International comparison of product supply chains in the agri-food sector:
determinants of their competitiveness and performance on EU and international markets

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Quality Upgrading, Competition and Trade Policy: Evidence from the Agri-Food Sector

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Abstract

This paper analyzes the extent to which the reduction of import tariffs - as a measure of import competition - affects the quality upgrading of the food products exported in the EU15 countries over the period 1995-2007. Product quality is inferred from trade data using the Khandelwal (2010) method. The relationship between quality upgrading and competition is studied within a 'distance to the frontier' model (Aghion et al., 2005). The results show the existence of an non-monotonic relationship between competition and quality upgrading, with varieties close to the world frontier more likely to upgrade quality in response to an increase in import competition.

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1 Introduction

In the last decades food quality and safety issues have been considered among the main topics in the agri-food markets of rich countries. This trend has been driven by a variety of factors exacerbated by several food scares, which triggered growing consumer concerns about the attributes of foods, the way of producing them and increased attention about the relationship between diet and health (Caswell and Mojduszka, 1996; Grunert, 2005; Bontemps et al., 2012). As a consequence, vertical and horizontal quality differentiation of food products has become a necessary condition to satisfy consumers' demand (Grunert, 2005). In this setting, competition in agri-food markets switches from price-based to quality-based, since consumers look for quality and safety differentiated food products (Jouanjean, 2012).

At the same time, the increased attention on food safety and quality and the growing set of regulations in the developed countries puts increasing pressure on producers from developing countries to adapt their processes and make goods eligible to be exported (Jouanjean, 2012). As a result, the last decades have witnessed a growth of contractual and technology transfers to transmit advanced production capabilities from high to low income economies with the aim of increasing both productivity and product quality (Swinnen, 2007; Swinnen and Vandeplas, 2007; Goldberg and Pavcnik, 2007).

According to Sutton (2001), product quality is the most important element that allows firms to have success in the international market, since a low productivity can be offset by lower wage rates, but firms producing low quality products cannot achieve any sales in global markets, however low the income level is (Swinnen and Vandeplas, 2007). Thus, especially for developing countries, which often have a comparative advantage in the agri-food sector, improving the quality of exported products represents a necessary condition for economic growth and development.

In this paper we analyze the extent to which growth in competition, triggered by trade liberalization in the origin country, affects the rate of quality upgrading in the exported products. This relation is investigated using highly disaggregated import data from more than 70 countries to the EU-15 for thousands of food products in the period 1995 to 2007. We infer product quality from trade data using the Berry's (1994) nested logit demand system, along the line recently proposed by Khandelwal (2010). This approach has a straightforward intuition: conditional on price, imports with higher market shares are assigned higher quality.

Our conceptual framework is in the spirit of a growing literature that tests the so-called 'distance to the frontier' model (see Aghion et al. 2005; 2009; Amable et al. 2010; Bourles et al. 2012; Amiti and Khandelwal, 2013). This class of models suggests that the relationship between competition and innovation is non-monotonic and conditional on the firm/product distance from the (world) technology frontier.

Empirically we borrow the strategy of Amiti and Khandelwal (2013), who studied the relationship between quality upgrading and competition in the manufacturing sector. However, we depart from this study in several respects. First, we work in a different destination market – the EU-15 instead of the US market – and with a specific sector – the food industry – not covered by their analysis and where the quality attributes play a critical role, since they represent a key prerequisite for market access in developed countries. Second, we make use of data on the FDI sector targeting and Preferential Trade Agreements (PTAs) with the EU, in order to test for the heterogeneity of the escape-competition and discouragement effects to different trade policies. Third, we test the sensitivity of our results to alternative methods of measuring products quality, along the line recently proposed by Khandelwal, Schott and Wei (2013). Fourth, since the EU countries share the same trade policy and, thus the same external tariffs, we also make use of the EU countries import penetration, instead of the import tariffs, as a proxy for the level of competition in the EU domestic markets. Finally, we control whether our main results are robust to controlling for the diffusion of the EU voluntary standards.

Main results strongly support the prediction of the distance to the frontier model. First, we find evidence of convergence in quality, namely varieties far from the frontier display, on average, faster quality upgrading. Second, results point to a non-monotonic relationship between competition and quality upgrading. Varieties close to the world frontier are more likely to upgrade quality in response to an increase in competition, while the opposite effect holds for varieties far from the frontier. These results hold true overall, considering sub-samples of OECD and non-OECD countries, and are stronger for country-sectors that are target of specific FDI policies and for countries *without* preferential trade agreement with the EU. Finally, we also find a strong positive relationship between quality upgrading and the diffusion of EU voluntary standards.

Our paper is related to two main strands of the international trade literature. First, the recent development of trade models with heterogeneous firms. Indeed, while there is broad evidence in the literature on the pro-competitive effect of trade liberalization (see Melitz and Trefler 2012, for a recent review), only few works have investigated the relation between competition and quality upgrading, and none of these is focused on the food industry. One of the most important contributions to this strand of literature comes from Melitz (2003), who 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. Starting from this seminal model, a new wave of theoretical and empirical contributions have considered explicitly heterogeneous quality across firms (Baldwin and Harrigan, 2011; Verhoogen, 2008; Crozet et al., 2012; Fajgelbaum et al., 2011; Crinò and Epifani, 2012).[1] All these contributions 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. Our empirical evidence

[1] See Linder (1961), Falvey and Kierzkowski (1987), and Flam and Helpman (1987) for seminal contributions studying the influence of product quality on international trade. Empirical evidence of the link between product quality and trade patterns can be found in Schott (2004) and Hallak (2010). Differently, firms' level evidence can be found in Verhoogen (2008), and Curzi and Olper (2012) for the food industry. The contribution of product quality to macroeconomic growth is investigated theoretically by Grossman and Helpman (1991) and empirically by Hummels and Klenow (2005).

corroborates this line of thinking, adding the important qualification about the role played by the country/firm/variety distance from the technological frontier to better understand the relationship between competition, productivity and quality upgrading.

