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Estimating Food Quality from Trade Data: An Empirical Assessment

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Abstract: Recent development in international trade theory gives growing emphasis to the quality of the exported products, showing that it affects both the direction of trade and the countries' export performances. However, as quality is unobservable, a measurement problem clearly emerges. In this paper we measure product quality relying on a nested logit demand structure developed by Berry (1994) and then applied to trade data by Khandelwal (2010). Our main goal is to investigate the reliability and the properties of this quality estimate, focusing on the EU food sector, where the growing attention on quality and safety issues have led to an increase in the demand for high quality products. Main results give credence to the accuracy of the quality estimates, which display some interesting properties. Indeed, the quality rankings we draw are in line with the expectations, and quality growth proves to be strongly correlated with TFP growth. Moreover, results reveal that the competitive strategy of countries, (high-quality vs. low-price) tends to change when moving from OECDs to non-OECDs. Finally, products quality proves to converge more rapidly in short than in long quality ladder markets. These results may have clear and interesting implications.

Keywords: Quality estimates; Nested logit, Food products; International trade; EU market.

JEL classification:

1. Introduction

Recent developments in the international trade theory have given increasing emphasis to the quality of traded products (Hallak and Schott, 2011; Fajgelbaum et al. 2013; Amiti and Khandelwal, 2013). The quality of the exported goods seems to have a fundamental role both in driving the direction of trade, and in determining the countries' (firms) export performances.¹ Indeed, product quality is more often viewed as a pre-condition for export success (Grossman and Helpman, 1991; Amiti and Khandelwal, 2013). Moreover, the importance of quality is increasing in recent studies about countries (firms) competitiveness, which consider exports to be driven by either price or quality competition (Baldwin and Harrigan, 2011; Baldwin and Ito, 2011; Crozet et al., 2011).

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¹ Product quality enters the international trade models with the seminal contributions of Linder (1960), Flam and Helpman (1987) and Falvey and Kierzowski (1987). First empirical evidence on the role of quality in determining the international trade patterns can be found in Schott (2004) and Hallak (2010). At the firm level, recent theoretical and empirical contributions allow quality to be heterogeneous across firms (Baldwin and Harrigan, 2011; Verhoogen, 2008; Crozet et al., 2012; Fajgelbaum et al., 2011; Crinò and Epifani, 2012; Curzi and Olper, 2012).

Recent evidence shows that quality can be particularly important in the analysis of economic growth and development. Indeed, according to the quality ladder models of Grossman and Helpman (1991) and Aghion and Howitt (1992), the ability of a country to upgrade and export high quality products can positively affect economic growth (see Hausman et al., 2007). Thus, studying the quality of the exported products can lead to a better comprehension of growth and development and thereby to more effective economic policies designed to raise standards of living (Helpman, 2011).

In this paper we focus on the food sector, where quality represents a fundamental element to make developing countries' products eligible to be exported in rich countries. This is due to the increasing attention of consumers towards the safety and quality of food products as result of an income growth, and consequently to their purchases being more and more conditioned by health and dietary issues, as well as by other products attributes (Caswell and Mojduszka, 1996; Grunert, 2005; Bontemps et al., 2012). This increasing attention to the quality attributes also conditions producers in developing countries. Indeed, international food supply chains are now largely governed by safety and quality (private) standards, and there is a growing empirical evidence showing the tendency of many developing countries to upgrade the quality of their food exports to meet the stringency of these standards (Maertens and Swinnen, 2009; Henson et al. 2011; Minten et al. 2012; Olper et al. 2013).

The importance of product quality for trade and development is however hindered by the difficulty to measure it, as data on products quality are not readily available. This prevents the quantification of the role of quality in international trade models and forces researchers 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 it captures several other elements that are not attributable to quality. To address this issue, some studies have recently developed alternative methods to infer products quality, in order to have more reliable quality estimates (see, e.g., Khandelwal, 2010; Hallak and Schott, 2011; Khandelwal et al. 2013).

The objective of this paper is to review and apply these new methods to infer quality with the aim of better understanding their ability to classify products, and to compare them with standard methods based on the use of unit value. In particular, the paper estimates product quality using a nested logit demand system developed by Berry (1994) and recently applied by Khandelwal (2010) to trade data. We focus on food imports of EU-15 countries from all the world partners, and our data cover the period 1995-2007. This approach is based on the intuition that, conditional on price, imports with higher market shares are assigned higher quality. Our paper is firstly aimed at testing the reliability of the quality estimates for the food industry, a sector only marginally covered by the Khandelwal (2010) estimates, which focused instead on the US market.² More specifically, we ask to the data the extent to which the obtained quality estimates, measured on the EU market, are in line with the common perception about food quality. Secondly, we want to use the information content of our quality estimates to better understand their difference with respect to

² Food products were only marginally included among the sectors analysed by Khandelwal (2010) as, according to the Rauch (1999) classification, they are largely considered as homogeneous goods, and thus do not exhibit substantial quality differentiation.

the use of unit values, and thus investigate whether the two indicators (price and quality) can be complementary in the analysis of countries' (industries) competition strategies in the international markets.

The paper is organized as follows. In the next Section, we review the main methods developed in the recent literature to infer quality from trade data. We focus our attention on the nested-logit demand structure of Berry (1994) that, for different reasons, seems until now the most promising approach to estimate quality at disaggregated product level. In Section 3, we present the data and the main econometric results which come from our quality estimates on the EU food markets. In section 4, we investigate the properties of our quality estimates using three main exercises. First, we conduct a comparison of the quality rankings for three specific food products (white wine, beer and beef meat) with the aim of understanding whether they are in line with the common perception. Second, we study the relationship between our quality estimates and TFP growth in the food sectors. Third, we test the correlation between quality growth and price growth across different groups of countries, using standard convergence regressions, and taking into account the so called quality ladder – namely the extent to which markets are characterized by a large scope for vertical quality differentiation (long quality ladder) or, differently, by a narrow quality range across products, suggesting that horizontal differentiation prevails (short quality ladder). Finally, in Section 4, some concluding remarks and the main implications of the results are discussed.

2. Estimating quality from trade data

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 traded products.

The most common proxy used in the economic literature is unit value (price), defined as nominal value divided into physical volume of a traded product. This indicator has been widely used in empirical studies which rely on the conjecture that higher unit value means higher quality, as in the important contributions of Schott (2004), Hummels and Klenow (2005) and Hallak (2006). These works provide the first formal evidence that export unit values increase with both the per capita income of the foreign destinations and the skill and capital intensity of the exporter country (Schott, 2004; Hummels and Klenow, 2005), as well as that higher quality products are disproportionately directed to higher income countries (Hallak, 2006).

Like any comprehensive indicator, unit value has advantages and disadvantages. Among the advantages, it is easily available, even at very disaggregated level and for several products (up to ten-digit), for any country, and even for bilateral trade flows (Aiginger, 2001). However, there is broad evidence in the literature showing that unit value is an imprecise measure of quality, because it also captures some aspects that are not attributable to quality. There are several reasons that lead 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 tried to purge all the elements above in order to obtain a more reliable proxy for quality. Basically, these methods share the same intuition, according to which countries selling large quantities of physical output, conditional on price, are classified as high quality producers. Based on this assumptions, Hallak and Schott (2011) develop a method that allows to decompose observed export prices into quality versus quality-adjusted-price components. They infer countries' exported products quality by combining data on their prices with information about global demand for them. The intuition behind this method is that 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. However, a major shortcoming of the Hallak and Schott (2011) method is that, being based on global trade balance, it is suitable for inferring quality at the country or industry level, but not at the products line level.

