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Three essays on the role of product quality in international trade

Francesco Guerra

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Francesco GUERRA

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Contents

Acknowledgments	v
Contents	vi
General Introduction	1
I Product quality and export volatility in international trade: an empirical assessment	13
1 Introduction	13
2 Empirical model and data	17
2.1 Empirical strategy	17
2.2 Data	18
2.3 Measure of export volatility	19
3 Quality estimation	20
3.1 Demand model	21
3.2 Identification and the instrumental variable	22
3.3 Quality estimation results	24
4 Results	26
4.1 Baseline model	26
4.2 Role of income fluctuations	28
4.3 Robustness	32
5 Conclusions	33
II Export quality and wage premia	41
1 Introduction	41
2 Theory	44
2.1 Demand	45
2.2 Technology	46
2.3 Relationship between wages and average export quality	47
3 Data and variables	48
3.1 Data	48
3.2 Variables of interest	49
4 Empirical analysis and results	55
4.1 Empirical model	55

4.2	Instrumental analysis	57
4.3	Additional results	60
5	Robustness	62
5.1	Alternative instruments	62
5.2	Alternative measures of quality	64
5.3	Excluded countries	66
6	Conclusion	67
III How taste proximity affects consumer quality valuation of imported varieties:		
Evidence from the French agri-food sector		73
1	Introduction	73
2	Theoretical framework	77
2.1	Setup	77
2.2	Implications for the price of varieties	78
2.3	Export prices and firm revenues	80
3	Data	81
3.1	Data on trade	81
3.2	Data on restaurants	82
4	Estimation of taste proximity	84
5	Empirical analysis	87
5.1	Empirical model	87
5.2	Additional controls	93
5.3	Robustness	95
6	Conclusion	96
General Conclusion		101
List of Figures		104
List of Tables		105

General Introduction

Product quality in trade theory

This thesis aims at contributing to the understanding of the role played by product quality in international trade. A vast literature has developed models to formalize the role of quality as a key determinant of trade patterns. The importance of product quality in determining trade dynamics has been first outlined by Linder (1961) with the well-known Linder hypothesis. In this seminal work, Linder highlights the importance of domestic demand conditions, suggesting that countries export and import products for which they have large domestic markets. The Linder's theory is based on the assumption that firms produce products to satisfy the domestic demand and realize sufficient economies of scale to be competitive in the export market. Therefore, trade between countries occurs in products for which there is a significant demand in the exporting country as well as in the destination market. As a result, international trade takes place mainly between countries that share similar consumer tastes and demand patterns. For this reason, the Linder hypothesis is also referred to as the theory of overlapping demands. The link between this hypothesis and the importance of product quality in international trade is that countries characterized by similar demands tend to consume products of the same quality. Using the between-countries similarity of per-capita income as a proxy for similarity of consumer demand, the hypothesis postulates that countries with similar income levels trade more between each other because they produce and consume products of the same quality. The theory presented by Linder was in contrast with the predictions of supply-based theories popular at the time, the Heckscher-Ohlin theory and the Ricardian model. While the latter models suggest that less similar countries are likely to trade more because of differences in comparative advantages and factor endowments, the empirical evidence at the time tended to show the contrary.¹

The apparent inability of supply-based theories to explain trade between similar countries has led to a new generation of theoretical models that propose alternative approaches for the specification of the demand side and mainly rely on imperfect competition with differentiated products. In this context, a number of studies have developed theoretical

1. The study of Leontief (1953) examines the import and export data from the United States in 1947 and observes that US exports are relatively more labor-intensive, while US imports are relatively more capital-intensive.

models to formalize the role of quality in explaining the coexistence of intra- and inter-industry trade flows. The major contribution in this strand of literature is that by the model of North-South trade of Flam and Helpman (1987). The model is based on vertical product differentiation where the emergence of quality depends on the level of technical progress, and includes a quality-based product cycle according to which new high-quality products appear and prior low-quality products vanish. The model predicts that technical progress causes the North to shift production to new high-quality products, dismissing the low-quality ones, production of which is taken up by the South. Other examples include the theoretical model proposed by Falvey and Kierzkowski (1987), based on constant-returns-to-scale technologies and a demand for vertically differentiated products that depends on income distribution. Stokey (1991) extends the model of Flam and Helpman (1987) and analyzes the effects of changes in population size and human capital on the resulting quality. Murphy and Shleifer (1997) develops a Ricardian model where countries rich in human capital produce high-quality products but also demand high-quality goods because human capital makes them wealthier. In the spirit of Linder, all of these models assume that high-income countries have a comparative advantage in the production of high-quality products and consume such products in larger proportions than do low-income countries.²

With the seminal work of Melitz (2003), the literature on international trade has shifted the focus to firm heterogeneity. Following the model of the cited study, new trade theories emphasize the differences in firms' productivity and competitiveness to explain the new empirical findings. In the above seminal paper, a firm's productivity is defined to be the amount of input required to produce one unit of output. The capability of firms to reduce their production costs due to improvements in productivity represents the main determinant of firms' competitiveness. Nonetheless, extended versions of the Melitz framework that include costly quality on the production side and a propensity to pay for quality on the demand side suggest that the relationship between prices and sales is not at all straightforward. Verhoogen (2008) develops a theoretical framework where consumers' willingness to pay for product quality across countries depends on their income and, on the supply side, production of higher-quality products requires hiring high-wage qualified employees. Kugler and Verhoogen (2012) propose an extension of the Melitz model where firm efficiency and input quality are complementary in generating output. The researchers' model predicts that highly efficient firms endogenously choose to produce high-quality products and have a higher probability of exporting. Hallak and Sivadasan (2013) introduce a model with two dimensions of firm heterogeneity, namely, process productivity, which is defined as the firm's capability of producing output using few inputs, and product productivity, which represents the ability to develop high-quality products at low cost. In this framework, firms exporting higher-quality products charge higher prices and pay higher input prices.

2. Partially related to these studies, a branch of literature on endogenous growth has emphasized the role of industrial innovations that improve product quality as a relevant source of economic growth (Aghion and Howitt, 1992; Grossman and Helpman, 1991; Segerstrom et al., 1990).

Empirical evidence

This section intends to present the recent findings concerning the relevance of product quality in explaining trade dynamics and the related implications for exporting firms. The literature review presented herein is not intended to be exhaustive of all topics in relating product quality and trade, but rather is meant to introduce the state of research to which this thesis contributes.³ In the first part of this section, we introduce the literature on product quality as a determinant of the direction of trade. Then, we present the recent studies on the implications of exporting high-quality products for firms. Finally, we conclude with the discussion of various types of measures of quality used in the literature.

Quality and the direction of trade

A substantial number of empirical studies point to product quality as a determinant of the global patterns of bilateral trade. The literature has outlined two main mechanisms through which product quality influences the direction of trade.

The first corresponds to the postulate of the Linder hypothesis that states that rich countries tend to export and import high-quality products. A part of this literature focuses on the supply-side relationship between per-capita income and product quality and points to the within-product specialization along quality ranges as a determinant of bilateral trade dynamics. Schott (2004) exploits product-level US import data to show that export unit values increase systematically with the exporter's per-capita income and relative endowments of capital and skilled labor. The author's findings suggest that rich countries use their endowment advantage to produce higher-quality product varieties (hereafter, "varieties") than those of such countries' competitors from low-wage countries. Hummels and Klenow (2005) use data on quantities, unit values and proxies to control for extensive margins to extract information about quality differences between exported varieties on a large panel of countries and products. The researchers' results show that within product categories, high-wage countries export high-quality products. Supporting the idea that within-product differentiation plays a major role in explaining international trade patterns, the studies of Schott (2008) and Rodrik (2006) analyze the degree of similarity in product categories exported by the US and China and note that both countries export the same types of products even though China is a low-income country abundant in unskilled labor. In addition, Schott (2008) observes that the unit values of exported products from China are considerably lower than those of the same products exported from the US. The scholars' findings reject a factor-proportions specialization across products but are consistent with a within-product specialization along quality ranges. Considering the demand-side

3. In particular, we do not discuss a large and growing body of literature on the effect of tariff reduction and competition from low-wage countries on the choice of quality produced by firms (Amiti and Khandelwal, 2013; Bas and Strauss-Kahn, 2015; Curzi et al., 2015; Fan et al., 2015; Khandelwal, 2010; Martin and Mejean, 2014).

relationship between the importer's per-capita income and product quality, Hallak (2006) identifies cross-country differences in product quality from cross-country variation in export unit values and observes that richer countries have greater demand for high-quality varieties. The study of Hallak and Schott (2011) introduces a novel measure of quality at the country-product level and notes that quality and per-capita GDP are strongly correlated in the cross-section of countries. More recent studies performed at the firm level provide additional evidence of a positive relationship between high-quality exported products and the per-capita income of destinations. Using labels and PDOs⁴ as proxies for quality, Curzi and Olper (2012) investigate the export behavior of Italian food firms and note that export intensity increases with the per-capita income of foreign destinations. Manova and Zhang (2012) focus on variations between exporting firms in China and observe that firms that charge higher export prices export more to high-income countries. Flach (2016) uses detailed data on product and process innovation of Brazilian exporters and notes that firms adapt product quality according to destination country characteristics.

The second mechanism relating product quality to trade dynamics was first described by Alchian and Allen (1964) and is known as the Alchian-Allen effect. In the cited study, the authors observe that the portion of oranges and apples shipped from California to New York is of high quality rather than low. To explain this finding, they argue that per-unit trade costs cause the prices of cheaper low-quality varieties to increase more in relative terms than do the prices of more expensive high-quality ones. Therefore, the prices of high-quality products relative to those of low-quality ones are lower at more distant markets, where per-unit trade costs are higher. In other words, the Alchian-Allen effect stipulates that because of per-unit trade costs, the relative price of high-quality products is lower in more distant destinations.⁵ The first empirical analysis to provide a solid evidence of the Alchian-Allen effect was that by Hummels and Skiba (2004), which examines the effect on the relative prices and demand of both per-unit and ad-valorem tariffs. The subsequent studies, performed at the firm level, demonstrate further empirical evidence of a positive correlation between export quality and distance to the destination. Using Portuguese firm-level data on exports by product and destination market, Bastos and Silva (2010) observe that FOB⁶ unit values increase systematically with distance, and tend to be higher in shipments to high-income nations. Using data on French exports, Martin and Mayneris (2015) and Martin (2012) note that more distant countries receive exports of high-end varieties and firms that charge higher FOB prices. The studies of Kneller and Yu (2016) and Baldwin and Harrigan (2011) observe that the average unit value of exports is not only positively related

4. A protected designation of origin (PDO) is a label that identifies food products that are produced, processed and prepared in a specific geographical area.

5. Few studies examined the original Alchian-Allen effect in theoretical models showing that the predictions of the conjecture hold under plausible conditions of the elasticity of substitution between varieties and price elasticity of transportation costs (Bauman, 2004; Borchering and Silberberg, 1978; Hummels and Skiba, 2004; Liu, 2011).

6. Free on Board, intended to be stated as not including trade costs.

to distance but also influenced by the market size of the importer. Finally, the recent analyses of Crozet et al. (2012) and Emlinger and Lamani (2020) validate the Alchian-Allen effect empirically, considering the export of wine and Cognac from France using a direct measure of quality.

Implications of exporting quality for firms

The models of Hallak and Sivadasan (2013), Kugler and Verhoogen (2012), and Verhoogen (2008) presented in the previous section predict that firms producing high-quality products are more efficient, have a higher probability of exporting, pay higher wages and purchase more expensive inputs.

A number of studies observe that the export status of firms depends on the quality of products produced. Using plant-level data of Colombian firms, Brooks (2006) shows that low product quality is the reason only few Colombian plants export to the United States. Similarly, studies performed on US manufacturing plants identify product quality as a major determinant of firms' selection into exporting (Gervais, 2015; Iacovone and Smarzynska Javorcik, 2012). A partial exception to these findings is represented by the study of Jäkel and Sørensen (2020) considering Danish manufacturing firms. In that study, the authors estimate product quality as a demand residual on the domestic market and observe that exported varieties are sold at lower prices but are of higher quality than non-exported varieties. The study's findings suggest that the relationship between prices and quality is not always straightforward and that prices and quality determine jointly the export status of a firm.

There is a small but growing body of literature that analyzes product quality as a determinant of export performance across exporting firms. The studies of Manova and Zhang (2012) and Crozet et al. (2012) observe that high-quality products are characterized by larger revenues in each destination and a greater geographic diversification of exports. Using detailed data on firms' employment, other studies note that firms exporting to high-income countries are more reliant on skilled labor (Brambilla et al., 2012), pay higher wages within working categories (Verhoogen, 2008) and purchase higher-quality inputs (Bastos et al., 2018). Finally, some studies focus on the role played by product quality in multiproduct firms and observe that in differentiated-good sectors, firms have an incentive to invest in quality of products they produce more efficiently (Eckel et al., 2015; Manova and Yu, 2017).

Measuring quality

One of the greatest impediments faced by the research on product quality and international trade is the lack of data on product quality. As quality is unobservable, several studies overcome this obstacle using prices or unit values as indirect measures of quality (Bastos

and Silva, 2010; Fasil and Borota, 2013; Hallak, 2006; Johnson, 2012; Martin, 2012; Schott, 2004). However, the problem with the use of prices is that while the difference in price between two varieties may be due to a difference in quality, the cheaper variety might also sell at a discount because the exporter incurs lower production costs, or because of an undervalued exchange rate or pricing-to-market strategies.

A few studies examining specific cases, including a restricted range of products, have had access to direct information on product quality. The analyses by Baller et al. (2015) and Crozet et al. (2012) of champagne in France and studies by Chen and Juvenal (2016, 2018, 2020) of wine in Argentina use expert ratings as a direct measure of quality. Similarly, Emlinger and Lamani (2020) rely on the amount of time the eau-de-vie used to spend in oak for French Cognac, while Atkin et al. (2017) use direct artisan assessments of quality of Egyptian rugs. As an alternative, some studies rely on aspects related to products or firms as proxies for quality. Several recent papers take advantage of direct information at the firm-product level, such as detailed characteristics of cars (Goldberg and Verboven, 2001), contamination of dairy products (Bai et al., 2019), sweetness of watermelons (Bai, 2018), the size and defect rate of coffee beans (Macchiavello and Miquel-Florensa, 2019) or the composition of primary materials used for apparel products (Medina, 2018). Others use a range of different proxies at the firm level, such as the R&D and advertising intensity (Kugler and Verhoogen, 2012; Sutton, 2001), labels and PDOs in the case of agri-food sector (Curzi et al., 2015), firms' certification of quality management (Hallak and Sivadasan, 2013; Verhoogen, 2008), detailed data on product and process innovation (Flach, 2016) or data on input prices (Bastos et al., 2018).