Second, we stress that, as it emerges from our findings, the average positive effect of the EU standards on the rate at which exporter countries update the quality of their products other than new, s in sharp contrast with a large literature based on the gravity model that, differently, more often highlighted the barrier to trade view of food standards (see Li and Beghin, 2012, for a recent survey).[2] By contrast, our results appear more in line with the catalyst of trade view of food standards (see Jaffee 2005; Maertens and Swinnen 2009), and, in particular, with the idea that international standards increase total factor productivity by helping firms to climb the technological ladder (through efficiency gains and quality signaling) and thus reducing the productivity gap with firms located in developed countries (see Goedhuys and Sleuwagen, 2013). Clearly, to the extent to which the quality of exported products matters for the firms' export performance, as the literature summarized above suggests, then our findings may have interesting and direct trade and welfare implications.

The remainder of the paper is organized as follows: the second section presents some theoretical considerations, summarizing the main intuition of the distance to the frontier model. The third section briefly presents the Khandelwal (2010) method, on which we rely to infer the quality of the exported products, and the data used in the empirical part. In the fourth section our main results are presented and discussed. Finally, in the last section, we draw the main conclusions.

2 Theoretical and empirical considerations

2.1 Theoretical background

How does an increase in competition affect firms' incentive to innovate? Aghion and Howitt (2005), following Schumpeterian growth theory, argue that this relationship is critically dependent on the incumbents' position relative to the world technology frontier. An increase in competition induces firms (sectors) that are initially close to the technology frontier to innovate more, while they reduce the expected rents from innovation for firms (sectors) further away from the technology frontier. This is because incumbent firms close to the frontier know that they can escape and survive the newcomers by intensifying the innovation activities. By contrast, firms far from the frontier have no hope to win competition against newcomers (Aghion et al. 2009). These two effects are respectively called the *escape-competition* and *discouragement* effects of competition on innovation. These and other authors (see especially the contributions of Acemoglu et al., 2006; 2010) argue that the interplay between these two forces induces a relationship between competition and innovation that is non-monotonic, and conditional on the firm (product) distance from the world technology frontier:

$$Y = f\,(C, D, X)$$

[2] See Swann (2010) for a review on the relation between standards and trade.

where *Y* is a firm-sector output performance, *C* is a measure of market competition, *D* represents the distance to the technological frontier and *X* are other covariates.

Aghion et al. (2009) found considerable empirical support for this relation by studying how firms' entry affects innovation incentives in incumbent firms using a detailed micro data panel for the United Kingdom.[3] More recently, Amiti and Khandelwal (2013) used a similar logic to study the relationship between the rate of growth of quality upgrading (as a measure of innovation) and the reduction of tariffs (as proxy for import competition). They show 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.

In the present application we rely on the idea 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. (2010) 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 evidence showing that leading firms' innovation effort is always more aggressive compared with that of the followers (e.g. Etro, 2008).

In what follows, we keep the logic of distance to the frontier model of Aghion and Howitt (2005) as our basic framework. This strategy offers the possibility to test whether the findings of Amiti and Khandelwal (2013) hold true in a different market – the EU-15 instead of the US market – and with a specific sector – the food industry – which is only marginally covered by their analysis, but where quality attributes represent a fundamental prerequisite for firms' export success (see Crozet et al. 2012; Altomonte et al. 2010; Curzi and Olper 2012).

2.2 The empirical model

The empirical strategy is in the spirit of the growing literature that tests the distance to the frontier model, where an output variable is regressed on a proxy for competition and its interaction with the distance to the frontier term (e.g. Aghion et al. 2009; Amable et al., 2010; Bourles et al. 2012; Amiti and Khandelwal, 2013). In particular, we test the relation between competition (here expressed as tariff reduction) and quality upgrading, which represents our country-product output variable. Let D_{cht} be the distance to the frontier of product *h*, exported by country *c,* at time *t*, namely, the ratio of its quality to the highest quality within the same product category (see section 3.1 for details). Formally, our strategy is aimed to test the following empirical model:

$$(1) \quad \Delta ln\phi_{cht}^{F} = \alpha_{iht} + \alpha_{ct} + \beta_1 D_{ch,t-5} + \beta_2 tariff_{ch6,t-5} + \beta_3 \left(D_{ch,t-5} * tariff_{ch6,t-5}\right) + \varepsilon_{cht}$$

The dependent variable, $\Delta ln\phi_{cht}^{F}$, represents the change in a variety's (country *c* – product *h* combination) quality between period t and $t-5$. All the explanatory variables are in level for the period t–*5* to reduce any potential endogeneity problem. Thus, quality growth is explained by the lagged distance to the frontier ($D_{ch,t-5}$), the lagged import tariff ($tariff_{chs6,t-5}$) and the interaction term of these two variables $\left(D_{ch,t-5} * tariff_{chs6,t-5}\right)$. This interaction term should

[3] Other evidence supporting the interaction between innovation activities and firms/countries distance to the technology frontier, can be found in Acemolgu et al. (2006) and Bourlès et al. (2012). By contrast, in Amable et al. (2010) and Alder (2010) the evidence in support of the distance to the frontier models is mixed, and often not in line with theoretical predictions.

allow for the non-monotonic relationship stressed by the distance to the frontier models of Aghion et al. (2005; 2009).

An important element to take into account considering the baseline specification (1), is the presence of both importer country-product-year (α_{iht}) and exporter country-year (α_{ct}) fixed effects. In particular, the importer country-product-year fixed effects are of fundamental importance since our quality measures, estimated using a nested logit demand function separately within each EU15 importer country and 4-digits industry, are only comparable within the same product category or industry. Thus, the presence of the importer country-product effects allows us to explore the variability between products' quality estimates that are comparable with each other, and moreover, within the same importing country. Differently, the exporter country-year fixed effects control for potential concerns that some country-level shocks (such as technological shocks, changes in relative endowments or changes in institutions) may affect the competitive environment. Thanks to these controls, running our specification (1) we take into account potential shocks which could affect both tariff changes and the quality growth.

In accordance with Aghion et al. (2009), we expect that $\beta_2 > 0$ and $\beta_3 < 0$. Hence, for varieties close to the world quality frontier – i.e. when the distance to the frontier variable is close to 1 – a fall in tariffs would stimulate a variety's quality growth in the subsequent period. This is because only high tariffs can protect investments in quality upgrading for varieties that are far from the frontier. Equation (1) is estimated by OLS, considering both the whole sample as well as different sub-samples of countries and products. We do this in order to investigate the possible heterogeneity of the results to specific country conditions, such as the level of development, the presence of specific policy affecting FDI inflows, and preferential trade agreements with the EU.