To overcome this limitation, Khandelwal (2010) develops a method to infer quality based on the nested logit demand system of Berry (1994), which embeds preferences for both horizontal and vertical attributes. In such method, quality represents the vertical component of the estimated model and captures the main valuation that consumers attach to an imported product. The procedure requires information on both import data (unit value and volume) and production quantity, and has this straightforward intuition: "conditional on price, imports with higher market shares are assigned higher quality". The main advantage of the Khandelwal (2010) approach is the possibility to obtain quality estimates at the very detailed product-country level and over time. Moreover, such method may be of particular interest in a trade analysis aimed to assess the role of product quality in influencing trade patterns. This is the case of the trade model recently developed by Fajgelbaum et al. (2013), which, indeed, is based on a nested logit demand system and thus shares the same consumers preference structure. According to this model, heterogeneous consumers with non-homothetic preferences face a consumption choice over varieties of a horizontally and vertically differentiated goods and it shows that, as a result of an income rise, a higher fraction of consumers buys higher quality goods.

Finally, more recently, Khandelwal, Schott and Wei (2013) develop a method to infer quality from a CES demand system which is conceptually similar to the one of Khandelwal (2010), but it does not require the use of any instrument for the (endogenous) price component in the demand system (more on this below).

All the above methods share a common assumption, namely that product quality is associated with the higher utility for the (representative) consumer, and that this is fundamental in determining the direction of trade. Indeed, countries' (firms') high quality products are not only aimed at satisfying consumers in the domestic markets, but also at attracting consumers abroad (Chi-Hung Liao, 2011).

Among all the above methods recently developed in the literature to infer quality we choose to follow Khandelwal (2010) as it allows to infer quality at the maximum level of product-country disaggregation and over time. Even if the method of Khandelwal, Schott and Wei (2013) would allow us to produce the same

pattern of estimates, our choice fell on Khandelwal (2010) as in our view the nested logit demand approach allows for a more reliable substitution pattern, by placing varieties into appropriate nests.³

In what follows, we first review the nested logit demand system of Berry (1994), that is at the core of the Khandelwal (2010) approach, and then we propose an application of this method to food products in the EU-15 market.

2.1 A nested logit demand approach

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 on the product characteristics. In this setting, the product market share will be the result of the aggregate outcome of consumers' decision.

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

$$U(x_j, \xi_j, p_j, v_i; \theta)$$

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). v_i captures the individual characteristics that are not observed by the econometrician. Finally, θ represents a demand parameter. Consumers characterized by different v make different choices. Thus, in order to derive the integrated demand system, the choice function is integrated out over the distribution of v in the population. Throughout, v will be taken to have a known distribution. This distribution may be considered either as the empirical distribution of characteristics, or as a standardized distribution where standardization parameters are estimated. In this model, θ includes any parameter determining the distribution of consumer characteristics.

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

$$u_{ij} = \delta_j(x_j, \xi_j, p_j) + v_{ij} \quad (1)$$

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

³ The Khandelwal, Schott and Wei (2013) approach needs an estimate of the elasticity of substitution to be implemented. Yet, these elasticities normally taken from Broda et al. (2006), are only available for each country at the 3-digit level of the Harmonized System classification and, thus, produce a less appropriate pattern of substitution than in Khandelwal (2010). Moreover, several authors have shown empirically the limits of the use of a Constant Elasticity of Substitution (CES) utility function when analyzing trade in food products (see Gothin and Femenia 2009; Liu and Yue 2012). For an indebt discussion about the limits of the CES approach in the context of new trade theory, see Neary (2012); differently for a more optimistic view, see Bertoletti and Epifani (2012).

$$\delta_j = x_j\beta - \alpha p_j + \xi_j \quad (2)$$

The discrete-choice market share function, s_j , is then derived from the consumer utility maximization, conditional on the product characteristics (x, p, ξ) and the consumer unobservable taste parameters v_i that lead consumer i to purchase product j . The market share of firm j is, in other words, the probability of purchasing product j , given the distribution of consumer preferences θ over the product characteristics.

The definition of the market size and the presence of an outside alternative completes the specification of the demand system. Consider now an outside good, $j = 0$, that the consumer i may choose to purchase instead of the competing differentiated products $j = 1, \dots, N$, with a price not affected by the variation of the prices 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 avoids the unfortunate feature of some discrete models, where, due to the absence of an alternative, an increase in the price of the inside goods does not affect the aggregate output.

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

$$u_{ij} = x_j\beta - \alpha p_j + \xi_j + \epsilon_{ij} \quad (3)$$

where ξ_j represents the mean valuation of an unobservable product characteristic that consumers attach to a product j and ϵ_{ij} represents the consumers' distribution around this mean, that is assumed to be mean zero and identically distributed across consumers and products. Assuming that ϵ_{ij} follows an extreme value distribution, the probability of purchasing product j is given by the following logit formula:

$$s_j(\delta) = \frac{e^{\delta_j}}{1 + \sum_{j=1}^n e^{\delta_j}} \quad \text{for } j = 0, \dots, N \quad (4)$$

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

$$\ln(S_j) - \ln(S_0) = \delta = x_j\beta - \alpha p_j + \xi_j. \quad (5)$$

However, this simple logit specification has the limitation that it 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 preferences across consumer. The heterogeneous preferences across consumers are simply generated in a discrete-choice model just by the interaction between consumer and product characteristics. One possibility

to do this is given by the nested logit models, that, in contrast to the simple logit model, allow consumer tastes to be correlated (albeit in a restricted way) across products.⁴

In the nested logit model the products are grouped in $G + 1$ exhaustive and mutually exclusive set of products $g = 0, 1, \dots, G$. 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:

$$u_{ij} = \delta_j + \zeta_{ig} + (1 - \sigma)\epsilon_{ij} \quad (6)$$

where, as in (2), $\delta_j = x_j\beta - \alpha p_j + \xi_j$ 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 $0 \leq \sigma < 1$), 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

$$\bar{s}_{j/g}(\delta, \sigma) = \frac{e^{\frac{\delta_j}{1-\sigma}}}{D_g} \text{ for } j \in g \quad (7)$$

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

Taking the log of market share, it is possible to define the main utility level that consumer i obtains from product j as:

$$\delta_j(s, \sigma) = \ln(s_j) - \sigma \ln(\bar{s}_{j/g}) - \ln(s_0) . \quad (8)$$

Setting $\delta_j = x_j\beta - \alpha p_j + \xi_j$ and substituting gives

$$\ln(s_j) - \ln(s_0) = x_j\beta - \alpha p_j + \sigma \ln(\bar{s}_{j/g}) + \xi_j. \quad (9)$$

The above expression relates the market share of product j to the observed and unobserved product characteristics, x_j and ξ_j respectively, the product price p_j , and the log of the nested share, $(\bar{s}_{j/g})$, multiplied by the substitution parameter, σ .

