f + \frac{1 - G(\theta_x^*)}{1 - G(\theta^*)} \left[\left(\frac{\widetilde{\theta_x}}{\theta_x^*}\right)^{\sigma-1} - 1\right] f_x$$

Substituting into the entry condition (1.11) finally yelds:

$$f\left[\left(\frac{\tilde{\theta}}{\theta^*}\right)^{\sigma-1} - 1\right] + \frac{1 - G(\theta_x^*)}{1 - G(\theta^*)} f_x \left[\left(\frac{\widetilde{\theta_x}}{\theta_x^*}\right)^{\sigma-1} - 1\right] = f_e$$

Which can be equivalently written as:

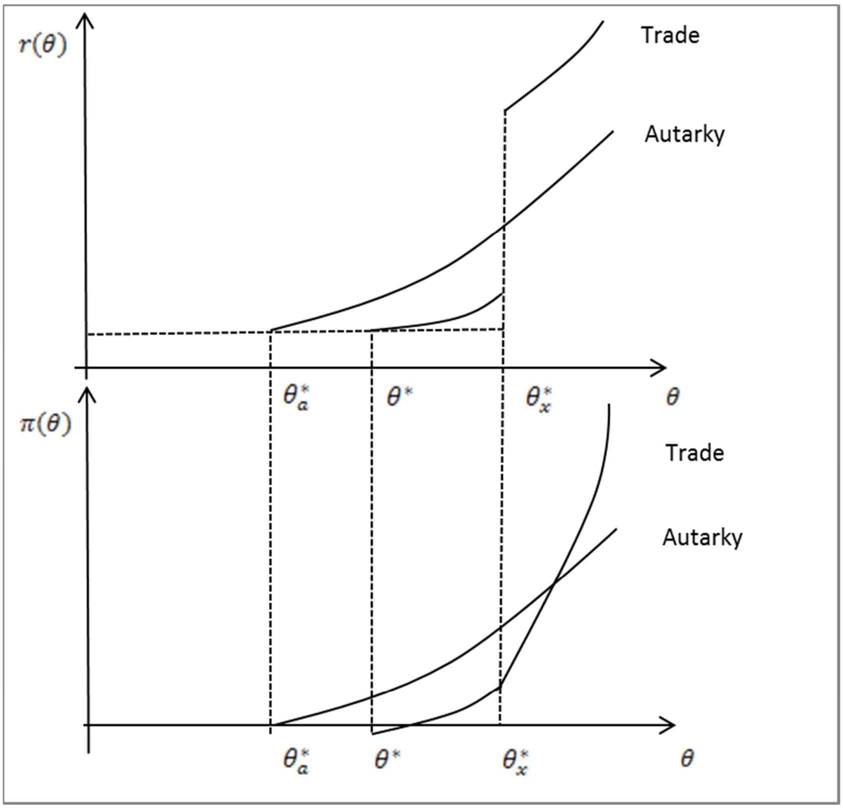
$$f \int_{\theta^*}^{\infty} \left[\left(\frac{\theta}{\theta^*}\right)^{\sigma-1} - 1\right] g(\theta) d\theta + f_x \int_{\theta_x^*}^{\infty} \left[\left(\frac{\theta}{\theta_x^*}\right)^{\sigma-1} - 1\right] = f_e \qquad (1.19)$$

Looking at (1.19) and comparing the free entry condition under costly trade and autarky, note that the left hand side of the relation is still monotonically decreasing in θ^*. Differently, the second term is positive and captures the increased value of entry due to the fact that firms have a positive ex ante probability of becoming exporters. Thus, moving from autarky to costly trade leads to a rise of θ^* and of the average productivity. The intuition behind is that trade increases average profits, thereby inducing entry, which reduce the revenue of active firms and forces the least productive ones to exit. It follows that productivity cutoff increases, reducing the probability of successful entry, and therefore restoring the free entry condition.
Consider the mass of firms, M:

$$R = L = \bar{r}M = \frac{L}{\bar{r}} \quad \text{where} \quad \bar{r} = \sigma(\bar{\pi} + f + p_x f_x)$$

note that the relation above implies that trade liberalization leads to a fall in the number of domestic firms and varieties relative to autarky. However, the welfare after trade liberalization unambiguously rises.

Figure 1.2: The reallocation of market share and profits



Source: Melitz (2003)

Thus, the aggregate price index P, in the costly trade equilibrium, is given by:

$$P = \left[Mp(\tilde{\theta})^{1-\sigma} + p_x M \tau^{1-\sigma} p(\tilde{\theta}_x)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

Finally, assume that $M_x = p_x M$ is the mass of exporting firms, and $M_t = M + M_x = (1 + p_x)M$ is the mass of firms competing (equals to the varieties) available in each market, the price index can also be written as:

$$P = M_t^{\frac{1}{1-\sigma}} p(\tilde{\theta}_t), \text{ where:}$$

$$\tilde{\theta}_t = \left[\frac{M}{M_t}\tilde{\theta}^{\sigma-1} + \frac{M_x}{M_t}\left(\frac{\tilde{\theta}_x}{\tau}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}} =$$

$$= (1+p_x)^{\frac{1}{\sigma-1}}\left[\tilde{\theta}^{\sigma-1} + p_x \tau^{1-\sigma}\tilde{\theta}_x^{\sigma-1}\right]^{\frac{1}{\sigma-1}}$$

Finally, Figure 1.2 graphically represents the changes in revenue and profit driven by trade, showing as the most efficient firms thrive and grow, due to the fact that they export and increase both their market share and profits.

1.4 Extending Melitz to quality heterogeneity

As said before, several empirical works on international trade and product quality have built on the seminal Melitz (2003) model to study the relationship between quality and international trade. In the following section we explore the model developed by Crinò and Epifani (2012), that represents the theoretical framework on which is based an empirical analysis on Italian food firm-level data, that will be presented in the next chapter. Crinò and Epifani (2012) extend a heterogeneous-firm's model *a la* Melitz (2003) by incorporating firms heterogeneity in product quality and non-homothetic preferences. In this setting, they show that, conditional on export, firm's export intensity monotonically increases in the per-capita income of export destinations and, most importantly, this effect should be largely driven by firms heterogeneity in product quality.

Consider a representative consumer characterized by the following utility function:

$$U = \left[_{v\in V}\int q(v)^{1-\rho} c(v)^{\rho}\, dv\right]^{1/\rho},\ 0<\rho<1, \qquad (1.20)$$

where V is a continuous set of varieties available for consumption, indexed by v and represents a Cobb-Douglas bundle of physical quantity; $c(v)$ is consumption and $q(v)$ is quality of variety v, as perceived by the representative consumer.

Maximizing the consumer's utility (1.20) subjected to the usual budget constraint, $y = \int_{v \in V} p(v)c(v)dv$ with *y* the exogenously given per capita income, the demand for *v* can be written as $c(v) = q(v)p(v)^{-\sigma} R / P^{1-\sigma}$, where *R* is total income, *p*(*v*) is the price of variety *v*, $\sigma = (1-\rho)^{-1} > 1$ is the constant elasticity of substitution among varieties, and *P* is the ideal price index.
The first key assumption of the model is about the preferences of a representative consumer. Unlike Melitz (2003) seminal model, where the preferences are homothetic, in this model the preferences for quality by the representative consumer are non-homothetic with respect to per capita income (*y*). Assume that $q(v) = \lambda(v)^{\alpha(y)}$, where $\lambda(v) \geq 1$ denotes true product quality and $\alpha(y) > 0$ captures the elasticity of demand with respect to product quality. The relative demand for higher-quality products is higher in high-income countries, if and only if, the following relation holds: $\alpha(y') > \alpha(y'')$ for $y' > y''$.
Consider now a partial equilibrium model of one sector economy open to international trade, where firms produce differentiated products under monopolistic competition and are heterogeneous in productivity and quality. Under this setting, it is possible to study the relationship between firm revenue and product quality with respect to the per capita income. Let *d* a domestic market and *x* a foreign market. Consider therefore a market $z \in \{d, x\}$, where θ measures firm productivity and $1/\theta$ is the marginal cost to produce *v*. In this first part of the model product quality is exogenous, but this assumption will be relaxed later.
The profit maximizing price is $p_z = \tau_z / \rho\theta$, where $1/\rho = \sigma/\sigma - 1$ is a constant price-marginal cost mark-up, and $\tau_z > 1$ is an iceberg trade cost. Using the expression for q_z, p_z and for consumer's demand for variety, *c*(*v*), it is possible to yield the firms' revenue in market *z* as a function of productivity and product quality:

$$r_z(\lambda,\theta)=\theta^{\sigma-1}R_z\left(\frac{\rho P_z}{\tau_z}\right)^{\sigma-1}\lambda^{\alpha(y_z)}\ ,\ z\in\{d,x\} \qquad (1.21)$$

which imply that the elasticity of firm revenue to product quality is increasing in per capita income of destination *z*, From (1.21) it is possible to study the ratio of exports to destination *x* over domestic sales:

$$\frac{r_x}{r_d}=\frac{R_x(P_x/\tau_x)^{\sigma-1}}{R_d(P_d/\tau_d)^{\sigma-1}}\lambda^{\alpha(y_x)-\alpha(y_d)} \qquad \text{which implies} \rightarrow$$

$$\frac{d\ln(r_x/r_d)}{d\ln\lambda}=\alpha(y_x)-\alpha(y_d) \qquad (1.22)$$

Relation (1.22) shows that the elasticity of the ratio r_x/r_d to product quality, for $y_x>y_d$, is increasing in per capita income of the foreign destination.
Consider now the export intensity of two foreign destinations indexed by $x\in\{l,h\}$, with differences in the per capita income, with $y_l<y_d<y_h$. The export intensity to the lower income destination can be written as: $EXP_l\equiv\frac{r_l}{r_d+r_l+r_h}=\frac{r_l/r_d}{1+r_l/r_d+r_h/r_d}$.
The assumption of non-homothetic preferences will affect EXP_l, because a rise of product quality reduces r_l/r_d and increases r_h/r_d , causing the reduction of EXP_l. Thus, using (1.22) it is possible to study the elasticity of export intensity to low-income destination respect to product quality:

$$\frac{d\ln EXP_l}{d\ln\lambda}=-[\alpha(y_d)-\alpha(y_l)](1-EXP_l)-[\alpha(y_h)-\alpha(y_d)]EXP_h<0\ .$$

The relation above shows the existence of a negative correlation between export intensity to low income destination, EXP_l, and the quality of the exported products, λ. Moreover, the model tends to also predict a positive relationship between product quality and the export share to higher-income destinations, $(EXS_h \equiv r_h / r_l + r_h)$, as well as an ambiguous effect of product quality on the overall export intensity, $(EXP \equiv r_h + r_l / r_d + r_l + r_h)$.

Next, after studying the relationship between export intensity and product quality, it will be analysed the implications of the second key assumption of the model, namely that there exists a positive relationship between products quality and fixed costs. In particular, Crinò and Epifani (2012) assume that higher quality products require higher fixed costs, due to the idea that quality upgrading is linked to more intensive products' development activities that require higher fixed costs, such as for R&D and marketing activities. To do this we study the relationship between endogenous product quality and technical efficiency, the latter captured by revenue-TFP.

The model assumes that firms produce a variety of quality λ paying a fixed cost $(1/\eta)\lambda^{\eta}$, where $\eta > 0$ is the elasticity of the fixed costs to product quality. An important assumption is that firms produce goods with different quality depending on the destination market, therefore firms choose the quality of their product based on the characteristics of each market.

As said before, technical efficiency, and therefore fixed costs, are captured by revenue-TFP, thereby the following formulation allows us to investigate the relationship between product quality and fixed costs, simply as the elasticity of product quality to productivity. The following expression shows how it is possible to choose the optimal product quality for a destination market *z*:

$$\max_{\lambda} \left\{ M_z \theta^{\sigma-1} \lambda^{\alpha(y_z)} - \frac{1}{\eta} \lambda^{\eta} - \phi_z \right\}, \quad z \in \{d, h, l\} \qquad (1.23)$$

where $M_z = \left(\frac{1}{\sigma}\right) R_z \left(\frac{P_z}{\tau_z} \rho\right)^{\sigma-1}$ represents a measure of market size, and ϕ_z is a fixed cost of entry into the destination market *z*. By solving this problem, the optimal product quality for market *z*, λ_z^*, will be:

$$\lambda_z^* = \left[\alpha(y_z) M_z \theta^{\sigma-1}\right]^{\frac{1}{\eta-\alpha(y_z)}} \tag{1.24}$$

where $\eta - \alpha(y_z) > 0$, by the second order condition for a maximum. Relation (1.24) says that more productive firms produce higher-quality products for all market destinations. This is possible because they get greater revenue from selling high-quality products in these markets, that allows them to spread the higher fixed costs paid for upgrading products' quality over a greater revenue. Using the expression for optimal product quality (1.24) into $r_z = \sigma M_z \theta^{\sigma-1} \lambda_z^{*\alpha(y_z)}$, it is possible to yield the ratio of export to domestic sales:

$$\frac{r_x}{r_d} = \frac{M_x \lambda_x^{*\alpha(y_x)}}{M_d \lambda_d^{*\alpha(y_d)}} = \frac{M_x}{M_d} \frac{\left[\alpha(y_x) M_x \theta^{\sigma-1}\right]^{\frac{\alpha(y_x)}{\eta-\alpha(y_x)}}}{\left[\alpha(y_d) M_d \theta^{\sigma-1}\right]^{\frac{\alpha(y_d)}{\eta-\alpha(y_d)}}} \tag{1.25}$$

Finally, it is possible to study the elasticity of the ratio r_x/r_d to productivity. Using the log of (1.25) and differentiating, yields:

$$\frac{d\ln(r_x/r_d)}{d\ln\theta} = (\sigma-1)\left(\frac{\alpha(y_x)}{\eta-\alpha(y_x)} - \frac{\alpha(y_d)}{\eta-\alpha(y_d)}\right) \tag{1.26}$$

Relation (1.26) implies that, conditional on exporting destination *f*, the export intensity to low-income destinations is inversely related to productivity, $\frac{d\ln EXP_l}{d\ln\theta} < 0$. As seen before for product quality, from (1.26) emerges that the elasticity of export intensity to productivity is increasing in per capita income of the foreign destination. The intuition is that high-productivity firms produce higher-quality goods, for which relative demand is lower in low-income destinations.[2]

[2] Crinò and Epifani (2010) highly also that, although revenue-TFP is closely related to product quality and productivity, it may also capture variation across firms in markups, which in this model are instead constant. Although markups may reflect pure demand shocks and pricing power, they are likely to be positively correlated with productivity and product quality, which may strengthen the positive correlation of revenue-TFP with both our key parameters.

1.4.1 Discussion

A key question is, how do the above predictions hold true when considering the other determinants of firms' export behaviour? Crinò and Epifani (2012) discussed such implications from recent literature showing that, although several other determinants of export may be at work, they never affect the conclusions summarized above.[3]

Consider first multiproduct firms, that as shown in Bernard et al. (2009), play a prominent role in international trade. The existence of multiproduct firms leads to the introduction of an extensive margin of product, which is likely to magnify the influence of firm heterogeneity in product quality and non-homothetic export behavior. Such an implication is given by the fact that more productive firms, by producing higher-quality products, can profitably sell a relatively larger number of products to high-income destinations. It follows that, introducing the extensive margin of products, strengthens the negative correlation between productivity and export intensity to low income destination and, more in general, the positive dependence of this relation on per capita income of foreign destinations.

Another issue that could affect the relationship between export intensity and product quality is represented by the fixed costs of exporting. As argued by Eaton et. al (2004; 2008), these costs are mainly country-specific, leading most exporters to sell just in few foreign countries. In the Crinò and Epifani (2012) empirical work, they make use of export data to broad destination that generally include more than one country. It follows that, considering multicountry export destinations, introduce an extensive margin of countries which tends to reduce the negative correlation between productivity and export intensity to low income

[3] Specifically, among other things, they discuss the implication of the model by considering multiproduct firms (see Bernard et al. 2011), country-specific fixed costs of exporting (see Eaton *et al.* 2004), and endogenous fixed costs of entry in foreign markets (see Arkolakis, 2010). They show that under all these conditions, the predictions of the model are, if any, even stronger.

destination, because more productive firms can break into a larger number of countries within any destination.

The baseline model includes exogenous and uniform fixed cost of entry in the export market. As shown by Arkolakis (2008), this assumption has the counterfactual implication that no firms could profitably export small volumes of output. However, considering endogenous fixed cost of entry, by assuming that reaching an additional consumer in each market involves an increasing marginal cost, it introduces an extensive margin of consumer. Such extensive margin of consumer, according to which more productive firms can afford higher market penetration costs and reach a larger share of the population in each market as they enjoy higher sales per consumer, strengthen the dependence of the relationship between productivity and export intensity on per capita income of foreign destinations. This extensive margin of consumer seems to strengthens in particular the negative relation between export intensity an product quality. This is because an endogenous market penetration cost, leads more productive firms, which produce higher-quality product, to concentrate marketing efforts and sales in higher income countries, where sales per consumer of higher quality products are relatively high.