To overcome the issue of the unavailability of data on quality for a wide range of countries and products, alternative methods of quality estimation using data on trade volume and unit values have been proposed. A number of advanced approaches based on different theoretical frameworks have arisen in the last decade. The more popular and widely used are the methodologies proposed by Khandelwal (2010) and Khandelwal et al. (2013) that estimate quality as a residual of a demand equation and can be implemented at the country-product level as well as at the firm-product level. Since these methods rely on the demand side to identify quality, the resulting estimation reflects any tangible or intangible attribute that increases consumers' valuation of a product. In Khandelwal (2010), quality is obtained as a residual of a nested logit demand function derived from a discrete choice model. The estimation relies on the hypothesis that, conditional on price, the larger a variety's market share is, the higher its corresponding quality. Conceptually similarly, Khandelwal et al. (2013) estimate quality from a demand function based on a consumer utility modeled as CES. Compared to the methodology proposed by Khandelwal (2010) based on a nested logit approach, this method implies the same elasticity of substitution

between varieties within an industry in each destination.⁷

In addition to these methods, other approaches have been developed in the preceding decade. Piveteau and Smagghue (2019) propose a new instrumental variable strategy to estimate product quality at the firm level on the demand side. The proposed instrument exploits information on firms' import shares by country and real exchange rates to obtain a cost shifter uncorrelated with product quality. Hallak and Schott (2011) introduce a different strategy to decompose country-level export unit values into quality and quality-adjusted components. Conditionally on export prices, countries with trade surpluses are inferred to offer higher-quality products than do countries running trade deficits. Feenstra and Romalis (2014) present a theoretical framework that allows obtaining a measure of product-level quality from the parameters estimated in a gravity-like equation. Compared to the methodologies mentioned above that estimate quality from trade unit values, relying on a demand-side structural framework, Feenstra and Romalis (2014) add the supply side modeled as an extended monopolistic competition framework where firms simultaneously choose prices and quality. Although the methodologies proposed by Feenstra and Romalis (2014) and Hallak and Schott (2011) are effective and quite elaborate from the theoretical point of view, they have found limited applications, as they require data on the value of trade exchanges expressed in CIF and FOB terms.⁸

Presentation of the chapters

This dissertation consists of three chapters that represent a contribution to the research on the role of product quality in international trade. These chapters are based on recent theoretical and empirical literature in international economics and each of them makes a distinct contribution to the current state of research.

Chapter 1

The first chapter of my thesis is titled "Product quality and export volatility in international trade: an empirical assessment". In this chapter, we present an empirical analysis of the relationship between the volatility of bilateral trade flows and the quality of products exported. Our research question is based on the hypothesis that consumer preferences are non-homothetic, and therefore the composition of demand depends on the level of income. Under the assumption of non-homothetic preferences, income shocks have two repercussions on consumer consumption patterns, namely, a direct income effect caused by a change in the overall purchasing power, and a change in consumer propensity to spend on quality. Thus, income shocks are likely to affect differently the demand for products

7. A more detailed explanation of these methods is provided in the first chapter of this thesis.

8. Cost, insurance and freight (CIF) indicate trade values including trade costs. Free on Board (FOB) indicates trade values not including trade costs.

of different quality. In view of this mechanism, the objective of this research is to analyze whether the demand for high-quality imported varieties is more responsive to income variability over time. To this end, we propose an empirical analysis to examine whether the volatility of bilateral exports depends on the quality of exported products.

The analysis is performed on the exported products of the manufacturing sector in a set of 145 countries. Export volatility is measured on bilateral trade flows as the standard deviation around a linear trend. As we do not have direct information on product quality, we follow the methodology proposed by Khandelwal (2010) and infer quality from the residual of a demand function. As the price is endogenous in the demand equation, we use an instrumental variable strategy to estimate the parameters of that function. We rely on the insights of the Hausman-type instruments and instrument prices with the weighted mean of the variety's price in the other destinations. Such an estimate of quality corresponds to all non-price determinants that explain the market share of a variety conditional on price.

The results of the empirical analysis indicate that exports of high-quality products are characterized by a higher volatility. In addition, the results indicate that export volatility increases with quality, and such an increase is further magnified for the variability of the income per capita in the destination markets. The findings of this study suggest that high-quality products are more income-elastic and the demand for high-quality products is more responsive to income shocks. Consequently, the variability of income of destination countries causes the demand for high-quality exported varieties to be more volatile than the demand for low-quality ones.

The results obtained in this study are consistent with the pattern described in several empirical studies that observe a more severe contraction of exports of high-quality products as a consequence of a negative income shock (Berthou and Emlinger, 2011; Chen and Juvenal, 2018; Esposito and Vicarelli, 2011). While these studies focus on a singular shock, we analyze export volatility over a time span of 11 years and regard income variability of the importing country as representative of the intensity of income shocks over time. Our findings also contribute to the literature on international trade that emphasizes product quality as a factor that allows firms to obtain access to a larger number of markets and to increase export revenues (Hallak and Sivadasan, 2013; Manova and Zhang, 2012; Martin and Mayneris, 2015). While several studies highlight the benefits of exporting high-quality products, we point out a possible drawback, namely, a major exposure of exports to demand fluctuations induced by income shocks.

Chapter 2

The second chapter is titled "Export quality and wage premia" and intends to shed light on the importance of quality of exports on wages offered at the industry level. This

chapter is related to a growing body of research that suggests a positive association between the quality of the products exported and the level of wages paid, in a dynamic identified as the quality provision mechanism by Brambilla and Porto (2016). A number of studies argue that the rationale behind this effect is that production of high-quality products requires the use of high-wage skilled labor (Brambilla et al., 2012; Verhoogen, 2008). The objective of this chapter is to provide worldwide evidence of the quality provision mechanism. To do so, we examine the effect of a quality upgrade of exports on the change in the average wages offered at the industry level on cross-country panel data.

In this chapter, we propose a partial equilibrium model that describes the effect of an upgrade of quality of exported products on changes of the industry wage premium. The underlying mechanism implies that product quality depends on the skills of employees, while the ability of a firm to attract higher-skill employees is determined by the wages it offers. An upgrade of exported products' quality requires an increase of average wages to attract high-skill labor. In compliance with our theoretical framework, we set up an empirical model to estimate the effect of an upgrade of exported products' quality on the change of a wage premium measured at the country-industry level. The study is performed on cross-country panel data. As in the first chapter, the quality of traded products is estimated as a demand residual, following the methodology proposed by Khandelwal (2010) and aggregated at the exporter-industry level. To establish a direct causal link between an upgrade of exports' quality and the change in the level of wages, we use an instrumental variable strategy. Quality is instrumented with the change in the demand for quality in the set of destinations where the country already exports. The proposed instrument is based on the assumption that high-income countries export high-quality products and that an increase of imports from rich countries corresponds to an increase in the demand for quality.

The results of our empirical analysis indicate that an upgrade of exported products' quality relative to a specific industry entails an increase of the industry wage premium. Our findings imply that industries that improve the quality of exported products change their workforce composition towards higher-wage skilled labor. The changes in the relative demand for skilled labor due to an upgrade of product quality lead to different implications. A rise in demand for skilled labor in developing countries could have beneficial effects on the countries' economic development. On the other hand, if the quality upgrade applies to a limited number of industries within a country, the documented effect could increase the inter-industry wage inequality.

The main contribution of this study is to generalize the findings of Verhoogen (2008) and Brambilla et al. (2012), who observe a positive association between export quality and the increase in wages offered by firms in the cases of Mexico and Argentina. This study is also related to the analysis of Brambilla and Porto (2016) that regards consumers in rich

countries as having a higher valuation of quality and explores the effect of the exposure of exports to high-income countries on industry wages. In contrast to these studies that use unit values as an indirect measure of product quality, we demonstrate evidence of the quality provision mechanism on a large panel of countries using a direct measure of product quality.

Chapter 3

The third chapter is titled “How taste proximity affects consumer quality valuation of imported varieties: evidence from the French agri-food sector”. This chapter focuses on the differences in consumer taste between countries and their impact on the perception of product quality in the case of food products. Consumer taste for food products can differ substantially between countries and represent an important element of trade promotion. However, few studies indicate that divergences in consumer taste may also generate differences in perceived quality. The objective of this chapter is to investigate how cross-country taste proximity for food products affects consumer valuation of quality of imported varieties in destination countries.

In this chapter, we present a theoretical framework that illustrates how taste proximity impacts differently the export revenues of vertically differentiated products. This framework is based on fewer assumptions about the underlying production technology and demand structure. The crucial hypothesis of our framework is that consumer propensity to spend on quality varies according to the origin of imported varieties and is positively related to taste proximity between trading countries. The results of our theoretical framework indicate that the relationship between export prices and export revenues in each destination market is determined by product-specific characteristics, which determine the correlation between a variety’s price and quality, and by taste proximity, which determines consumer propensity to spend on quality. Assuming a positive correlation between quality and export prices, consumer propensity to pay for quality increases with taste proximity and affects positively the sales of varieties exported at higher prices. Based on firm-product customs data related to French exports, we propose an empirical analysis of how differences in consumer taste across destination markets affect export revenues with respect to the price at which a variety is exported. To identify taste proximity, we introduce a novel methodology based on information collected from the online travel company TripAdvisor. Using data on the type of cuisine offered in restaurants, we derive a measure of cuisine popularity for each country and an index of similarity between the distributions of restaurants advertising a cuisine for each pair of countries. We then obtain a measure of taste proximity using a control function approach where the two measures – cuisine popularity and an index of similarity – are embedded in a gravity equation. Conceptually, the measure of taste proximity obtained corresponds to the unobserved affinity in taste for food products between consumers that

promotes trade.

The results of our empirical analysis indicate that because the difference in taste between France and other countries negatively affects the consumer propensity to pay for quality, firms exporting at lower prices have, in general, larger export revenues. Nonetheless, we observe that firms that export high-quality products exhibit relatively larger export revenues in countries with a strong taste proximity. Our findings indicate that quality is more strongly appreciated and consumers are more willing to spend on high-quality products in countries with taste similar to that of French consumers.

This chapter offers two contributions. First, we propose a novel methodology based on a distinctive database to derive estimates of taste proximity for food products between countries. The information on restaurants' cuisine from the TripAdvisor website has already been used in a recent study of Waldfogel (2019) to analyze the main determinants of cuisine distribution across countries. Nonetheless, we use data on cuisine distribution innovatively to derive a measure of taste proximity. We use a control function approach and derive a measure of taste proximity between two countries that captures the average consumer's appreciation for food products from an origin country and is common to all products and firms. Second, we provide evidence of the role that consumer taste plays in export dynamics in the case of the food sector. Several studies have explored cultural proximity as an element that influences the preferences of consumers and can help promote trade (Disdier and Mayer, 2007; Disdier et al., 2010; Guiso et al., 2009). In our analysis, we go beyond the consideration of taste proximity as a factor that promotes trade between countries and analyze its impact on exports according to product quality.

Chapter I

Product quality and export volatility in international trade: an empirical assessment ¹

(Chapter co-authored with Stéphane Turolla and Carl Gagné)

1 Introduction

A major issue in international trade is to identify the determinants of firms' and countries' export drivers. Within this context, several studies focus on the role played by product quality as a determinant of the *level* of export revenues. Recent empirical analyses observe that firms that export high-quality products enter more markets and earn larger revenues in each destination (Crozet et al., 2012; Manova and Zhang, 2012; Manova and Yu, 2017). The present study focuses on a specific aspect of export performance and investigates the relationship between export *volatility* and the quality of products traded.

Our analysis relies on the hypothesis that consumer preferences are non-homothetic, and therefore the demand composition depends on the level of income. Under the assumption of non-homothetic preferences, a negative income shock has two repercussions on consumer consumption patterns, namely, a direct income effect caused by a decline in the overall purchasing power that reduces the demand for all products, and a change in consumer propensity to spend on quality, which amplifies the negative effect on the demand for high-quality products. On the other hand, a positive income shock increases both consumer purchasing power and consumer propensity to spend on quality. Consequently, income shocks are likely to affect differently the demand for products according to their quality. With preferences assumed to be non-homothetic, variations of aggregate income produce more pronounced variations in the aggregate demand for high-quality products. This implies that such products are more income-elastic and characterized by a higher demand

1. A version of this chapter was presented at JRSS 2018 in Nantes (FR), at the ETSG 2019 in Bern (CH) and at the 10th TSE conference on "Industrial Organization and the Food Industry" 2019 in Toulouse (FR).

variability, especially in markets with high income variability. Since the variability of demand in foreign markets is a major source of export volatility, the objective of our study is to examine the demand-driven mechanism described above through the analysis of the relationship between product quality and export volatility.

Recent studies emphasize that export volatility negatively impacts firms' employment and growth (Bricongne and Gigout, 2018) and reduces the incentives to invest in productivity improvements (Juvenal and Santos Monteiro, 2013).² Although a number of studies outline the negative consequences of export volatility, the literature on trade that explores the potential implications of product quality on the exposure to demand variability remains scarce. To our knowledge, this is the first study to analyze the volatility of exports with respect to the quality of products exported.

We analyze bilateral trade at the country-product level for more than 100 importing countries and 5 000 products over the period 1997–2008. A variety is defined the exporter-product combination as in Armington (1969). Since we do not have information about the quality of exported products, we infer quality from the residual of a demand function as in Khandelwal (2010). The estimation relies on the hypothesis that conditional on price, the greater the sales of a variety are, the higher its corresponding quality. The major challenge related to the estimation of the demand system is the need to instrument prices, as they are correlated with (unobserved) quality. We exploit the large extent of the database at our disposal and instrument prices with the weighted mean of the variety's price in the other destinations. Quality estimated through this methodology corresponds to the mean of consumers' valuation of product attributes, also defined as quality perceived by consumers and is variety-destination-specific. Overall, we consider 5 803 regressions and estimate quality for a total of 16 245 230 observations. Once the measure of quality has been obtained, we analyze the relationship between the variety's quality and the volatility of its bilateral exports through a fixed-effects panel regression.