3 Quality estimates, data and measures

3.1 Quality estimates

Product quality is unobservable. The most common proxy used to measure the quality of the exported goods is unit value, defined as nominal value divided by physical volume of a traded product, according to which higher unit value reflects higher quality. However, there are several indications that unit values are an imprecise measure of quality, because they also capture other product characteristics unrelated to quality.[4] Hence, in order to measure quality, we follow the approach proposed by Khandelwal (2010). This author estimates the quality attached by the US consumers to the imported products. We borrow his method but we implement it separately in each of the EU-15 countries. In this respect we mitigated the potential bias due to specific country preferences towards certain products.

The method is based on a nested logit demand system, developed by Berry (1994), that embeds preferences for both horizontal and vertical attributes. Unlike prices, product quality is unobservable and thus, it must be estimated. Here we briefly highlight the salient aspects

[4] First of all, higher unit values could reflect higher quality, but also higher costs (see Aiginger, 1997). Moreover, higher unit values could also be the consequence of higher margins created by market power (Knetter, 1997). See Hallak and Schott (2011) and Khandelwal (2010), for recent evidence about the poor ability of export unit values to capture product quality.

of this approach, while the more technical details and the estimation results are presented in the Appendix 1. In this approach, quality represents the vertical component of the estimated model and captures the main valuation that consumers attach to an imported product. The procedure requires both import data (value and volume) and quantity information (production quantity) and has the straightforward intuition that conditional on price, imports with higher market shares are assigned higher quality. The demand for each variety is modeled such that the market share of a variety, within its relative industry, is a function of the variety's price and some controls for horizontal differentiation. After estimating the demand function separately for each importer country-industry, product quality is obtained by summing the regression residuals, the time fixed effects and the variety fixed effects.

As a robustness check, we also test our main findings inferring product quality using an alternative and simplified method recently proposed by Khandelwal, Schott and Wei (2013). The main aspects of this method, which is conceptually similar to Khandelwal's, are reported in the Appendix 1.

With the quality estimates ϕ_{cht} in hand we can measure the distance to the frontier (D_{cht}). This is measured by first taking a monotonic transformation of the quality estimates to ensure that all estimates are non-negative, $\phi_{cht}^{F} = exp[\phi_{cht}]$. Then we define a variety's distance to the frontier as the ratio of its transformed quality to the highest quality within each CN 8-digit product: $D_{cht} = \frac{\phi_{cht}^{F}}{max_{c \in ht}(\phi_{cht}^{F})}$, where the max operator selects the maximum value of ϕ_{cht}^{F} within a product-year, and $D_{cht} \in (0,1]$. Thus, for varieties close to the frontier, D_{cht} will be close to 1. Differently, for varieties far from the frontier, D_{cht} will be close to 0.

3.2 Data and other variables

In order to infer product quality in each of the EU-15 countries, treated as destination markets, we rely on trade data from the EUROSTAT-Comext database. We make use of yearly import data in value and in volume for all the EU-15 countries (except Luxembourg, for which we do not have production data) and from all trading partners in the world with data. We work at the maximum level of disaggregation (CN 8-digit) over the period 1995-2007. We decide to use 2007 as final year, because as an effect of the 2008 and 2010 price spikes, extending the analysis also to these periods could introduce noise in our quality estimates.

Data on domestic production for the EU-15 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 the EU countries from 1995 onwards and is based on an extensive yearly survey of the production activities carried out by firms. Quality estimates are based on 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.

In order to study the level of competition that exporters face in their own country and industry, use was made of ad valorem tariffs for all the exporting countries with data. We collect these data from WITS (World Bank), at the HS 6-digit level and over time. Note that we do not need to aggregate the tariff rate, thus avoiding any bias linked to choice of the aggregation method. All tariffs are expressed as ad valorem equivalent. For products where there are also specific duties, we transform these in ad valorem equivalents using the world unit values.[5] There are no tariffs data for all the countries in our sample. Thus, the distance to the frontier for each product-year is defined considering only the set of countries with tariffs data.[6]

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 70 countries to the European Union, and on the level of EU import tariffs at the HS 6-digit level. Table 1 reports data on the CN-8 products belonging to each NACE 4-digit industries, as well as the level of the respective 4-digit (simple) average tariffs faced by the exporting countries sample over the period 1995-2007.

An important innovation of our analysis is related to the investigation of how FDI policies affect the link between competition and quality upgrading. For that purpose, we use data on industry-level targeting, coming from the 2005 Census of Investment Promotion Agencies (IPAs), conducted by the World Bank.[7] Sector targeting is considered one of the most effective ways of attracting FDI. Recently, Harding and Javorcik (2011) found empirical evidence that targeting a particular sector by a national IPA can lead to attract more than the double of FDI inflows. Thus, as argued by Harding and Javorcik (2012), data on sector targeting can be considered a good proxy for FDI inflows, and moreover they are less susceptible to the possible simultaneous relationship between FDI and quality upgrading. In fact, FDI can improve the quality of the exported products, but it could also be attracted by those countries-sectors that already produce and export higher quality products. Clearly, this possible endogeneity bias is strongly attenuated by using the IPA data on FDI industry-level targeting.

The IPA data set covers 105 countries over the period 1984-2000. For our purpose, we use IPA data from 1995 to 2000, covering about 50 countries of our sample. The data set includes time-varying information on which SITC 4-digit agri-food sectors were targeted by the national IPAs in their investment promotion efforts.[8] One of the main advantages of using this data is that developing countries are highly represented in our sample, while data on direct FDI inflows are not readily available for those countries at detailed level of disaggregation. This allows us to test whether an increase in competition due to a fall in tariffs exerts a heterogeneous effect on the rate of product quality upgrading according to whether countries-sectors are targeted as more attractive for FDI inflows, and thus, where it is more likely to find a better business environment.