However, it could be of interest to discuss how the results may be affected by relaxing the hypothesis on variable trade costs. Indeed, in the model, in line with the theoretical literature, it has been assumed that the variable trade costs are of the iceberg type, namely *ad valorem*. However it is well known that the distinction between iceberg trade costs and *per unit trade costs* is not innocuous in trade models, as, in reality, transport costs are better represented as per unit costs (see Hummels and Skiba, 2004). Interestingly, per unit trade costs may provide an alternative explanation for the relationship between export intensity, quality and the income of foreign destination. In addition, the fact that, in the food industry, the border protection structure of many developed countries is often based on *per unit* (and composite) tariffs, rather than *ad valorem* tariffs, may induce a compositional

effect in favour of higher quality exports to these destinations (see Ramos *et al.* 2010).
As shown by Crinò and Epifani (2012), if trade costs are per unit, the relationship between export intensity and productivity/quality is affected by the size of the elasticity of marginal cost to productivity(ξ).[4] For ξ<1, marginal costs is decreasing in productivity, and export intensity is inversely related to TFP also for similar income countries. This is because per unit trade costs represent a higher share of the marginal costs for high productivity firms, and therefore have a stronger negative impact on such firms' relative sales abroad.
Differently, for ξ>1, marginal costs are increasing in productivity and the elasticity of export intensity to productivity is positive, this is because the per unit trade costs now represent a lower share of the marginal costs for high-productivity firms. Moreover, because per unit trade costs increase with distance (see Hummels and Skiba 2004), the above relationship would also increase with distance, namely firms producing higher quality products and with higher productivity can be expected to export more to distant markets.[5]
A final issue is related to the degree of sustainability between export activities and (horizontal) foreign direct investment (FDI). If the FDI option is more profitable within more productive firms, as shown by Helpman *et al.* (2004) then, by reducing the exports of these firms, FDI will induce a negative relation between export intensity and productivity, that should be particularly strong for high-income destinations.[6] Moreover, as FDI tends to be a substitute of export, especially when trade costs are particularly

[4] All the above results hold true assuming that marginal costs is increasing in product quality, i.e. firms need to use more expensive inputs to produce higher quality products.
[5] See also Baldwin and Harrigan (2011) for an in depth discussion about which conditions in heterogeneity-firm model satisfy a positive relation between product price/quality and distance.
[6] This is because horizontal FDI are a better substitute for export especially between similar countries. Thus, working with Italy, this should happen with high income countries.

high, the negative relationship between export intensity and productivity would be more likely in trade with more distant countries. However, as we will show in the empirical analysis, we find exactly the opposite relation.

Chapter 2

Export behaviour of Italian food firms: does product quality matter?

2.1 Introduction

In this chapter we empirically investigate the relationship between product quality and food export performance using an alternative approach to infer product quality. Specifically, we make use of a (unbalanced) panel of roughly 750 Italian food firms, observed in the period 2001-2006. The main advantage of this dataset is that it allows the construction of a large set of firm-level variables, strictly correlated with product quality, like investment intensity, R&D expenditure, product and process innovations, as well as quality standard certifications. Using this data we study the relationship between TFP, product quality and firms export across destinations.

The analysis is based on the theoretical model of Crinò and Epifani (2012) presented in the previous chapter. The key predictions of such model show that, conditional to export, firm's export intensity monotonically increases in the *per-capita* income of export destinations and, most importantly, this effect should be largely driven by firms heterogeneity in product quality.
Our analysis departs from Crinò and Epifani (2010) in several respects. First, the attention is focused explicitly on the food and beverage industry. This can be important as working at a narrow product level can offer additional insights by reducing any potential aggregation bias due to sector heterogeneity (see Hallak, 2010). The Italian food industry represents an 'ideal' case study to investigate this relationship. This is because a lot of anecdotal evidence emphasizes how the performance of Italian food products in international markets is driven by their high quality nature. Yet, and quite surprisingly, formal evidence of this link is rare, only based on export unit values, and not always in line with common intuition (see Ninni *et al.* 2006; Fischer 2010).[7] Second, it is investigated the relationship for both the overall food industry and the 'sub-samples' related to firms producing typical 'Made in Italy' and 'Protected Designation of Origin' (PDO) products. This offers two main advantages. It gives the possibility to investigate if the perceived quality of these two product aggregations really matters for firm export behaviour, and, moreover, it represents an indirect test to investigate whether the firm-level proxies for quality, suggested by industrial organization literature, correlate with the recognized quality of these food products. Third, among the proxies for capturing firm level quality we also consider information about the ISO 9000 certification, an international standard directly linked to product quality, which was recognised in previous studies as being important to characterize a firm's export performance (see Hallak and Sivadasan 2009; Brown *et al.*

[7] Ninni *et al.* (2006) studied the role of quality vs. price competition for Italian pasta, cheese, wine, and olive oil, finding weak evidence of quality premium and, more often than expected, indications of price competition. Mixed evidence on the role of quality for export performance is also reported by Fischer (2010). Both papers used export unit values for their analyses.

1998). Finally, the analysis has been extended to the period 2004-2006, combining the 9th (2001-2003) and 10th Surveys (2004-2006) on Manufacturing Firms (*Indagine sulle Imprese Manifatturiere*) carried out by Unicredit-Capitalia.

2.2 Data description

To test the predictions discussed above we need firm-level data with information on firm export behaviour across destinations, basic data to estimate revenue-TFP, and, last but not least, firm-level proxies for product quality. This sections will introduce the dataset.

We make use of an unbalanced panel of Italian food and beverage firms drawn from the 9th and 10th Surveys on Manufacturing Firms (*Indagine sulle Imprese Manifatturiere*) carried out by Unicredit-Capitalia.[8] The overall sample contains firm level data on roughly 750 food firms with more than 10 employees observed in the period 2001-2006. The panel is stratified and rotating, so there is an overlapping of just 40 firms between the two surveys. The sample stratification is based on the 4-digit ISTAT ATECO 91 nomenclature (equivalent to NACE), size class and geographic area, and is representative of the population of the Italian food industry. In accordance with standard cleaning procedures, firms that present negative values for sales, material purchases, labour costs and capital stock were dropped.

In order to calculate firm's productivity with a Cobb-Douglas production function, we use a revenue-based measure of output that equals the value of shipments plus changes in stock of finished goods and capitalised costs, deflated with the corresponding ISTAT three-digit producer price index. As input it we use the labour cost deflated with an ISTAT wage index, the book value of capital deflated with the ISTAT common price index

[8] Several previous studies used the Unicredit-Capitalia survey to investigate Italian manufacturing firms behaviour in export markets (see Barba Navaretti *et al*. 2007; Benfratello and Razzolini, 2008; Castellani and Giovanetti, 2010; Crinò and Epifani, 2010). However, our paper is the first one to focus exclusively on the sub sample of the food and beverage industry.

for investment goods, and materials, defined as the difference between purchases and change in inventories of intermediate goods, deflated with the ISTAT common price deflator for intermediate inputs.
Table 2.1 reports the descriptive statistics on firm inputs and outputs. The average firm in the sample is characterized as follows: produces roughly 10 million Euros worth of output, employs about 30 workers, with a labour productivity (value added per worker) equal to 54 thousand Euros. With respect to the overall sample, exporting firms present a higher average value for all the considered variables, except for the number of employees that was equal in both samples. Information on the firms' internationalization is for the years 2003 and 2006 in the first and second surveys, respectively. To take a preliminary look at the data, we divide the sample of exporting firms, roughly 60%, into two groups, on the basis of the per capita income of the destination market: high income and low income destinations, respectively. The former group includes the firms' exports to EU15, North America and Oceania, the latter group includes exports to Latin America, Africa, the new EU member states and China. Note that, with the exclusion of China, the information about export destinations in the data set are available only at the group, and not country, level.

Table 2.1: Sample description

	Mean		Std. Deviation		Observations	
	Overall	Exporter	Overall	Exporter	Overall	Exporter
Output (€, '000)	29585	34325	72269	78891	758	459
Output per worker (€, '000)	571	644	2514	3132	758	459
VA per worker (€, '000)	97	120	680	870	770	468
Labor cost per worker (€, '000)	47	57	253	324	770	468
Materials per worker (€, '000)	337	354	972	1084	770	468
Capital stock per worker (€, '000)	123	136	374	461	770	468
Number of employees	78	78	219	150	793	478

Notes: Variables definition: Output equals the value of shipments plus change in stock of finished goods and capitalised costs. Materials are the difference between purchases and change in inventories of intermediate goods. Capital stock is the book value of capital.

Table 2.2 gives some descriptive statistics for variables of interest. Specifically, are reported the level of firm export intensity, measured as firm export value over total sales (domestic and abroad), considering both high and low income destinations, and also sub-samples of firms producing ‘Made in Italy’ products and those producing ‘Protected Designation of Origin’ (PDO) products. Firms producing ‘Made in Italy’ products are selected according to the 4-digit industry classification proposed by the *Istituto Nazionale di Economia Agraria* (INEA).[9] Differently, firms producing PDO products were selected through a two-step procedure. First, we select just the firms located in the PDO areas and belonging to the corresponding PDO sector, according to the Italian Agricultural Ministry PDO list. Second, we verify whether the selected firms actually do produce PDO products, through a careful check of their internet website.

Italian food firms export mostly to high income destinations (423 firms out of 456, about 93% of the exporters), the firms exporting to low income destinations being significantly lower (144 firms, about 31%). Similarly, the firm’ average export intensity (the ratio of exports over total sales) to high income destinations, equal to about 23%, is significantly higher than export intensity to low income destinations, equal to only 10%.[10] A similar pattern emerges considering firms producing ‘Made in Italy’ products. By contrast, when firms producing PDO are considered, these differences are very small, suggesting that these firms are no longer different from the average, at least in terms of the export indicators.

[9] According to the INEA classification, food and beverage sectors belonging to typical ‘Made in Italy’ in the 4-digit ATECO 91 nomenclature are: 15130, 15300, 15411, 15512, 15520, 15610, 15620, 15810, 15811, 15812, 15820, 15840, 15850, 15930.

[10] Export intensity to all destinations is higher than the average between high and low income, as we were forced to give no consideration to destination areas, where classification into high vs. low income is impossible. Specifically, it has been excluded ‘Other Europe’ and ‘Other Asia’ from the two groups as they include countries that are very heterogeneous in terms of per capita income.

Table 2.2: Export intensity across destinations

	Export intensity (%)			# (%) of firms		
	Overall	*Made in Italy*	*PDO*	*Overall*	*Made in Italy*	*PDO*
All destinations	27.8	31.0	28.2	456 (57.5%)	233 (29.3%)	113 (14.2%)
High income destination	23.2	26.6	23.6	423 (53.3%)	225 (28.3%)	107 (13.4%)
Low income destination	10.0	8.8	9.7	144 (18.1%)	69 (8.7%)	39 (4.9%)

Notes: Export intensity is the ratio of exports to total sales. High income destinations include EU15, North America (USA and Canada) and Oceania (Australia and New Zealand) countries. Low income destinations include New EU member states, China, Africa and Latin American countries. The reported figures are based on the average between 2003 and 2006 periods (See text).

Finally, to implement the empirical analysis, data on destinations GDP *per capita* and average distances from Italy to each foreign destination are also needed. Real GDP *per capita* variables were obtained from the World Bank, World Development Indicators (WDI). Differently, the measures of average distance are based on data taken from CEPII (Centre d'Etude Prospectives et d'Informations Internationales).[11]

2.3 Econometric approach

In this section we first explain how TFP has been estimated and the main results obtained. Then, we present the overall econometric strategy to test the key model predictions.

2.3.1 TFP estimation

One of the central points of our analysis is the estimation of revenue-based measures of TFP. These measures reflect both technical efficiency and product quality (Klette and Griliches, 1996; Amiti and Konings, 2007). We estimate TFP with different methods to address the problem of simultaneity bias. Generally speaking, there is no simple and unique solution to this problem. Thus, following a standard approach (e.g. De Loecker, 2011), we

[11] See the CEPII web site, http://www.cepii.fr/anglaisgraph/bdd/gravity.htm.

estimate a set of TFP measures and then we study their correlation with export intensity. We use a Cobb-Douglas specification, which has the advantage of a simple log-linear form. The first method used to estimate the production function parameters is the OLS. However, as the OLS estimates may be biased due to measurement error and potential correlation between inputs and unobserved productivity shock, we also use the semi-parametric approaches of Olley and Pakes (1996) and Levinsohn and Petrin (2003).[12]
In order to calculate TFP, we start from a standard Cobb-Douglas production function:

$$Y_{it} = A_{it} L_{it}^{\beta_l} K_{it}^{\beta_l} M_{it}^{\beta_m} \tag{2.1}$$

Where Y_{it} is revenue-based output of firm *i* in period *t*, L_{it}, K_{it} and M_{it} are, respectively, labour, capital and materials inputs, β_l, β_k and β_m the input coefficients, and A_{it} is the Total factor productivity. While L_{it}, K_{it} and M_{it} are all observable by the econometrician, A_{it} is unobservable to the researcher.
Considering the log-linearization of (2.1) yields:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \eta_{it} \tag{2.2}$$

where:

$$\ln A_{it} = \beta_0 + \eta_{it} . \tag{2.3}$$

In the relation (2.3), β_0 represents a measure of the mean efficiency level across firms and over time and η_{it} is the time- and producer-specific deviation from that mean.
In order to calculate TFP, the variable of interest in (2.2) is the error term, η_{it}. Note that, to get a consistent OLS estimator of the

[12] We implemented the Levinsohn-Petrin method in Stata 11 using the *levpet* routine (see Petrin *et al.*, 2004 for additional information on this command).

production function, therefore extracting TFP as the residual, η_{it} must be uncorrelated with the input variables. However, using OLS to estimate our production function, η_{it} results correlate with the input variables, generating the well-known simultaneity problems. Following Griliches and Mareisse (1995), it is possible to explain this problem considering that profit-maximizing firms immediately adjust their inputs each time they observe a productivity shock, consequently input levels will be correlated with the same shocks. As said before, while firm productivity shocks are normally observable and observed by firms, they are unobservable by the econometrician.

Because of this, productivity shocks enter in the error term of the regression, hence inputs turn out to be correlated with the error term, causing a bias OLS estimation of the productivity function. Olley and Pakes (OP, 1996) and Levinsohn and Petrin (LP, 2003) have proposed two similar methods to solve this problem, based on a semi-parametric estimation in which the error term η_{it} can be decomposed into two parts. The equations (2.2) becomes:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \varpi_{it} + \varepsilon_{it}. \qquad (2.4)$$

Therefore the error term in (2.4) has two component: ϖ_{it}, that represents the transmitted productivity component and ε_{it}, an error term that is uncorrelated with input choices. The key difference between the two components is that ϖ_{it} is a state variable that impacts the productivity shocks and it is observed by the firm but not by the econometrician. Hence OP and LP propose an estimation method to make observable the productivity shocks, finding an observable proxy for the productivity term ϖ_{it}. In particular, the OP methodology uses investment as proxy, while the LP methodology uses material costs.

OP and LP assume that, respectively, investment demand function and materials demand function, depend on the firm's state variables k_{it} and ϖ_{it}. Assuming that these demand functions are monotonically increasing in TFP, it is possible to invert them to express TFP in terms of observables.

Solving (2.4) for ϖ_{it}, productivity can be calculated as follows:

$$\hat{\varpi}_{it} = y_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_m m_{it} \tag{2.5}$$

where ϖ_{it} is the (log of) TFP.

Table 2.3 shows the estimated coefficients of the production function based on the three different techniques. In particular, all outputs' elasticity are positive and, excluding the capital coefficient in the Levinsohn and Petrin procedure, precisely estimated.

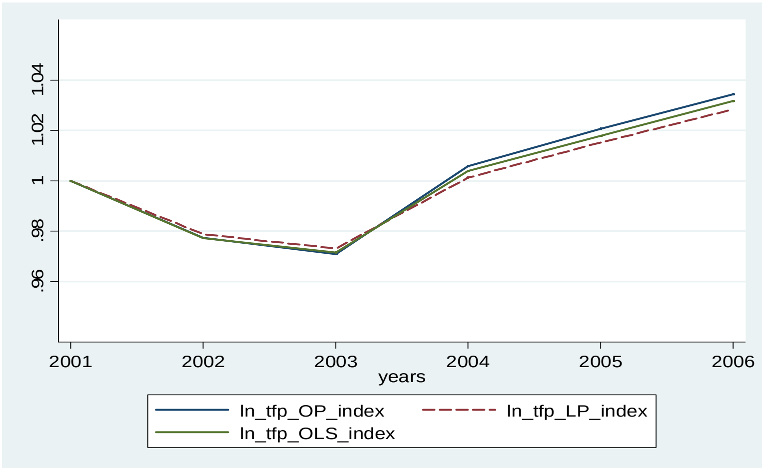
For each specification the bottom of the table reports estimated returns to scale: all the estimates are close to constant returns to scale. Finally note that the correlation among TFP estimates is quite high, and ranges from 0.95 (Olley-Pakes vs. Levinsohn-Petrin) to 0.98 (OLS vs. Levinsohn-Petrin).

Table 2.3. TFP estimation results using different methods

Dependent variable	*Log of Output*		
TFP method	OLS	OP	LP
Parameter	(1)	(2)	(3)
Ln labor	0.354***	0.331***	0.337***
	(0.010)	(0.012)	(0.023)
Ln capital	0.040***	0.051***	0.040
	(0.008)	(0.016)	(0.045)
Ln material costs	0.603***	0.611***	0.610***
	(0.008)	(0.009)	(0.214)
Return to scale	1.00	0.99	0.99
Observations	2275	2275	1737

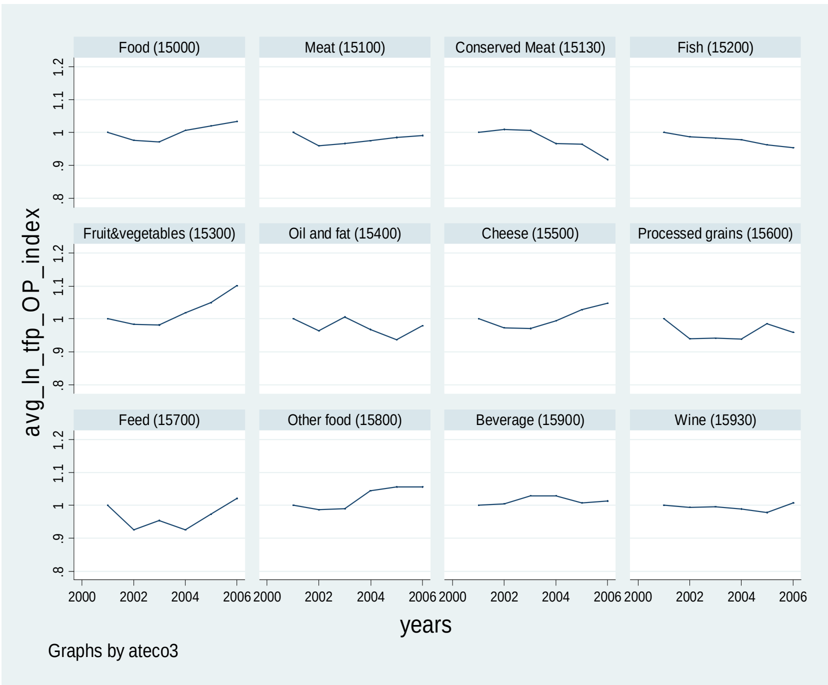
Notes: In columns (1) robust standard errors in round brackets; In columns (2) and (3) standard error based on 100 bootstrap replications in round brackets.. ***, **, * significant at 1, 5 and 10 percent levels, respectively.