Our results show that, overall, the export revenues of high-quality varieties are larger in each destination, and such varieties are also characterized by greater export volatility. The estimated coefficients indicate that the predicted value of exports of a variety that upgrades its quality from the first to the second quartile of the quality distribution increases by 26%, while the volatility of this variety increases by 21%. In addition, we observe that the volatility of exports increases with quality, and such an increase is further magnified by higher variability of income in the destination country. Our findings indicate that export volatility depends on the quality of products exported and that, as income variability affects consumer propensity to spend on quality, the export of high-quality products is

2. Starting from Hirsch and Lev (1971), several studies analyze the geographic diversification of exports as an effective strategy to reduce market-specific idiosyncratic shocks (Vannoorenberghe et al., 2016; Wagner, 2014).

more exposed to the volatility of demand. Our results are robust to the use of volatility calculated in terms of values and volumes, as well as to the use of the alternative measure of quality obtained as in Khandelwal et al. (2013). The findings expressed in this chapter have a major implication. Consistently with the literature, we observe a positive correlation between product quality and export revenues. Nonetheless, while several studies highlight the benefits of exporting high-quality products, we point out to a possible drawback, namely, a major exposure of exports to demand fluctuations induced by income shocks.

Our paper takes its cue from the study of Chen and Juvenal (2018) that analyses the export of Argentinian wines during the great trade collapse of 2008. In the above study, researchers use expert wine ratings as a measure of quality and observe not only a global contraction of the demand for Argentinian wine in general but also a more than proportionate reduction of the demand for Argentinian high-quality wines relative to that for low-quality ones. The study's findings suggest that the 2008 trade crisis not only affected the overall demand for imports but also had an impact on the consumers' consumption pattern. In the wake of the trade crisis of 2008, other studies provide indirect evidence of a more than proportionate reduction in trade of products sold at higher prices (Berthou and Emlinger, 2010; Esposito and Vicarelli, 2011). The analysis of Esposito and Vicarelli (2011) notes a shift in consumption from high to medium quality for Italian exported products worldwide, while Berthou and Emlinger (2011) observes a larger decrease of the demand for high-quality varieties exported by France. In view of Chen and Juvenal (2018), the analyses performed by Esposito and Vicarelli (2011) and Berthou and Emlinger (2010) use export unit values as proxies for quality. Overall, the findings of these studies suggest that the demand for high-quality imported products is more sensitive to income shocks. Compared to the aforementioned empirical analyses, our study does not consider a specific demand shock but investigates the relationship between export volatility and product quality over a long time span. Moreover, our analysis is performed on a large panel of data and relies on a direct measure of product quality.

Our study contributes to the literature that focuses on the determinants of export volatility. Part of this literature concentrates on firm-level strategies aimed at minimizing the exposure to demand shocks of importing countries. Vannoorenberghe (2012) notes that firms that export more tend to adjust their exports according to the specific shocks in destination countries. The study of Vannoorenberghe et al. (2016) instead observes that the diversification of a firm's export portfolio is likely to have a stabilizing effect for the overall firm's export volatility, although exporting to less-stable markets increases the risk. Other studies explore how trade openness affects firm-level output volatility (Buch et al., 2009a) or focus on the impact of idiosyncratic firm-level variations on the fluctuations at the aggregate level (Buch et al., 2009b; Di Giovanni et al., 2014; Gabaix, 2011).

The present study also contributes to the broad literature on product quality in international trade. The first insights into the role of quality as a relevant trade determinant were by Linder (1961), who emphasized the importance of domestic demand for quality goods in the delineation of trade patterns. Linder asserted that the degree of product quality reflected the country's level of income and, as a consequence, countries with similar incomes per capita had a comparative advantage in trading with each other, as they produced and consumed products of similar quality. Since Linder (1961), the role played by product quality in international trade has been studied from different angles. Major findings of the recent literature emphasize that firms exporting high-quality products have high revenue and larger worldwide sales, access a large number of destination markets, pay higher wages and are more productive and skill-intensive (Bastos et al., 2018; Crozet et al., 2012; Curzi and Olper, 2012; Hummels and Skiba, 2004; Manova and Zhang, 2012; Martin and Mayneris, 2015; Verhoogen, 2008). Within this extensive literature, our study also relates to the analyses that propose methodologies for estimating quality from data on international trade.³ Particularly popular is the methodology proposed by Khandelwal et al. (2013) that estimates quality as the residual logarithmic transformation of the demand curve based on the Dixit-Stiglitz framework. This approach, although very intuitive and straightforward, is constrained by its assumptions on cross-price elasticities and by the need for estimating the elasticity of substitution. Similarly, the studies of Hallak and Schott (2011) and Feenstra and Romalis (2014) propose other methodologies that are quite elaborate from the theoretical point of view but that have found limited application, as they require hardly available data, such as the value of trade exchanges expressed in CIF and FOB terms.

Finally, our study is related to the literature on non-homothetic preferences in trade. The assumption of non-homothetic preferences appears to be particularly useful for studying trade patterns in vertically differentiated products, as such preferences allow income level and distribution to affect the demand for imports according to product quality (Fajgelbaum et al., 2011). The studies of Fajgelbaum and Khandelwal (2016) and Fieler (2011) highlight the importance of including non-homothetic preferences in explaining the different gains from trade across consumers and predicting trade flows of products differentiated according to their income elasticity.

The rest of the study is organized as follows. Section 2 presents the empirical strategy and the data used. Section 3 explains the methodology used to infer product quality. Section 4 presents the results of the empirical model, and Section 5 concludes.

3. Direct measures of quality have been used in the case of wine by Crozet et al. (2012) and Chen and Juvenal (2016) and for Cognac by Emlinger and Lamani (2020). Other studies use a range of different proxies such as R&D and advertising intensity (Kugler and Verhoogen, 2012; Sutton, 2001), labels and PDOs for the case of the agri-food sector (Curzi et al., 2015) or firms' certification of quality management (Hallak and Sivadasan, 2013).

2 Empirical model and data

In this section, we present the empirical strategy we design to analyze the relationship between export volatility and the quality of the variety exported, the data used, and the measure of export volatility considered.

2.1 Empirical strategy

We propose a reduced-form analysis to explore the effect of product quality on export volatility. The objective of our empirical analysis is to examine whether fluctuations of the aggregate demand in destination markets induced by income shocks impact differently the exports of vertically differentiated products. The fundamental hypothesis behind our analysis is that income shocks affect consumer demand for products as well as consumer propensity to spend on quality. Under the assumption that high-quality products are more income-elastic, income shocks cause demand fluctuations to be more pronounced for high-quality products. Because of the demand-driven mechanism described, we expect the exports of high-quality products to be more volatile.

We perform the analysis at the country-product level where a variety is defined as a product h exported by country i .⁴ For each variety, the volatility is specific to a destination j and is measured as the standard deviation of bilateral trade flows, expressed as values, over the entire period under analysis. Our empirical strategy consists of regressing the volatility of exports of variety ih (where i corresponds to the exporting country, and h to the product) to country j against the quality of the variety exported, and a set of control variables as in the following:

$$\ln volatility_{ijh} = \gamma_1 \ln quality_{ijh} + \varphi_{jh} + \varphi_{ij} + \epsilon_{ijh}, \quad (\text{I.1})$$

where $volatility_{ijh}$ is the volatility of exports of variety ih to market j , and $quality_{ijh}$ is the time-invariant average quality of the variety exported. The two parameters φ_{ij} and φ_{jh} correspond to exporter-destination and destination-product fixed effects. The exporter-destination fixed effect φ_{ij} allows us to control for all bilateral elements such as geographical and cultural proximity and average trade barriers that could have an impact on trade between two countries. In addition, the destination-product fixed effect φ_{jh} controls for all factors related to the importing market, such as the average volatility of consumer income and the average quality of imported varieties for a given product. Parameter ϵ_{ijh} is the error term and includes all variety-specific factors that could affect export volatility. The coefficient of interest in our analysis is γ_1 , which determines the relationship between export volatility and a variety's quality. Given our assumptions, we expect a positive effect of quality on volatility, i.e., $\gamma_1 > 0$. Equation (I.1) models the correlation between a variety's quality

4. Varieties are defined as in Armington (1969).

and its export volatility, but states nothing about the rationale governing this relationship. To capture the effect of the demand fluctuation induced by income shocks on the volatility of vertically differentiated varieties, we augment the empirical model in Equation (I.1) with an interaction variable between a variety's quality and the time variability of income:

$$\ln volatility_{ijh} = \gamma_1 \ln quality_{ijh} + \gamma_2 \ln quality_{ijh} * SD(y_j) + \varphi_{jh} + \varphi_{ij} + \epsilon_{ijh}, \quad (I.2)$$

where $SD(y_j)$ is the time variability (the standard deviation) of consumer income in destination country j . In Equation (I.2), the sum $\gamma_1 + \gamma_2 * SD(y_j)$ determines the relationship between export volatility and a variety's quality, while coefficient γ_2 indicates whether the correlation between volatility and quality is affected by the variability of consumer income in the importing country. A positive value of γ_2 implies that the volatility of exports of high-quality products to destination j increases with consumer income variability.

2.2 Data

We perform our study on a panel of countries and products, which allows us to obtain results applicable to a wide variety of both aspects. Data on country-level trade flows is from BACI, a detailed international trade database provided by the CEPII that covers a large number of countries and approximately 5 000 products expressed in terms of the 6-digit Harmonized System (HS) level classification, revision 1996.⁵ The BACI dataset has been created by the CEPII through a process of data harmonization between import and export values, reported by the COMTRADE database. The process of harmonization performed by the CEPII takes into account the reliability of the importer and exporter declarations and allows working with more reliable data from a large panel of countries.⁶ For the purpose of the empirical analysis, we need to express the trade flows as CIF values in order to estimate a demand function relative to imported varieties. The CEPII made available to us an estimation of the ratio CIF/FOB for the data with values relying more on the FOB values reported by COMTRADE. We therefore use the CIF/FOB ratio to obtain a consistent database of trade exchanges, including trade costs. In addition to trade values, BACI also reports the quantity of exports in terms of weight. Since prices are not directly reported, we instead use unit values calculated as the ratios of values and weights of trade flows and deflated to real values using the Consumer Price Index of each destination country.⁷ Data on population and distance has been obtained from the Gravity dataset of CEPII; data on oil prices is from the Federal Reserve Bank databases,⁸ and exchange rates are from the World Bank. Data on domestic production at industry level are taken from the INDSTAT 2 dataset made available by UNIDO. Overall, this dataset covers a total of 116 different manufacturing industries defined at the 4-digit level according to

5. Data are available at http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp.

6. See Gaulier and Zignago (2010) for further details.

7. Data are from the World Bank database <https://data.worldbank.org>.

8. Source: <https://fred.stlouisfed.org>.

the International Standard Industrial Classification (ISIC) Revision 3 nomenclature. As a result, we obtain a database for trade flows among 145 countries at the HS6 product level and output at the industry level over a period from 1997 to 2008.

Data on international trade are known to be noisy; thus, we remove observations that include aberrant or too small trade values. Following Khandelwal (2010) and Smeets et al. (2014), we remove observations characterized by trade values under US\$ 7 500 and unit values that are 20 times larger or smaller than the median value for each exporter-product pair. Finally, as the objective of the paper is to analyze the volatility of trade flows over time, we remove from the analysis the observations related to varieties that are traded occasionally. Hence, for each product-exporter-importer combination, we keep only the observations for which a positive trade flow is recorded for at least 9 years over the period under analysis.

2.3 Measure of export volatility

Measuring volatility consists of calculating the deviation between the values of a variable and its reference or equilibrium value. From a statistical point of view, volatility is usually measured by the standard deviation, or sometimes a higher moment, around the reference value. There are various methodologies for calculating the reference value of a time series that range from a simple mean to different types of filters that can include cyclical and trend components.⁹ Nonetheless, filters and other complex methods perform better and are preferred when dealing with long time series. In our study, we analyze annual observations over a time range of 12 years, which is particularly short and not appropriate for the use of filters. Thus, we measure volatility as the standard deviation of detrended exports. Accordingly, the volatility of variety ih exported to country j is calculated as the standard deviation around a linear trend:

$$volatility_{ijh} = \sqrt{\sum_t (x_{ijht} - \hat{x}_{ijht})^2}, \quad (I.3)$$

where x_{ijht} represents the exports of variety ih to country j at time t , and \hat{x}_{ijht} is the predicted value obtained from a linear trend:

$$x_{ijht} = \underbrace{\delta_1 + \delta_2 t}_{\hat{x}_{ijht}} + \epsilon_{ijht}.$$

Export volatility is measured in terms of values and volumes.¹⁰ The reason for using both measures is that, conditional on volatility in terms of volume, varieties exported at higher prices have a higher volatility in terms of value than do varieties sold at lower prices. Assuming a positive correlation between price and quality, high-quality varieties might be characterized by a higher volatility in terms of value because of their higher prices. In Table 1, we regress the logarithm of volatility measured in terms of value on a set of different

9. Cariolle (2012) proposes a comprehensive review of the existing methods used for calculating volatility.

10. Table B1 in the Appendix reports the distribution of volatility measured in terms of value and volume over the whole sample.

fixed effects to distinguish how different dimensions contribute to volatility. We observe in Columns (1) and (2) that the importer and exporter fixed effects explain a small part of the observed variation. In contrast, the product dimension appears as a much more important source of variation, as shown in Column (3). Similarly, in Columns (4) and (5) we observe that the exporter-product and importer-product dimensions contribute more to explaining volatility than does the importer-exporter dimension in Column (6). The results reported in Table 1 indicate that export volatility depends mainly on product category, although specific factors related to the exported variety and the demand in the importing countries are also important.