[5] For further details, see the documentation about the 'calculation of ad valorem equivalents' in the WITS web site at http://wits.worldbank.org/wits/.
[6] For those countries with no tariffs data for a particular year, we include data for the preceding year. Note also that countries within the European Union have common tariffs.
[7] Data on direct FDI inflows does not exist at detailed level of disaggregation.
[8] Countries in our sample which have one or more sectors targeted as more attractive for the FDI inflows are: Australia, Chile, Greece, Jordan, Pakistan, Sweden and Venezuela. Countries in our sample which not have any sector targeted as more attractive for the FDI inflows are: Argentina, Bulgaria, Brazil, Canada, Switzerland, China, Costa Rica, Cuba, Cyprus, Czech Republic, Ecuador, Finland, France, Great Britain, Guatemala, Hungary, Island, Israel, Italy, Japan, Kenya, Korea, Lithuania, Latvia, Madagascar, Mexico, Malta, Mauritius, Netherlands, Norway, New Zealand, Portugal, Singapore, Slovakia, Togo, Tunisia, Turkey, Taiwan, Uruguay, South Africa.

Another relevant issue from a developing country's perspective is to understand the extent to which the recent development of PTAs played some role in affecting the rate of quality upgrading. Recent assessment of the EU PTAs effect through gravity model clearly suggests that PTAs have a positive and significant impact on trade flows (see Jean and Bureau, 2013). However, to the best of our knowledge, there is no evidence on their effect on quality upgrading. This relationship is tested by using a PTA dummy following Scoppola et al. (2013). In particular, the PTA dummy has been built by considering for each year the presence of a PTA with the EU already in force. Hence, in addition to the GSP preferential schemes, we have included the PTA signed with the ACP, South Africa, the Mediterranean countries, Chile and Mexico and the initiative Everything but Arms.

We use several other data and variables to check for the robustness of our results. First, in order to control the extent to which the properties of our quality estimates are consistent with the previous findings, we make use of UNIDO data to measure countries-sectors' factor endowments and total factor productivity. The UNIDO database provides data on nominal value added at factor cost, capital labor ratio, number of employees and gross fixed capital formation for 34 exporting countries and five processed food industries, defined according to the 3-digit ISIC (Revision 3) classification, over the period 1995-2007.[9] Moreover, data on countries' GDP per capita to proxy for country's endowment are taken from the World Bank.

We also test the robustness of our main findings using price (unit value) as proxy for product quality. Since for this test we need FOB (free on board) prices, we use data from the BACI database (CEPII) at HS 6-digit product level. The main advantage of this database is that FOB prices are obtained through a procedure that corrects discrepancies between the import values, which are generally reported CIF (cost, insurance and freight), and export values, reported FOB. For further details on the BACI database, see Gaulier and Zignago (2010).

Finally, in order to test whether our main results hold controlling for the diffusion of EU voluntary standards we make use of data on European standards, taken from the European Union Standard database (EUSDB) (see Shepherd, 2007). EUSDB provides data on voluntary standards in force in the European Union from 1995 to 2003. Data are collected from two sources, CE-Norm and Perinorm International, and 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.[10]

4 Results

4.1 A preliminary look at the quality estimates

Before analyzing the relationship between competition and quality upgrading, we study whether our quality estimates are consistent with the expectations. In particular, we are interested in how countries' productivity and factor endowment measures are correlated to our quality estimates. Note that we are simply interested in robust correlation and not in the causality relation. Indeed, to some extent, this correlation should be tautological, because

[9] For further details concerning the TFP estimation, see Gopinath and Ruan (2008) and Olper et al. (2013).
[10] For a technical explanation of the EUSDB data, see Shepherd (2007).

total factor productivity (TFP) rises as a result of innovation, either reducing costs, or, indeed, increasing the quality of the input or the final products (Helpman, 2011).

In columns 1 and 2 of Table 2, we test the relationship between product quality and country-sector productivity, measured as total factor productivity (TFP) and real value added per employee, respectively.[11] In both cases we find the existence of a robust positive partial correlation between the quality of the exported products and countries' productivity. These results are consistent with previous research inspired by firm heterogeneity models *à la* Melitz (2003) which indicates that more productive firms produce and export higher quality products (see Verhoogen, 2008; Crinò and Epifani, 2012; Curzi and Olper, 2012). Columns 3 and 4 of Table 2 show that this positive correlation exists also between the quality of the exported products and two standards measures of factor endowment, the countries-industry capital-labor ratio and GDP per-capita, respectively. Thus, more capital intensive and richer countries export higher quality products, a result that again supports previous findings based on unit values as proxy for quality (e.g. Schott, 2004; Hallak, 2010).

The above correlations corroborate the expectations giving credence to the property of our quality estimates. However, our main focus is on the relation between competition and quality upgrading, an issue addressed in the next section.

4.2 Baseline results

In this section we present our main results of estimating equation (1) by OLS. In all specifications, the estimated standard errors are clustered within exporting countries, with EU countries treated as one country because of their common trade policy. Column 1 of Table 3 reports our baseline results that allow to test whether the effect of tariffs on quality upgrading is indeed conditional to the distance of the world quality frontier. Results strongly support this conclusion. First, in line with the expectation, a negative coefficient on the lagged distance to the frontier variable suggests that varieties far from the frontier, on average, display a faster rate of quality upgrading. Namely, there is clear evidence of convergence in quality among varieties.

Second, a significant negative coefficient on the interaction between tariffs and the distance to the frontier variable implies that varieties close to the world frontier are more likely to upgrade products in response to an increase of competition (tariffs reduction). By contrast, the significant positive coefficient on the linear tariff implies that tariffs are likely to have the opposite effect for varieties far from the frontier. Quantitatively, our results show that a 10 percentage point reduction in tariffs induces a decrease in the rate of quality upgrading of -2.1% for varieties far from the world quality frontier and an increase of +2.5% for varieties close to the frontier. Thus, countries/sectors that produce leader varieties to escape the growing competition increase the rate of quality upgrading, while laggards countries/sectors behave exactly in the opposite direction, reducing the rate of quality upgrading due to the discouragement effect. These results are in line with the predictions of Aghion et al (2005;

[11] Country-industry specific total factor productivity (TFP) has been estimated using UNIDO data. We estimate a value-added function which allows for country, industry and time-specific effects and assuming variable returns to scale (see Harrigan, 1999; Gopinath and Ruan, 2008). Data on gross fixed capital formation are used to calculate capital stock, following the perpetual inventory method (see Hall et al., 1988; Crego et al., 1998; Gopinath and Ruan, 2008). The estimated TFP is then linked to the NACE 4-digit classification through appropriate correspondence tables provided by the United Nations Statistical Division.