2.2 Applying the nested logit demand approach to trade data

Khandelwal (2010) applies the method explained above to infer product quality using price and quantity information from trade data, with the aim of relaxing the strong quality-equals-price assumption. In this

⁴ The nested logit approach allows to model the correlation between groups, allowing correlation patterns to be dependent only on grouping of products which are pre-determined and not on the values of continuous variables (see Berry (1994) for more details)

method, product quality accounts for the Berry (1994) model's unobservable product characteristics, ξ_j , and represents the mean valuation that consumers attach to an imported product. Such method allows to consider consumers' preferences for both horizontal and vertical attributes and has the following straightforward intuition: “*conditional on price, imports with higher market shares are assigned higher quality*”.

The quality of a product j , exported by a country c is then inferred using the following estimable demand function:

$$\ln(s_{cjt}) - \ln(s_{0t}) = \xi_{1,jh} + \xi_{2,t} + \alpha p_{cjt} + \sigma \ln(ns_{cjt}) + \gamma \ln pop_{ct} + \xi_{3,cjt} \quad (10)$$

where s_{cjt} represents the inside variety overall market share and is defined as $s_{cjt} = q_{cjt}/MKT_t$, where q_{cjt} is the imported quantity of such variety, and $MKT_t = \sum_{cj \neq 0} q_{cjt}/(1 - s_{0t})$ is the industry size. The outside variety s_{0t} completes the model and represents the domestic alternative to the imported variety computed as one minus the industry's import penetration.⁵ $\xi_{1,ch}$ represents the exporter-product fixed effects and represents the time invariant component of quality, while $\xi_{2,t}$ are the year fixed effects that account for the common quality component. Finally, $\xi_{3,cht}$ is a variety-time specific deviation (residual). In the relation (10) derived from Berry (1994), Khandelwal (2010) adds the term pop_{ct} , which represents the population of the country c , and accounts for the so called hidden varieties.⁶ The quality of a product j exported by the country c , at time t , ξ_{cjt} , is then inferred using the estimated parameters from (10) as follows:

$$\xi_{cjt} = \hat{\xi}_{1,cj} + \hat{\xi}_{2,t} + \hat{\xi}_{3,cjt}.$$

Quality is the sum of the cj -fixed effect, the time effect, and the residual. Thus, for several reasons, the method is in the spirit of the TFP estimation, that is indeed obtained as the residual from a production function.

3. Estimating quality in the EU food markets

In what follows, we apply the method outlined above to infer the quality of the imported food products in the EU-15 countries (except Luxembourg, for which we do not have production data) from all trading partners in the World with data, and at the finest level of product aggregation. We estimated equation (10) considering separately each of the EU-15 countries and thus mitigating the potential bias due to specific country preferences towards certain products, which may occur when working on a single destination market.

To this end, we exploit information of yearly trade value and volume from the EUROSTAT Comext database at the maximum level of disaggregation (CN 8-digit). We collected data over the period 1995-2007, considering 2007 as the final year because, as an effect of the 2008 and 2010 price spikes and 2009 financial crisis, extending the analysis also to these periods may introduce noise in our quality estimates.

⁵ We define Import Penetration as the ratio of imports over imports plus production and has been estimated separately for each country, NACE 4-digit industry and year.

⁶ The importance of this term is due to the fact that larger countries may have a greater market share just because they export more unobserved or hidden varieties within a product. In this case, population controls for country size.

Data on the volume of the domestic production for each of the considered EU-15 countries are drawn from the EUROSTAT Prodcom database. Production data are available at 8-digit level according to the Prodcom classification, which is directly connected to the NACE 4-digit classification, as the first four digits of the Prodcom code identify the 4-digit NACE industry.

The final database has more than 1,000,000 observations and contains information on the quality of more than 2200 CN 8-digit food products exported by 150 countries in the EU-15. The CN 8-digit food products are mapped into 21 industries according to the NACE 4-digit Revision 1.1 classification, through appropriate corresponding tables provided by EUROSTAT. Table 2 shows the number of CN-8 products contained in each NACE 4-digit industry.

We estimate equation (10) using both OLS and 2SLS regression (our preferred one). The instrumental variable approach is required because, looking at the right-hand side of equation (10), it emerges a potential endogeneity problem due to the correlation of the error term, $\xi_{3,cjt}$, with both the nest share and the j -variety's price. Indeed, both variables are clearly endogenous to the market share. To this end, as proposed by Khandelwal (2010) and, especially, by Colantone and Crinò (2011), the following variables are used as instruments for the price and the nest share: the interaction between unit transportation costs and the distance from c , and the interaction between the oil price and the distance from c ;⁷ the number of varieties within each product p , and the number of varieties exported by each trading partner.

In order to estimate product quality we run equation (10) separately for each imported country – NACE 4-digit industry. Table 1 summarizes the median parameters obtained by estimating equation (10). We run 468 different regressions (considering both OLS and 2SLS), with a average number of observations per estimation of 4,378. Importantly, the pattern of estimated signs and the mean values of the price and nest share elasticities match the ones of Khandelwal (2010) and, especially of Colantone and Crinò (2011), who estimate quality with the Khandelwal (2010) method in the EU market. In particular, note that the median IV price coefficient is about 3 times higher in absolute value than the OLS one, suggesting that the 2SLS approach moved the price coefficient in the expected direction. Moreover, the mean p -value computed from the Sargan test, suggests that the validity of the over-identifying restrictions cannot be rejected. Finally, the bottom of the panel shows that 67% and 93% of the estimations, report a significant price and nest share coefficients, respectively.

Before and after the quality estimations we apply some standard cleaning procedures. First, we drop varieties with unit values that fall below the 5th or above the 95th percentile of the distribution within industries. Second, varieties with less than 4 observations detected at least twice are dropped. Third, we excluded varieties with an annual price growth of more than 200 percent and less than 66 percent. Finally, as

⁷ Oil prices are from Brent. Bilateral distance is the population-weighted number of kilometers between the two countries' largest cities, provided by CEPII. Since Eurostat does not provide data on unit transportation costs, following Colantone and Crinò (2011), we compute product-level transportation costs, starting from variety-specific unit transportation costs for the U.S., using data from Feenstra et al. (2002). Then, these transportation costs are regressed on partner fixed effects, in order to remove the influence from the U.S. From this regression we take the average of the residual across all partners within each 6-digit product code.

the quality estimates obtained can be noisy, quality estimates that fall below the 5th and above the 95th percentiles are dropped.

4. Going inside our quality estimates

In this section we first present some quality rankings for selected products, whose quality reputation for specific countries is well known. In this way, we can test whether our quality measures can be considered reasonably realistic. After verifying the reliability of our estimates, we move to testing the correlation between price and quality growth in order to analyze the evolution of the two measures. Our results can lead to some important policy implications in terms of development analysis, which will be discussed in the final section.

4.1 Quality rankings

Our quality estimates allow to easily rank the quality of a specific product considering the mean value for each exporter country.⁸ We take as representative examples three specific product categories where quality assumes particular importance, and the ranking of quality is reasonably defined by the common perception: *white quality wine*, *beer*, and *fresh bovine meat*. To simplify the readability of the graphical representation, for each of the three considered products we select a sample of countries considering the ones with the highest market shares. We also rank the median value, and the 25th and 75th percentiles values. We compare quality at the beginning (1995-1996) and at the end (2006-2007) of the considered period, to also track the variation in quality ranking over time.