Table 1: Sources of variations in volatility

	Explained variable: $\ln \text{volatility}(\text{value})_{ijh}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	5.568*** (0.002)	5.568*** (0.002)	5.568*** (0.002)	5.592*** (0.002)	5.586*** (0.002)	5.568*** (0.002)
FE exporter	Yes	No	No	No	No	No
FE importer	No	Yes	No	No	No	No
FE product	No	No	Yes	No	No	No
FE exporter-product	No	No	No	Yes	No	No
FE importer-product	No	No	No	No	Yes	No
FE importer-exporter	No	No	No	No	No	Yes
R-squared	0.028	0.082	0.230	0.431	0.419	0.164
Observations	768,544	768,556	768,559	735,108	751,434	767,861

3 Quality estimation

Our analysis is performed on a large database that covers a variety of manufacturing products actually traded worldwide. Information on product quality is rarely available in international trade, especially for such a large range of products. Unit values have been largely used as proxy for quality, although they also reflect other characteristics such as differences in pricing strategies and costs due to efficiency of production processes. While a product's unit value has proven to perform poorly as a proxy of quality in the case of products with a narrow scope for quality differentiation, a number of studies provide different approaches to estimate quality from data on trade.¹¹ The procedure we adopt has been grounded in the pioneering work of Berry (1994) and has been first implemented in the case of international trade by Khandelwal (2010). The procedure consists of estimating a discrete choice model of demand where imports of a variety are explained by its price and a set of control variables. The variety's quality is then obtained from the residual of the demand equation, and it represents all non-price determinants that explain the market share of the variety

11. See Benkovskis and Wörz (2014), Feenstra and Romalis (2014), Hallak and Schott (2011), and Khandelwal et al. (2013).

conditional on price. This estimate corresponds to the variety's quality perceived by consumers. In this section, we first describe the demand model being estimated, explain the instrumental variable used to deal with price endogeneity and finally present the results of quality estimation.

3.1 Demand model

Berry (1994) derives the demand function from a discrete choice model where a consumer's utility depends on observable and unobservable product characteristics, the price and individual preferences for horizontal attributes of a product. Products are partitioned into groups determined prior to estimation, and substitutions across products are defined according to a nested logit structure. This setup allows for consumer preferences to be correlated across products belonging to each group, or nests. In our case, nests are represented by a product's category defined at the HS6 level, while the demand system is specific to an industry defined at the 4-digit ISIC level. Within an industry, different alternatives are represented by imported products. Conditional on quality and price, consumer n in country j chooses variety ih that provides the consumer the highest utility u_{nijht} among all imported varieties within an industry:

$$u_{nijht} = \ln \lambda_{ijht} - \alpha \ln p_{ijht} + \sum_H [d_{ht} \zeta_{nHt}] + (1 - \sigma) \epsilon_{nijht}, \quad (\text{I.4})$$

where λ_{ijht} represents a variety's quality and corresponds to the characteristics of a variety commonly perceived by all consumers in country j but unobserved by the econometrician, p_{ijht} is the price, and ϵ_{nijht} corresponds to the consumer-specific taste parameter.¹² Term ζ_{nHt} is the consumer-specific taste parameter for all products belonging to category H , and d_{ht} is a dummy variable equal to one if product h belongs to group H and zero otherwise. Variable σ denotes the within-nest correlation of consumer preferences and is between zero and one. Hence, the vertical component of a variety is captured by $\ln \lambda_{ijht}$, while the horizontal component is captured by $\sum_H [d_{ht} \zeta_{nHt}] + (1 - \sigma) \epsilon_{nijht}$. Assuming ϵ_{ijht} to be i.i.d. extreme value of type 1, Berry (1994) shows that $\sum_H [d_{ht} \zeta_{nHt}] + (1 - \sigma) \epsilon_{nijht}$ is also distributed as a Type 1 extreme value. Following Cardell (1997), the researcher derives the aggregate demand function for a variety as the aggregation of individual consumer choices. The demand function includes an outside good, or numeraire, that has an average utility equal to zero and allows for the existence of an alternative option to the purchase of imported varieties. In our case, products that are domestically produced and consumed for a given industry represent the outside good. Without the presence of such a good, the choice of consumers is limited to only imported varieties, and the demand for a specific variety depends only

12. The term $\ln \lambda_{ijht}$ can be thought as the mean of consumers' valuation of product quality, while ϵ_{nijht} represents the distribution of consumer preferences around this mean.

on characteristics relative to the available alternatives.¹³ Following Khandelwal (2010), the demand for variety ih in country j at time t is given by:¹⁴

$$\ln(s_{ijht}) - \ln(s_{0jt}) = \alpha \ln p_{ijht} + \sigma \ln(s_{ijht|H}) + \ln \lambda_{ijht}, \quad (\text{I.5})$$

where s_{ijht} is the market share of variety ih within the industry, s_{0jt} is the market share of the outside variety, and $s_{ijht|H}$ is the variety's market share within its nest H . The presence of $s_{ijht|H}$ accounts for the effect of correlated preferences among varieties of the same product. The demand function obtained can be estimated through classic methods, as $\ln p_{ijht}$ and $\ln \lambda_{ijht}$ enter the equation linearly. The estimation of the demand system presents two main challenges. First, to derive the market share of the outside option s_{0jt} we need to measure the market size at the industry level for each importing country. Second, as $\ln p_{ijht}$ and $\ln s_{ijht|H}$ are likely to be correlated with the error term $\ln \lambda_{ijht}$, we choose to estimate the demand parameters through an instrumental variable (IV) approach.

For each industry-importer pair, varieties' quality is inferred from the demand system as described in Equation (I.5). In the demand equation, we also control for the logarithm of population of the exporting country $\ln(pop)_{it}$ as in Khandelwal (2010). The reason for this additional control is that a country's large size may reflect the fact that it exports different typologies of varieties horizontally differentiated within a product category.¹⁵ The demand system is estimated for each importer-industry pair as follows:

$$\ln(s_{ijht}) - \ln(s_{0jt}) = \lambda_{1,ijh} + \lambda_{2,jt} + \alpha \ln p_{ijht} + \sigma \ln(s_{ijht|H}) + \beta \ln(pop)_{it} + \lambda_{3,ijht}, \quad (\text{I.6})$$

where $\lambda_{1,ijh}$ and $\lambda_{2,jt}$ correspond to a variety (product-exporter) and time fixed effects, while the third term $\lambda_{3,ijht}$ corresponds to the error term of the regression. The quality of variety ih estimated on market j consists of the three components: $\ln \hat{\lambda}_{ijht} = \hat{\lambda}_{1,ijh} + \hat{\lambda}_{2,jt} + \hat{\lambda}_{3,ijht}$. The first term $\lambda_{1,ijh}$ is the time-invariant quality of the specific variety, and the second term $\lambda_{2,jt}$ represents the consumers' time trend for all products included in the industry.

3.2 Identification and the instrumental variable

To calculate the market shares s_{ijht} , $s_{ijht|H}$ and the numeraire s_{0jt} , we follow Khandelwal (2010). The outside option is defined at the industry level and is obtained as $s_{0jt} = 1 - IP_{jt}$, where $IP_{jt} = \frac{Import_{jt}}{Production_{jt} - Export_{jt} + Import_{jt}}$ is the import penetration index calculated at the

13. Suppose, for example, that an increase of tariffs on imports increases the price of all imports related to a specific industry; ignoring the presence of the outside good, the demand would depend only on the relative prices of the imported varieties, and consumers would not respond to a general price increase.

14. Since the demand is at the industry level, the industry indexes are omitted.

15. Within a given 6-digit product classification, large countries are likely to export a larger number of 8-digit varieties with similar attributes (price, quality, etc.). A computation of market shares at a higher aggregation level (such as a 6-digit HS level) will inevitably attribute higher market shares to larger countries due to these hidden varieties. Consequently, the estimation of the demand equation will lead to an upward bias of the unobserved characteristics such as quality.

industry level as the total industry imports divided by the domestic consumption of the same industry. Then, in ideal conditions, we would calculate the imported variety's market share in terms of quantity as the ratio of the quantity of the variety imported and the total quantity consumed for industry $s_{ijht} = \frac{q_{ijht}}{Consumption_{jkt}}$, where q_{ijht} denotes the quantity of the imported variety ih , and $Consumption_{jkt}$ is the sum of imported and domestically produced products consumed. Since data on quantities are available only for imported products, we use a proxy for the total quantity consumed in country j that is calculated as the total quantity of imported varieties for a given industry divided by $Q_{jt} = \sum_i \sum_h \frac{q_{ijht}}{1-s_{0jt}}$. The value obtained is used to derive the imported variety's market share as $s_{ijht} = \frac{q_{ijht}}{Q_{jt}}$. The market share of the variety within its product is also calculated in terms of quantity as $s_{ijht|H} = \sum_i \sum_{h \in H} \frac{q_{ijht}}{(1-s_{0jt})}$.

As we mentioned, the two variables $\ln p_{ijht}$ and $\ln(s_{ijht|H})$ are likely to be correlated with the error term of the demand Equation (I.5). Using an OLS estimator will then give us biased estimates of coefficients of price and variety's market share. To handle the endogeneity issue, we resort to the use of an IV approach. Indeed, studies of international trade often confront the necessity to instrument prices in demand equations. One of the most common strategies followed to instrument prices is to use cost-shifters, as they are independent from factors related to destination markets. For example, Irwin and Pavcnik (2004) use a combination of the price of aluminum and hourly manufacturing wages to instrument the price of airplanes, Gervais (2015) uses physical labor productivity at plant level, and in a recent study Fontagné et al. (2018) use electricity price shocks specific to each firm. Other examples include Smeets et al. (2014) and Piveteau and Smagghue (2019), which use the changes of exchange rates relative to imported products as a cost shock to instrument the price of output of exporting firms. The study of Khandelwal (2010) instead proposes instrumenting prices using ad valorem transportation costs,¹⁶ while Bernini and Tomasi (2015) and Jäkel (2019) use the average price of the competing varieties on the same market as a proxy for the average marginal cost for a given product. In the present study, we exploit the large coverage of bilateral trade data at our disposal and instrument the price of variety ih on market j with the weighted average price of the same variety on all the other markets, derived as:

$$\ln \bar{p}_{ijht} = \frac{\sum_{j' \neq j} \ln p_{ijh't} * \omega_{ijh't}}{\sum_{j' \neq j} \omega_{ijh't}}, \quad (I.7)$$

where $\omega_{ijh't}$ corresponds to the share of exports to country j' in terms of value in the total exports related to variety ih . Our instruments borrow from the insights of the Hausman-type instruments that are extensively used in the literature on industrial organization (see, for instance, Hausman et al. (1994) and Nevo (2001)), and exploit the common cost component across a variety's CIF prices to construct a powerful predictor of the price that is supposed

16. Feenstra et al. (2002) provides data on US product-level import quantities, values and transportation costs from 1989 to 2001. Colantone and Crinò (2014) and Curzi et al. (2015) adapt the transport costs used by Khandelwal (2010) to a case involving European countries.

to be uncorrelated with destination-specific demand shocks under the assumption of independent demands in destination markets. The nest share term $s_{ijht|H}$ is also endogenous and has to be instrumented. Following Khandelwal (2010), two count variables are used as instruments: the number of varieties imported within a product by country j , which is supposed to be negatively correlated with the nest share, and the number of products exported by country i within the same industry, which instead is expected to be positively correlated.

3.3 Quality estimation results

The demand system presented in Equation (I.6) is first estimated without instrumental variables to verify the soundness of the coefficients of the price and nest share variables. As the price and nest share variables are endogenous, we expect the OLS regressions to underestimate the coefficient of price α and overestimate the coefficient of nest share σ . Nonetheless, we expect the price coefficient to be negative and the nest share coefficient to be positive.

Table 2: Summary statistics

		Mean	p25	p50	p75
Coef. ln price α	OLS	-0.328	-0.444	-0.294	-0.182
	IV	-0.884	-1.317	-0.827	-0.283
Coef. nest share σ	OLS	0.713	0.614	0.740	0.838
	IV	0.283	-0.053	0.225	0.637
Coef. ln population β	OLS	-0.134	-0.866	-0.044	0.716
	IV	-0.162	-1.876	-0.158	1.270
Number of obs. per est.		2799	405	1137	3102
Total number of observations			16 245 230		
Total number of estimations			5803		

Table 2 reports the distribution of coefficients obtained from OLS and 2SLS estimators. The total number of regressions run is equal to 5 803, which accounts for more than 16 million observations. The distributions of coefficients of price and nest share are consistent signwise with our expectations. The median and the mean for the price are lower for 2SLS than for OLS, which means that the OLS estimator underestimates the coefficient for the price. Similarly, the resulting coefficients of the nest share are higher for OLS than for 2SLS.¹⁷ In contrast, the coefficient of the logarithm of population is not significant, and its distribution seems to be centered around zero.

Next, we perform two different tests to verify the soundness of the instruments used. The validity of instruments is evaluated under two criteria, namely, relevance, which is meant as the predictive power of the instruments in explaining the instrumented variables, and exogeneity, with respect to the unexplained part of the dependent variable. The first two rows of Table 3 report the distribution of p-values of the F-statistic test for relevance of the two instrumented variables. Rows three and four report the distribution of p-values of

17. For more details on the distribution, see Figure D1 in the Appendix.

the Sanderson-Windmeijer (SW) first-stage test, which corresponds to a modification and an improvement of the F-test.¹⁸ Row 5 reports the distribution of the p-value for the J-test of over-identifying restrictions.

Table 3: Distribution of tests for relevance and exogeneity of the instruments

	Mean	p25	p50	p75
First stage F-stat p-value, $\ln p_{ihjt}$	0.099	0.000	0.008	0.097
First stage F-stat p-value, $\ln(s_{ihjt H})$	0.042	0.000	0.000	0.009
First stage chi2-stat p-value, $\ln p_{ihjt}$	0.091	0.000	0.001	0.068
First stage chi2-stat p-value, $\ln(s_{ihjt H})$	0.063	0.000	0.000	0.015
Overidentifying restrictions J-test p-value	0.265	0.029	0.167	0.435

The first four rows of Table 3 indicate that the means of distributions of the p-values of the F-test and the chi-squared test are below the 0.1 significance level for both instruments, which implies that for the large majority of the regressions estimated, the instruments are highly relevant. The median of the p-value for the J-test in row 5 is 0.167, which ensures that for the large part of the sample, the instruments are deemed to be exogenous. Overall, the distribution of the tests complies with our expectations, and the instrument used are reported to be relevant and exogenous for the large majority of the 5 803 regressions run.