2009) and they represent a broad confirmation of the findings of Amiti and Khandelwal (2013).

Since countries in our sample vary strongly in terms of the level of income and development, it is important to study the heterogeneity of the escape-competition and discouragement effects according to different country characteristics. In columns 2 and 3 we present the results of estimating equation (1) giving the possibility to have separate coefficients for OECD and non-OECD countries. The non-linear relation between quality upgrading and competition is statistically significant in both the OECD and non-OECD sample, although in the latter case the estimated coefficient of the (linear) tariffs term is not statistically significant, but the two terms are jointly significant. Quantitatively, our results suggest that for OECD countries, a reduction by 10 percentage points in tariffs induces a decrease in the rate of quality upgrading of –2.6% for varieties that are far from the frontier and an increase of 1.2% for varieties close to the frontier. The equivalent numbers for non-OECDs are respectively –1.3% and 4.8%. Thus, products' quality of firms/industries close to the frontier is particularly sensitive to the level of market competition in developing countries.

Overall, these findings are relatively close to those of Amiti and Khandelwal (2013) for US imports in the manufacturing industry, although they found a higher magnitude of the estimated effects for OECD countries. Thus, there is evidence that, working with only agri-food products instead of other manufacturing products, developing countries' quality upgrading is more sensitive to a change in import competition. This result has an interest *per se*, because it suggests that a process of trade liberalization in developing countries can induce potentially large effects on their rate of quality upgrading in food products.

4.3 FDI sector targeting, PTAs and quality upgrading

An important element of globalization that more often affects the competitive environment, especially of the developing countries, is represented by the FDI inflows. A large body of literature points out that attracting foreign investors can lead to faster economic growth, thanks to increasing capital inflows, transfers of new technologies and know-how and, as a consequence, positive productivity spillovers to local firms (Görg and Strobl, 2001; Görg and Greenaway, 2004; Javorcik, 2004; Javorcik and Spatareanu, 2011).[12] For our purpose, an interesting issue to address is whether there exists a heterogeneous effect of an increase in the level of competition on the rate of quality upgrading, depending on different policies on the attraction of FDI inflows.

Columns 1 and 2 of Table 4 show results obtained by interacting the variables used in specification (1) with a dummy variable that takes the value of 1 if a country's IPA at time *t* considered the sector as a priority target for attracting FDI inflows, and zero otherwise. Thus, we are estimating separate coefficients for countries-sectors that are considered a priority by national investment promotion agencies and those which are not. The results show that the

[12] The FDI spillover effect, however, is conditional on different elements. Javorcik (2004), using a firm-level panel data set from Lithuania, provides evidence that the productivity spillover is positively linked to the foreign presence in the downstream sectors (backward linkage channel) and with a partially and thus not fully owned foreign projects. However, she does not find evidence of spillovers due to either the horizontal or the forward linkage channel. Rojas-Romagosa (2006) argued that the spillover effects are conditional on the absorptive capacity of the firms and/or the host country. He pointed out that, counter intuitively, the spillover effect is higher for developed countries than for emerging economies and that it depends also on the technological gap (i.e. the lower is the technological gap, the larger is the spillover).

escape-competition and discouragement effects hold for both groups. However, the effect is more pronounced for those countries' sectors considered as a priority target. Broadly speaking, these results are in line with the recent literature on the effects of FDI, which shows that FDI inflows improve the quality of the products exported by the hosting countries. The entry of multinationals in the economy increases the ability of those countries to upgrade the quality of their production and, consequently, of their export basket (Wang and Wei 2008; Iacovone and Javorcik 2008; Harding and Javorcik, 2012).[13]

A second relevant issue, especially from a developing country's perspective, is to understand the extent to which the recent development of PTAs played some role in affecting the rate of quality upgrading. Recent findings on the EU PTAs effect, obtained by using gravity models, have led also to investigate their direct effects on the extensive margin of trade, namely the number of varieties exported. From this relatively new but growing literature it clearly emerges that PTAs seem to positively affect the extensive margin. However, the effect is heterogeneous across PTAs (Wilhelmsson and Persson 2012) and, interestingly, appears mostly driven by other than the tariff provision of the PTAs, such as service and investment liberalization, regulation of competition and protection of property rights (see Scoppola et al. 2013), a results not inconsistent with the IPAs effect discussed above.

Thus, Columns 3 and 4 of Table 4 test the relation between competition-quality upgrading by splitting the sample into countries with and without a PTA with the EU. Results show that the non-monotonic relation is confirmed only for countries without a PTA. Instead, for countries granting a PTA, although some non-linearity in the data is confirmed, the estimated relationship is not statistically significant. Thus, we do not find any evidence that granting preferential access to developing countries in the food sectors, *per se*, contributed to increase the rate of their products quality upgrading, *ceteris paribus*.[14]

4.4 Robustness checks

In order to verify the robustness of our findings, we control whether the results hold under alternative definitions of the quality frontier, different quality measures, and a different definition of competitiveness. A first possible concern is that the distance to the frontier measure could be affected by some errors due to randomness or outliers of the highest quality variety. In Table 5, we demonstrate that the results are robust to an alternative definition of the world quality frontier. Columns 1 and 2 show that excluding respectively the top quality (observations for which $D_{cht-5} = 1$) and the top two quality products (and thus redefining the frontier) does not significantly change the main results.

Second, we also check the robustness of our results by using, as an alternative quality measure, the percentile of a variety's quality within each product-year pair. Compared to our earlier measure of quality, the percentile measure has the advantage of being easier to

[13] Wang and Wei (2008) provide evidence that products exported by Chinese foreign-invested firms tend to have systematically higher unit values than the other domestic firms, suggesting that they produce higher quality products. Iacovone and Javorcik (2008) reached a similar conclusion comparing the unit value of the new products introduced by foreign and domestic firms in Mexico, finding that foreign establishments tend to export higher quality products. Finally, Harding and Javorcik (2012), using data on IPAs sector targeting, provide evidence that attracting FDI inflows can boost the ability of a country to upgrade the quality of its export basket.