Figure 2.1. Evolution of average TFP in the food industry under different estimation methods.



Notes: The figure reports across firms and sectors *average* TFP estimated with the three different methods described in the text.

Figure 2.2. Evolution of average TFP in different food sectors .



Notes: The figure reports across firms *average* Olley-Pakes TFP in the main sectors considered.

Using the three estimation methods, Figure 2.1 shows the evolution of aggregate TFP indices, computed as the ratio between the yearly un-weighted average of the firm level TFP and its initial (2001) value. Results point to a high correlation of the three estimates and a declining trend for the sample of firms from 2001 to 2003, followed by an increasing trend from 2004 to 2006.
Figure 2.2, shows the evolution of the TFP index according to its industrial dimension, using OP estimates as baseline. Across food industries the patterns are quite heterogeneous. Indeed, we found sectors with a declining TFP level in the observed period, such as *Conserved and preserved meat* (15130), *Fish preparation* (15200), *Oil and fat* (15400) and *Processed grains* (15600); sectors with an increasing TFP level, such as *Conserved fruit&vegetables* (15300) and *Cheese* (15500), and, finally, sectors that do not display any relevant trend in the observed period, such as *Meat* (15100), *Beverage* (15900) and *Wine* (15930).

2.3.2 Export intensity, TFP and product quality

With the firm-level TFP in hand now it will be presented the empirical strategy for testing the main model predictions. The key dependent variable of interest is a firm-level ratio of export to total sales. This definition of export intensity is in line with the empirical literature, and have some practical advantages over the simple ratio between exports to domestic sales. This is because it is less susceptible to outlier and measurement errors, and gives the possibility to also include observations where firms sell all their output to the international market.[13]
As the model predictions for a developed country like Italy hold, especially, for exports towards low income destinations, we start by using an index of firm export intensity to low income destinations, measured as the ratio of exports to these areas over

[13] This is because firm exports to total sales tend to give too much weight to firms selling a small share of their output in the domestic market.

total sales, $EXP_l \equiv \frac{r_l}{r_d + r_l + r_h}$.[14] The first proposition of the model suggests the existence of a *negative* relationship between firm TFP and its export intensity to low income destinations, conditional to export. This hypothesis can be tested by running the following cross-sectional OLS regression on firm-level data:

$$\ln EXP_{lj} = \alpha_0 + \alpha_1 \ln TFP_j + \eta_i + \varepsilon_j \quad (2.6)$$

where EXP_{lj} is the export intensity to low income destinations for the firm *j*, TFP_j is the firm-level total factor productivity, η_i are industry fixed effects and, finally, ε_j is an error term. The expectation is that the TFP coefficient should be negative, namely $\alpha_1 < 0$.

The second proposition of the model asserts that the key channel through which there exists a correlation between TFP and export intensity, conditional to export, is product quality, as an effect of the positive correlations between revenue-TFP and product quality. These predictions has been tested in several different ways.

First, relying on simple categorical dummies to indirectly capture the quality nature of Italian food products. Specifically, we construct two dummy variables for typical *Made in Italy* products and *PDO* products, respectively. The first dummy equals 1 if a firm belongs to one of the 4-digit sectors of *Made in Italy* (0 otherwise); the second dummy, is equal to 1 for firms producing *PDO* products (0 otherwise). Hence, in order to test the main hypothesis, we simply add the two dummies into (2.6), controlling for TFP. To the extent to which firms belonging to *Made in Italy* and/or producing *PDO*, produce higher quality products, it is likely to expect their coefficients to be negative.

The second strategy follows Crinò and Epifani (2010), and exploits the richness of the dataset. According to the literature (e.g.

[14] These destinations include New EU member states, China, Africa and Latin American countries.

Sutton, 1998, 2007; Kugler and Verhoogen, 2008), product quality differentiation is normally associated with specific firm characteristics. Thus, we selected the following proxies for some of these firms' features linked to product quality differentiation: total investment expenditure, sale of innovative products, ICT investments, a dummy variable for R&D investments, average wage as proxy for input quality, number of employees as proxy for size, a dummy variable for product innovation and, last but not least, a dummy variable for ISO 9000 quality certification. With respect to the last variable, there exists an extensive literature pointing to its relation with product quality (see Buttle 1997; Brown et al., 1998; Withers and Ebrahimpour, 2001; Hallak and Sivadasan, 2009). Each of these proxies for quality are regressed on TFP, to test if the expected positive relationship exists between them. Then, we generate a synthetic variables proxy for quality, extracting the principal component by factor analysis. Three quality proxies are generated. The first, Q_A, is the principal component of all the variables described above, except for firm size and input quality. The second proxy for quality, Q_B, is generated by adding a variable proxy for *firm size,* number of employees, to the variables used to generate Q_A. Finally, the third proxy for quality, Q_C, is generated by also adding a variable proxy for *input quality*, the firm's average wage, to the variables used for Q_B.

In a second step, after assessing how these firm-level quality variables correlate with TFP and dummies for *Made in Italy* and *PDO*, we test the main proposition of the model adding into (2.6) the proxies for quality in place of (or together with) TFP, in order to verify whether, also in this case, there exists a negative correlation between export intensity to low income destination and product quality.

Finally, we exploit the panel dimension of the dataset to check and extend the main findings. Specifically, we run panel regressions of the following form:

$$\ln EXP_{zj} = \delta_z + \eta_i + \beta_1 \ln X_j + \beta_2 (\ln X_j \times y_z) + \mu_{zj} , \qquad (2.7)$$

where EXP_{zj} is the firm *j*'s export intensity to (foreign) destination *z*, X_j is *TFP* or quality, y_z is the per-capita income of the destination *z* relative to Italy per-capita income and, finally, δ_z and η_i are destinations and industry fixed effects, respectively. The expectation is that the sign of coefficient β_2 should be positive. One key advantage of the above specification, is the possibility to control also for the robustness of the main findings to concurrent explanations like, especially, the effect of distance. To this end it has been took the distance in kilometers between Rome and the capital city of the main country of each destination, then normalizing it by the average distance across all the considered destinations.

2.4. Econometric results

Table 2.4 shows the regression results of equation (2.6), namely the relationship between export intensity to low income destinations and TFP. To save space, we show only the Olley and Pakes (OP) and Levinsohn and Petrin (LP) TFP estimates. However, all the results reported below are robust to the use of TFP estimates based on simple OLS.

As it is clear from the figures, the results strongly confirm that the TFP elasticity of export to low income destination is negative, large in magnitude, and statistically different from zero at 5% level (Columns 1-2). The result holds irrespective of the different TFP estimation methods, although the TFP elasticity to export is slightly higher for the Levinsohn and Petrin method. The estimated elasticity is large in magnitude, implying that a 1% increase in TFP is associated with about 0.9% fall in the export to low income destinations. Thus, firm-level export intensity to low income destinations appears quite sensitive to TFP, *ceteris paribus.*

Table 2.4. Export intensity to low income destinations, TFP and product quality

Dependent variable	*Export intensity to low-income destinations*							
TFP method	*OP*	*LP*	*OP*	*LP*	*OP*	*LP*	*OP*	*LP*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln TFP	-0.886**	-0.933**	-0.793**	-0.859**	-0.887**	-0.933**	-0.703*	-0.783*
	(0.439)	(0.466)	(0.400)	(0.427)	(0.447)	(0.465)	(0.415)	(0.436)
Dummy Made in Italy			-0.818***	-0.819***			-0.923***	-0.923***
			(0.222)	(0.223)			(0.211)	(0.210)
Dummy PDO					-0.003	-0.004	0.348	0.345
					(0.295)	(0.293)	(0.269)	(0.226)
R-squared	0.10	0.10	0.18	0.18	0.10	0.10	0.20	0.20
Observations	135	135	135	135	135	135	135	135

Notes: OLS regressions with robust standard errors in round brackets . ***,** ,* significant at 1, 5 and 10 percent level, respectively. All specifications include a full set of industry dummies, defined at the 3-digit level classification. (See text).

The rest of the Table tests whether firms producing *Made in Italy* products (columns 3-4) and *PDO* (columns 5-6) have, after controlling for TFP, an export intensity significantly different from the average firm. In line with the theoretical predictions, the coefficients of these variables are, indeed, negative, although only the *Made in Italy* dummy is estimated with high precision (p-value < 0.01). Adding the two 'quality' dummies together (columns 7-8) confirms the previous results, although now the *PDO* dummy coefficient is positive, probably due to collinearity problems.[15] It is also worth noting that when the dummy for *Made in Italy* is included, the magnitude of the TFP elasticity, although still significant at 5% level, shrinks by about 20%, suggesting that the TFP elasticity to export intensity for firms producing *Made in Italy* is higher in (absolute) magnitude. This result gives a preliminary confirmation to the idea that product quality may effectively represent a first order explanation for the observed link between productivity and export behaviour.

[15] Indeed, in this (small) sample of firms exporting to low income destinations, the degree of overlapping between firms producing Made in Italy and PDO is quite high. The simple correlation between the two dummies is indeed 0.40 in that sample, but shrinks to 0.20 in the overall sample.

In order to test the relationships directly, Tables 2.5 and 2.6 report results of regressing each of the selected proxies for quality on the TFP. The results clearly point to a positive relationship between TFP and all the quality variables, considered both individually (Table2.5) and as synthetic quality proxies extracted through factor analysis (Table 2.6). Thus, as assumed by the theory, the findings point to a strong positive correlation between TFP and firm level proxies for quality. Moreover, in columns 4-9 of Table 2.6 it has been also checked whether the firm level proxies for quality are correlated with *Made in Italy* and *PDO* dummies.
These additional regressions give broad confirmation to that hypothesis, although only the Made in Italy dummy turns out to be positive and strongly significant. Thus in the sample, firms producing PDO display different behaviour both in terms of export (see Table 2.4) and activities linked to quality upgrading like investments, process/product innovations and R&D.

Table 2.5. Quality related variables and TFP (panel regressions)

Dependent variable	Investment expenditure	Dummy for product innovation	ICT investments	Sales of innovative product
	(1)	(2)	(3)	(4)
ln TFP (Olley-Pakes)	0.021** (0.009)	0.033** (0.016)	0.036*** (0.010)	0.093** (0.47)
R-squared	0.26	0.09	0.10	0.10
Observations	1636	2221	1863	1767
Dependent variable	Dummy for R&D investments	Dummy ISO 9000	Number of employees	Average Wage
	(5)	(6)	(7)	(8)
ln TFP (Olley-Pakes)	0.080*** (0.023)	0.033*** (0.005)	0.028** (0.014)	0.096* (0.056)
R-squared	0.07	0.07	0.10	0.07
Observations	2235	2251	2224	2164

Notes: OLS regressions with robust standard errors in round brackets. ***,** ,* significant at 1, 5 and 10 percent level, respectively. All variables are standardized with mean 0 and variance 1. TFP is based on the Olley - Pakes estimates. All specifications include a full set of industry dummies, defined at the 4-digit level classification and time dummies. (See text).

Table 2.6. Correlation between TFP and proxy for quality (panel regressions)

Dependent variable	Q_A	Q_B	Q_C	Q_A	Q_B	Q_C	Q_A	Q_B	Q_C
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln TFP (Olley-Pakes)	0.066***	0.065***	0.051***						
	(0.014)	(0.011)	(0.011)						
Dummy Made in Italy				0.181***	0.223***	0.220***			
				(0.066)	(0.067)	(0.069)			
Dummy PDO							0.030	0.047	0.047
							(0.039)	(0.041)	(0.042)
R-squared	0.14	0.14	0.14	915	911	900	915	911	900
Observation	1421	1416	1415	0.17	0.18	0.18	0.16	0.18	0.18

Note: OLS regressions with robust standard errors in round brackets. ***,** ,* significant at 1, 5 and 10 percent level, respectively. Quality A, B and C represent proxies for product quality obtained through factor analysis, by extracting the principal components of the quality proxy variables of Table 2.5 (see text). All variables are standardized with mean 0 and variance 1. All specifications include a full set of industry dummies, defined at the 4-digit level classification and time dummies.

After having assessed the positive correlation between TFP and quality indicators, we test the crucial implication of the model. This is done by replacing, in equation (2.6), the three proxies for product quality in place of TFP, in order to verify if the negative relation between TFP and export intensity to low income destinations, is indeed driven by firm heterogeneity in product quality. Table 2.7, columns 1-3, shows the results. For all the quality proxies the estimated coefficient is, as expected, negative, and significant at 5% level or more.

Because the three quality proxies are standardized variables, the magnitude of their estimated effect is comparable. Interestingly, when the quality proxy also incorporates firm size (Q_B), the estimated effect on export intensity shrinks substantially, from 0.497 to 0.325, but it is partially recovered when also the input quality dimension (Q_C) is included. This result represents an indication that in the Italian food and beverage industry, firm size no longer represents a key firm characteristic affecting export behaviour, a result fully in line with the most recent empirical evidence (see Hallak and Sivadasan, 2009; Bastos and Silva, 2010; Altomonte et al., 2011).

Columns 4-6 add to the specification also the TFP. Controlling for TFP, the results about the quality effects are even stronger and, moreover, the TFP coefficient although still negative is not significant. As a further check, in columns 7-9 it has been added export destination fixed effects, to control for omitted variable bias due to difference in size and price. This can be important, as any increase in the economic mass of the high-income countries leads to a reduction of the export intensity of firms exporting to low-income countries. However, adding destinations fixed effects, the results are virtually unchanged, suggesting that they are fairly robust across different specifications.

Table 2.7. Export intensity to low income destinations and product quality

	Q_A	Q_B	Q_C	Q_A	Q_B	Q_C	Q_A	Q_B	Q_C
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Proxy for quality	-0.497***	-0.325**	-0.370***	-0.521***	-0.372**	-0.377***	-0.572***	-0.395***	-0.406***
	(0.162)	(0.144)	(0.130)	(0.162)	(0.140)	(0.130)	(0.163)	(0.141)	(0.132)
ln TFP (Olley-Pakes)				-0.333	-0.555	-0.583	-0.128	-0.212	-0.226
				(0.888)	(0.904)	(0.906)	(0.893)	(0.932)	(0.931)
Destinations fixed effects									
EU new member states							0.504*	0.556*	0.580**
							(0.279)	(0.288)	(0.284)
Africa							-0.067	0.109	0.102
							(0.288)	(0.284)	(0.281)
Cina							0.719**	0.582**	0.605**
							(0.284)	(0.276)	(0.277)
Latin America							0.430	0.267	0.293
							(0.314)	(0.322)	(0.321)
R-squared	0.39	0.35	0.38	0.40	0.37	0.38	0.47	0.42	0.43
Observations	97	97	96	97	97	96	97	97	96

Notes: OLS regressions with robust standard errors in round brackets. ***,** ,* significant at 1, 5 and 10 percent level, respectively. Proxies for quality are standardized variables with mean 0 and variance 1. All specifications include a full set of industry dummies, defined at the 4-digit level classification. (See text).

Finally, we also investigate the relationship between TFP, quality and firms' export behaviour in terms of the number of export destinations. Indeed, some previous firm-level evidence has shown that more productive firms export to a higher number of destination markets (Crozet et al. 2011; Bernard et al., 2007; Crinò and Epifani, 2010; Gullstrand, 2011). Thus, a natural extension consistent with the model is that the positive relation between TFP and the number of export destinations could be once again mediated by product quality. This is fully consistent with the idea that firms can spread higher fixed costs of quality upgrading over a larger output and across a higher number of foreign markets.

Table 2.8. Number of export destinations, TFP and quality

Dependent variable	*Number of export destinations (from 1 to 8)*					
	(1)	(2)	(3)	(4)	(5)	(6)
ln TFP (Olley-Pakes)	0.239* (0.141)	0.230* (0.137)	0.276** (0.141)	0.287* (0.149)	0.304** (0.149)	0.325** (0.149)
Dummy Made in Italy		0.193*** (0.060)				
Dummy PDO			0.288*** (0.072)			
Proxy for quality (Q_A - Q_C)				0.151*** (0.035)	0.164*** (0.039)	0.161*** (0.037)
R-squared	0.08	0.11	0.12	0.16	0.17	0.17
Observations	438	438	438	308	308	308

Notes: OLS regressions with robust standard errors in round brackets . ***, **, * significant at 1, 5 and 10 percent level, respectively. In columns 4-6 the proxy for quality correspond to Q_A, Q_B and Q_C, respectively. All specifications include a full set of industry dummies, defined at the 3-digit level classification and time dummies. (See text)

Table 2.8 reports the results of regressing the number of served markets on TFP and our proxies for quality. The evidence clearly points to positive and robust correlations. The number of export destinations covered by each firm, thus their so called extensive margin of trade, is, as expected, higher for more productive firms (columns 1), for firms producing *Made in Italy* and *PDO* products (columns 2-3), as well as for the firm-level proxies for quality (columns 4-6). Thus, in line with previous evidence, we find that more productive firms, and firms producing higher quality products, also serve more export markets.

2.4.1 Robustness checks and extensions

The results reported in the previous section, although broadly in line with model predictions, may suffer several potential limitations. First, though it is remarkable to find such robust findings working with a sample of less than 100 firms, they are the result of using only a cross-section of firms that export to low income destinations. However, the model prediction is more general, suggesting that the elasticity of export intensity to productivity and quality should be increasing in the per capita income of the foreign destinations. Second, there are other potential concurrent explanations for the predicted correlation between export intensity, TFP/quality, and the income of foreign destinations, like (horizontal) FDI and/or relevant per unit trade costs. Thus, a central point is to check whether the key findings are robust to the inclusion of proxy for trade costs, like distance.

Columns 1-3 of Table (2.9) run panel regressions based on equation (2.7) using TFP, and controlling for both destinations, sector and time fixed effects. As expected, the interaction term between TFP and the destination's per capita income is significantly positive, although only at the 10% level. Importantly, controlling for the interaction between TFP and distance (column 2) the results are even stronger, reinforcing the idea that the elasticity of export intensity to productivity indeed increases with per capita income of foreign destinations. Moreover, and this is interesting, the elasticity of export intensity to TFP also increases with distance, a result inconsistent with the (horizontal) FDI argument, but totally in line with relevant per unit trade costs.