Given the large number of estimations, we do not report the values of $\ln \hat{\lambda}_{ijht}$.¹⁹ Instead, the estimation of quality is next compared with a number of factors by now acknowledged in the literature on international trade. The first well-established finding in the literature refers to the hypothesis formulated by Linder (1961), which states that a country tends to produce and export products of a level of quality that reflects the domestic demand for quality. An implication of this hypothesis is that high-quality products are mainly exported by high-income countries. Then, considering the Alchian-Allen effect that predicts that per-unit transport costs make it more convenient to export high-quality products to further destinations, we analyze the correlation between exported quality and distance.²⁰ Finally, as the production of high-quality products requires costly investments that increase marginal costs, we compare quality to export prices (unit values). The first column of Table 4 shows that quality and the level of income of the exporter are positively correlated. This finding confirms that rich countries tend to export high-quality varieties. Column (2) reports the results of regressing variety's quality on distance. We note a positive and significant correlation, which is consistent with the Alchian-Allen effect. In Column (3), we observe a positive correlation between quality and price. Finally, considering Column (4), we note that the results hold if quality is regressed on the three variables jointly.

18. See Sanderson and Windmeijer (2016).

19. Data on the estimated varieties' quality $\ln \hat{\lambda}_{ijht}$ is available upon request.

20. See Alchian and Allen (1964), Bastos and Silva (2010), and Hummels and Skiba (2004).

Table 4: Correlation between the value of quality and other related factors

	Explained variable: $\ln \hat{\lambda}_{ijht}$			
	(1)	(2)	(3)	(4)
$\ln \text{gdp}/\text{cap}_{it}$	0.089*** (0.001)			0.085*** (0.001)
$\ln \text{distance}_{ij}$		0.036*** (0.001)		0.053*** (0.001)
$\ln \text{price}_{ijht}$			0.075*** (0.001)	0.049*** (0.001)
Constant	-0.840*** (0.007)	-0.284*** (0.009)	-0.181*** (0.002)	-1.344*** (0.013)
FE importer-prod-year	Yes	Yes	Yes	Yes
R-squared	0.191	0.190	0.191	0.191
Observations	15,177,205	15,225,052	15,225,052	15,177,205

Significance levels: ***0.01 **0.05 *0.10

In the next section, we analyze the relationship between export volatility and the quality of the exported product. The estimated quality $\ln \hat{\lambda}_{ijht}$ is characterized by a temporal dimension, which implies that the quality of a variety exported to a destination can vary over time. To compare quality with volatility over time, we consider the fixed effect $\hat{\lambda}_{ijh}$ estimated in Equation (I.6), which represents the time-invariant quality of variety ih exported to market j as our variable of interest.²¹

4 Results

This section reports and discusses our main findings. We use product quality estimated as in Section 3 to determine the correlation between it and export volatility according to the empirical strategy presented in Section 2. In addition, we show that our results are robust to the use of quality estimated through the methodology proposed by Khandelwal et al. (2013).

4.1 Baseline model

We present the results of the estimation of the empirical model delineated in Equation (I.1) of Section 2. The objective of the analysis is to assess whether the export volatility of varieties depends on the quality of varieties exported. To obtain a generic view of the effect of product quality on volatility, we first regress the logarithm of export volatility on quality and a set of fixed effects as follows:

$$\ln \text{volatility}_{ijh} = \gamma_1 \ln \widehat{\text{quality}}_{ijh} + \varphi_{jh} + \varphi_{ij} + \epsilon_{ijh}, \quad (\text{I.8})$$

21. Figure E3 in the Appendix shows that quality estimated for a given variety is characterized by small variations over time.

where $\ln \widehat{quality}_{ijh}$ is the time-invariant quality of variety ih exported to market j , estimated as a fixed effect $\hat{\lambda}_{ijh}$ in Equation (I.6). In Tables 5 and 6, we report the results of the estimation of Equation (I.8). In Table 5, the dependent variable is the logarithm of volatility measured in terms of value, while in Table 6 volatility is measured in terms of volumes exported. A possible criticism of the specification defined in Equation (I.8) is the use of the fixed effect φ_{ij} . Since several studies have noted that countries with high incomes and abundance of capital and skilled labor tend to export higher-quality products (Hummels and Klenow, 2005; Schott, 2004; Sutton and Trefler, 2016), the use of the fixed effect φ_{ij} is likely to capture a part of variety's quality, as it controls for the average level of quality of exports relative to exporter i . Hence, in Column (1) of Tables 5 and 6 we replace the exporter-importer fixed effect with a set of control variables likely to affect trade. The controls used belong to the category of gravity variables and include the logarithm of distance and a series of standard indicators such as contiguity, common official language, common colonial past and common religion. In Column (2) of Tables 5 and 6, we report the results of the regression expressed by Equation (I.8), while in Column (3) we add an exporter-product fixed effect. The latter allows us to control for all aspects related to the supply of variety ih such as the volatility of production, the size of the manufacturer and the diversification in terms of destinations to which the variety is exported. While the use of an exporter-product fixed effect allows us to control for many factors, it also captures the average level of quality for variety ih perceived across all destinations to which it is exported. Thus, our preferred result is that expressed in Column (2). Finally, in Column (4) of both Tables 5 and 6 we evaluate the impact of quality on the predicted value of exports. To do so, we calculate the time-invariant predicted value of exports as a simple average of the predicted value of exports obtained in Section 2.3 as $\hat{x}_{ijht} = \hat{\delta}_1 + \hat{\delta}_2 t$. The time-invariant predicted value of exports corresponds to $\bar{x}_{ijht} = \frac{1}{T} \sum_t \hat{x}_{ijht}$. We then regress the logarithm of the time-invariant predicted value on the logarithm of quality, an importer-product fixed effect and an exporter-importer fixed effect. The results in Column (4) not only provide us an understanding of the effect of quality on the level of exports but also allow us to compare the magnitude of the effect of quality on exports with its effect on the volatility of exports.

The results obtained in Tables 5 indicate that, in general, the volatility of exports increases with the quality of varieties exported. The results in Column (1) also show that volatility of exports is higher for geographically closer countries, as the volumes of trade are generally larger. In Columns (2) and (3), we observe that the addition of the importer-exporter and exporter-product fixed effects reduces the explanatory power of the coefficient of the logarithm of quality. This effect likely occurs because the two fixed effects capture a part of the intrinsic quality of exported varieties. Column (4) indicates that the time-invariant predicted level of exports increases with product quality. The results obtained in Table 6 are very similar in terms of magnitude and significance of the coefficient of quality to the results obtained in Table 5. This implies that the volatility of exports of a higher-quality product

is robust to the measure of volatility being in terms of values or volumes. Nonetheless, the effect of quality on volatility is slightly larger if volatility is measured in terms of value. This difference in the coefficients likely occurs because high-quality products are sold at higher unit values. Overall, our results show that, consistently with our main hypothesis, there is a positive correlation between quality and volatility. In view of our preferred specification in Columns (2) and (4) of Table 5, our results indicate that a variety that upgrades its quality from the first to the second quartile of the quality distribution, which corresponds to a rise by 1.43 of $\ln \widehat{quality}_{ijh}$, increases its predicted value of exports to destination j by 26%, while its volatility increases by 21%.

Table 5: Baseline regression with volatility measured in terms value

	ln volatility(value) $_{ijh}$			ln \bar{x} (value) $_{ijh}$
	(1)	(2)	(3)	
ln quality $_{ijh}$	0.168*** (0.001)	0.149*** (0.001)	0.083*** (0.001)	0.181*** (0.001)
ln distance $_{ij}$	-0.188*** (0.002)			
contiguity $_{ij}$	0.427*** (0.006)			
language $_{ij}$	-0.046*** (0.006)			
colony $_{ij}$	0.003 (0.006)			
religion $_{ij}$	-0.161*** (0.007)			
Constant	6.976*** (0.017)	5.515*** (0.001)	5.568*** (0.001)	5.961*** (0.002)
FE exporter-product	No	No	Yes	No
FE importer-product	Yes	Yes	Yes	Yes
FE importer-exporter	No	Yes	Yes	Yes
R-squared	0.513	0.581	0.778	0.567
Observations	751,423	750,701	715,160	732,489

Significance levels: ***0.01 **0.05 *0.10

4.2 Role of income fluctuations

The objective of our empirical analysis is to verify whether income shocks affecting consumer demand for products have an impact on consumer propensity to spend on quality. To derive more insights into the mechanism that relates the fluctuations of income and the demand for quality in destination countries, we follow the empirical model delineated in Equation (I.2) in Section 2, and augment the regression model expressed in Equation (I.8) with an interaction term between quality and the variability of income in the importing country j as follows:

Table 6: Baseline regression with volatility measured in terms quantity

	ln volatility(volume) _{ijh}			ln \bar{x} (volume) _{ijh}
	(1)	(2)	(3)	(4)
ln quality _{ijh}	0.163*** (0.001)	0.142*** (0.001)	0.076*** (0.001)	0.180*** (0.001)
ln distance _{ij}	-0.223*** (0.002)			
contiguity _{ij}	0.600*** (0.007)			
language _{ij}	-0.012 (0.007)			
colony _{ij}	-0.026*** (0.007)			
religion _{ij}	-0.381*** (0.009)			
Constant	5.243*** (0.020)	3.477*** (0.002)	3.515*** (0.001)	3.860*** (0.002)
FE exporter-product	No	No	Yes	No
FE importer-product	Yes	Yes	Yes	Yes
FE importer-exporter	No	Yes	Yes	Yes
R-squared	0.652	0.719	0.850	0.712
Observations	751,423	750,701	715,160	750,701

Significance levels: ***0.01 **0.05 *0.10

$$\ln volatility_{ijh} = \gamma_1 \ln \widehat{quality}_{ijh} + \gamma_2 SD(y)_j * \ln \widehat{quality}_{ijh} + \varphi_{ij} + \varphi_{jh} + \epsilon_{ijh}. \quad (I.9)$$

The coefficient of the interaction variable γ_2 indicates whether the positive correlation between export volatility and the variety's quality depends on the variability of consumers' income in the importing country. Such variability is measured as the standard deviation of annual growth of income per capita over time, $SD(y)_j = \sqrt{\sum_t (y_{jt} - \bar{y}_j)}$, where y_{jt} is the annual growth of per-capita income $GDP/cap_{jt} - GDP/cap_{j,t-1}$, and \bar{y}_j is the average growth over the whole period, $\bar{y}_j = \frac{1}{T} \sum_t y_{jt}$.²² Income fluctuations may not impact consumer purchases identically for all product categories. Some industries are more income-elastic than others, and the repercussion of income shocks on consumer consumption patterns may differ by industry. Hence, we propose another variable to interact with quality that represents the variability of the expenditure per capita on products related to the industry to which the exported variety belongs. Expenditure per capita is measured as $exp/cap_{jt}^k = \frac{P_{jt}^k + M_{jt}^k - X_{jt}^k}{population_{jt}}$, where P_{jt}^k is the total production in country j by industry k , M_{jt}^k represents the total imports, and X_{jt}^k denotes the total exports. As to income, the variability of expenditure per capita $SD(exp/cap)_{jt}^k$ is obtained as the standard deviation of its annual growth over time. Since $SD(exp/cap)_{jt}^k$ is calculated at the industry level, it captures the changes in

22. Variability of income is measured as in Cavallo et al. (2008), Malik and Temple (2009) and Haddad et al. (2013).

the aggregate demand for products at a finer scale than does variability of income per capita.

In Table 7, we reproduce the regressions performed as in Columns (2) and (4) of Tables 5 and 6 with the addition of variability of income and expenditure per capita in interaction with quality. In Columns (1) to (4), the dependent variable is measured in terms of value, while in Columns (5) to (8) it is measured in terms of volume.

For all specifications reported in Table 7, the coefficient of the interaction variable is positive and significant, which indicates that both the level and the volatility of exports of higher-quality products increase more than proportionally with the variability of the aggregate demand in destination countries. We observe that the coefficient of quality γ_1 remains positive and significant even after the addition of the interaction variables. This implies that the changes in consumer preferences for quality may not be fully captured by the variability of income or expenditure per capita. The findings reported in Table 7 show that fluctuations in consumer income affect the demand for imported varieties differently than does the varieties' quality. Negative income shocks are likely to reduce consumer demand for imported products and to negatively affect the intensity of the consumer preference for quality. By lowering the propensity to spend on quality, negative income shocks reduce the imports of higher-quality varieties more than proportionally. On the other hand, positive income shocks increase the consumers' propensity to spend on quality and the demand for high-quality imported varieties accordingly. Greater fluctuations in the income per capita over time imply a more than proportionate volatility of demand for high-quality products.