[14] A potential shortcoming of this finding is that our sample considers only food manufactured products and disregard agricultural products. However, the latter often represent the lion's share of the exports of less developed countries with PTAs. Thus, in our estimation the number of observations of the PTAs sub-sample is quite small.

compare across products. In column 3 of Table 5, we see that running the baseline specification using the change in quality percentile as dependent variable does not change the main results. However, differently from Amity and Khandelwal (forthcoming), the magnitude of all the coefficients increases in absolute value.

A fundamental test for the robustness of our results is presented in columns 4 and 5 of Table 5, where we run our baseline specification (1) using alternative methods to Khandelwal's (2010) estimate of product quality. In column 4 we use a recent method proposed by Khandelwal, Schott and Wei (2013) that allows to infer quality from a CES demand function. Intuitively, their method assigns a higher quality to a variety if, conditional on price, that variety has a higher export quantity. This method, summarized in Appendix 1, is conceptually similar to the one we used in the previous section, but it does not require the use of any instrument. Results in column 4 strongly support our previous findings. Moreover, the magnitudes of the coefficients are similar to the ones of our baseline estimate.[15]

In column 5, we re-estimate our main specification (1) using prices (unit values) as proxy for quality. Thus, our dependent variable is computed as the change in (log) prices between the year t and $t{-}5$, while the distance to the frontier is defined as a variety's price distance from the maximum price, within the same product category.[16] The results again support our main findings, even if the magnitudes of the escape-competition and the discouragement effects are lower in absolute terms with respect to the ones of our baseline estimate.

A further potential issue of our results is related to the EU trade policy. In fact, since EU countries share the same trade policy, there is no variability in the import tariffs between this set of country-products. For this reason, in column 6 of Table 5 we test our main specification (1) using EU countries' import penetration, rather than the level of tariffs, as a proxy for the level of competition faced by firms in the home country.[17] This represents a very important test, since data on intra-EU trade represents about 70% of the sample in our baseline estimate. Thus, the use of a proxy for the level of competition, which has also intra-EU country variation as the import penetration, allows us to address possible concerns due to the low variability in EU import tariffs. Column 6 reports the result of regressing the change in (log) quality of a variety on the (lagged) distance to the frontier, the (lagged) EU country-industry import penetration and its interaction with the (lagged) distance to the frontier. Consistent with the expectation, the coefficient on import penetration is negative while that of the interacted term is positive, and both are strongly significant. Thus our findings are robust to the use of other indicators of competitiveness.

Finally, one possible not trivial concern of our analysis is that the quality upgrading of the products exported in the EU market could be affected not only by a change in the domestic competitive environment due to an increase or decrease in the level of import tariffs, but also by the presence of rigid food standards in the destination (EU) market. Indeed, 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 is

[15] We trim data along two dimensions: we drop the quality estimates at the 1st and 99th percentiles and also any observation with five year quality growth outside the 1st and the 99th percentiles.
[16] We drop observations that report unit values change that fall below the 1st or above the 99th percentile.
[17] We compute import penetration in each NACE 4-digit industry and year for all the EU countries in the sample using turnover and import data from Eurostat. Import penetration is defined as the ratio of total imports over the sum of imports plus output, minus exports.

considered, however there are several exceptions (see Moenious, 2006; Swann, 2010). In column 7 we augment equation (1) by including in the specification the lagged value of the (log) numbers of standards and its interaction with the distance to the frontier, in order to test whether our main results hold even when controlling for the diffusion of EU voluntary standards.[18]

Results in column 7 show that, even when controlling for the diffusion of EU voluntary standards, the effect of tariffs remains stable and robust. Moreover, the estimated effect of standards is positive and significant for the linear term and negative and significant for the interaction term. However, note that the estimated size of the coefficient on the interaction effect is about six times lower, in absolute value, than that of the standard linear coefficient. Thus, although we detect some non-linearity (the effect is decreasing with the distance to the frontier), the relation is positive for both varieties close and far from the world frontier. Because the previous standards literature has stressed the heterogeneity of standards' (trade) effects at different levels, the above results do not come as a surprise. However, the finding that EU voluntary standards, on average, have a positive effect on the rate at which exporter countries update the quality of their products, to the best of our knowledge, is remarkable and new, and totally in line with the most recent firm-level evidence showing a positive relationship between TFP and the diffusion of international standards (Goedhuys and Sleuwagen, 2013).

5 Conclusions

Product quality and safety issues have become central features in both domestic and international markets for food products. The quality of the exported goods is increasingly considered by the literature to be both a determinant of the direction of trade and a key element that contributes to economic growth and development. In this study 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. We use a distance to the frontier framework (Aghion et al., 2005; 2009), according to which firms' innovation activities – like quality upgrading – is a non-monotonic function of the level of competition and the firms' distance to the technological frontier. To test this prediction we inferred products quality following Khandelwal (2010), considering imported agri-food products in the EU-15 from more than 70 exporters in 1500 CN 8-digit agri-food products.

We find strong evidence that an increase in the level of competition leads to a faster quality upgrading only for products close to the world quality frontier. These results are consistent with the main predictions of the Aghion et al. (2005; 2009) model and they hold true when we split the sample into OECD and non-OECD countries. Interestingly, we showed that in countries-sectors considered as a priority target for the FDI inflows, the escape-entry and discouragement effects are much more pronounced. This result is in line with recent findings, showing that FDI inflows can boost the rate of quality upgrading in the hosting countries. By contrast, our results do not support any effect of PTAs on the rate of quality upgrading.

[18] Since data on EU food standard vary at the HS 4-digit level, using importer-product (CN-8)-year fixed effects would lead to have singular matrix. Thus, in order to avoid this problem we use imported-product (CN-8) fixed effects instead of importer-product (CN-8)-year fixed effects.

Our results remain stable and robust under different definitions of the quality frontier and using alternative measures of the level of competition faced in the domestic country. Finally, we found that the effect of tariffs is not affected by the diffusion of voluntary standards in the EU countries, and that EU standards have overall a positive effect on the rate of products quality upgrading.

Our results support the notion that 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 trade liberalization policies. Our findings also suggest that policies oriented at attracting FDI inflows should be considered a viable strategy, in particular for developing countries wishing to climb up the quality ladder, in order to increase their presence in the international markets. Finally, it can be considered of particular interest that 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 from the distance to the quality frontier.