Column 3 adds the interaction between TFP and the number of countries for each destination. This can be important because there is evidence that the fixed costs of exporting are mainly country-specific, thus many exporters will sell to only a few foreign countries. However, due to data limitation, we observe only exports to broad destinations, which in most cases include more countries. Thus there is an (unobserved) extensive margin of countries potentially inducing a selection bias that should lower the negative (positive) relation between TFP and export intensity to low-income (high-income) destinations. Note that, if this is the case then, controlling for the number of countries in each destination we should expect an increase in magnitude of the estimated elasticity between export intensity and TFP. This is indeed what we found in the data. First, the estimated coefficient of the interaction effect is positive and significant at 10% level, meaning that the elasticity of export intensity to TFP increases with the number of countries of each destination, a result consistent with country-specific fixed costs of exporting. Second, controlling for the number of countries at each destination the magnitude of the elasticity of export intensity to TFP increases.

Table 2.9. Robustness checks (panel regressions)

Dependent variable	(ln) Export intensity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln TFP (Olley-Pakes)	-0.726**	-1.167***	-1.911***	-0.625	-0.784*	-0.817*	-1.954**	-2.253***	-2.500***
	(0.308)	(0.422)	(0.620)	(0.435)	(0.426)	(0.422)	(0.861)	(0.832)	(0.817)
Ln TFP * Relative income	0.515*	0.740**	0.953***	0.430	0.557	0.584	0.965**	1.172**	1.286***
	(0.290)	(0.328)	(0.353)	(0.378)	(0.374)	(0.371)	(0.473)	(0.462)	(0.455)
Ln TFP * Relative distance		0.249**	0.476***				0.514*	0.587**	0.649**
		(0.125)	(0.182)				(0.267)	(0.258)	(0.253)
Ln TFP * Number of countries			0.423*				0.438	0.445	0.528
			(0.249)				(0.328)	(0.326)	(0.321)
Quality				-0.417***	-0.463***	-0.461***	-0.841***	-0.951***	-0.895***
				(0.111)	(0.122)	(0.112)	(0.235)	(0.245)	(0.204)
Quality * Relative income				0.357***	0.394***	0.393***	0.551***	0.616***	0.589***
				(0.101)	(0.112)	(0.103)	(0.137)	(0.143)	(0.121)
Quality * Relative distance							0.141*	0.129*	0.121*
							(0.0781)	(0.0748)	(0.0663)
Quality * Number of countries							0.149*	0.198**	0.176**
							(0.0772)	(0.0783)	(0.0689)
R-squared	0.428	0.43	0.432	0.469	0.476	0.481	0.480	0.490	0.495
Observations	789	789	789	566	566	566	566	566	566

Notes: the above panel regressions are obtained considering export intensity all destinations, but 'other Europe' and 'other Asia'. All specifications include a full set of destinations fixed effects, industry fixed effects, and time fixed effects. For other variables definitions see text. Robust standard errors in round brackets. ***,** ,* significant at 1, 5 and 10 percent level, respectively.

Columns 4-6 add to the specification proxies for quality and their interaction with the income level of foreign destinations. We start from a parsimonious specification where it has been omitted both the interactions with distance and the number of countries within each destination. The results are stark. Quality emerges as a first order explanation for the firms' export behaviour, giving strong confirmation that the elasticity of export intensity to quality is increasing in the per capita income of foreign destinations. Once again, controlling for quality, the estimated effect of TFP loss its significant level. As a final check, columns 7-9 add to the specification interaction terms between TFP/quality and both the distance and the number of countries for each destination, respectively. The inclusion of these additional controls do not affect, to any degree, the quality coefficients that, as expected, increase in magnitude and remain significant at 1% level. Moreover, now also the TFP coefficient and the interaction with income level turn out to be significant. As the last specifications are very demanding it is possible to conclude that our findings are very robust to potentially omitted variable (and selection) bias, and totally in line with the model predictions.

Finally, it is worth noting that also the interaction between product quality and distance is positive and significant, a result totally different from what Crinò and Epifani (2012) found for the overall manufacturing industry using a more parsimonious specification. However, what is interesting here is the fact that the significant positive interaction effect between quality and distance is broadly in line with relevant per unit trade costs.

This pattern is consistent with the Alchian and Allen (1964) effect on 'shipping the good apples out', highlighted recently by Hummels and Skiba (2004), and with the growing evidence showing that export unit values tend to be higher in more distant markets (see Bastos and Silva, 2010; Manova and Zhang 2011; Baldwin and Harrigan, 2011). Yet there is the novelty that it has been found a similar relation using proxies for quality, instead of unit-values. Thus these findings also support the notion that what matters for a firm's competitiveness is quality-adjusted price, namely higher quality goods are more costly, more profitable, and better able to penetrate more distant markets.

2.5 Discussion

Understanding the determinants of firms' export success and behaviour is important for their implications on international trade patterns, the welfare effects of globalization and economic growth and development. Moreover, a deeper comprehension of the factors driving firms' export performance can facilitate the design of policies that promote trade.

Motivated by the recent literature on firms' heterogeneity and international trade, this empirical work by exploiting the export behaviour of a sample of 750 Italian food and beverage firms, tests the predictions of a trade model based on firms' heterogeneity in product quality and non-homothetic preferences. Using different measures of revenue-TFP and several direct and indirect proxies for product quality, we find strong support for the key model prediction, namely product quality matters for export performance. Specifically, this work reveals robust evidence that the correlation between export intensity and TFP/quality increases with the per-capita income of foreign destinations. Thus, more efficient firms have higher export performance as they use more expensive and quality inputs to sell higher-quality goods at higher prices. Moreover, we also find evidence that firms producing higher quality products export more to more distant markets, a result consistent with the idea that the presence of per unit transaction costs lowers the relative price of high-quality goods, as recently suggested by Hummels and Skiba (2004).

The above results may have potential interesting implications. First, they highlight that government priority should be given to encourage investment in R&D and to establish technology policies that would allow firms to produce and export higher quality products. Clearly this statement is of particular importance for the developing countries access to richer markets. From this point of view, the growing concern about the effect of food quality and safety standards, on developing country exports – i.e. the view of standards as a barrier to trade – could be overemphasized. Indeed, if rich countries' food standards do not over marginalize small

agri-food producers in developing countries, by inducing a process of quality upgrading they will increase, not decrease, the firms' access to these markets (see Henson *et al.* 2011).
Second, the notion that richer countries export higher quality foods to other rich countries – the Linder (1961) hypothesis – could suggest that European countries should not worry too much about the adverse effects of competition from developing countries' exports, due, for example, to further trade liberalization. This is because, price competition is softened by vertical differentiation through quality differences and, moreover the trade-reducing effect of non-homothetic preferences is exacerbated in the presence of firms' heterogeneity in productivity and quality.

Chapter 3

Estimating Quality from Trade Data

3.1 Introduction

The growing importance assumed by the quality of the exported products in explaining the international trade patterns, leads to face an important issue, that is the measurement of the quality of the treaded products. In fact, the quantification of the role of quality in explaining trade outcomes is often prevent by the lack of direct measures of quality, forcing researchers to use proxies to make quality measurable, such as unit values computed from trade data (Schott, 2004; Hallak, 2006; Hummels and Klenow, 2005) or making other indirect measures that attempt to grasp the effects of quality differentiation on the residual demand addressed to an exporting country (Hallak and Schott, 2011; Khandelwal, 2010).

The most common proxy used to measure the quality of the exported goods is unit values, defined as nominal value divided into physical volume of a traded product. Unit value has been widely used in the economic literature, basically relying on the conjecture that higher unit value means higher quality. According to this view, as richer countries export goods with higher unit values, this is interpreted to mean that a country's income per capita is positively correlated with the quality of its exports (see Schott, 2004; Hummels and Klenow, 2005; Hallak and Schott, 2010). Like any comprehensive indicator, unit value has advantages and disadvantages. Among the advantages, it is easily available, also at very disaggregated level and for several products (up to ten-digit), for any country, and even for bilateral country to country trade flows (Aiginger, 2001).

However, there are several evidences in the literature showing that unit values are imprecise measure of quality, because it also captures several aspects that are not attributable to quality. For example, consider the export price of Chinese shirts: it might be cheaper than Italian shirts in a country such as United States. In this case, the lower price should be assimilate not only to a lower quality but also for example to a Chinese lower production costs or an undervalued exchange rate (Hallak and Schott, 2011).

Beyond this simple example, there are several reason that leads to the conclusion that unit value does not represent a reliable proxy for quality. First, because product heterogeneity and classification errors are important sources of unit value noise (Lipsey, 1994). Second, because higher unit values could reflect higher quality but also higher costs (Aiginger, 1997). Finally, because higher unit values could also be the consequence of higher margins created by market power (Knetter, 1997).

To overcome these problems, some recent papers in order to obtain a more reliable measure of the quality of traded products, tried to purge all the elements above obtaining a proxy for product quality from demand residual (Helpman, 2011). Basically, these methods share the same intuition, according to which firms selling large quantities of physical output, conditional on price, are classified as high quality producers. Based on this assumptions, Hallak and Schott (2011) provide a method to estimate product quality that allows to decompose observed export prices into quality versus quality-adjusted-price components. They define quality as "any tangible or intangible attribute of a good that increases all consumer's valuation of it". They infer countries' product quality by combining data of their exported export prices with information about global demand for them. The intuition behind this method is that, given the attention of consumer on price relative to quality in choosing among products, two countries with the same export prices but different global trade balances must have products with different levels of quality. According to this method, the country with the higher trade balance is revealed to possess higher product quality.

Khandelwal (2010) develops an innovative method to infer quality derived from a nested logit demand system, based on Berry (1994), that embeds preferences for both horizontal and vertical attributes. In such a method, quality represents the vertical component of the estimated model and captures the main valuation that consumers attach to an imported product. The procedure to infer quality with this method requires both import data (unit value and volume) and quantity information (production quantity) and has this straightforward intuition: "conditional on price, imports with higher market shares are assigned higher quality".

Relying on this innovative method, Khandelwal (2010) finds empirical evidence that developed countries export higher quality products relative to developing countries. Moreover, he points out that there exists a substantial heterogeneity in product market scope for quality differentiation, or quality ladders. Markets with a larger scope for quality differentiation show a long quality ladder, and, in this case, unit value should be considered an appropriate proxy for quality, due to its positive correlation with the estimated quality. Differently, in markets with a narrow range of estimated quality (short quality ladder), price appears to be less appropriate proxies for product quality. In markets characterized by a short quality ladder, expensive imports coexist with cheaper rivals due to horizontal product differentiation. This means that, although consumers give low valuation to the expensive imports, there are some consumers who still value the product.

Finally, Khandelwal et. al (2011) develop a method to infer quality from a demand function, based on the following intuition: conditional on price, a variety with a higher export quantity is assigned higher quality. They define quality as follows: "it is anything that raises consumer demand for a product other than price". They develop a method to infer quality where the consumers' demand for a particular firm's export product in a destination country, depends on product's price, quality, and on an income and a price index, relative to the destination country. In this relation product quality is unobservable and is captured by the residual. Hence, after estimating the demand function, product quality is carried out by dividing the residual, to the elasticity of substitution of the considered sectors (in this case textile and clothes) minus one.

3.2 A nested logit demand approach

In this section it will be explored the method used to infer quality proposed by Khandelwal (2010). Since he derives this method from a nested logit demand system, based on Berry (1994), it will be presented first the Berry's discrete model, used to estimate the demand function in differentiated product markets. Then, it will be shown the integral version of the Khandelwal's model.

3.2.1 The model

Berry (1994) proposes a discrete choice model to estimate the demand function in differentiated product markets. In this model firms are price-setting in oligopolistic competition and the utility of the consumer depends both on the consumer preferences and the product characteristics. In this setting, the product market share will be the result of the aggregate outcome of consumer decision.

Consider an utility function of consumer i for a product j that depends both on individual and product characteristics:

$$u_{ij} = U(x_j, \xi_j, p_j, v_i; \theta) \tag{3.1}$$

where the vector of product characteristics is represented by the observed (x_j) and unobserved (by the econometrician) (ξ_j) product characteristics and the price (p_j). On the other side, v_i captures the individual characteristics that are not observed by the econometrician. Finally, θ represents a demand parameter of the distribution of consumer characteristics.

Denoting with δ_j the main utility that consumers receive from purchasing product j, the produced utility function results exclusively dependent on the interaction between the product and the consumer characteristics

$$u_{ij} = \delta_j\left(x_j, \xi_j, p_j\right) + v_{ij} \tag{3.2}$$

Assuming a linear specification for δ_j, it is possible to define the main utility level that consumer i obtain from product j as:

$$\delta_j = x_j\beta - \alpha p_j + \xi_j \tag{3.3}$$

The discrete-choice market share function, s_j, is then derived from the consumer utility maximization: conditional on the product characteristics (x, p, ξ), consumer i will purchase one unit of the product j if and only if $U\left(x_j, \xi_j, p_j, v_i; \theta\right) > U(x_k, \xi_k, p_k, v_i; \theta)$, for all $k \geq 0$ and $k \neq j$.

Define the set of consumer unobservable taste parameters that lead consumer i to purchase product j as $A_j(\delta) = \left\{v_i/\delta_j + v_{ij} > v_{ij}/\delta_k + v_{ik}, \forall\, k \neq h\right\}$. Thus, the market share of firm j, s_j, is given by the probability that v_i falls into the region A_j. Given a distribution, $F(\cdot)$, for v, with density $f(\cdot)$, the discrete choice market share of product j is:

$$s_j(\delta(x,p,\xi),x,\theta) = \int_{A_j(\delta)} f(v,x)\, d \tag{3.4}$$

The market share of firm j is, in other words, the probability of purchase product j, given the distribution of consumer preferences over the product characteristics.

The definition of the market size and the presence of an outside alternative complete the specification of the demand system.

Considering the total number of consumer as a proxy for the market size, M, it is possible to define the output quantity of the j product as:

$$q_j = Ms_j(x,\xi,p,\theta) \tag{3.5}$$

Consider now an outside good, $j = 0$, that the consumer i may choose to purchase instead of the competing differentiated products $j = 1, \ldots., N$, with a price not affected by the variation of the price of the inside goods. The presence of an alternative good is important because, in a market without the option of the outside good, consumers are forced to choose among N inside goods, basing their decision only on differences in prices. Moreover, the possibility of choose an outside good, avoid the unfortunate future of some discrete model, where, due to the absence of an alternative, an increase in the price of the inside good does not affect the aggregate output.

Consider now a demand equation where the observed market share, S_j, is related to the market share predicted by the model s_j:

$$S_j = s_j(x,\xi,p,\theta) \tag{3.6}$$

Looking on the right-hand side of the equation, emerge the simultaneous presence of prices and of the product level demand error, that we expect to be correlated. Thus, the correlation between prices and the “unobservable”, leads prices to be endogenous. Problems of endogeneity are usually solved using instrumental variable methods, but in this case the unobserved product characteristics enter in (3.6) in a non-linear fashion, preventing the application of this approach. However, Berry (1994) overcomes this problem transforming market share so that the unobserved product characteristics comes out as a linear term. It is possible to do this following two alternative procedures, based on the distribution of v_i: *i.* assuming a known distribution of v_i; *ii.* assuming that v_i is unknown but depends on a vector of unknown parameters (σ) to be estimated.

In the first case, it is assumed that the distribution of unobservable individual characteristics v_i is known, so that markets share depend only on mean utility level

$$S_j = s_j(\delta) \text{ for } j = 1, \dots, N. \tag{3.7}$$

Considering now that, at the true values of δ and s, this equations must hold exactly and that the main utility levels δ_j contain the aggregate error ξ_j. If it is possible to invert the vector-value equation $S = s(\delta)$ producing the vector $\delta = s^{-1}(S)$, then the mean of consumer utility for each good will be exclusively determined by the observed market share. In this way, the market share function depends on not unknown parameters other then δ. Thus, the demand equation at the true values of (β, α) will be:

$$\delta_j(S) = x_j\beta - \alpha p_j + \xi_j. \tag{3.8}$$

Now, the equation (3.8) can be solved running an instrumental variable regression of $\delta_j(S)$ on x_j, p_j, obtaining the unknown parameters (β, α), considering ξ_j as an unobserved error term.

The second alternative method used to overcome the endogeneity problem assumes that, on the opposite with what made before, the density of unobservable individual characteristics v_{ij} is unknown and depends on a vector of unknown parameters (σ) to be estimated. Thus, the mean utility levels and the market share function do not depend only by δ, but also by σ. Therefore, the mean utility level will be define by inverting the vector of equation $S = s(\delta, \sigma)$, yielding the following equation:

$$\delta(s, \sigma) = x_j\beta - \alpha p_j + \xi_j \tag{3.9}$$

The unknown parameters of the above equation (σ, β, α) can be estimated using the instrumental variable technique.
Different assumptions about the consumer preferences affect the utility function and, thus, the specification of the demand and the patterns of substitution. Assuming homogeneous preferences across consumers, the utility function takes the following form

$$u_{ij} = x_j\beta - \alpha p_j + \xi_j + \epsilon_{ij} \tag{3.10}$$

where ξ_j represents the mean valuation of an unobservable product characteristic (such as quality) that the consumers attach to a product j and ϵ_{ij} represents the consumer distribution about this mean, that it is assumed to be mean zero and identically distributed across consumers and products. Otherwise, assuming that ϵ_{ij} follows an extreme value distribution, the probability of purchase product j is given by the following logit formula:

$$s_j(\delta) = \frac{e^{\delta_j}}{1+\sum_{j=1}^{n} e^{\delta_j}} \quad \text{for } j = 0, \dots, N \tag{3.11}$$

Normalising the utility of the outside good to zero, it is possible to obtain the following linear model in price and product characteristics:

$$\ln(S_j) - \ln(S_0) = \delta = x_j\beta - \alpha p_j + \xi_j \tag{3.12}$$

Considering ξ_j as an unobserved error term, the logit case suggests to use an instrumental variable regression of $\delta_j(S)$ on x_j, p_j to obtain the unknown parameters (β, α).
However, this simple logit specification has the limitation that produces unreasonable substitution patterns, because products are differentiated just by their mean utility levels (δ_j), thus the

substitution effects are the same independently of the degree of similarity between product characteristics.

To solve this problem, the obvious solution is to switch from homogeneous to heterogeneous preference across consumer. The heterogeneous preferences across consumers are simply generated in a discrete-choice model just by interacting consumer and product characteristics. One possibility to do this is given by the nested logit models, that, in contrast to the simple logit model, allowing consumer tastes to be correlated (albeit in a restricted way) across products.