Figure 1 shows the quality ranking and its evolution for *white quality wine* (CN code 22042111). Consistently with the expectations, from the ranking it emerges that, among the traditional wine producer countries, France, Italy and Spain are the top quality wine exporters in both periods. Moreover, the figure shows that, during the observed period, there has been a process of convergence in the mean value of the estimated quality between the considered countries, a result in line with the dynamic of growth experienced by these countries in the world wine sector. Moreover, if one looks at the range of wines' quality for each of the considered producers, it is possible to note some differences between them. Consider for example France and USA which are in both the considered periods, respectively, first and last. While France shows a narrow range of quality, USA shows a wide range of quality, namely very low quality measures for both the 25th percentile and the median values and a very high value for the 75th percentile. This could mean that the whole basket of French exports is considered by the consumers of very high-quality. By contrast, the USA export basket is almost equally divided between some products considered of very low quality and some others of very high quality. As a result, the mean quality value of the USA white quality wine is almost aligned to the one of the other countries, even if in the two considered periods it results last in the rank.

⁸ The estimated quality from (10) has been normalized and then standardized (with mean 0 and variance 1) within each product category (nest) in order to control for the potential bias in the distribution of quality estimates, due to the different product structure of exports from various countries,.

Figure 2 shows the quality ranking for *beer* (CN code 22030001) in the two considered periods. In line with the expectations, the first five countries ranked – Ireland, Belgium, Nederland, Germany and Denmark – are in fact among the biggest producers and exporters of beer in the world. Unlike wine, the quality of beer does not show substantial differences between these five top quality producers, a result confirmed by the short (mean) quality ladder that characterizes this sector (see Table 1). Thus, apparently, competition in the beer market seems to be largely based on a horizontal differentiation strategy, more than on a vertical differentiation one. This evidence appears consistent with the actual situation of the world beer market. Indeed, excluding the phenomena of special beer production as the microbrewery, which represents an important reality especially in Belgium and US, at the international level the market is still largely based on beers with similar intrinsic quality values. Their competition is largely based on differences in the flavor and, especially, in the advertising strategy.

As for the product category *fresh bovine meat*, (CN code 02011000), Figure 3 shows that, consistently with the expectations again, USA, Brazil, Germany and France are the top quality exporters. The estimates are quite similar between the two considered periods, except for Brazil, which increases the quality of its exported products, becoming first in the quality ranking. Interestingly, USA moves from the first to the fourth position of the ranking. In comparison with beer, fresh bovine meat displays a longer quality ladder, suggesting that such market is characterized by relevant vertical differentiation. Moreover, considering price as proxy for quality, even if countries are ranked differently, the last result is confirmed, namely the fresh bovine meat market is characterized by a higher vertical differentiation than the beer one (results are not shown but are available upon request). This suggests that the use of prices, as well as quality, may be useful when the aim is to identify if a market is mainly characterized by vertical or horizontal differentiation.

4.2 *Quality and TFP growth*

Understanding the evolution of quality over time can have a key role in a growth analysis. Starting from the quality ladder models of Grossman and Helpman (1991) and Aghion and Howitt (1992), a strand of literature has developed showing the existence of a positive link between quality and economic growth. Hausmann et al. (2007), followed by Minondo (2010), give support to the idea that countries that export higher quality goods tend to grow more rapidly.

Total Factor Productivity (TFP) is indeed at the heart of the growth process and can rise as result of innovation and technological change. The positive link between quality and TFP has been shown by the literature at both macro and micro level. At macro level, quality upgrading can be viewed as a specific component of TFP in a growth analysis (Amiti and Khandelwal, 2013). This is empirically confirmed both for the whole manufacturing sector (Khandelwal, 2010) and for the food sector (Curzi et al., 2013). At the micro level, the existence of a positive correlation between quality and TFP has been theoretically introduced by the firm heterogeneity model of Melitz (2003) and empirically proved by Verhoogen (2008) for the manufacturing sector and by Curzi and Olper (2012) for the food sector.

Our proxy for quality allows to test whether, as expected, quality and TFP are positively correlated. Note that we are simply interested in correlation and not in the causality relation, since we are aware of the potential problems of endogeneity that may affect such relation.

In Figure 4 we relate quality growth to TFP growth between 2000 and 2007.⁹ The correlation between the two measures proves to be strongly positive, as most of the considered countries has experienced a positive growth in productivity accompanied by an increase in the quality of their food products. This is consistent with the fact that quality upgrading has a key role in the technology improvement of countries and, consequently, in their growth and competitiveness in international markets. As pointed out by Helpman (2011), international trade can stimulate countries to upgrade the quality of their products and thus lead to a faster productivity improvement. Thus, quality can be considered as vehicle through which countries can grow and develop.

4.3 Price vs. Quality growth

A central question related to the quality estimates is represented by their relationship with price, until now the most used proxy for quality. Thus, as a further step, we compare quality and price growth between 1995 and 2007. This analysis gives back a picture which is in sharp contrast with the common assumption that quality and price go hand in hand. When considering the whole sample, the correlation between the average quality and price growth, both normalized within each product category, is negative and very close to zero (-0.01). This finding reinforces the above evidence giving a strong confirmation that quality and price provide different and complementary information when analyzing competition strategies of countries in the international trade market. In order to make the results clearer and to identify the specificities of the considered countries, we present two separate graphs for OECD and non-OECD (or emerging) countries.. Considering the OECD sample (Figure 5), most of the countries show a positive quality growth in the considered period. However, in most of the cases this is not linked to a corresponding growth of their unit values but, and quite surprising, to their reduction. This is even more evident when considering the sample of emerging countries (Figure 6). Here, by splitting the sample in primary and secondary emerging countries, according to the Financial Times Stock Exchange (FTSE) classification, we find that all the secondary emerging countries show a dynamic of price reduction. By contrast, some of the primary emerging countries display an opposite pattern, namely an increase in price. However, all the countries which experienced a price reduction show a quality upgrading. Interestingly, all the Asiatic countries of this sample display such a pattern. This is in line with what pointed out by Lall and Albaladejo (2004), namely that China's competitive

⁹ TFP has been estimated using data from UNIDO for each country, year and food sector according to the ISIC Rev. 3 classification. To this aim, a value added function with variable returns to scale is used (see Harrigan, 1999; Gopinath and Ruan, 2008). Capital is estimated from gross fixed capital formation, through the perpetual inventory method (see Hall et al., 1988; Crego et al., 1998). The estimated TFP is then linked to the NACE 4-digit categories through correspondence tables provided by the United Nations Statistical Division. We use 2000 as the initial year (instead of 1995) as starting from this year allows to have data on a higher number of countries for which it is possible to estimate TFP,

pressure is pushing its neighbors to raise their technological skills and thus their high quality exports. By contrast, some countries whose price rose show a reduction in quality.