Appendix A.1

Quality estimation

Khandelwal (2010) develops a method to infer product quality using price and quantity information from trade data. The method, based on the nested logit demand function of Berry (1994), 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. According to this method, conditional on price, imports with higher market shares are assigned higher quality. Following Berry (1994), each imported product *h*, belonging to an industry *I*, represents the nest. The demand for an imported variety (product *h* from country *c*), at the time *t,* depends on the following demand function:

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

where s_{0t} is the outside variety, representing the domestic alternative to the imported variety and computed as one minus the industry's import penetration. s_{cht} represents the variety *ch*'s overall market share and is defined as $s_{cht} = q_{cht}/MKT_t$, where q_{cht} is the imported quantity of such variety and $MKT_t = \sum_{ch\neq 0} q_{cht}/(1-s_{0t})$ is the industry size. ns_{cht} is the nest share, that is the variety *ch*'s market share within product *h*. $\phi_{1,ch}$ are the variety fixed effects and represent the time invariant component of quality, while the year fixed effects $\phi_{2,t}$ account for the common quality component. Finally, $\phi_{3,cht}$ is a variety-time specific deviation (residual). The term pop_{ct}, differently, represents the population of the country *c*, and accounts for the so-called hidden varieties.[19] Within this framework, the quality of variety *ch* at time *t*, λ_{cht}, is defined as the sum of the estimated parameters, *quality* $\equiv \phi_{cht} = \hat{\phi}_{1,ch} + \hat{\phi}_{2,t} + \hat{\phi}_{3,cht}$.

We estimate two different versions of the equation (2), separately for each NACE 4-digit industries in all the considered importing countries (the EU-15 Member States). The first version is based on simple OLS estimator, while the second one, by using 2SLS, accounts for the potential correlation of the error term, $\lambda_{3,cht}$, with both the nest share and the variety's price. Indeed, both variables are clearly endogenous to the market share. Following Khandelwal (2010) and, especially, Colantone and Crinò (2011), we use the following variables as instruments for nest share and price in the 2SLS: the interaction between unit transportation costs and the distance from *c*; the interaction between the oil price and the distance from *c*; the number of varieties within each product *p*; the number of varieties exported by each trading partner.[20]

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, we exclude varieties with fewer than 4 observations, detected at

[19] According to Khandelwal (2010), a large country size can lead such country to have a greater market share, due to the fact that it exports more unobserved or hidden varieties within a product. Thus, population controls for country size. Population data are taken from World Bank.

[20] 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 transport 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.

least twice. Finally, since the quality estimates obtained are noisy, we drop the quality estimates at the 5th and 95th percentiles. We trim also any observation with five year quality growth outside the 1st and the 99th percentiles, since the dependent variable that we will use in the empirical part is defined as the quality growth over a five-year interval.

Table A.1 summarizes the results of our quality estimates for both OLS and 2SLS regressions. We estimate quality for each importer -NACE 4-digit industry, performing 250 regressions. The median number of observations for each estimation is 4,379, while the average number is 2,427. The pattern of signs matches the ones of Khandelwal (2010), with a negative price elasticity and a positive nest share elasticity. Finally, for both OLS and 2SLS, the median price and nest share elasticity in our estimates is comparable to the ones in Colantone and Crinò (2011), who estimate quality with the Khandelwal (2010) method in the EU market.

Moreover, we test the robustness of our main findings by also estimating product quality with the approach proposed by Khandelwal, Schott and Wei (2013). Their method is conceptually similar to the one of Khandelwal (2010) and is based on the following straightforward intuition: "*conditional on price, a variety with a higher quantity is assigned higher quality".*

Using the country-industry specific elasticity of substitution, product quality is inferred making use of the residual from the following OLS regression:

$$\ln q_{cht} + \sigma \ln p_{cht} = \alpha_h + \alpha_{ct} + e_{cht} \qquad (3)$$

where α_h and α_{ct} account for, respectively, product and country-year fixed effects and q_{cht} and p_{cht} are, respectively, the demanded quantity and the price of product *h*, imported by country *c,* in the year *t*. Thus, product quality is inferred by using the estimated residual from (3) over the country-industry specific elasticity of substitution minus one, $\hat{\phi}_{cht} \equiv \hat{e}_{cht}/(\sigma - 1)$.

Using an OLS regression, we estimate equation (3) separately for each of the EU 15 importer country and NACE 4-digit industry. Country-industry specific elasticities of substitution are taken from Broda, Greenfield and Weinstein (2006), which are available at the HS 3-digit level of disaggregation. Thus, we aggregate these elasticities at the NACE 4-digit level of disaggregation, by taking the median value across all corresponding HS 3-digit product. Before estimating equation (5), as usual, we drop varieties with unit value that falls below the 5th and above the 95th percentile.

Table A.1 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	1,138,022			

Notes: The top panel reports estimation results of running equation (2) separately for each of the NACE 4-digit food industries in our sample. The bottom panel reports statistics that refer to the entire sample. Sargan test has been computed in order to test whether the instruments are uncorrelated with the error term.

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Table 1: Numbers of products and mean tariffs for the food sectors considered

NACE 4	Short description	#CN8	Mean Tariff
(1)	(2)	(3)	(4)
1511	Production and preserving of meat	142	0.26
1512	Production and preserving of poultry meat	196	0.15
1513	Production of meat and poultry meat products	108	0.18
1520	Production and preserving of fish and fish products	401	0.12
1530	Production and preserving of fruit and vegetables	495	0.18
1540	Manifacture of vegetables and animal oils and fats	144	0.10
1550	Manifacture of diary products	204	0.39
1560	Manifacture of grain mill products, starches and starch products	178	0.26
1580	Sugar and cocoa	60	0.17
1581	Manifacture of bread; manifacture of fresh pastry goods and cakes	2	0.25
1582	Manifacture of rusked and biscuits	29	0.18
1585	Manifacture of maccaroni, noodles and couscous	11	0.18
1586	Processing of tea and coffee	22	0.12
1587	Manifacture of condiments and seasoning	11	0.09
1588	Manifacture of omogenized food preparaison and dietetic food	7	0.19
1589	Manifacture of other food products n.e.c.	37	0.12
1590	Production of ethyl alcohol, cider, malt and other non-distilled fermented beverages	18	0.20
1591	Manifacture of distilled potable alcoholic beverages	67	0.11
1593	Manifacture of wine	99	0.10
1596	Manifacture of beer	4	0.11
1598	Production of mineral water and soft drinks	11	0.09

Notes: Table 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 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. Column 4 reports data on the mean import tariff (1995-2007) in the exporting countries.