Table 7: Results with interaction variable

	ln volatility(val) _{ijh}		ln \bar{x} (val) _{ijh}		ln volatility(vol) _{ijh}		ln \bar{x} (vol) _{ijh}	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln quality _{ijh}	0.124*** (0.001)	0.124*** (0.001)	0.147*** (0.001)	0.148*** (0.001)	0.118*** (0.001)	0.116*** (0.001)	0.145*** (0.001)	0.145*** (0.001)
ln quality _{ijh} * s.d.(gdp/cap) _j		0.014*** (0.000)	0.020*** (0.001)		0.014*** (0.001)		0.019*** (0.001)	
ln quality _{ijh} * s.d.(exp/cap) _j ^k		0.697*** (0.018)		0.925*** (0.020)		0.738*** (0.020)		0.950*** (0.022)
Constant	5.515*** (0.001)	5.514*** (0.001)	5.960*** (0.002)	5.960*** (0.002)	3.477*** (0.002)	3.477*** (0.002)	3.859*** (0.002)	3.859*** (0.002)
FE importer-product	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE importer-exporter	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.582	0.582	0.568	0.569	0.719	0.720	0.713	0.713
Observations	750,701	750,701	732,489	732,489	750,701	750,701	750,701	750,701

SD(gdp/cap_j) and SD(exp/cap_j^k) correspond to the variability of income and domestic expenditure in industry *k* respectively, and are measured as the standard deviation of annual growth of the two variables over time. Dependent variable is the log of volatility in terms of value in Columns (1) and (2), the time-invariant predicted export value in Columns (3) and (4), the log of volatility in terms of volume in Columns (5) and (6), the time-invariant predicted export volume in Columns (7) and (8). Significance levels: ***0.01 **0.05 *0.10

4.3 Robustness

In Table 8, we report the results of our empirical analysis that estimates quality following the demand-residual approach proposed by Khandelwal et al. (2013). This methodology is conceptually similar to that of Khandelwal (2010) with the difference that it assumes a representative consumer who maximizes a CES aggregate function for product h . The resulting demand function is estimated for each exporter-industry pair as

$$\ln q_{ijht} + \sigma \ln p_{ijht} = \kappa_{jt} + \kappa_h + \epsilon_{ijht}, \quad (\text{I.10})$$

where κ_{jt} and κ_h correspond to importer-year and product-specific fixed effects, and q_{ijht} represents exports in terms of volumes. To compute the left part of the equation, we use the country-industry specific elasticity of substitution σ from Broda and Weinstein (2006). Compared to the methodology proposed by Khandelwal (2010) based on a nested logit approach, this method implies the same elasticity of substitution between varieties for a given importer-industry pair. The quality of variety ih in market j is obtained as

$$\ln \widehat{quality}_{ijht} = \frac{\hat{\epsilon}_{ijht}}{\sigma-1}.$$

Quality at the exporter-importer-product level is then calculated as a simple average of quality estimated over the whole period. The first three columns of Table 8 report the results for the case of volatility expressed in terms of value, while in Columns from (4) to (6) volatility is measured in terms of volumes. The results reported in Table 8 confirm our main findings indicating that export volatility is higher for exports of high-quality varieties and that the volatility of a high-quality variety increases as the variability of income and expenditure per capita rise.

Table 8: Results with alternative measure of quality

	ln volatility(value) _{ijh}			ln volatility(volume) _{ijh}		
	(1)	(2)	(3)	(4)	(5)	(6)
ln quality _{ijh}	0.120*** (0.001)	0.097*** (0.002)	0.102*** (0.001)	0.097*** (0.001)	0.080*** (0.002)	0.086*** (0.002)
ln quality _{ijh} * SD(gdp/cap) _j		0.013*** (0.001)			0.009*** (0.001)	
ln quality _{ijh} * SD(exp/cap) _j ^k			0.507*** (0.030)			0.309*** (0.033)
Constant	5.530*** (0.001)	5.530*** (0.001)	5.528*** (0.001)	3.509*** (0.002)	3.509*** (0.002)	3.508*** (0.002)
FE importer-product	Yes	Yes	Yes	Yes	Yes	Yes
FE importer-exporter	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.551	0.551	0.551	0.703	0.703	0.703
Observations	697,865	697,865	697,865	697,865	697,865	697,865

SD(gdp/cap_j) and SD(exp/cap_j^k) correspond to the variability of income and domestic expenditure in industry *k* respectively, and are measured as the standard deviation of annual growth of the two variables over time. ln quality_{ijh} is estimated following the methodology proposed by Khandelwal et al. (2013). Significance levels: ***0.01 **0.05 *0.10

5 Conclusions

This paper contributes to the empirical literature on quality as a determinant of export performance in international trade and analyzes the volatility of product exports (“export volatility”) in relation to products’ quality. The objective of the analysis is to assess whether export volatility depends on the quality of products exported and whether income variability in the importing country increases the volatility of demand for high-quality products more than proportionally. Our inquiry is based on the assumption that the demand for high-quality products depends on income and therefore is more exposed to income shocks than is demand for other products. Instead of relying on a product’s unit value as a proxy of product quality, we estimate quality following the demand-residual approach proposed by Khandelwal (2010). This approach relies on the idea that the quality of a variety corresponds to its relative market share after controlling for exporter size and price. The results of our analysis show that exports of higher-quality products are in general more volatile. The estimates from our reduced-form analysis indicate that on average, upgrading a variety’s quality from the first to the second quartile of the quality distribution increases its predicted value of exports by 26%, while its volatility increases by 21% (see Columns (2) and (4) of Table 5).

In addition, we observe that the volatility of exports increases even more with quality if the income per capita in the importing country is characterized by a higher variability. The obtained results are consistent with the pattern described in several empirical studies that observe particularly severe contractions of exports of high-quality products as a consequence

of a negative income shock (Berthou and Emlinger, 2011; Chen and Juvenal, 2018; Esposito and Vicarelli, 2011). While these studies focus on a singular shock, we consider income variability of the importing country to be representative of the intensity of income shocks over time and analyze export volatility of vertically differentiated products over a period of 11 years. Our findings contribute to the literature on the relationship of export performance to product quality. While several studies emphasize the latter as a factor that improves export performance, we observe that exporting high-quality products increases the exposure to demand fluctuations in foreign markets.

Appendix A - Countries in the sample

Country	Region	Country	Region
Albania	East Europe	Yemen, Rep.	Middle East
Belarus	East Europe	Bermuda	Northern America
Bulgaria	East Europe	Canada	Northern America
Czech Republic	East Europe	United States	Northern America
Greece	East Europe	Australia	Oceania
Hungary	East Europe	New Zealand	Oceania
Kazakhstan	East Europe	Afghanistan	South-east Asia
Kyrgyz Republic	East Europe	Bangladesh	South-east Asia
Macedonia, FYR	East Europe	Brunei Darussalam	South-east Asia
Malta	East Europe	Cambodia	South-east Asia
Moldova	East Europe	India	South-east Asia
Poland	East Europe	Indonesia	South-east Asia
Romania	East Europe	Iran, Islamic Rep.	South-east Asia
Russian Federation	East Europe	Lao PDR	South-east Asia
Slovak Republic	East Europe	Malaysia	South-east Asia
Slovenia	East Europe	Pakistan	South-east Asia
Tajikistan	East Europe	Philippines	South-east Asia
Turkmenistan	East Europe	Singapore	South-east Asia
Ukraine	East Europe	Sri Lanka	South-east Asia
China	Eastern Asia	Thailand	South-east Asia
Japan	Eastern Asia	Vietnam	South-east Asia
Korea, Rep.	Eastern Asia	Burundi	Sub-Saharan Africa
Mongolia	Eastern Asia	Cameroon	Sub-Saharan Africa
Argentina	Latin America - Caribbean	Congo, Rep.	Sub-Saharan Africa
Bolivia	Latin America - Caribbean	Eritrea	Sub-Saharan Africa
Brazil	Latin America - Caribbean	Ethiopia	Sub-Saharan Africa
Chile	Latin America - Caribbean	Ghana	Sub-Saharan Africa
Colombia	Latin America - Caribbean	Kenya	Sub-Saharan Africa
Ecuador	Latin America - Caribbean	Malawi	Sub-Saharan Africa
Mexico	Latin America - Caribbean	Nigeria	Sub-Saharan Africa
Panama	Latin America - Caribbean	Rwanda	Sub-Saharan Africa
Paraguay	Latin America - Caribbean	South Africa	Sub-Saharan Africa
Peru	Latin America - Caribbean	Tanzania	Sub-Saharan Africa
Uruguay	Latin America - Caribbean	Austria	West Europe
Algeria	Middle East	Belgium	West Europe
Armenia	Middle East	Denmark	West Europe
Azerbaijan	Middle East	Estonia	West Europe
Bahrain	Middle East	Finland	West Europe
Cyprus	Middle East	France	West Europe
Egypt, Arab Rep.	Middle East	Germany	West Europe
Georgia	Middle East	Iceland	West Europe
Israel	Middle East	Ireland	West Europe
Jordan	Middle East	Italy	West Europe
Kuwait	Middle East	Latvia	West Europe
Lebanon	Middle East	Lithuania	West Europe
Morocco	Middle East	Netherlands	West Europe
Oman	Middle East	Norway	West Europe
Qatar	Middle East	Portugal	West Europe
Saudi Arabia	Middle East	Spain	West Europe
Syrian Arab Republic	Middle East	Sweden	West Europe
Tunisia	Middle East	Switzerland	West Europe
Turkey	Middle East	United Kingdom	West Europe

Appendix B - Descriptive statistics

Table B1: Summary statistics of the main variables

	Mean	p25	p50	p75
volatility(value) _{ijh}	1793	75.9	227	772
volatility(volume) _{ijh}	1073	6.88	31.7	158
ln volatility(value) _{ijh}	5.57	4.33	5.43	6.65
ln volatility(volume) _{ijh}	3.54	1.93	3.46	5.07
ln quality _{ijh}	0.467	-1.08	0.357	1.93

Appendix C - On the nested logit approach

Berry (1994) was the first to derive the basic formulation of the demand model assuming a constant elasticity of substitution across products. The resulting utility function is as in equation I.11, where ϵ_{ijht} is i.i.d. across products and consumers and follows a Type I extreme value distribution:

$$u_{nijht} = \ln \lambda_{ijht} - \alpha \ln p_{ijht} + \epsilon_{nijht}. \quad (\text{I.11})$$

The demand function derived by the utility function in equation I.11 entails the property of independence of irrelevant alternatives (IIA). If the IIA property holds, the substitution pattern of products in the consumer choice is independent from product characteristics, making all products strict substitutes for one another. Berry (1994) point out that this assumption places a strong restriction on cross-price elasticities, which therefore would only depend on the mean utility level $\delta_{nijht} = \ln \lambda_{ijht} - \alpha \ln p_{ijht}$ without any additional possible interaction effects stemming from the effects of the taste parameter ϵ_{nijht} . The nested logit approach overcomes this problem, assuming that consumer-specific taste is correlated across alternatives belonging to the same nest but not across alternatives belonging to different nests. In this approach, the set of alternatives is partitioned into subsets (the nests); i.e., while the IIA property holds within the alternatives of each nest, the substitution pattern between two alternatives of different nests depends on the attributes of other alternatives in the two nests.

The substitution pattern designed for the nested logit approach and its implications can be explained through the example in Figure C1, representing the pattern of choices of a consumer and its consequences on market shares of imported products. Consider the choice of a French consumer in the case of the industry defined as “processing and preserving of fruits and vegetables”. At the top of the decision tree, the consumer is able to choose between consuming domestic or imported products. If the consumer chooses imported ones, the nested logit structure generates a choice pattern such that the correlation between choosing lemons from Italy and lemons from Spain is higher, as both belong to the same nest, than

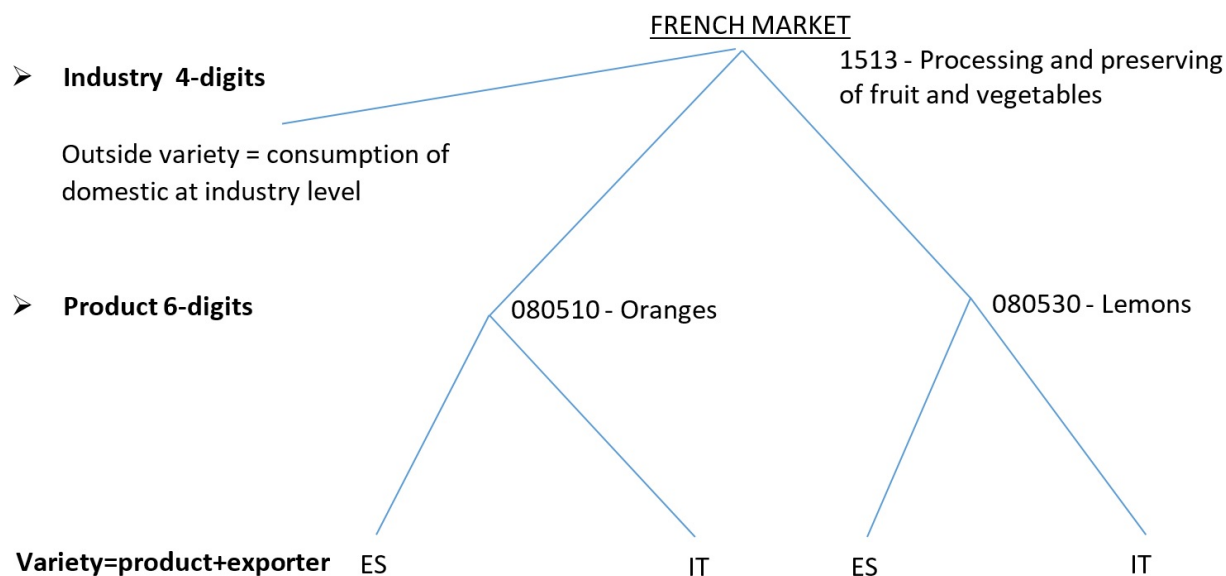


Figure C1: Example of nests structure

the correlation between choosing lemons from Italy and any variety of oranges. Let us assume that for consumer n , lemons from Italy result in the highest utility and that, for some reasons, Italian lemons disappear from the market. Consumer n is more likely to replace Italian lemons with lemons imported by another exporter instead of other products. Consequently, once lemons from Italy are no longer on the market, a large part of their former market share will be absorbed by lemons from Spain while a smaller part will be taken by oranges from Italy and Spain.

Appendix D - Distribution of coefficients and p-values in regressions

Figure D1 reports the distribution of coefficients and the coefficient p-values for the covariates of 5803 demand regressions discussed in section 3.1 for the OLS and IV cases. For both methods and the large majority of regressions, the coefficient of price is negative and that of nest share is positive. We observe that the distribution of the coefficient of population is centered around zero and is often nonsignificant.