This dynamic is also evident when considering one single sector. In Figure 7, we take as representative example the wine sector. This sector has some interesting peculiarities, since it is characterized by three main producers and exporters (France, Italy and Spain). However, in the last decades some extra-EU countries have become increasingly important in terms of production and also exports. The figure shows that France and Italy, whose wines are universally known as the ones of the highest quality, increased both quality and price. This means that even if the price grew up, consumers still show a preference towards these wines. By contrast, Spain and other extra-EU countries, where the wine sector is developing at a fast rate, show a decrease in prices joint with an increase in quality. This is in line with the recent dynamics of the wine sector, where French and Italian wines maintain their top positions in term of quality, while, at the same time, consumers start to know and appreciate wines coming from non-traditional producers, whose reputation is increasing.. Indeed, Anderson (2004 and 2013) underlines that, in recent years, Italy and France are facing a growing competition from new producers like Australia, New Zealand, California, Chile and Argentina, whose wines, characterized by a lower cost, are becoming more and more sophisticated. As an example, Argentinean and Chilean wines, whose exports were almost zero in the 80's, represent now the 5% and the 10% of the global wine exports (Pacero and Villanueva, 2011).

From previous figures the presence of convergence in product quality is apparent from our data. However, we further deepen the analysis by formally testing if, during the observed period, there has been a convergence in quality and prices of the countries' food products. More specifically, in addition to verifying if there are differences in the convergence rate between quality and prices, we also study if these dynamics are conditional to the quality ladder of the products.¹⁰ Indeed, according to Khandelwal (2010) long quality ladder markets are characterized by a larger scope for quality differentiation, while in short quality ladder ones there is a narrow quality range across products, suggesting that horizontal differentiation prevails. Although the food sector is not taken into account by Khandelwal (2010), we find substantial heterogeneity in food products according to the within sector quality differentiation. Looking at Table 2, where each NACE 4 category is associated to its average quality ladder, we can see how the vertical differentiation prevails in some sectors, being particularly strong in the production of wine and in the one of alcoholic distillates, while the horizontal differentiation dominates in others.

Our convergence analysis is drawn by regressing the growth rate of product quality over the 1995-2007 period on the initial (1995) level of quality.¹¹ The results show convergence in both price and quality in the considered period (Table 3). However, when comparing long and short quality ladder, we find that while for

¹⁰ Following the approach of Khandelwal (2010) quality ladder has been computed for each product category (CN 8) as the difference between the maximum and the minimum value of quality for the first year of the considered period. From this measure we classify products in long quality ladder (if they are above the median value) and short quality ladder (if they are below the median value).

¹¹ Specifically, we run the following regression: $\Delta \xi_{ic} = \alpha + \beta I + \xi_{ic(1995)} + \varepsilon_{ic}$, where ξ_{ic} is our estimated quality for product I and country c , and Δ represents growth between 1995 and 2007. Product fixed effects (I) are included in the equation.

price the difference in convergence rate are virtually zero, considering quality the rate of convergence in short quality ladder is three times higher than in long quality ladder. This pattern, beside the confirmation of the usefulness of our quality measure with respect to prices, suggests that countries which export lower quality products grew at a faster rate than higher quality exporters, and this happened especially in sectors where the scope for vertical differentiation is low across products. These results are not surprising, considering that while in long quality ladder it is difficult to compete with the traditional top quality producers, short quality ladder represent an opportunity to be competitive also for developing or emerging countries. Indeed, developing countries exports mainly consist of primary or not very refined processed products. This may imply that it is easier to increase competitiveness and to climb the quality ladder in markets with a lower scope for (vertical) quality differentiation. At the same time, it clearly emerges that firms in developed countries, to contrast the competitive pressure coming from developing countries' exports, have to focus their efforts in sectors where the scope for vertical differentiation is higher.

5. Conclusions

The quality of the exported products is more often viewed as a fundamental element which allows countries (firms) to have success in the international trade market. This is particularly true for the food sector, where the growing attention on the quality and safety issues has led to an increase in the demand for high quality foods, in particular in the richer countries. In this paper we infer quality relying on the nested logit demand framework developed by Berry (1994) and then applied by Khandelwal (2010) using trade data. The main goal of the work is to test the reliability and to discuss the properties of these quality estimates focusing on the EU food sector, making a comparison with standard methods based on the use of unit value.

We highlight interesting properties of our quality estimates that, overall, can offer new insights in the analysis of countries' and sectors' behavior in the international markets. First, testing the reliability of our quality estimates through quality rankings for three specific food products we find that the quality estimates are in line with the expectations, giving credence to the validity of Khandelwal's (2010) approach. The reliability of our measures is also confirmed by the positive correlation between quality upgrading and TFP growth. Our result is in line with the recent international trade literature arguing that a positive growth in productivity is often associated with an increase in the quality of their products. Even if our results show a simple correlation between the two measures, it is important to underline that the increase in product quality can be considered as a vehicle of an economic growth. Indeed, quality is a key element in the relationship between trade and productivity. International trade pushes countries/sectors to develop new competitive varieties and to improve the quality of the ones which are already produced, thus impacting the level of growth and development.

When comparing our quality estimates with the use of the unit value, we find that quality upgrading is often poorly correlated with price variation and, in line with the Khandelwal (2010) findings, this is especially true in sectors characterized by a short quality ladder. Moreover, we find that the use of this proxy for quality in a convergence analysis leads to different results than the use of unit values. In particular, we

find that the rate of convergence in short quality ladder markets is three times higher than in long quality ladder ones. This finding, other than new, may have interesting practical implications. Indeed, especially for developing countries wishing to climb up the quality ladder, it would be a viable strategy to compete in markets characterized by a short quality ladder. This is because in these markets, where there is a lower scope for quality differentiation, countries could be more competitive as there is a faster convergence dynamic, which allows them to strengthen their presence in the international markets. On the other hand, from these results it derives that developed countries should put their efforts in markets with a larger scope for quality, in order to preserve their market shares and to contrast the potential competition coming from the developing countries.

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Table 1. Summary statistics of quality estimates

	OLS	2SLS
	(1)	(2)
Price (<i>mean</i>)	-0.260	-0.735
Nest Share (<i>mean</i>)	0.877	0.677
Sargan test (p-value) (<i>mean</i>)		0.15
Observation per estimation (<i>mean</i>)	4378	
Varieties per estimation (<i>mean</i>)	635	
Total number of estimations	468	
Total observations across all estimations	1,138,022	
Estimation with stat. sig. price coeff.	67%	
Estimation with stat. sig. nest share coeff.	93%	