In the nested logit model the products are grouped in $G+1$ exhaustive and mutually exclusive set of products $g = 0,1, \ldots, G$. Products within the same set are assumed to be higher correlated than products belonging to different sets.

Denote the set of products in group g as J. Regarding the outside good, $j = 0$ is assumed to be the only member of group 0. Thus, the utility that consumer i obtains for purchasing a product j, belonging to a group g will be:

$$u_{ij} = \delta_j + \zeta_{ig} + (1-\sigma)\epsilon_{ij} \tag{3.13}$$

where, as in (3.8), $\delta_j = x_j\beta - \alpha p_j + \xi_j$ and ϵ_{ij}, as in the logit model, follows an extreme value distribution. The variable ζ, for all consumer i, is assumed to be common to all products in group g and has a distribution that depends on σ (with $0 \le \sigma < 1$), that can be thought as a substitution parameter.

In the nested logit model, the market share of product j belonging to a group g, will be a fraction of the total group share

$$\overline{s}_{j/g}(\delta,\sigma) = \frac{e^{\frac{\delta_j}{1-\sigma}}}{D_g}\; for\, j\, \in g \tag{3.14}$$

where $D_g = \sum_{j \in J_g} e^{\frac{\delta_j}{(1-\sigma)}}$.

The probability of choose one of the group g products (the group share) is:

$$\bar{s}_g(\delta,\sigma) = \frac{D_g{}^{(1-\sigma)}}{\sum_g D_g{}^{(1-\sigma)}} \tag{3.15}$$

with a market share given by the interaction between the share of product j within group g ($\bar{s}_{j/g}$) and the share of group g over the total of products ($\bar{s}_g$)

$$s_j(\delta,\sigma) = \bar{s}_{j/g} \cdot \bar{s}_g = \frac{e^{\frac{\delta_j}{1-\sigma}}}{D_g} \times \frac{D_g{}^{(1-\sigma)}}{\sum_g D_g{}^{(1-\sigma)}} = \frac{e^{\frac{\delta_j}{1-\sigma}}}{D_g^{\sigma}[\sum_g D_g{}^{(1-\sigma)}]} \tag{3.16}$$

with the outside good as the only member of group zero and with $\delta_0 \equiv 0, D_0 = 1$ and so:

$$s_0(\delta,\sigma) = \frac{1}{\sum_g D_g{}^{(1-\sigma)}} \tag{3.17}$$

Taking the log of market share, it is possible to derive a simple analytic expression for the mean utility levels:

$$\ln(S_j) - \ln(S_0) = \delta_j/(1-\sigma) - \sigma \ln(D_g) \tag{3.18}$$

where $\ln(D_g) = \left[ln(\bar{s}_g) - \ln(s_0)\right]/(1-\sigma)$.

Substituting this into (3.18) and combining terms gives the analytic expression for $s_j^{-1}(s,\sigma)$

$$\delta_j(s,\sigma) = \ln(s_j) - \sigma \ln\ (\bar{s}_{j/g}) - \ln(s_0) \tag{3.19}$$

Setting $\delta_j = x_j\beta - \alpha p_j + \xi_j$ and substituting in from (3.19) for δ_j gives

$$\ln(S_j) - \ln(S_0) = x_j\beta - \alpha p_j + \sigma \ln\ (\bar{s}_{j/g}) + \xi_j \tag{3.20}$$

The estimation of the parameters (β,α,σ) can be obtained by a linear instrumental variables regression of difference in log market shares on product characteristics, price and the log of the conditioned share. The last term (ξ_j) is endogenous suggesting the need for additional exogenous variables that are correlated with the within group share.

3.2.2 Applying the method to trade data

In this section it will be described the method proposed by Khandelwal (2010) to infer product quality, using price and quantity information from standard trade data that embeds preferences for both horizontal and vertical attributes. Quality is the vertical component of the estimated model and captures the mean valuation that consumers attach to an imported product. The approach is based on the nested logit framework of Berry (1994) summarized above. This methodology has the main advantage that does not require special data beyond what is readily available in standard disaggregate trade data. In his work Khandelwal uses U.S. trade data, which contain five-digit SITC *industries* that have been mapped to ten-digit HS *product* denoted by h. The products represent the nests. The imported product h, from country c within a product is called *variety*.
Following Berry (1994), Khandelwal models the consumer preferences as the one variety that provide the consumer's highest indirect utility, given by:

$$V_{ncht} = \lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht} - \alpha p_{cht} + \\ + \sum_{h=1}^{H} \mu_{nht} d_{ch} + (1-\sigma)\varepsilon_{ncht}. \qquad (3.21)$$

Quality is defined as follows:

$$\lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht}$$

The previous relation reflects the common valuation attached by consumers to the variety ch (notice that these terms are not subscripted by n).

This quality term is decomposed into three components. The first term, $\lambda_{1,ch}$, represents the time-invariant valuation that consumers attach to variety ch. The second term, $\lambda_{2,t}$, captures the secular time trend common across all varieties. The third term. $\lambda_{3,cht}$, is observed by the consumer and unobserved by the econometrician and represent the variety-time deviation from the fixed effect. Notice that, this last term is potentially correlated with the variety's c.i.f. price, p_{cht}.

From the relation (3.21), the term $\sum_{h=1}^{H} \mu_{nht} d_{ch} + (1-\sigma)\epsilon_{ncht}$ captures the horizontal component of the model. The logit error ϵ_{ncht} is assumed to be distributed Type-I extreme value and explains why a variety that is expensive and has low quality is ever purchased. The common valuation that consumer n attaches within all varieties within product h is captured by the first term, μ_{nht}, with a dummy variable d_{ch} that takes a value of 1 if country c's export lies in product h. Notice that this term generates the nest structure because it allows consumer n's preferences to be more correlated for varieties within product h than for varieties across products.

Finally, in order to allow consumer the possibility not to purchase any of the inside varieties, the demand system is completed by an *"outside"* variety, that represents the domestic substitute of the inside variety. Thus, consumers can choose to purchase a domestic variety (or to not make any purchase) if the price of all imports rises. The utility of the outside variety is given by the following relation:

$$u_{n0t} = \lambda_{1,0} + \lambda_{2,0} + \lambda_{3,0t} - \alpha p_{0t} + \mu_{n0t} + (1-\sigma)\varepsilon_{n0t} \quad (3.22)$$

The mean utility of the outside variety is normalized to zero. The outside variety market share is then set as one minus the industry's import penetration, that is defined as import over the sum of import plus output. Once the outside variety market share (s_{0t}) is defined, it is possible to compute the total industry output as follows:

$$MKT_t = \sum_{ch \neq 0} q_{cht} /(1 - s_{0t}) .$$

Where q_{cht} represents the import variety of quality ch. Then, the imported variety market shares are defined as follows:

$$s_{cht} = q_{cht} / MKT_t .$$

Hence, the consumer choses variety ch if $V_{ncht} > V_{nc'h't}$. Then, following the distributional assumption for the random component of consumer utility shown by Berry (1994), the demand curve implied by the preferences in (3.21) is:

$$\ln(s_{cht}) - \ln(s_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \alpha p_{cht} + \sigma \ln(ns_{cht}) + \lambda_{3,cht} \quad (3.23)$$

Where s_{cht} represents the variety ch's overall market share and ns_{cht} is the nest share, that is the variety ch's market share within product h. $\lambda_{1,ch}$ are the variety fixed effects and represent the time invariant component of quality, while the year fixed effects $\lambda_{2,t}$ account for the common quality component. This implies that the inferred quality cannot separate the technology of the variety from the consumers' valuation for quality. Finally, $\lambda_{3,cht}$ is not observed and plays the role of the estimation error. Since the $\lambda_{3,cht}$ and the nest share are potentially correlated with the variety's price, it is requested an instrumental variable approach to identify the parameters.

Given the possible correlation between price and nest share, Khandelwal's instruments the variety's price with the variety-specific unit transportation cost. Given the obvious correlation between transportation costs and c.i.f. price, one may be concerned that they are correlated with quality because the "Alchian-Allen conjecture", i.e. distant countries may ship higher quality goods in order to lower unit transportation costs (Hummels and Skiba, 2004). Thus, trade costs might be correlated with variety's quality. However, the exclusion restriction remains valid as long as transportation costs do not affect deviations from average quality, $\lambda_{3,cht}$. Moreover, Hummels and Skiba (2004) identifies the impact of distance on prices using cross-country variation in distance rather than variation in transportation costs over time. Thus variety's price is instrumented using also exchange rate and an interactions between distance to U.S. and Brent oil prices.

Considering for the possible endogeneity of the nest share ns_{cht}, this term is then instrumented by using the number of varieties within product h and the number of varieties exported by country c. Obviously, these instruments are correlated with the nest term and uncorrelated with $\lambda_{3,cht}$, if variety entry and exit occur prior to exporting firms' quality choice.

Beyond the concern on possible endogeneity, a second issue that arises in estimating (3.23), is that the market shares are likely to be an aggregation of even more finely classified imports. In fact, as argued by Feenstra (2004), a country's large market share may simply reflect the fact that it exports more unobserved or hidden varieties within a product. For example, suppose that China and Italy export at the same price identical varieties and split the market equally at the (unobserved) twelve-digit level, but that China exports more twelve-digit varieties (such as more colors). Thus, an aggregation at ten-digit level leads to assigning a larger market share at identical prices to China, that would cause a China's estimated quality biased upward simply due to the hidden varieties. Following Krugman (1980), Khandelwal uses the country population as proxy for the hidden varieties. The demand curve adjusted for the hidden varieties is then given by:

$$\ln(s_{cht}) - \ln(s_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \alpha p_{cht} + \\ +\sigma \ln(ns_{cht}) + \gamma \ln pop_{ct} + \lambda_{3,cht} \quad (3.24)$$

where pop_{ct} represents the population of country c. Then, estimating separate demand curve for each industry, the quality of variety *ch* at time *t* will be defined using the estimated parameters as follows:

$$\lambda_{cht} = \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,cht} \tag{3.25}$$

This relation shows that the inferred quality relies on the intuitive idea that quality of an imported variety is its relative market share after controlling for exporter size and price. As a consequence the quality of a variety will rise if its price rises without losing market share.

3.3 Quality estimates: Data, results and application

This section presents the data used to infer product quality in the EU 15 market with the Khandelwal (2010) method, the main results and some empirical applications. In particular, we will show that, even using different data, and different destination countries, the quality estimation results are in close accordance with the ones of Khandelwal (2010). Moreover, it will be also shown through simple quality ranking in some key products, that our measure of quality appears in line with actual intuition and it allows to look at the evolution of product quality at a country level and over time.

3.3.1 Data

In order to infer product quality in the EU 15 countries, treated separately as destination markets, we rely on trade data by the Eurostat-Comext database. We make use of yearly import data, both in value and in volume, for all the EU 15 countries (except Luxembourg), from all trading partners in the World with data at the maximum level of disaggregation (CN 8-digit)[16] for the period 1995-2007.[17] Data on domestic production, for all the importing countries, are drawn from the Eurostat Prodcom database, which contains yearly information on the value and volume of domestic production. Prodcom collects data for all the EU countries from 1995 and is based on an extensive yearly survey of the production activities carried out by firms. For our quality estimates we make use of production volume data at 8-digit level, classified according to the Prodcom classification. This classification is directly linked to the NACE 4-digit classification, since the first four digits of the Prodcom code identify the 4-digit NACE industry, enabling us to easily map products into industries. The Prodcom classification is also easily linked to the CN 8-digit classification through appropriate correspondence tables provided by Eurostat.

As it is usual in this situation, we trim data along different dimensions, both before and after the quality estimations. First, varieties with extreme unit values that fall below the 5th or above the 95th percentile of the distribution within industries have been excluded. Second, we drop varieties with annual price increases of more than 200 percent or price declines of more than 66 percent. Third, varieties with export quantities below a minimum threshold have been excluded.

The final database has more than 1,500,000 observations, 150 exporters, more than 2400 CN 8-digit food products, mapped in 21 industries according to the NACE 4-digit Revision 1.1 classification (see Table 3.1).

[16] The CN (Nomenclature statistique des activités économiques dans la Communauté européenne) is an eight-digit subdivision of the Harmonised System (HS), comprising four two-digit levels: HS2, HS4, HS6 and CN8.

[17] We measure quality until 2007, instead of using the disposable more recent year, to assure that the price spike of 2008 and the subsequent financial crisis do not affect too much the quality estimation.

Table 3.1. Industries and numbers of cn8 products within the food sectors considered

NACE 4 (1)	Short description (2)	n_cn8 (3)
1511	Production and preserving of meat	142
1512	Production and preserving of poultry meat	196
1513	Production of meat and poultry meat products	108
1520	Production and preserving of fish and fish products	401
1530	Production and preserving of fruit and vegetables	495
1540	Manifacture of vegetables and animal oils and fats	144
1550	Manifacture of diary products	204
1560	Manifacture of grain mill products, starches and starch products	178
1580	Sugar and cocoa	60
1581	Manifacture of bread; manifacture of fresh pastry goods and cakes	2
1582	Manifacture of rusked and biscuits	29
1585	Manifacture of maccaroni, noodles and couscous	11
1586	Processing of tea and cofee	22
1587	Manifacture of condiments and seasoning	11
1588	Manifacture of omogenized food preparaison and dietetic food	7
1589	Manifacture of other food products n.e.c.	37
1590	Production of ethyl alcohol, cider, malt and other non-distilled fermented bevera	18
1591	Manifacture of distilled potable alcoholic beverages	67
1593	Manifacture of wine	99
1596	Manifacture of beer	4
1598	Production of mineral water and soft drinks	11

Notes: Table reports information on the NACE 4-digit food industries, for which we estimated equation (3.24), considering separately each EU15 country. Due to the lack of production data for some importing countries we did the following aggregations: codes 1531, 1532, and 1533 are included in code 1530; codes 1541, 1542, and 1543 are included in the code 1540; codes 1551 and 1552 are included in the code 1550; codes 1561 and 1562 are included in the code 1560; codes 1583 and1584 are included in the code 1580; and finally codes 1592, 1594, and 1595 are included in the code 1590. Column 3 reports data on the number of cn8 products belonging to each NACE 4-digit industries.

In order to infer the quality of all the cn8 exported products to the EU15 at the country level, the estimating equation (3.24) is run separately for each of the 21 NACE (rev. 1.1) 4-digit food industries in the 14 European importing countries considered.

3.3.2 Results

Table 3.2 shows some descriptive statistics of our quality estimates for both OLS and 2SLS regressions. We estimate quality for each importer-NACE 4-digit industry within each of the EU 15 countries, performing 250 regressions. The median number of observations for each regression is of 4,379, while the average number is 2,427. The pattern of signs matches the ones of Khandelwal (2010), with a negative and positive, respectively, price and nest share elasticity. Moreover, for both the OLS and 2SLS, the median price and nest share elasticity in our estimates is comparable to the ones in Colantone and Crinò (2012), who estimate quality with the Khandelwal (2010) method in the EU market.

Table 3.2: Summary statistics on quality estimates

	Mean		Median	
	OLS	2SLS	OLS	2SLS
Price	-0.260	-0.735	-0.231	-0.655
Nest Share	0.877	0.677	0.892	0.775
Observation per estimation	4379	4379	2427	2427
R-squared	0.851		0.852	
Sargan test (p -value)		0.15		0.02
Varieties per estimation	635	635	354	354
Estimation with stat. sig. price coeff.	0.67			
Estimation with stat. sig. nest share coeff.	0.93			
Total estimations	468			
Total observations across all estimations	1138022			

Notes: The top panel reports estimation statistics of running equation (3.24) separately for each of the food industries in our sample. The bottom panel reports statistics that apply to the entire sample.

As discussed in the introduction of this chapter, previous studies have found empirical evidence using unit price as a proxy for quality, that the quality of the exported products is increasing in the per-capita income of the exporting countries (Schott, 2004; Hallak, 2006). We test this prediction using our estimated product quality and the exporters' GDP per capita, in the following equation:

$$\lambda_{cht} = \alpha_{ht} + \beta lnY_{ct} + v_{cht} \qquad (3.26)$$

where λ_{cht} is the estimated quality of country c′s export in product h at time t and Y_{ct} is country c′s GDP per capita. The inclusion of a product-year dummy, α_{ht}, indicates that the regression considers the cross-sectional relationship between quality and income within products.

Table 3.3: Relation between quality and per-capita GDP

	(1) ALL	(2) OECD	(3) NON OECD
(ln) GDP	0.239***	0.132***	0.0830***
	(0.0106)	(0.0149)	(0.0186)
N	1133123	1133123	
R-sq	0.148	0.148	

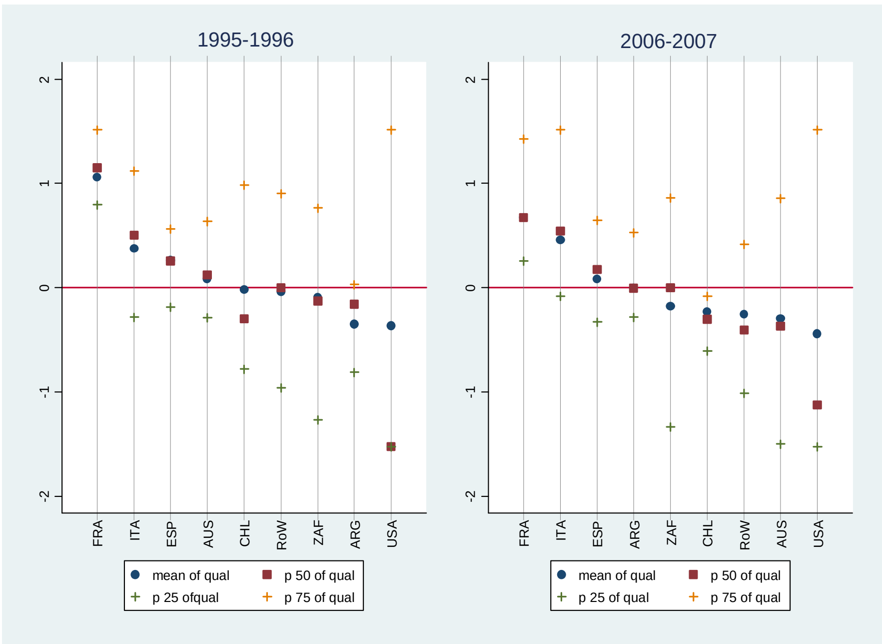
Notes: Table regresses the quality estimates on the log of per capita GDP. Standard errors under the coefficients clustered by exporting country. Significance levels: *** .01; **.05; * .10.