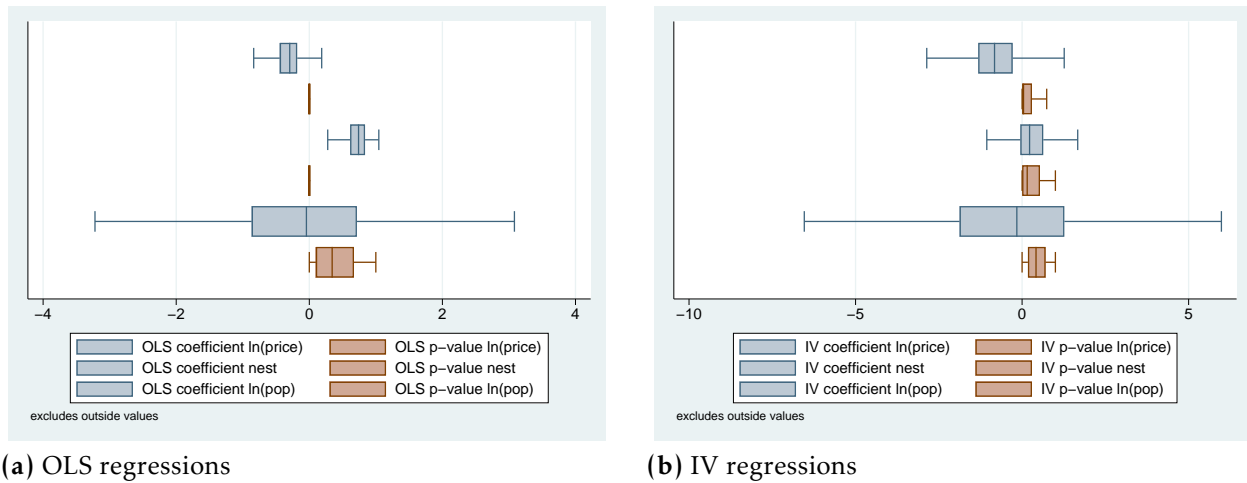


Figure D1: Distribution of coefficients and p-values demand regressions

Appendix E - Insights into estimated quality

In this section, we present the distribution of the measure of quality inferred. Figure E1 reports the distribution of the quality of imported dairy products for France and the US. Because of the construction of the quality indicator, for each industry-importer pair, the quality of imported products is distributed around zero. In contrast, the range of values quality can assume depends on the specific characteristics of the market of the importing country. As figure E1 shows, the distribution of quality is more dispersed in the case of the US market than for the French one.

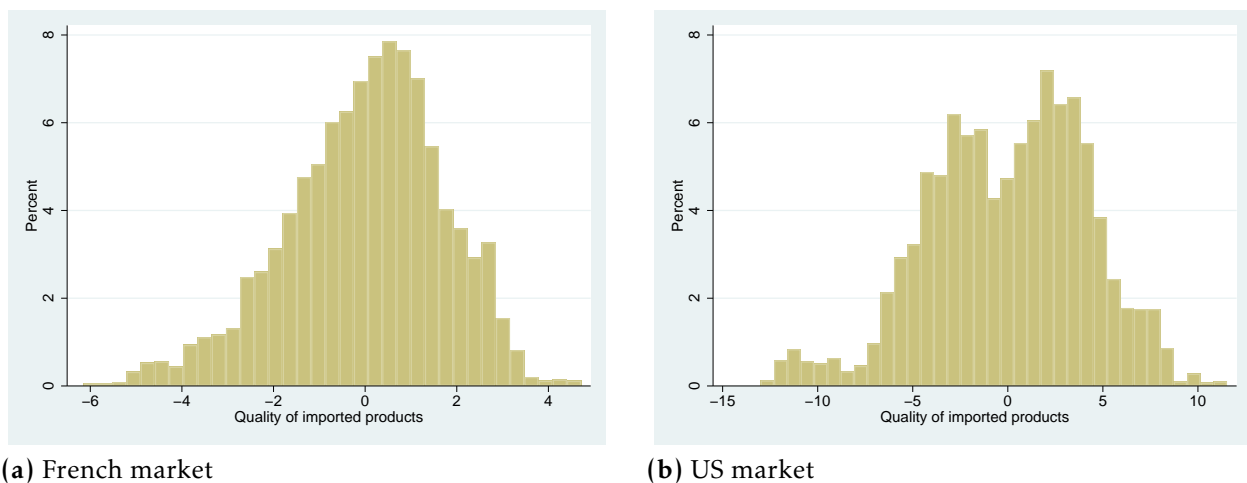


Figure E1: Distribution of quality of imported products for industry "1520 - Manufacture of dairy products"

Figure E2 shows the distribution of quality of product "HS6 020110 - Carcasses or half-carcasses of bovine animals, fresh or chilled" for two importing countries, namely, France and Germany. While for some varieties, such as beef from the Netherlands, the estimated

quality is relatively high for both importers, for other varieties, such as beef from Spain, the resulting quality is high in the French market and yet particularly low in Germany. As quality is estimated from the demand side, its estimation not only captures the intrinsic quality of a product but also is highly influenced by the difference in taste between consumers of different countries. Hence, the same product exported by Spain to France and to Germany can have an estimated quality that depends not only on the intrinsic quality of the product but also on consumers' taste in the importing countries. Another explanation of differences between the estimated quality values for the same variety is that countries export different grades of the same product according to the destination.

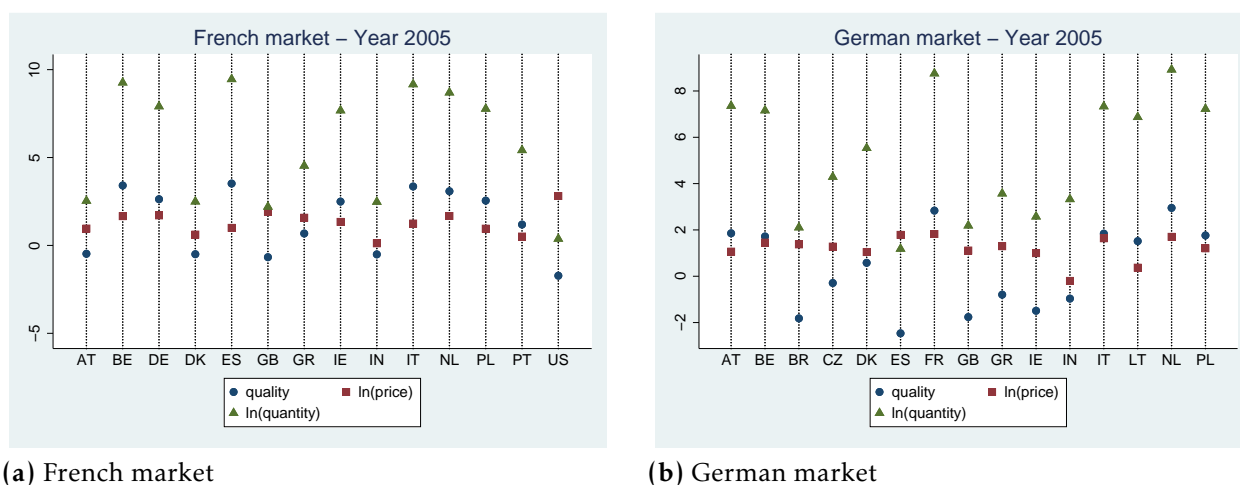
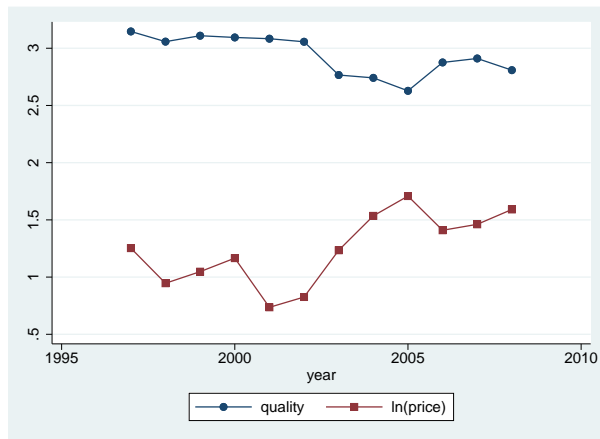
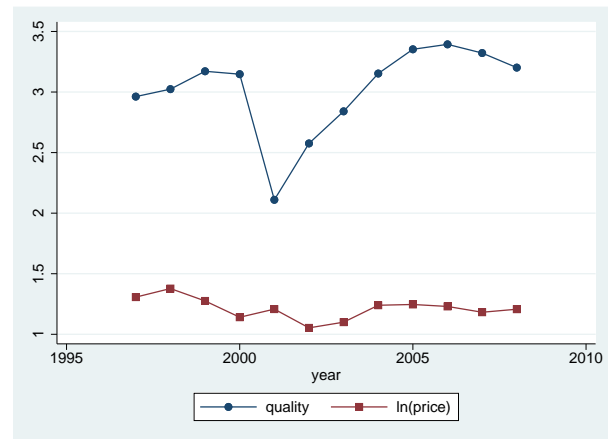


Figure E2: Quality, price and quantity imported of "hs6 020110 - Carcasses or half-carcasses of bovine animals, fresh or chilled" for year 2005

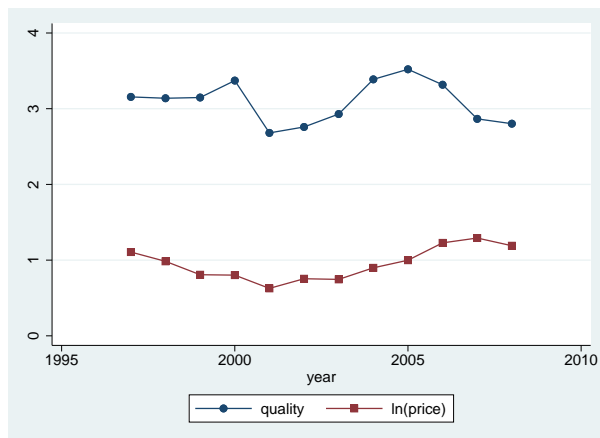
Figure E3 displays the evolution of prices and quality estimated for four different varieties of product "HS6 020110 - Carcasses or half-carcasses of bovine animals, fresh or chilled" imported by France. The charts show high quality during the period under analysis for exports from Germany, Italy and Spain. In contrast, exports from Greece are perceived to be of low quality in France. For the four cases, we can observe that the levels of quality are quite stable during the period of time under analysis.



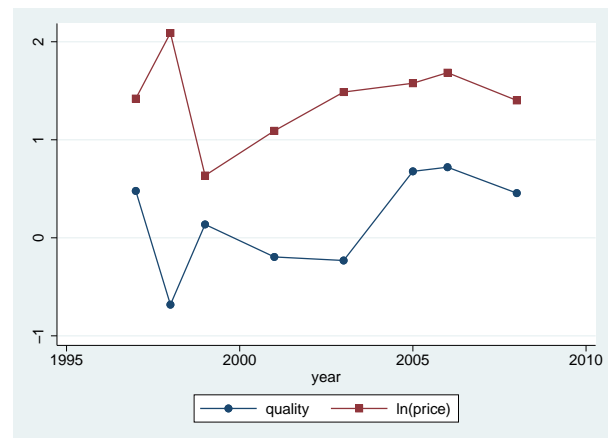
(a) Exports from Germany



(b) Exports from Italy



(c) Exports from Spain



(d) Exportes from Greece

Figure E3: Quality and prices of exports to France. Data are relative to imported products of bovine meat (6-digit code: 020110)

Chapter II

Export quality and wage premia ¹

1 Introduction

The quality of goods produced and exported by a country affects its economic environment in different ways. The literature often highlights the role played by demand for product quality in foreign markets as a decisive incentive for firms to improve product quality to be competitive in the export market.² This is particularly true for less developed countries, for which the transition from production of low-quality to high-quality products is seen as an important condition for export success.³ Firms that choose to upgrade the quality of their export products need to become more intensive in skilled labor. The studies of Verhoogen (2008) and Brambilla et al. (2012) examine and verify the positive association between exports and an increase in the wages offered by firms in the cases of Mexico and Argentina. Both studies concern developing countries in which exports are mainly directed toward high-income countries characterized by a higher propensity to spend on quality. Their results imply that firms exporting to high-income markets need to upgrade the quality of export products and, for this reason, to increase the number of skilled workers employed. This circumstance generates a demand for skilled employees, which translates into an increase in average wages paid by firms.

This chapter is oriented within this context and intends to provide insights into the quality provision mechanism according to which production of high-quality products requires employment of skilled labor, which, in turn, demands higher wages. The study is conducted on the manufacturing sector over a set of 23 countries and 116 different industries. The analysis is, therefore, conducted at the country-industry level. The objective of the paper is to study the effect of export product quality upgrades on average wages paid to employees. The use of data at such a large scale does not allow us to distinguish the documented

1. A version of this chapter was presented at the ADRES conference 2021 in Strasbourg, France. In preparing this chapter, I have benefited from discussions with Stéphane Turolla, Carl Gaigné, Chantal Le Mouel, Zhihong Yu, Banu Demir and Thilo R. Huning.

2. Empirical studies on this issue include Bustos (2011), Kugler and Verhoogen (2012), and Verhoogen (2008).

3. See Goldberg and Pavcnik (2007).

effect across firms within the same industry. However, thanks to the broad coverage of our dataset, we are able to provide worldwide evidence of the quality provision mechanism.

In this paper, we develop a theoretical model that explains the mechanism whereby upgrades of the quality of export products entails employment of highly skilled workers. As wages paid to highly skilled workers are higher than average, the hiring of newly skilled employees affects the labor force composition within an industry and leads to an augmentation of average wages paid. As product quality corresponds to intangible product characteristics, one major challenge of this paper is to measure export quality. In this study, we infer quality from a demand equation following the methodology proposed in Khandelwal (2010). The quality measure obtained in this way corresponds to the residual of a demand function and is such that higher quality is assigned to products with higher market shares, conditional on price. In alignment with our theoretical framework, we propose an empirical strategy to estimate the effect of quality upgrades of export products on industry wage premia. To address endogeneity issues, we use an instrumental variable (IV) strategy that allows us to document a causal effect. Quality is instrumented with the change in demand for quality in the set of destinations where the country already exports. Demand for quality is proxied by the import value weighted by exporters' income per capita. The instrument proposed is based on the assumptions that high-income countries export high-quality products and that an increase in imports from rich countries corresponds to an increase in demand for quality.