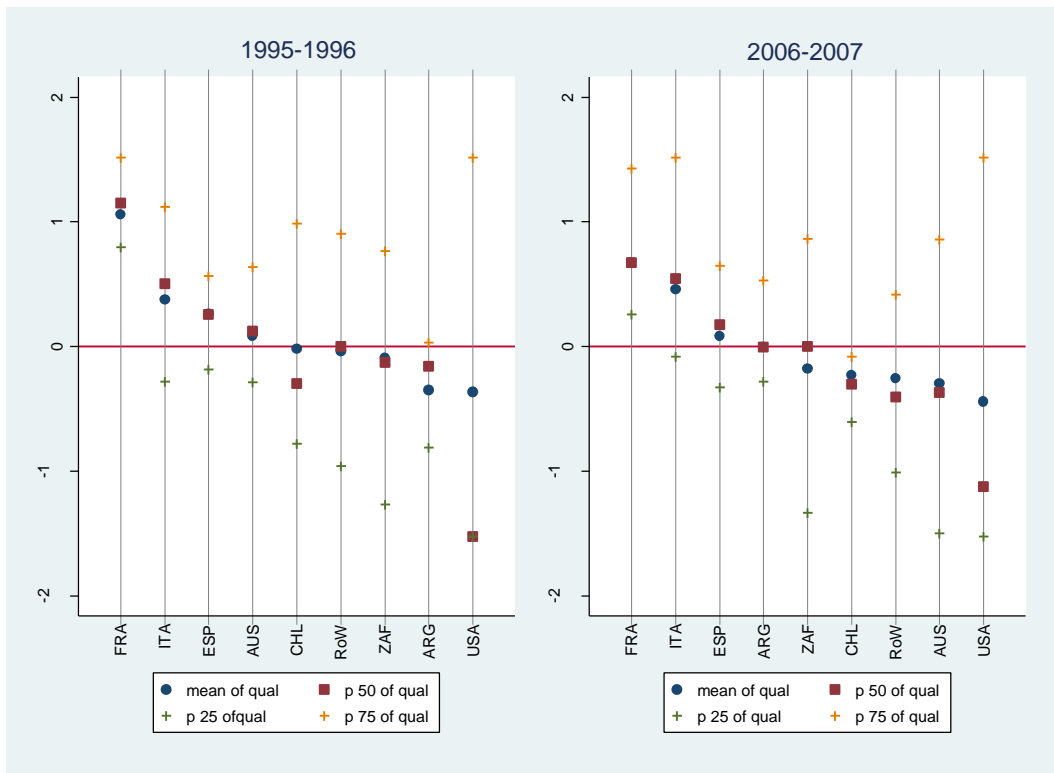
Notes: Table 1 reports estimation statistics coming from running equation (10) separately for each of the food industries in our sample with both OLS and 2SLS. Sargan test has been computed in order to test whether the instruments are uncorrelated with the error term.

Table 2. Numbers of products and mean quality ladder for the food sectors considered

NACE 4	Short description	#CN8	Mean Ladder
(1)	(2)	(3)	(4)
1511	Production and preserving of meat	142	3.54
1512	Production and preserving of poultry meat	196	3.05
1513	Production of meat and poultry meat products	108	3.11
1520	Production and preserving of fish and fish products	401	1.42
1530	Production and preserving of fruit and vegetables	495	2.77
1540	Manufacture of vegetables and animal oils and fats	144	1.60
1550	Manufacture of diary products	204	2.02
1560	Manufacture of grain mill products, starches and starch products	178	1.85
1580	Sugar and cocoa	60	1.70
1581	Manufacture of bread; manufacture of fresh pastry goods and cakes	2	0.59
1582	Manufacture of rusked and biscuits	29	1.47
1585	Manufacture of macaroni, noodles and couscous	11	2.15
1586	Processing of tea and coffee	22	2.05
1587	Manufacture of condiments and seasoning	11	2.37
1588	Manufacture of omogenized food preparaiso and dietetic food	7	1.93
1589	Manufacture of other food products n.e.c.	37	2.76
1590	Production of ethyl alcohol, cider, malt and other non-distilled fermented beverages	18	2.90
1591	Manufacture of distilled potable alcoholic beverages	67	4.78
1593	Manufacture of wine	99	3.44
1596	Manufacture of beer	4	0.86
1598	Production of mineral water and soft drinks	11	1.45

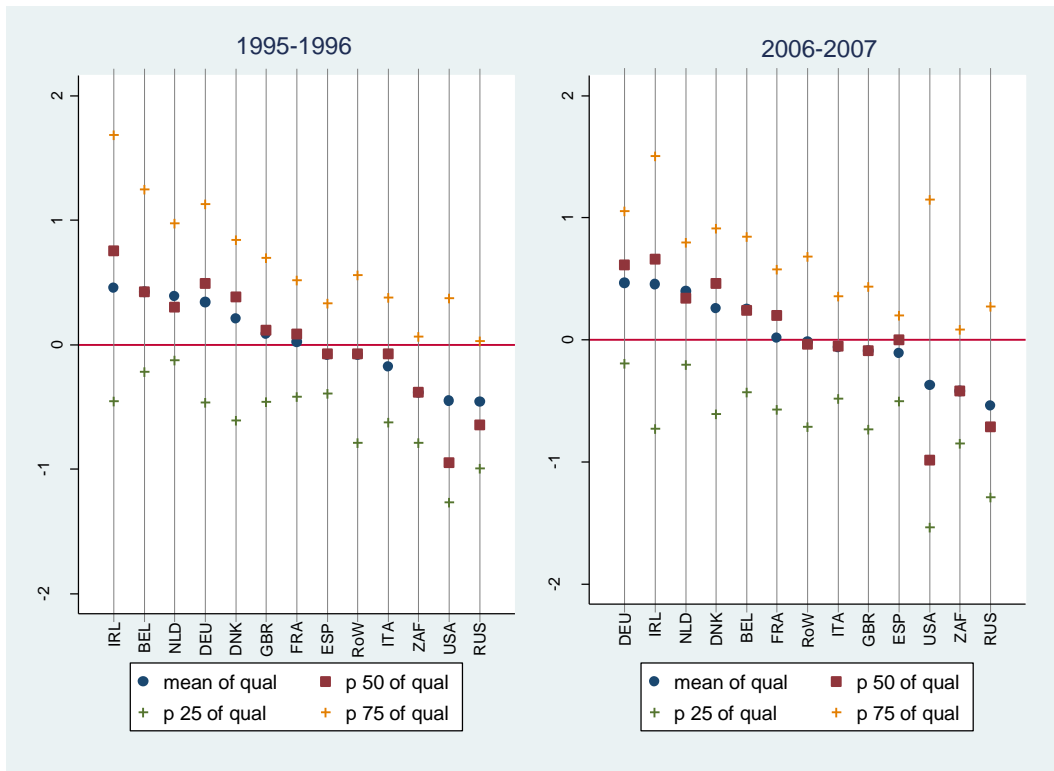
Notes: Table 2 reports information on the NACE 4-digit food industries, for which we estimated equation (2), considering separately each EU15 country. Due to the lack of production data for some importing countries we did the following aggregations: codes 1531, 1532, and 1533 are included in code 1530; 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 and 1584 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. Column 4 shows the mean quality ladder level associated to each NACE 4-digit industry. Following the approach of Khandelwal (2010) quality ladder has been computed for each product category (CN 8) as the difference between the maximum and the minimum value of quality for the first year of the considered period. From this measure we classify products in long quality ladder (if they are above the median value) and short quality ladder (if they are below the median value).