The results shown in Table 3.3 clearly show a positive and significant relationship between the quality of the exported products and the per-capita income of the exporting countries, both for OECD and non-OECD countries. These results are consistent with the common prediction that richer countries produce and export higher quality products.

Next, figure 3.1, 3.2 and 3.3, show some examples of the evolution of the estimated quality for certain products in two different periods (1995-1996 and 2006-2007), mapping the country ranking according to the mean quality value of the respective product. These figures allow first of all to represent the evolution of product quality for the considered product over time and, moreover, to show that our estimated quality can be considered reasonably realistic.

Figure 3.1 shows the evolution of quality for the cn8 category 22042111, that account for the product "*white quality wine*". From the ranking it emerges that France, Italy and Spain are the top quality wines in both the periods, within the traditional wine producer countries. Moreover, this figures shows that in the observed period emerges a convergence in the mean value of the estimated quality within these countries, a result in line with the growth experienced by these country in the world wine sector.

Figure 3.1: Quality ranking on "quality white wine" (cn8 code 22042111)

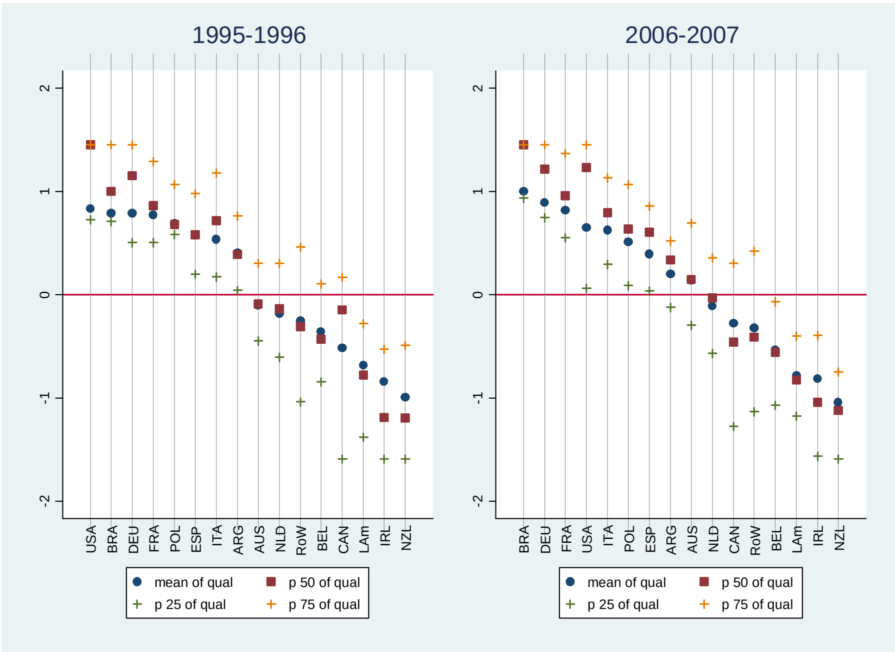


Notes: Countries in this figure are ranked according to the mean quality value of their exported product in the EU 15 for the considered cn8 category, for the periods 1995-1996 and 2006-2007.

Figure 3.2 and Figure 3.3 show the evolution of the inferred quality for the cn8 categories 02011000 and 20021010, that

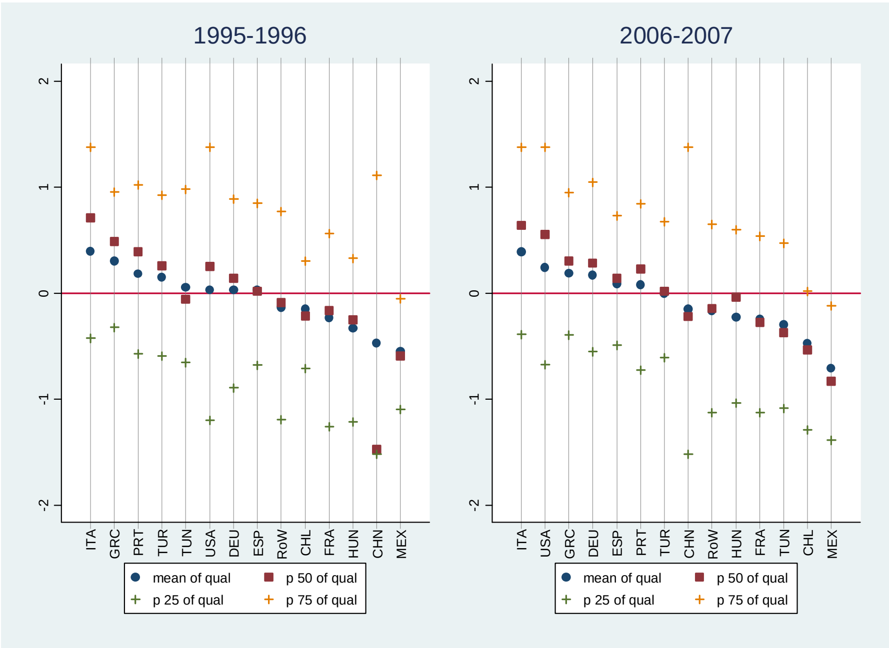
account, respectively, for the products "*fresh bovine meat*" and "*preserved tomato*".
Figure 3.2 shows that the quality ranking, for the product "fresh bovine meat" in the two considered periods are quite similar, except for Brazil, which increases the quality of its exported products, becoming first in the quality ranking. Interestingly, albeit the mean quality values are quite equal, USA moves from the first to the fourth position of the ranking.

Figure 3.2: Quality ranking on "fresh bovine meat" (cn8 code 02011000)



Notes: Countries in this figure are ranked according to the mean quality value of their exported product in the EU 15 for the considered cn8 category, for the periods 1995-1996 and 2006-2007.

Figure 3.3: Quality ranking on "preserved tomato" (cn8 code 20021010)



Notes: Countries in this figure are ranked according to the mean quality value of their exported product in the EU 15 for the considered cn8 category, for the periods 1995-1996 and 2006-2007.

Figure 3.3 shows that Italy is the top quality producer of preserved tomato in the two considered periods. It is also interesting to underline the decrease of the mean value of quality of the Turkey and Tunisia exported products and the simultaneous increase of the mean value of Chinese product quality in the tomato industry.

3.4 Conclusions

This chapter explored the problematic of "measure the quality" of products by using international trade data. Since products quality is considered of primary importance in determining the international trade patterns, a reliable method to measure quality becomes a fundamental instrument for empirical studies.

After a short review of the traditional and the most recent methods to measure product quality, we focus on the nested logit model proposed by Khandelwal (2010). Such method allows to infer the quality of the exported products in a destination market, relying on a simple intuition: "*conditional on price, imports with higher market shares are assigned higher quality*". We apply this methods to infer product quality of more than 2,500 food products exported by about 150 countries into the European Union market. We show that, even using different data and focusing on a specific industry and in a different market, our econometric results of the estimated nested demand functions are very close with the ones of Khandelwal (2010). Moreover, our quality estimates appear reasonable and realistic to common intuition and, thus, particularly useful in assessing the role of product quality in influencing trade patterns. Our quality estimates will be used in next Chapter to empirically investigate the role played by trade policies and market regulation on the process of quality upgrading.

Chapter 4

Quality upgrading, competition and food standards

4.1 Introduction

In the last decades the world market has been characterized by a progressive fall of traditional trade barriers, like tariffs, leading countries to face an increased competition, either in the home and in the international markets. At the same time, the reduction of border protection has been followed by a progressive diffusion of domestic market regulations, where food standards represent the lion share. Understanding how the increase in market competition, on the one hand, and the diffusion of standards, on the other hand, have affected the pattern of quality upgrading in the agri-food sector represents an interesting question rarely empirically investigated.

An emerging literature agrees that exporting higher quality products is one of the main determinants of the firms' performances in the export markets. Hence, understanding the factors that influence a country's transition from the production of low-quality to high-quality products is important as the production of high-quality goods is viewed as a pre-condition for export success, leading to economic growth and development (Helpman, 2011; Amiti and Khandekwal, forthcoming). This is especially true for developing countries exporting to rich markets, since their economic development passes necessarily through a greater presence in these export markets.

In this chapter it is first analyzed to what extent an increase in competition (expressed by a fall in import tariffs) in the origin country, affects the rate of quality upgrading in the agri-food sector. Such relation has been empirically studied using highly disaggregated export data from more than 100 countries to the EU15 in thousands of food products, in the period 1995 to 2007.

We focus on product quality, because it is considered an important element of innovation, and on the trade liberalization, that represents one of the key policy tool that stimulates competition. While there is broad evidence on the pro-competitive effect of trade liberalization, only few works have investigated the relation between competition and product quality. Melitz (2003) in his seminal paper, suggests that an increase in competition leads to an increase in the average export quality, since the less-productive firms are driven out from the market. Verhoogen (2008) and Bustos (2011) provide the evidence that a wider access to the destination markets gives an incentive to the firms to improve their product quality. More recently, Amiti and Khandelwal (forthcoming) use a 'distance to frontier' approach to study the relationship between the countries rate of quality upgrading (as a measure of innovation) and the reduction of tariffs (as proxy for import competition). They showed that the growth of quality upgrading is positively affected by the reduction of tariffs, but the magnitude of the effect is indeed conditional to the product distance from the (world) quality frontier.

Moreover, in this work we also study the effect of the diffusion of voluntary standards in the importing country (in this case European Union) on the quality upgrading of the exported products. More specifically, we investigate the extent to which the number of voluntary standards affects the competitive environment in the exporting market, namely, if standards act as a catalyst (thus increasing the level of competition) or as a barrier to trade.

Studies focusing on public standards, like sanitary and phytosanitary measures (SPS), more often find that they act as non-tariff barriers to trade (see Li and Beghin, 2012, for a recent survey). On the other hand, studies based on private and, especially, voluntary standards more often find a positive effect of standards on the intensity of trade flows, at least when harmonized standards and North-North trade are considered, however with several exceptions (see Moenious, 2006; Shepherd and Wilson, 2010; Swann, 2010). Albeit broadly studied, the evidences on the trade effects of standards are quite inconclusive.

To rationalize our empirical exercise we rely on the approach proposed by Amiti and Khandelwal (forthcoming), by studying the relationship between quality upgrading and competition within a model of 'distance to frontier' of Aghion et al. (2005; 2009). These authors, within the logic of the work on technological convergence and endogenous growth theory, argued that the relationship between competition and innovation is non-monotonic and conditional to the firm/product/sector distance from the (world) technology frontier. According to this model, an increase in competition reduces the incentive to innovate for firms far from the frontier, cause the ex-post rents from the innovation are eroded by the new entrants (*discouragement effect*). Differently, as firms approach to the frontier, a tougher competition increase the

incentive to innovate, in order to escape and survive to the newcomers by intensifying the innovation activities.
Our strategy offers, in addition, the possibility to test whether the findings of Amiti and Khandelwal (forthcoming) hold true working in a different market – the EU15 instead of the US market – and especially with a specific sector – the food industry – only marginally covered by their analysis and where the quality attributes represent a fundamental prerequisite for firms' export success (see Crozet et al. 2011; Altomonte et al. 2010).

4.2 Competition, quality upgrading and distance to the frontier

This section presents the main predictions of the distance to the frontier model developed by Aghion et al. (2005; 2009), on the relationship between innovation activity and competition.

4.2.1 The model

Consider a unit mass of identical consumers, each supplying a unit of labor. The logarithmic instantaneous utility function is $u(y_t) = lny_t$, where the good y is produced at the time t, using input services from a continuum of intermediate sectors, according to the following production function:

$$lny_t = \int_0^1 lnx_{jt}d_j \qquad (4.1)$$

Where each x_j represents an aggregate of two intermediate goods produced by duopolists in sector j, defined by the subutility function,

$$x_j = x_{Aj} + x_{Bj}$$

In this setting, in equilibrium each individual spends the same amount on each basket x_j, than normalized to unity by using current expenditure as the numeraire for the prices p_{Aj} and p_{Bj} at each date.

Thus, the representative household chooses x_j subject to the budget constraint:

$$p_{Aj}x_{Aj} + p_{Bj}x_{Bj} = 1.$$

The only input used by each firm is labor, according to a constant-returns production function, and take the wage rate as given. Let k denote the technology level of duopoly firm in some industry j: the unit of labor employed by the firm i generates an output flow equal to:

$$A_i = \gamma^{ki}, \quad i = A, B \tag{4.2}$$

Where the parameter $\gamma > 1$ measures the size of leading-edge innovation. The state of an industry is then characterized by a pair of integers (l,m) where l is the leader's technology and m is the technology gap of the leader over the follower. Now, let define with π_m (respectively π_{-m}) the equilibrium profit flow of a firm m that is one steps ahead of (respectively, behind) its rival.

Assume that the knowledge spillover between leader and follower in any intermediate industry are such the maximum sustainable gap, m=1. It follows that, if the leader innovate, the followers automatically learn to copy the leader's previous technology and thereby they remain one step behind. There will be two possible kind of intermediate sectors in the economy: (*i*) *leveled* or *neck-and-neck* sectors where both firms share the same technology, so that m=0; (*ii*) *unleveled* sectors, where there is a leader firms one step ahead the laggard (or follower firm) in the same sector, so that m=1.

Assume that $\psi(n) = n^2/2$ is the R&D cost in unit of labor, that allow the leader firms to move one step ahead the laggard firms,

with a Poisson hazard rate of n. Assume that all the laggard firms move one step ahead with an hazard rate of h, even if they spend nothing and just copying the leader's technology.
Now, denote with n_0 the R&D intensity of each firm in a neck-and-neck industry and with n_{-1} the R&D intensity of a laggard firm in an unleveled industry. Thus, if n_1 denote the R&D intensity of the leader firm in the unleveled industry, note that n_{-1}=0, since the assumption of automatic catch-up means that a leader cannot gain any further advantage by innovating.
The degree of product market competition is then settled as the inversely of the degree to which the two firms in a neck-and-neck industry are able to collude. Otherwise, when the industry is unleveled they do not collude, Thus, the laggard firm makes zero profits, while the leader firm makes a profit equal to the difference between its revenue and its cost, γ^{-1} times its revenue, given that its price is γ times its unit cost:

$$\pi_{-1} = 0 \text{ and } \pi_{-1} = 1 - \gamma^{-1}$$

Thus, the potential profit of each firm goes from 0, if it is in a unleveled industry, up to $\pi_1/2$ if there is maximum collusion. More in general, assume that

$$\pi_0 = \varepsilon\pi_1, \qquad 0 \leq \varepsilon \leq 1/2$$

Where the product market competition is indexed by $\Delta = 1 - \varepsilon$, i.e. one minus the fraction of a leader's profit that the level firm can attain through collision.

The Schumpeterian and "Escape-Competition" Effects

It is now analyzed how the R&D intensities n_0 and n_{-1}, and consequently the aggregate innovation rate, vary with the measure of competition, showing the so called Schumpeterian and Escape-Competition Effects.

Proposition 1: *The equilibrium research intensity by each neck-and-neck firm is*

$$n_0 = \sqrt{h^2 + 2\Delta\pi_1} - h$$

which increases with higher product market competition Δ, *whereas the equilibrium research intensity of a laggard firm is*

$$n_{-1} = \sqrt{h^2 + n_0^2 + 2\pi_1} - h - n_0$$

which decreases with higher product market competition.

The latter effect (on n_{-1}) represents the Schumpeterian effect, that results from reducing the rents that can be captured by a follower that succeeds in catching up its rival by innovating. Differently, the effect on n_0 refers to the "escape competition effect", according to which an increase in competition leads neck-and-neck firms to innovate in order to escape competition. It follows that an increase in product market competition has an ambiguous effect on growth, since it induces a faster growth in currently neck-and-neck industries and slower growth in currently unleveled sectors.

Thus, the overall effect on growth will depend on the (steady-state) fraction of leveled versus unleveled sectors. However, this steady-state is endogenous, because it depends upon equilibrium by the R&D intensities in both type of sectors. Thus, it will be shown under which condition this overall effect is an inverted U, and at the same time derive additional predictions for further empirical testing.

Let assume that μ_1 (respectively, μ_0) denotes the steady-state probability of being an unleveled (respectively, neck-and-neck) industry. Then, the probability, in any unit time interval, for a sector to move from being unleveled to leveled is $\mu_1(n_{-1} + h)$, and the probability that it moves from being in the opposite direction is $2\mu_0 n_0$. In the steady-state equilibrium, these probabilities must be equal:

$$\mu_1(n_{-1} + h) = 2\mu_0 n_0 \quad (4.3)$$

Considering this, associated to the fact that $\mu_1 + \mu_0 = 1$, it implies that the aggregate flow of innovation is:

$$I = 2\mu_0 n_0 + \mu_1(n_{-1} + h) = 2\mu_1(n_{-1} + h) = \frac{4n_0(n_{-1}+h)}{2n_0+n_{-1}+h} \quad (4.4)$$

The model then provide some prediction on how the innovation activity should be affected by product market competition and establishing the possibility of an inverted-U pattern. Let assume that n_0 is the proxy to measure product market competition, and that it takes the values in the interval $[\underline{x};\overline{x}]$, where $x = \underline{x}$ corresponding to maximum collusion ($\pi_0 = \pi_1/2$) and $x = \overline{x}$ corresponding to maximum competition ($\pi_0 = 0$). It follows that:

Proposition 2: *Whenever the value of $\tilde{x}$ is interior to the interval $[\underline{x};\overline{x}]$, the aggregate innovative ratio $v(n_0)$ follows an inverted-U pattern, i.e. it increases with competition n_0 for all $n_0 \in [\underline{x};\tilde{x})$ and decreases for all $n_0 \in (\tilde{x};\overline{x})]$. Thus, if $\tilde{x} > \overline{x}$, then the aggregate innovation rate increases with n_0 for all $n_0 \in [\underline{x};\overline{x}]$ so that the escape-competition effect always dominates. Otherwise, if $\tilde{x} < \underline{x}$, then it decreases with n_0 for all $n_0 \in [\underline{x};\overline{x}]$ so that Schumpeterian effect always dominates.*

In other words, with a lower market competition, there is hardly incentive for neck-and-neck firms to innovate, and, therefore, the innovation rate is higher when the sector is unleveled. Thus, the industry leaves quickly the unleveled state and, as a result, will spend most of the time in the leveled state, where the escape competition effect dominates. Differently, when initially there is a higher competition, there is relatively a little incentive for the laggard in an unleveled state to innovate. Thus, the industry will be relatively slow to leave the unleveled state. Meanwhile, the large incremental profit $\pi_1 - \pi_0$ gives to firms in the leveled state a relatively large incentive to innovate, so that the industry will be

relatively quick to leave the leveled state. Thus, this industry will spend most of the time in the unleveled state, where the Schumpeterian effect is at work on the laggard, while the leader never innovates. Thus, with a higher degree of competition to begin with, an increase in competition should result in a slower average innovation rate.
Finally, the model provides two more predictions about the inverted-U pattern, uncovered in the previous section.