Table 2: Product quality and countries' factor endowments

	Ln Quality$_{cht}$			
	(1)	(2)	(3)	(4)
Ln TFP	0.270***			
	(0.0854)			
Ln labour productivity		0.134***		
		(0.0436)		
Ln capital labour ratio			0.105**	
			(0.0516)	
Ln per capita GDP				0.0887***
				(0.0241)
Country-Year fixed effects	YES	YES	YES	YES
Importer-Product-Year fixed effects	YES	YES	YES	YES
No. of obs.	536,519	554,785	617,271	1,016,582
R-squared	0.90	0.89	0.89	0.84

Notes: Table shows results of regressing the estimated quality on (log) total factor productivity, (log) value added per employee, (log) capital-labor ratios and (log) per capita GDP. All regressions include country-year and importer country-product-year fixed effects. Standard errors are clustered by exporting country. Significance levels: * 0.10 **0.05 *** 0.01.

Table 3: Quality, distance to the frontier and competition: baseline results

Dependent variable: Δ Quality	(1) ALL	(2) OECD	(3) NON OECD
Lagged distance to the frontier (*t* - *5*)	-0.831***	-0.881***	-0.551***
	(0.0956)	(0.0357)	(0.0621)
Lagged tariffs (*t* - *5*)	0.217***	0.264***	0.129
	(0.0776)	(0.0913)	(0.126)
Lagged tariffs * distance to the frontier (*t* - *5*)	-0.463**	-0.384***	-0.607***
	(0.184)	(0.135)	(0.234)
Country-Year fixed effects	YES	YES	
Importer-Product-Year fixed effects	YES	YES	
No. of obs.	239,332	239,332	
R-squared	0.54	0.54	

Notes: All regressions include importer country-product (CN-8)-year 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 levels: * 0.10 ** 0.05 *** 0.01.

Table 4: FDI sector targeting, PTAs and quality upgrading

Dependent variable: Δ Quality	(1) FDI Sector target	(2) No FDI Sector target	(3) PTAs	(4) no-PTAs
Lagged distance to the frontier (*t* - *5*)	-0.856***	-0.785***	-0.756***	-0.826***
	(0.0826)	(0.219)	(0.110)	(0.101)
Lagged tariffs (*t* - *5*)	0.385***	0.0612	0.160	0.223**
	(0.0991)	(0.0740)	(0.0978)	(0.0916)
Lagged tariffs * distance to the frontier (*t* - *5*)	-1.586***	-0.731**	-0.130	-0.513**
	(0.160)	(0.321)	(0.282)	(0.220)
Country-Year fixed effects	YES		YES	
Importer-Product-Year fixed effects	YES		YES	
No. of obs.	70,386		239,332	
R-squared	0.67		0.54	

Notes: All regressions include importer country-product (CN-8)-year 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 levels: * 0.10 ** 0.05 *** 0.01.

Table 5: Robustness checks

Dependent variable: Δ Quality	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Exclude D=1	Frontier Defined After Dropping Top 2 Qualities	Change in quality percentile	Quality Khandelwal, Schott and Wei (2013)	Unit Values	Import penetration	Controlling for Standards
Lagged distance to the frontier (*t - 5*)	-1.323***	-1.742***	-3.270***	-1.135***	-0.710***	-1.021***	-0.625***
	(0.0693)	(0.0701)	(0.283)	(0.0127)	(0.0237)	(0.0336)	(0.0556)
Lagged tariffs (*t - 5*)	0.241***	0.208***	0.807***	0.147***	0.106	-0.0686***	0.202***
	(0.0516)	(0.0450)	(0.264)	(0.0369)	(0.0660)	(0.0149)	(0.0750)
Lagged tariffs * distance to the frontier (*t - 5*)	-0.528***	-0.608***	-2.202***	-0.314***	-0.149**	0.115**	-0.547***
	(0.135)	(0.147)	(0.518)	(0.0645)	(0.0726)	(0.0423)	(0.145)
Lagged ln standard (*t - 5*)							0.256**
							(0.116)
Lagged ln standard * distance to the frontier (*t - 5*)							-0.0461***
							(0.0158)
Exporter-Year fixed effects	YES	YES	YES	YES	YES	YES	YES
Importer-Product-Year fixed effects	YES	YES	YES	YES	YES	YES	NO
Imported-Product fixed effects	NO	NO	NO	NO	NO	NO	YES
No. of obs.	209,540	179,008	239,332	197,203	144,389	218,900	239,332
R-squared	0.57	0.60	0.53	0.55	0.54	0.62	0.24

Notes: All regressions, but the one in column 7, include importer country-product (CN8) and exporter country-year fixed effects. The regression in column 7 uses importer country-product and 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 levels: * 0.10 ** 0.05 *** 0.01

Project information

Title:	International comparisons of product supply chains in the agri-food sectors: determinants of their competitiveness and performance on EU and international markets (COMPETE)
Funding:	Collaborative research project (small or medium-scale focused research project), FP-7-KBBE.2012.1.4-09, total EU contribution is 2,422,725 €
Duration:	01/10/2013-30/09/2015 (36 months)
Objective:	The objective of the COMPETE project is to gain a more comprehensive view on the different elements which contribute to the competitiveness of the European agri-food supply chain in order to provide better targeted and evidence based policies on the EU as well as on the domestic level. The project investigates selected determinants of competitiveness like policy interventions and the business environment, productivity in agriculture and food processing, the functioning of domestic and international markets, the choice of governance structures, and innovative activities in food processing. The research results will enable a congruent, coherent and consistent set of policy recommendations aiming at improving competitiveness of European product supply chain.
Coordinator:	IAMO, Germany, Prof. Heinrich Hockmann
Consortium:	16 Partners from 10 European countries. COMPETE brings together academics, trade bodies, NGOs, agricultural co-operative, industry representative advisory services. In addition, the project is supported by the group of societal actors, incorporating farmer, food processing and consumer associations, providing in-depth knowledge on the agri-food sector and speeding up the achievement of the project goals.
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COMPETE
International comparison of product supply chains in the agro-food sector

SEVENTH FRAMEWORK PROGRAMME

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