Figure 1. Quality ranking on “quality white wine” (CN8 code 22042111)



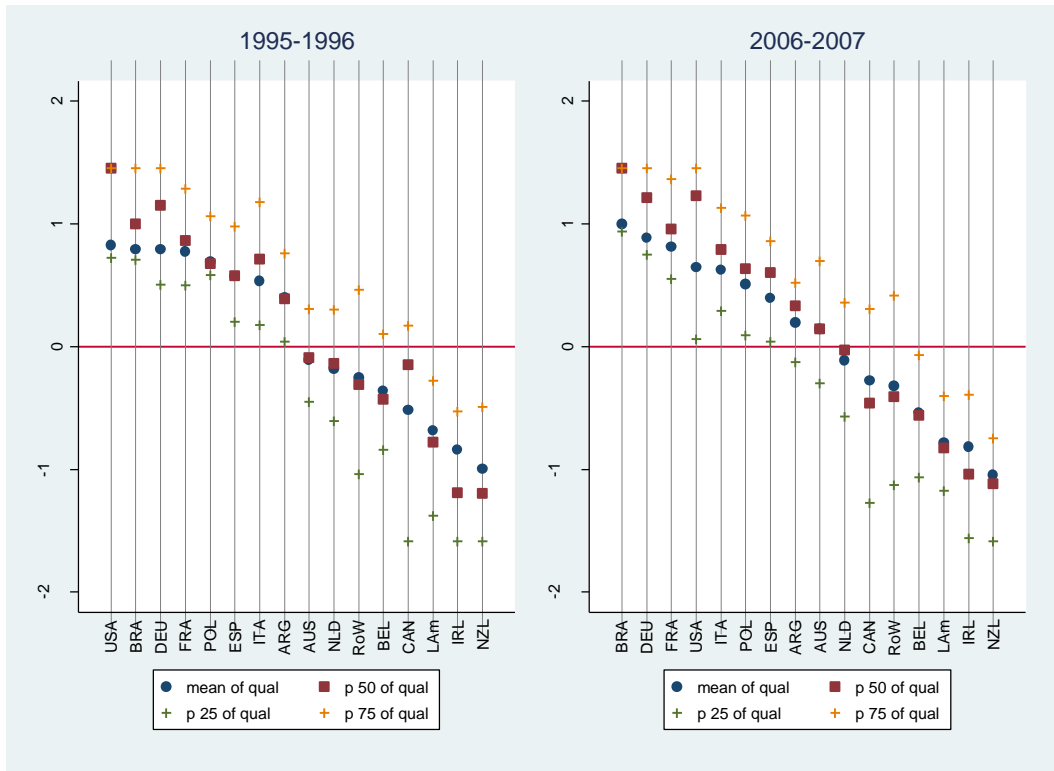
Notes: Countries rank are based on the their mean quality value in each of the two considered periods. See text for calculation details.

Figure 2. Quality ranking on beer (CN8 code 22030001)



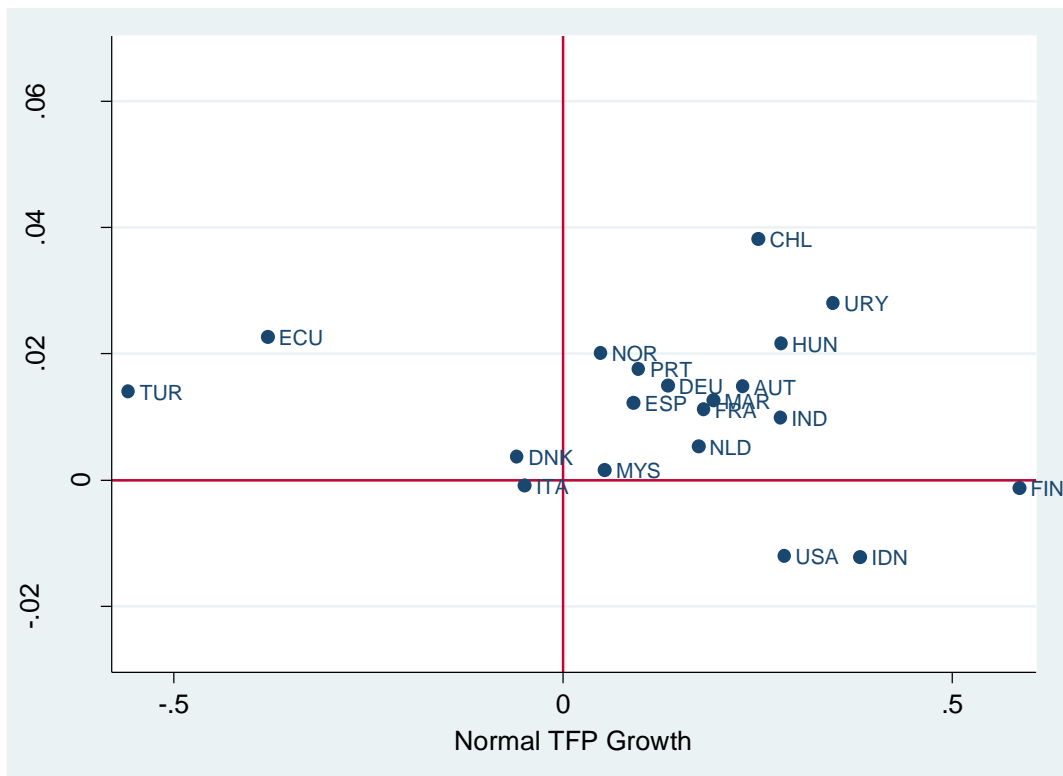
Notes: Countries rank are based on their mean quality value in each of the two considered periods. See text for calculation details.

Figure 3. Quality ranking on “fresh bovine meat” (CN-8 code 02011000)



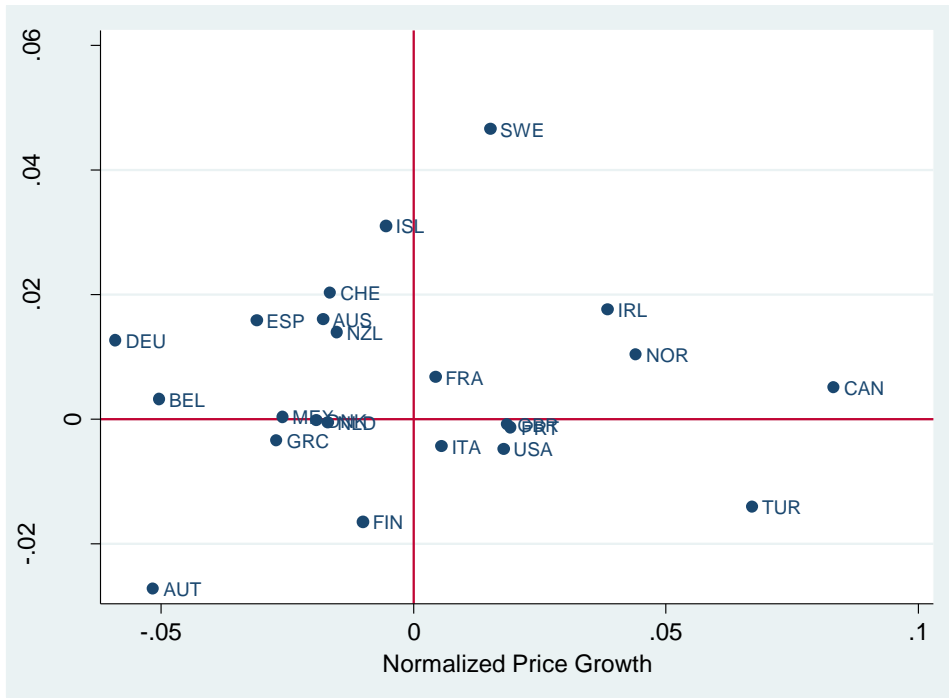
Notes: Countries rank are based on their mean quality value in each of the two considered periods. See text for calculation details.