Proposition 3: The expected technological gap in an industry increases with product market competition.

The intuition behind is very simple: given the fact that an higher degree of product market competition leads to an higher research intensity in a neck-and-neck sector, this, in turn, implies that any sector will spend a most of its time being unleveled. Thus, on average over time, the technological gap between firms in that industry will be higher.
The next proposition relying on the existence of a positive interaction between the escape-competition effect and the average distance of the industry to its frontier. This means that, over time the escape-competition effect tends to be stronger in industries where firms are closer to their technological frontier, leading the increasing part of the inverted-U to be steeper. Indeed, supposing that there are industries with large spillover parameter h and industry with smaller h. Hence, industries with larger h will tend to be more neck-and-neck on average over time. Proposition 4 compares the magnitude of the escape competition effect across industries with different value of h and establish that:

Proposition 4: The peak of the inverted-U is larger, and occurs at higher degree of competition, in more and neck-and-neck industries.

4.3 Quality upgrading and competition: evidences from the EU market

The following section will test the main predictions of the model discussed above, focusing on the relationship between quality upgrading, proximity to the frontier and competition. We start by discussing the data needed to implement the empirical model. Then, we present the empirical strategy. Finally, we discuss the main econometric results.

4.3.1 Data and Measures

Starting from the quality estimates presented in section 3.2, we can measure the proximity to the world frontier for each country-product in any specific year (PF_{cht}). This variable is measured by taking first a monotonic transformation of the quality estimates, in order to ensure that all estimates are non-negative, $\lambda_{cht}^{F} = exp[\lambda_{cht}]$. Then, we define a variety' proximity to the frontier as the ratio of its transformed quality to the highest quality within each CN 8-digit product: $PF_{cht} = \frac{\lambda_{cht}^{F}}{max_{c \in ht}(\lambda_{cht}^{F})}$, where the max operator selects the maximum value of λ_{cht}^{F} within a product-year, and $PF_{cht} \in (0,1]$. Thus, for varieties close to the frontier PF_{cht} will be close to 1, differently for the varieties far to the frontier, PF_{cht} will be close to 0.

In order to study the level of competition that exporters face in their own country and industry, we use ad valorem tariffs data for all the exporting countries with data. We collect these data from WITS, at the HS 6-digit level and over time.[18] However, there are no tariff data for all the countries in our sample. Thus, the proximity to the frontier for each product-year is defined considering only the set of countries with tariff data.

[18] All tariffs are expressed as ad valorem equivalent. For products where are present also specific duty, we have transformed them in ad valorem equivalent, using the world unit values. See the documentation about the 'calculation of ad valorem equivalents' in the WITS web site. (see http://wits.worldbank.org/wits/).

Table 4.1: Mean level of import tariff faced by the exporting countries within each NACE 4-digit industry over time

NACE 4 (1)	Short description (2)	Mean Tariff (3)
1511	Production and preserving of meat	0.26
1512	Production and preserving of poultry meat	0.15
1513	Production of meat and poultry meat products	0.18
1520	Production and preserving of fish and fish products	0.12
1530	Production and preserving of fruit and vegetables	0.18
1540	Manifacture of vegetables and animal oils and fats	0.10
1550	Manifacture of diary products	0.39
1560	Manifacture of grain mill products, starches and starch products	0.26
1580	Sugar and cocoa	0.17
1581	Manifacture of bread; manifacture of fresh pastry goods and cakes	0.25
1582	Manifacture of rusked and biscuits	0.18
1585	Manifacture of maccaroni, noodles and couscous	0.18
1586	Processing of tea and cofee	0.12
1587	Manifacture of condiments and seasoning	0.09
1588	Manifacture of omogenized food preparaison and dietetic food	0.19
1589	Manifacture of other food products n.e.c.	0.12
1590	Production of ethyl alcohol, cider, malt and other non-distilled fermented bevera	0.20
1591	Manifacture of distilled potable alcoholic beverages	0.11
1593	Manifacture of wine	0.10
1596	Manifacture of beer	0.11
1598	Production of mineral water and soft drinks	0.09

Notes: the table reports the level of ad valorem tariffs at the NACE 4-digit level, averaged by all countries with data. (see text).

The final database has more than 700,000 observations and contains information on the quality of more than 1,500 CN 8-digit food products, exported by more than 100 countries in the European Union, and on the level of import tariff at the HS6-digit level. Table 4.1 shows the mean level of import tariff in each NACE 4-digit industry, faced by the exporting countries in our sample.

4.3.2 Empirical strategy

Our empirical strategy is aimed to test the relation between competition (here expressed as tariff reduction) and quality upgrading, using the Amiti and Khandelwal (forthcoming) approach. The authors test such relation with the following empirical model:

$$\Delta ln\lambda_{cht}^{F} = \alpha_{ih} + \alpha_{ct} + \beta_1 PF_{ch,t-5} + \beta_2 tariff_{c,h6,t-5} + \\ + \beta_3 (PF_{ch,t-5} * tariff_{c,h6,t-5}) + \varepsilon_{cht} \quad (4.5)$$

The dependent variable, $\Delta ln\lambda_{cht}^{F}$, is the change in a variety's quality between period t and t–5. All the explanatory variables are in level for the period t–5. Thus, quality growth is explained by the lagged proximity to the frontier (PF_{cht-5}), the lagged import tariff ($tariff_{chs6,t-5}$) and the interaction term of the these two variables $(PF_{ch,t-5} * tariff_{chs6,t-5})$. This interaction term should allow for the non-monotonic relationship, stressed by the distance to the frontier models of Aghion et al. (2005; 2009).

The specification includes both importer country-product (α_{ih}) and country-year (α_{ct}) fixed effects. Importer country-product fixed effects deal with two issues. First, because the quality is estimated using a nested logit demand function separately within each 4 digits product/industry, they are only comparable within the same product category or industry. Thus, the presence of the importer country-product effects ensures that the estimation exploits only the variation between comparable quality estimates and, moreover, within the same importing country, since product quality has been estimated separately for each of the 14 different European countries. The country-year fixed effects sweep out country-level shocks that affect competition such as technological shocks, changes in relative endowments, changes in institutions which affect the competition. Thus, the specification controls different shocks that may be correlated with tariff changes and quality growth.

In accordance with Aghion et al. (2009), the model suggests that $\beta_2 > 0$ and $\beta_3 < 0$. Thus, for varieties close to the world quality frontier ($PF_{ch,t-5}$ close to 1) a fall in tariffs would stimulate a variety's quality growth in the subsequent period. The reason is that, successful innovation enables the incumbent leader to escape from the threat of entry, which is "escape competition effect". In contrast, if a product variety is far from the frontier, a fall in tariffs could reduce quality upgrading due to the discouragement effect. This is because varieties far from the frontier need high tariffs to protect rents, in order to promote quality upgrading. Moreover, note that the model predicts $\beta_1 < 0$, thus varieties that are far from the frontier ($PF_{ch,t-5}$ close to 0) should experience faster quality upgrading, implying convergence in quality.

4.3.3 Results

In what follows, we present our main results of estimating equations (4.5) by OLS. All regressions include a full set of country-year fixed effects as well as importer-product fixed effects, as discussed above.

Table 4.2 column (1) reports our baseline results, that allow to test if the effect of tariffs on quality upgrading is indeed conditional to the proximity of the world quality frontier. Results strongly support this conclusion. First, in line with the expectation, a negative coefficient on the lag proximity to the frontier suggests that varieties far from the frontier, on average, display a faster rate of quality upgrading, namely there is a clear evidence of varieties convergence in quality.

Second, a negative coefficient on the interaction between tariffs and the proximity variable, implies that varieties close to the world frontier are more likely to upgrade products in response to an increase of competition (tariffs reduction). Differently, the positive coefficient on the linear tariff implies that tariffs are likely to have the opposite effect for varieties far from the frontier. Thus, countries/sectors that produce leader varieties to escape the increase in competition, increase the rate of quality upgrading, while laggards countries/sectors behave exactly in an opposite direction, namely they reduce the rate of quality upgrading due to the discouragement effect. These results are in line with the predictions of Aghion et al (2005; 2009), and they represent a broad confirmation of the findings of Amiti and Khandelwal (forthcoming).

Table 4.2 Quality, proximity to the frontier and competition: baseline results

	(1) ALL	(2) OECD	(3) NON OECD
L5.$PF_{ch,t-5}$	-0.485***	-0.504***	-0.367***
	(0.0369)	(0.0303)	(0.0436)
L5.$tariff_{c,h6,t-5}$	0.0704**	0.0526*	0.136**
	(0.0286)	(0.0281)	(0.0513)
L5.$PF_{ch,t-5}$ * $tariff_{c,h6,t-5}$	-0.184***	-0.166***	-0.220*
	(0.0474)	(0.0441)	(0.126)
FE Importer-Product	YES	YES	
FE Exporter-Year	YES	YES	
N	226485	226485	
R-sq	0.230	0.230	

Notes: Table reports regression results of change in (log) quality of a variety on the varieties lag proximity to the frontier, the lag HS6 tariff of the origin country and its interaction with the lag proximity to the frontier. Columns 2-3 estimate separate coefficients for the OECD and non-OECD countries. All regressions include imported-product (cn8) and exporter country-year fixed effects. Standard errors are clustered by exporting country (with EU countries treated as one country because of its common trade policy). Significance * .10 **.05 *** .01.

Quantitatively, our results suggest that for OECD countries, a reduction of the 10% points in tariffs induces a decrease (or an increase) in the rate of quality upgrading of –0.53% (+1.1%), for varieties that are far (close) to the world quality frontier. Differently, for non-OECD varieties far from the frontier, a 10% points fall in tariffs is associated with a reduction of –1.4% in quality upgrading, while for varieties close to the frontier to an increase of 0.84%. Overall these findings are relatively close with those of Amiti and Khandelwal (forthcoming) on US market, although they found a higher significant estimated effects for OECD countries.

Table 4.3 Robustness Checks

	(1)	(2)	(3)
	Exclude PF=1	Frontier Defined After Dropping Top 2 Qualities	Change in quality percentile
$L5.PF_{ch,t-5}$	-0.717***	-0.832***	-1.993***
	(0.0119)	(0.0134)	(0.132)
$L5.tariff_{c,h6,t-5}$	0.0384*	0.0281	0.217**
	(0.0239)	(0.0265)	(0.107)
$L5.PF_{ch,t-5} * tariff_{c,h6,t-5}$	-0.152***	-0.170***	-0.920***
	(0.0337)	(0.0370)	(0.170)
FE Importer-Product	YES	YES	YES
FE Exporter-Year	YES	YES	YES
N	174335	130814	226485
R-sq	0.262	0.284	0.237

Notes: Table reports regression results of change in (log) quality of a variety on the varieties lag proximity to the frontier, the lag HS6 tariff of the origin country and its interaction with the lag proximity to the frontier. Column 1 excludes observations with a proximity to frontier equal to one. Column 2 presents the results after removing the top two qualities from each product and redefines the proximity to frontier measure (that is, the third highest quality becomes the frontier). Column 3 uses the as dependent variable the change in the percentile of the variety's quality, instead of the actual quality measure. All regressions include imported-product (cn8) and exporter country-year fixed effects. Standard errors are clustered by exporting country (with EU countries treated as one country because of its common trade policy). Significance * .10 **.05 *** .01.

In order to verify the robustness of our findings, we control whether the results hold under alternative definitions of the quality frontier and of different quality measures. One possible concern stems from the fact that the proximity to the frontier measure could be affected by some errors due to randomness or outliers of the highest quality variety. Thus, in Table 4.3, it is demonstrated that the results are robust to an alternative definition of the world frontier. Column 1 and 2, confirm that, excluding respectively, the top quality (observations for which $PF_{cht-5} = 1$) and the top two quality products, thus redefining the frontier, the main results do not change significantly (even if the coefficient of the linear tariff is no longer significant).
We control also the robustness of our results using as quality measure, the percentile of a variety' s quality within each product-year pair. This kind of measure has the advantage over the actual measure of quality, of being easier to compare across products. From column 3 of Table 4.3, it is possible to see that re-running the baseline specification with the change in quality percentile as the dependent variable the main results hold. However, differently from Amity and Khandelwal (2012), the magnitude of all the coefficients is increased in absolute value.

4.4 Standards, competition and quality upgrading

Food standards increasingly govern the international food supply chains. One of the most studied issue is about their trade effects. Standards could either act as non-tariff barriers to trade – diminishing country exports – or as catalysts to trade – leading to export gains, by modernizing the food supply chains through innovation and products upgrading.
Extending the Amiti and Khandelwal (forthcoming) approach, used in the previous section, in what follow it is empirically investigated the extent to which the diffusion of voluntary

standards in the European Union affects the rate of quality upgrading in the food exports.

The empirical analysis is linked to a large body of literature that has tried to investigate the role played by standards in determining the trade patterns. As said before, although broadly investigated, two contrasting hypothesis emerge: standards can act as catalysts or barriers to trade. On one side, as discussed by Leland (1979), Hudson and Jones (2003) and many others, standards can serve as an important quality signal in trade and thus helping to promote the competitiveness of those that meet stringent standards. Evidences that food standards can stimulate and enable competitiveness can be found in Jaffee (2005) and Maertens and Swinnen (2009). Blind and Jungmittag (2005) stress that even the publication alone of standards and technical rules on a national level codifies the local knowledge and the preferences, which in the long run can be more easily anticipated by foreign competitors, so that their import efforts can be facilitated. Moreover, standards can help to overcome the ‘lemons’ problem, in which the incomplete and the asymmetric information on the quality of products leads to a market failure and a reduction in average product quality. In the literature on the integration of economic areas, the trade-promoting effects of common (harmonized) standards and technical rules find considerable empirical support (e.g. de Frahan and and Vancauteren, 2006).

On the other side, as it is well known, standards could have also a negative effect, raising barriers to entry, especially by increasing compliance costs. Indeed, while in principle standards can be considered like a public good, because they can be used by every producer, in practice, due to their high adaptation costs, outsiders with no influence on the standardization process may face considerable disadvantages in using the specification of the standards (see Swann, 2010). Moreover, the content of the standards can only be efficiently used in other countries when there is an absorptive capacity with corresponding technical knowledge (Blind and Jungmittag, 2006). From this point of view, the effect of standards may affect negatively especially the competitiveness of developing countries exports, ceteris paribus. For example, Maskus et al. (2005) estimate the costs of complying with standards in developing countries, showing that these costs influence whether some exporters find it profitable to start trading or whether, instead, they find the barriers to trade, too great. In this situation, standards will hinder competition by acting as a barrier to entry. Moreover, studies focusing on public standards, like sanitary and phytosanitary measures (SPS), more often find that they act as non-tariff barriers to trade (see Li and Beghin, 2012, for a recent survey).

Using the 'distance to frontier' approach, developed in section 4.2, we extend, in the following empirical exercise, the analysis on the effect of the diffusion of voluntary standards in the European Union on the quality upgrading of the food exports. We provide the first broad formal evidence that the diffusion of (voluntary) standards in the export destination market, systematically affects the rate at which exporters upgrade the quality of their food products.

4.4.1 Data

Data on European standards are taken from the European Union Standard database (EUSDB). EUSDB provide data on voluntary standards in force, in the European Union from 1995 to 2003. Data are mapped according to the standard trade HS 4-digit classification. EUSDB includes only standards at the Community level, hence, excluding national standards set by individual Member States. The EUSDB database collects data from two sources: CE-Norm and Perinorm International. The former, maintained by CEN, is publicly available and it collects data of European standards. Differently, Perinorm is a large database (1.1 million records), not publicly available, and it collects data on standard set by 22 countries, in addition to international bodies such as ISO and CEN. Moreover, the EUSDB database provides information on whether or not a particular EU standard implements a corresponding international harmonized, ISO, standard. For a more technical explanation of the EUSDB data see Shepherd (2006). Table 4.4 shows the mean number of voluntary standard in each NACE 4-digit industry, shared by the EU countries in the period 1995-2003.

4.4.2 Empirical strategy

In order to study the effect of the European standards in the food industry on quality upgrading, we augment equation (4.5) by including in the specification, a variable about standards and the interaction between standards and the proximities to the frontier:

$$\Delta ln\lambda^{F}_{cht} = \alpha_{ih} + \alpha_{ct} + \beta_1 PF_{ch,t-5} + \beta_2 tariff_{c,h6,t-5} + \beta_3 (PF_{c,h6,t-5} * tariff_{cht-5}) + \beta_4 standard^{eu}_{h4,t-5} + \beta_5 (PF_{ch,t-5} * standard^{eu}_{h4,t-5}) + \varepsilon_{cht} \quad (4.6)$$

Within the Aghion et al. (2005; 2009) model framework, the effect of standards on quality upgrading should be dependent on their competitive effect, which is however, a-priory, uncertain given the mixed effect of standards. Thus, as explained in the introduction of this section, according to the literature, the diffusion of standard can affect the competitive environment, either by acting as catalyst or as barrier to trade. From this point of view, within the distance to the frontier model, it is possible to formulate, at least, two, contrasting, hypotheses.

Proposition 1: *If standards act as a catalysts of trade, then the diffusion of standards should boost quality upgrading in the leading firms/sectors, but would hinder it in laggard firms/sectors, ceteris paribus.*

The empirical consequence of proposition 1 is that the relationship between standards and quality upgrading should be positive for products and sectors close to the quality frontier, but it could be eventually turned out to be negative, or close to zero, for products and firms far from the quality frontier. Thus if standards act especially as a catalysis to trade, we should expect $\beta_4 < 0$ and $\beta_5 > 0$.

Proposition 2: *If standards act as barriers to entry, then their diffusion is expected to hinder the rate of quality upgrading, and this effect should be greater when a firm is close to the technology frontier, ceteris paribus.*

Within this second hypothesis the distance to the frontier model, predicts a negative relation between the diffusion of standards and the rate of quality upgrading, particularly for firms and products close to the quality frontier. Thus, if standards act as a barrier to trade, the prediction will be reversed, with $\beta_4 > 0$ and $\beta_5 < 0$.

Finally, if the two effects tend to counterbalance each other, then the overall effect of standards could be also independent by the distance to the frontier, and thus $\beta_4 < 0$ (or $\beta_4 > 0$) and $\beta_5 = 0$.

At the empirical level, the two hypotheses summarized above represent a useful guide to interpret our results. Indeed, because the previous discussion, as well as the previous evidences, clearly point to a mixed effect of standards on competition, according to which the empirical relation between quality upgrading and standards, will depend on which of the two effects will dominate. Moreover, it is important to note that our predictions strongly rely on the fact that the distance to the frontier model incorporates all the key features of the competitive-innovation relation. However, in the literature other mechanisms have been highlighted. For example, Amable et al. (2005; 2009) proposed a simple modification of the distance to the frontier framework showing that the conclusion of an increasing negative impact of regulation on innovation can be reversed when one enables the leader to innovate, making it more difficult for the follower to catch-up. The last extension is coherent with several evidences showing that leading firms' innovation effort is always more aggressive, compared with the one of the followers (e.g. Etro, 2008).

Before presenting the results, however, some qualification of this empirical exercise should be taken into account. First, as it is clear from equation (4.6), while tariffs are measured in the exporting countries, thus representing their own tariffs, standards are related to the (EU) destination market. While this can represent an important difference, in practice, this should not be the case. Indeed, if anything, this particular situation could enrich our exercise. First of all, because the EU market represents one of the biggest trading areas in the world, and every exporter is interested there. Thus, EU standards should affect directly the to sell their products incentives to quality upgrading in the exporting countries.

Table 4.4: Mean number of standards shared by the EU countries within each NACE 4-digit industry over time

NACE 4 (1)	Short description (2)	Mean Standard (3)
1511	Production and preserving of meat	15.68
1512	Production and preserving of poultry meat	19.81
1513	Production of meat and poultry meat products	18.39
1520	Production and preserving of fish and fish products	18.08
1530	Production and preserving of fruit and vegetables	22.91
1540	Manifacture of vegetables and animal oils and fats	30.44
1550	Manifacture of diary products	23.96
1560	Manifacture of grain mill products, starches and starch products	23.01
1580	Sugar and cocoa	18.31
1581	Manifacture of bread; manifacture of fresh pastry goods and cakes	20.75
1582	Manifacture of rusked and biscuits	20.00
1585	Manifacture of maccaroni, noodles and couscous	20.38
1586	Processing of tea and cofee	18.70
1587	Manifacture of condiments and seasoning	14.38
1588	Manifacture of omogenized food preparaison and dietetic food	22.16
1589	Manifacture of other food products n.e.c.	20.40
1590	Production of ethyl alcohol, cider, malt and other non-distilled fermented bevera	3.47
1591	Manifacture of distilled potable alcoholic beverages	0.0
1593	Manifacture of wine	0.11
1596	Manifacture of beer	0.11
1598	Production of mineral water and soft drinks	0

Notes: Table reports information on the mean number of EU standard within each NACE 4-digit sector considered in the period 1995-2003.

Second, and perhaps more important, a large fraction of our quality estimates (> 60%), are related to EU countries exports. Thus, in this particular case, we are indeed measuring the impact of EU country own standards on the quality upgrading of their exports, thus just as with tariffs. Moreover, running regression (4.6) it is possible to split the sample in OECD (non-EU), EU and non-OECD countries for studying the extent to which international vs. national standards matter the most for quality upgrading. Indeed, from the point of view of OECD (non-EU) and non-OECD countries, the EU standards can be viewed as national (EU) standards. Differently, from the point of view of the EU countries, clearly EU Standards represent international or harmonized standards.

4.4.3 Results

Table 4.5 reports the results that stem by adding the lag value of the (log) numbers of standards and its interaction with the proximity to the frontier to the specification previously studied on the relation between quality upgrading and the level of import tariffs. The first thing to note is that, in this augmented specification, the effect of tariffs remain very stable and robust. The estimated effect of standard is positive and strongly significant for the linear term and negative, but marginally significant (10% level) for the interaction term. However, note that the estimated size of the coefficient on the interaction effect is much lower, in absolute value, than the one of the standard linear coefficient. Thus, although we detect some non-linearity, namely the effect is decreasing with the proximity to the frontier, the relation is positive for both varieties close and far to the world frontier. Similar results can be shown by splitting the estimated coefficients of standards in the OECD and non-OECD countries (columns 2 and 3), or further in EU15 and OECD non-EU countries (columns 4 and 5). Quantitatively, the economic effect is not irrelevant. An increase of the 10% in the number of standards, induces an increase in the rate of growth of quality upgrading of about 1.5% for varieties far from the frontier' an effect that only marginally decreased to 1.4% for varieties close to the frontier.

Table 4.5: Quality, competition and standards: baseline results

	(1) ALL	(2) OECD	(3) NON OECD	(4) EU 15	(5) OECD NON EU
L5.$PF_{ch,t-5}$	-0.458***	-0.469***	-0.368***	-0.512***	-0.266***
	(0.0417)	(0.0399)	(0.116)	(0.00680)	(0.0784)
L5.$tariff_{c,h6,t-5}$	0.0768**	0.0604**	0.141**	0.0603**	0.0105
	(0.0293)	(0.0282)	(0.0533)	(0.0288)	(0.0349)
L5.$PF_{ch,t-5}$ * $tariff_{c,h6,t-5}$	-0.183***	-0.164***	-0.228*	-0.104***	-0.339***
	(0.0471)	(0.0427)	(0.124)	(0.00656)	(0.108)
L5.(ln) $standard^{eu}c_{,h4,t-5}$	0.158***	0.157***	0.159***	0.150***	0.184***
	(0.0324)	(0.0330)	(0.0330)	(0.0278)	(0.0321)
L5.$PF_{ch,t-5}$ * (ln) $standard^{eu}_{c,h4,t-5}$	-0.0101*	-0.0133**	0.000791	-0.0105***	-0.0165
	(0.00578)	(0.00539)	(0.0307)	(0.00159)	(0.0342)
FE Importer-Product	YES	YES		YES	
FE Exporter-Year	YES	YES		YES	
	226485	226485		226485	
	0.230	0.230		0.230	

Notes: Table reports regression results of change in (log) quality of a variety on the varieties lag proximity to the frontier, the lag HS6 tariffs of the origin country, and the lag HS4 (log) number of EU standards, and their respective interaction with the lag proximity to the frontier. Columns 2-3 estimate separate coefficients for the OECD and non-OECD countries; Columns 4 and 5 estimate separate coefficients for EU15 countries and OECD countries not belonging to the EU15. All regressions include imported-product (cn8) and exporter country-year fixed effects. Standard errors are clustered by exporting country (with EU countries treated as one country because of its common trade policy). Significance * .10 **.05 *** .01.

Thus, by comparing these results with the discussion presented in the section 4.4.1, it emerges that, on average, our findings do not support neither the Hypothesis 1, nor the Hypothesis 2, about the supposed effects of the diffusion standards on the rate of quality upgrading. Because the previous standards literature have stressed the heterogeneity of their (trade) effects at different level, the above results do not come at surprise. However, we think that it is remarkable to find that, on average, EU voluntary standards affect positively the rate at which exporter countries update the quality of their products 'a results that hold true also for developing country.

4.5 Conclusions

In this chapter we study the relationship between competition and quality upgrading in the agri-food industry, within the distance to the frontier model of Aghion et al. (2005; 2009). We test such relation across a large longitudinal panel, covering more than 100 exporters in thousands of food products, by inferring products quality from the Khandelwal (2010) nested logit demand function. In this setting, *first*, we investigate how the increase in competition, due to a reduction in the import tariffs, affects the rate of quality upgrading in the exported food products, relying on the approach proposed by Amiti and Khandelwal (forthcoming). *Second*, we extend this approach, to investigate the effect of the diffusion of voluntary standard in the European Union on the quality upgrading of the exported products. The main results can be summarized as follow. First, we confirm the findings of Amiti and Khandelwal (forthcoming) on the EU food markets, showing that trade liberalization in exporting countries boosts the rate of quality upgrading for varieties close to the quality frontier, a result which is particularly robust, for the developed countries. Second, these results hold for both, OECD and non-OECD countries by using alternative measures of the world quality frontier and of the quality upgrading.
Because of the effects of standards on competition and in particular, their character as barriers or catalysts to trade, which is strongly product (and country) specific, it was not surprising to

find that, on average, the effect of standards on the rate of quality upgrading is only marginally affected by the products distance from the quality frontier.

From these results, clearly emerges that a change in the competitive environment affects the rate at which countries upgrade the quality of their exported products. Moreover, the initial distance to the world quality frontier should be considered an important element to be taken into account in valuing the subsequent effect of the trade liberalization policies. Differently, the diffusion of standards seems to have overall a positive effect on the quality upgrading of the exported products in the food industry, quite independently by the distance to the quality frontier.

Conclusions

Recent developments in the international trade theory have given increasing emphasis to the quality of traded products. According to the literature, the quality of exported goods seems to has a fundamental role either in driving the direction of trade, that in determining the countries' (firms) export performances. Recent evidence shows that quality can be particularly important in the analysis of economic growth and development, since international trade stimulates incentives to invent entirely new products and to upgrade the quality of the existing ones (Helpman, 2011). Thus, understanding how the quality of the exported products affects the international trade patterns can lead to a better comprehension of growth and development and thereby to more effective economic policies designed to raise standards of living.

However, data on products quality are not readily available, thus preventing the quantification of the role of quality in determining trade patterns and forcing the researcher to use proxies to make quality measurable, such as unit values computed from trade data. Albeit convenient, the use of unit values leads to an imprecise measure of quality, as they capture several other elements that are not attributable to quality.

These issues represent the point of departure on which is set this dissertation. In this essay, we have investigated the ways in which products quality enter in the study of the international trade, exploring different issues. More specifically, we analyze either how the quality of the exported food products affects the direction of trade, as well as how changes in the competitive environment can affect the rate of quality upgrading of the exported products. We do this by using new methods to estimate the (unobserved) quality of trade products, that is alternative to the simple use of unit value from trade data.

In order to investigate the extent to which product quality affects the direction of trade, we exploit the export behavior of a sample of 750 Italian food and beverage firms, testing the predictions of a trade model based on firms' heterogeneity in product quality and non-homothetic preferences. In this first exercise, we deal with the 'measurement issue' of products quality, relying on two different strategies. First, we exploit the richness of an original database selecting different variables that, according to the industrial organization literature, are correlated with products quality. The principal component of these variables has been extracted through factor analysis, generating different proxies that account for the firms' innovative behavior. Second, we generate two dummy variables for typical Made in Italy and PDO products, respectively to test if the perceived quality of these product aggregations really matters for firm export behavior, and, moreover, as an indirect test to investigate whether the firm-level proxies for quality correlate with the recognized quality of these food products.

By using different measures of total factor productivity (TFP) and proxies for products quality, we show that the correlation between export intensity and TFP is increasing in the per capita income of foreign destinations, and that this link is largely attributable to products quality. This findings support the notions that, more efficient firms have higher export performance as they use more expensive and quality inputs to sell higher-quality goods at higher prices. Moreover, we also find strong evidence that firms producing higher quality products export more to more distant markets, a result consistent with the idea that the presence of per unit transaction costs lowers the relative price of high-quality goods, as suggested by Hummels and Skiba (2004).

The above results may have potential interesting implications. First, they highlight that government priority should be given to encourage investment in R&D and to establish technology policies that would allow firms to produce and export higher quality products. Clearly this statement is of particular importance for the developing countries access to richer markets. From this point of view, the growing concern about the effect of food quality and safety standards, on developing country exports – i.e. the view of standards as a barrier to trade – could be overemphasized. Indeed, if rich countries' food standards do not over marginalize small agri-food producers in developing countries, by inducing a process of quality upgrading they will increase, not decrease, the firms' access to these markets, a result totally consistent with our empirical evidence discussed below.

Second, the notion that richer countries export higher quality foods to other rich countries – the Linder (1961) hypothesis – could suggest that European countries should not worry too much about the adverse effects of competition from developing countries' exports, due, for example, to further trade liberalization. This is because, price competition is softened by vertical differentiation through quality differences and, moreover the trade-reducing effect of non-homothetic preferences is exacerbated in the presence of firms' heterogeneity in productivity and quality.

The quality of the exported products should be considered not only a determinant of the direction of trade, but also a key element that contribute to economic growth. In a context of globalization and trade liberalization, a greater presence in the export markets is a fundamental element for the economic development. Thus, since product quality is more often considered a pre-condition for the export success, the need of increasing the participation in the export markets, should represent an important incentive, especially for developing countries. Hence, we empirically investigated the extent to which the trade liberalization wave of the last decades affected the rate of quality upgrading in the exported food products. To study this relationship, we rely on a distance to the frontier approach, as proposed by Aghion et al. (2005; 2009), according to which firm' innovation activities – like the upgrade of products quality – is a non-monotonic function of the level of competition and the firms' distance to the technological frontier. To test this prediction, we measure product quality using the innovative approach proposed by Khandelwal (2010), based on the following intuition: "conditional on price, imports with higher market shares are assigned higher quality". Such method embeds preferences for both horizontal and vertical attributes. Quality is the vertical component of the estimated model and captures the mean valuation that consumers attach to an imported product. We infer products quality of the imported agri-food products in the EU 15 countries at the country-product level, considering more than 150 exporters in 2400 CN 8-digit agri-food products.

With the quality estimations in hand, we empirically investigate how a reduction of import tariffs in the exporting countries affects the rate of quality upgrading in the agri-food exported products. We find a strong evidence that an increase in the level of competition (a fall in tariffs) leads to a faster quality upgrading only for products close to the world quality frontier, thus, supporting the main predictions of the Aghion et al. (2005; 2009) model.

Moreover, we extended this approach in order to study the effect of the diffusion of voluntary standards in the EU market on the quality of the imported products. In this way, because in a distance to the frontier model the effect of the diffusion of standards on quality upgrading should depend by their pro- or anti-competitive effects, although indirectly, we can speculate on this important point. From this perspective, we found evidence of an overall positive effect of the diffusion of standards on the rate of quality upgrading, an effect that is only marginally affected by the products position on the world quality frontier. This results corroborate, and complement, previous findings about the mixed effect of standards on trade flows.

Overall, the main findings of this thesis give a general support to the emerging literature about the importance of considering the role of products quality to understanding trade patterns and the firm/sector/country success in the international markets. Clearly we need more data and new empirical evidence to support our conclusions and implications properly. There are indeed several unresolved issues that need to be fixed before concluding that product quality may represent the new panacea for export success. For example, while the results discussed above seem to suggest that trade liberalization and more competition are beneficial for food quality upgrading and, indirectly, also for productivity growth, we do not know nothing about the effect of competition, especially from developing country exports, on the within sector and across sector labor adjustment in developed countries. This is clearly a very sensitive research area. For example, one can suppose that firms producing high quality product should be more 'protected' by import-competition from developing countries, although the evidence so far are rare in this regard, and thus this represent an important area for future research. Similarly, findings evidence that EU food standards affect positively the rate of quality upgrading of imported (EU) products says us nothing about their overall effects in the origin countries, as well as in the destination (EU) countries. Here, the literature focused especially on the potential trade reduction effect of standards for developing countries exports, with mixed results. However, again, we have very few information and empirical analysis about the effect of EU food standards on the export performance of the EU firms. Because the EU (public and private) standards are the most stringency around the world, clearly on the one hand they contributed to increase the quality upgrading of firms selling their products in the EU market, as showed by our findings. On the other hand, because standards increase also the costs of production of the EU firms, well above the foreign firms, one can think that they may also reduce their comparative advantage in the world market. Thus, future research should also explore the extent to which quality vs. price competition, and the related policies, is the main driving force of the performance of developed countries' vs. developing countries' food exports.

Appendix

Summary statistics of variables used in regressions of Table 2.7

Variable	Obs	Mean	Std. Dev.	Min	Max
Ln export intensity to low-income destinatic	135	-1.67	1.12	-4.61	0
Ln TFP (Olley-Pakes)	135	1.22	0.21	-0.06	1.64
Dummy Made in Italy	135	0.50	0.50	0	1
Dummy PDO	135	0.29	0.45	0	1
Quality A	96	0.37	1.05	-1.48	2.85
Quality B	96	0.24	1.07	-1.26	4.02
Quality C	96	0.28	1.39	-3.50	4.30

Summary statistics of variables used in regressions of Table 2.9

Variable	Obs	Mean	Std.Dev.	Min	Max
Ln export intensity	789	-1.20	1.19	-6.91	0
Ln TFP (Olley-Pakes)	789	1.22	0.23	-0.06	1.92
Ln TFP * Relative income	789	1.11	0.58	-0.07	2.48
Ln TFP * Relative distance	789	0.96	1.16	-0.18	5.98
Ln TFP * Number of countries	789	1.11	1.00	-0.06	6.17
Quality A	566	0.31	1.03	-1.65	3.54
Quality B	566	0.26	1.02	-1.84	4.90
Quality C	566	0.28	1.10	-3.50	5.14
Quality A * Relative income	566	0.35	1.54	-3.24	6.55
Quality A * Relative distance	566	0.19	0.80	-2.84	4.39
Quality A *Nnumber of countries	566	0.16	0.83	-3.62	6.99
Quality B * Relative income	566	0.29	1.51	-3.61	9.04
Quality B * Relative distance	566	0.18	0.82	-2.34	5.18
Quality B * Number of countries	566	0.14	0.84	-3.02	9.84
Quality C * Relative income	566	0.30	1.62	-6.90	9.51
Quality C * Relative distance	566	0.19	0.86	-2.15	5.43
Quality C * Number of countries	566	0.15	0.90	-2.73	10.53

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