Figure 4. Quality and TFP growth (2000-2007)



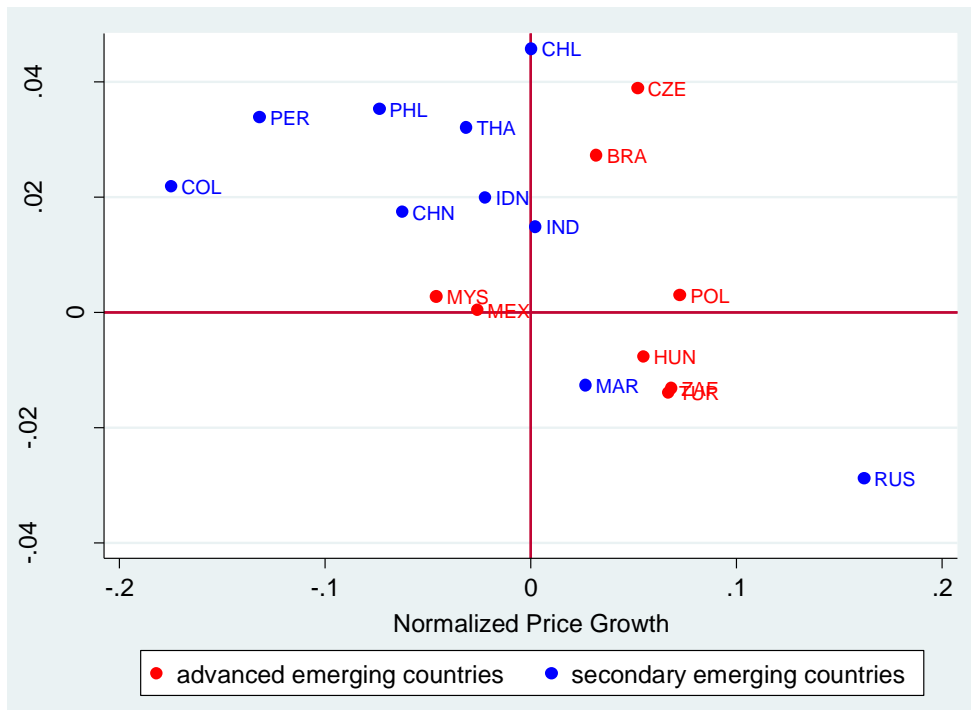
Notes: The figure shows a comparison between normalized quality (y-axis) vs. normalized TFP (x-axis) growth in the period 2000-2007 for all countries with data available for both Quality and TFP estimation. For more details about the TFP estimation, see the text.

Figure 5. Change in Quality vs. Price, OECD countries (1995-2007)



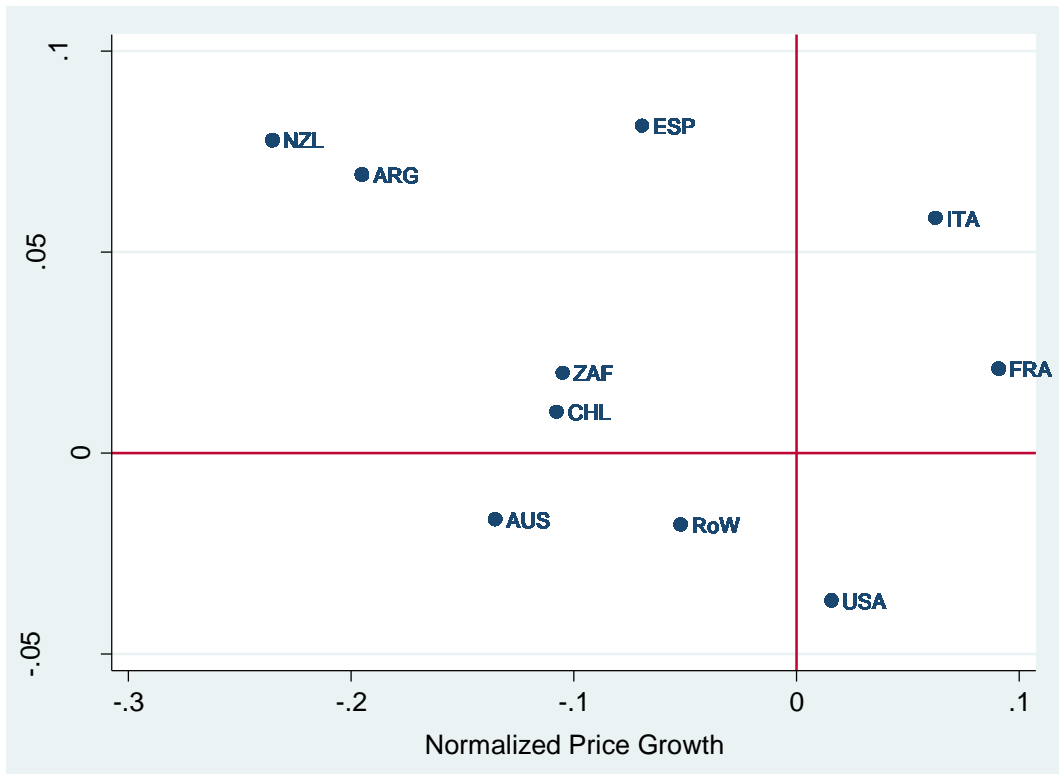
Notes: The figure shows a comparison between normalized quality (y-axis) vs. normalized price (x-axis) growth in the period 1995-2007 for the sample of OECD countries.

Figure 6. Change in Quality vs. Price in non-OECD Countries (1995-2007)



Notes: the figure shows a comparison between normalized quality (y-axis) vs. normalized price (x-axis) growth in the period 1995-2007 for the sample of advanced and secondary emerging countries. Countries are classified in primary and secondary emerging according to the Financial Times Stock Exchange (FTSE) classification.

Figure 7. Change in Quality vs Price – Wine Sector (1995-2007)



Notes: The figure 7 shows a comparison between normalized quality (y-axis) vs. normalized price (x-axis) growth in the period 1995-2007 for a representative sample of countries typical wine producers.

Table 3. Price and Quality convergence in vertical and horizontal differentiated markets

	PRICE			QUALITY		
	(1) All	(2) Long QL	(3) Short QL	(4) All	(5) Long QL	(6) Short QL
(log) Price 1995	-7.77*** (0.147)	-7.60*** (0.199)	-8.06*** (0.222)			
Quality 1995				-0.351*** (0.0365)	-0.360*** (0.0531)	-1.15*** (0.0787)
Product FE	YES	YES	YES	YES	YES	YES
N	54569	29502	25067	57357	31872	25485
R-sq	0.101	0.117	0.126	0.046	0.064	0.097

Notes: Following the approach of Khandelwal (2010) quality ladder has been computed for each product category (CN 8) as the difference between the maximum and the minimum value of quality for the first year of the considered period. From this measure, we classify products in long quality ladder (if they are above the median value) and short quality ladder (if they are below the median value). All regressions include product (CN 8-digit) fixed effects. Standard errors are clustered by exporting country. Significance levels: * 0.10 **0.05 *** 0.01.