We find a positive and significant causal relationship between quality upgrades of export products and wage premia at the industry level. Our results indicate that an industry that upgrades the quality of its export products by moving from the first quartile to the second quartile of the quality distribution shows an increase in its wage premium of 3.5%.⁴ Moreover, we find the effect of product quality upgrades on wage premia to be stronger for differentiated products and low-income countries. These additional results are likely to be explained by the fact that returns to investing in upper-grade quality are higher for highly differentiated products and that in low-income countries, the wage differential between low-skilled and high-skilled workers is larger. Our findings imply that industries that improve their export quality adjust their workforce composition toward better-paid work categories. The change in workforce composition due to export product quality upgrades has different implications. A rise in demand for skilled labor in developing countries could have beneficial effects on the countries' economic development. On the other hand, when quality upgrades involve a limited number of industries within a country, they could increase between-industry wage inequality.

4. A major issue with the quality measure obtained as a demand residual is that it cannot be interpreted according to its absolute value but only in terms of position on the quality ladder in a market.

The main contribution of this chapter is to provide evidence of the quality provision mechanism in a large panel of countries through the use of a direct measure of quality. Previous studies testing the relationship between export quality and wages have relied on proxies for quality, such as unit values or the income level in destination markets (Brambilla et al., 2012; Brambilla and Porto, 2016; Zhou and Zhang, 2021). While the positive correlation between unit values and quality and the fact that richer countries import high-quality products are well established in the literature, the use of such proxies has some limits. Unit values include factors such as costs relative to physical efficiency or pricing to market strategies that are not related to product quality. On the other hand, even in high-income countries, there is a market for imported products in low-quality segments.⁵

This chapter is closely related to the work of Brambilla and Porto (2016), which studies the importance of exporting to countries where quality is valued more and establishes a link between destination-country income and average wages paid at the industry level in the exporting country. In their paper, the authors explore two mechanisms: the quality valuation mechanism, whereby industries that export to high-income destinations export higher-quality goods, and the quality provision mechanism, whereby production of high-quality products requires the hiring of better-paid highly skilled employees. With respect to Brambilla and Porto (2016), which studies both mechanisms, we focus our analysis on the quality provision mechanism only. This chapter contributes to the literature on the relationship between export product quality and labor force composition. The seminal paper of Verhoogen (2008) examines wages offered by Mexican firms that increased their exports after the peso devaluation in 1995 and finds that firms exporting to the US are more skill intensive and pay, on average, higher wages to both skilled and unskilled workers. Using Argentinian data, Brambilla et al. (2012) show that Argentinian firms that increase exports to richer countries are characterized by higher skill composition of their workforce and, therefore, pay on average higher wages. Similarly, the study of Brambilla et al. (2019) explores the link between firm export status and demand for skilled tasks and finds that exporters use more skilled labor than non-exporters. Finally, the recent study of Zhou and Zhang (2021) finds that export expansion toward rich countries positively affects firm skill utilization and inter-regional skill migration in China.

Our study is also related to the literature on export specialization and country development. The seminal paper of Hausmann et al. (2007) points out that certain products are growth promoting and that countries that produce and export these kinds of products are likely to grow faster. The ability of developing countries to specialize in the production and export of products that permit knowledge and technological spillovers is seen as determinant of long-run economic growth (Hausmann et al., 2014). While several studies analyze the dynamics of industry specialization (Chiappini, 2014; Schott, 2003), inter-industry mobil-

5. See Martin and Mejean (2014).

ity (Ban, 2017) and the role of growth-promoting products in relation to country income trends, our analysis focuses on the upgrading of product quality as a potential determinant of wage increases.⁶ Sutton and Trefler (2016) proposes an interesting perspective in which country specialization across goods interacts with specialization within goods along the quality dimension. The paper develops a model in which changes in the capability to produce higher-quality products simultaneously affect the sector export mix.

This chapter also contributes to the broad literature on the effects of trade liberalization on country development. As trade liberalization can affect the domestic economic environment through many channels, the findings of this literature do not display a consensus. On the one hand, liberalization seems to increase productivity and therefore have a positive effect on wages (Goh and Javorcik, 2005; Kumar and Mishra, 2008); on the other hand, liberalization increases competition and, in turn, leads to a drop in the wage level of previously highly protected sectors (Feliciano, 2001; Goldberg and Pavcnik, 2005; Pavcnik et al., 2004). Interestingly in this context, the paper of Huchet-Bourdon et al. (2018) finds a minimum level of export quality under which trade can be detrimental to growth.

The remainder of this paper is organized as follows. In Section 2, we present the theoretical model describing the relationship between export quality and wages. In Section 3, we present the data used in the analysis and the estimation of quality as demand residual. In Section 4, we present the identification strategy and the main results. In Section 5, we present some robustness analysis, and Section 6 concludes.

2 Theory

In this section, we introduce a partial equilibrium model of exports and quality describing the relation between an export product quality upgrade and an increase in the average wage offered by a firm. The underlying mechanism implies that product quality depends on the combination of the technology level and employee skills. The capability of a firm to attract better-qualified employees is determined by the wages that it offers. As a consequence, to upgrade product quality, a firm needs to employ higher-quality workers and offer higher wages. The model is based on a representative monoproducer firm for a given exporting country. In the model, we assume competitive labor markets with no labor market frictions such that employees with the same level of skills and ability working in different industries are paid the same wage. An increase in the wages offered by a firm determines an increase in the share of highly skilled workers in the firm's labor force composition. The structure of

6. A number of studies point out the importance of country specialization in different quality segments. Schott (2004) observe that within-product specialization is at least as important as specialization across products. The papers of Schott (2008) and Rodrik (2006) analyze the export similarity of China and the US and find that both countries export the same products despite China being endowed with unskilled labor.

the model presented is based on the theoretical framework proposed by Verhoogen (2008) and reminiscent of its extended version in Brambilla and Porto (2016).

2.1 Demand

The demand system is derived from a discrete choice model of consumer behavior. We base the model on a simple utility specification that is still flexible enough to illustrate our main objectives. We assume that each representative firm from exporting country i exports only one type of product h , so that different varieties are indexed with ih . The discrete choice structure of the model implies that consumer n living in country j chooses the variety ih that provides her with the highest utility among all varieties available for a given industry k . We assume a nested logit framework that allows consumer tastes to be correlated across varieties of the same product and implies a more logical correlation structure of consumer preferences. Products h , therefore, represent the nests, while each variety ih corresponds to the alternatives within the nests. Following Berry (1994), the indirect utility provided by the consumption of variety ih is:

$$V_{nijh} = -\alpha \ln p_{ijh} + \ln \lambda_{ijh} + \sum_{h=1}^H d_{ih} \mu_{nh} + (1 - \sigma) \epsilon_{nijh}, \quad (\text{II.1})$$

where p_{ijh} corresponds to the price of the variety in country j and λ_{ijh} represents the quality of the variety.⁷ The quality of the variety corresponds to the quality perceived by consumers and can differ in each destination j . Indeed, consumer perceptions of product quality are influenced by a common national taste for specific product features. For example, in the market for bakery products, Mediterranean countries are used to lower quantities of butter than northern European countries, and it is likely that biscuits made with significantly high quantities of butter are perceived to be of higher quality in northern Europe than in the Mediterranean area. For these reasons, quality is indexed with ijh .

ϵ_{nijh} corresponds to the idiosyncratic preference of each consumer for a variety and captures heterogeneity in consumer tastes for horizontal attributes.⁸ The term $\sum_{h=1}^H d_{ih} \mu_{nh}$ is proper to the nested logit structure, where μ_{nh} is the common valuation of product h from consumer n and d_{ih} is a dummy variable equal to one when variety ih belongs to product h and has a distribution that depends on σ .⁹ The probability that variety ih has the highest valuation

7. The direct utility function is equal to $u_{nijh} = \ln(\lambda_{ijk} v_{nijh}^{(\sigma-1)} e^{\mu_{njh}})$, where v_{nijh} is assumed to be Fréchet distributed or extreme value type II with a cumulative distribution function equal to $\exp\{-(v/s)^{-\alpha}\}$, where α reflects the heterogeneity of consumer preferences and s corresponds to the scale parameter. We set $s = 1$ and $\alpha = 1$ by default. In the indirect utility function, $\epsilon_{nijh} = \ln v_{nijh}$; therefore, ϵ_{nijh} is distributed according to a type I extreme value distribution, also known as a Gumbel distribution, with a mean equal to zero and a scale parameter equal to 1.

8. λ_{ijh} can also be interpreted as the average appreciation of variety ih , while ϵ_{nijh} is consumer deviation from the average appreciation.

9. Cardell (1997) shows that if ϵ_{nijh} is distributed according to a type I extreme value distribution, there exists a unique distribution for μ_{nh} that depends on the parameter $0 < \sigma < 1$ such that $\mu_{nh} + (1 - \sigma)\epsilon_{nijh}$ is also type I extreme value distributed. The parameter σ is an approximative measure of correlation among the

across all import varieties depends on its price and quality relative to the other varieties and is:

$$P_{ijh} = \frac{(p_{ijh})^{-\frac{1}{1-\sigma}} (\lambda_{ijh})^{\frac{1}{1-\sigma}}}{D_h} * \frac{D_h^{1-\sigma}}{\sum_{h \in k} [D_h^{1-\sigma}]} = \frac{(p_{ijh})^{-\frac{1}{1-\sigma}} (\lambda_{ijh})^{\frac{1}{1-\sigma}}}{D_h^\sigma \sum_{h \in k} [D_h^{1-\sigma}]}, \quad (\text{II.2})$$

where $D_h = \sum_{ih \in h} (p_{ijh})^{-\frac{1}{1-\sigma}} (\lambda_{ijh})^{\frac{1}{1-\sigma}}$ corresponds to the probability of choosing a variety of products h among the set of all varieties of industry k .

2.2 Technology

Industries are heterogeneous along two attributes: their capability of producing quality for a given destination ξ_{ijh} , which reflects the technologies available for the production of product quality, and their productivity φ_{ih} , which corresponds to firms' efficiency in the physical production of output, conditional on quality. This twofold firm heterogeneity recalls the framework of Hallak and Sivadasan (2013), who distinguish between process productivity and product productivity, with the difference that in our model, the capability to produce quality varies across firms producing different products and is specific to each destination. The parameter ξ_{ijh} is interpreted as the entrepreneurial capacity to produce quality and is destination specific because it depends on knowledge of the market and consumer preferences in the destination country. Considering the previous example of bakery products, a firm may be capable of producing biscuits of superior quality with high quantities of butter but be unable to produce good-quality biscuits using low quantities of butter. This attitude corresponds to an entrepreneurial capability to produce high-quality products for northern European countries but not for Mediterranean countries. Labor is the only factor of production, and the production function of physical units is $x_{ijh} = \varphi_{ih} \ell_{ijh}$, where ℓ_{ijh} is the number of workers used for production of variety ih exported to country j . The cost of producing one unit of physical output is equal to $\frac{w_{ih}}{\varphi_{ih}}$, where w_{ih} is the average salary paid to employees in charge of producing product h . Input quality and firm capability are complements in determining output quality, as in Kugler and Verhoogen (2012). The quality production function of variety ih serving country j is:

$$\lambda_{ijh} = \left[\xi_{ijh}^{-\zeta} + \theta_{ih}^{-\zeta} \right]^{-\frac{1}{\zeta}}, \quad (\text{II.3})$$

where θ_{ih} refers to the capability to produce the quality of workers employed in the production of product h . The parameter ζ represents the degree of complementarity between industry technologies used to produce quality and employee capabilities. We assume $\zeta > 0$ such that the function of quality λ_{ijh} is log-supermodular in ξ_{ijh} and θ_{ih} . A higher ζ implies a higher level of complementarity between worker ability and firm capability. As in Ver-

alternatives in each nest and is assumed to be the same for all nests (see Train (2009)). When $\sigma = 1$, $\mu_{nh} = 0$, and the choice probability comes down to a standard logit.

hoogen (2008), employees' capability to produce quality, θ_{ih} , depends on the wages offered by the industry. The higher the wages offered, the better are the capabilities of employees:¹⁰

$$\theta_{ih} = \kappa_{ih}(w_{ih}/\bar{w}_i)^\eta, \quad (\text{II.4})$$

where w_{ih} is the average wages offered to employees producing variety ih while \bar{w}_i is average wages in country i . The ratio w_{ih}/\bar{w}_i corresponds to the wage premium, η corresponds to the elasticity of worker capabilities to the wages offered and κ_{ik} represents labor supply shocks.¹¹ The resulting firm profit function for a variety in each destination corresponds to:

$$\pi_{ijh} = \left(p_{ijh} - \frac{w_{ih}\tau_{ijh}}{\varphi_{ih}} \right) x_{ijh}, \quad (\text{II.5})$$

where $\tau_{ijh} > 1$ corresponds to the cost of exporting variety ih to destination j and is modeled as an iceberg trade cost.

2.3 Relationship between wages and average export quality

The firm problem in relation to the model introduced consists of choosing wages and prices such that profits are maximized. Firms maximize total profits by separately maximizing profits that it could potentially generate in each destination. A firm characterized by productivity φ_{ih} and capability of producing quality for a given destination ξ_{ijh} chooses the optimal wage w_{ih} and the optimal price p_{ijh} for country j .

$$\max_{w_{ik}, p_{ijh}} \pi_{ih} = \max_{w_{ik}, p_{ijh}} \sum_j \pi_{ijh} = \max_{w_{ik}, p_{ijh}} \sum_j \left(p_{ijh} - \frac{w_{ik}\tau_{ijh}}{\varphi_{ih}} \right) x_{ijh} \quad (\text{II.6})$$

Setting N_j equal to the number of consumers living in country j , x_{ijh} represents the export value of variety ih to destination j and corresponds to the probability of a variety being purchased multiplied by the number of consumers living in the destination country $x_{ijh} = p_{ijh}N_j$. The equilibrium price p_{ijh} and the wages at equilibrium w_{ih} are obtained by differentiating the first-order conditions with respect to the corresponding arguments using Equations (II.2), (II.4) and (II.3):

$$p_{ijh} = \frac{1}{\sigma} \frac{w_{ih}\tau_{ijh}}{\varphi_{ih}} \quad \text{and} \quad \left(\frac{w_{ih}}{\bar{w}_i} \right)^\eta = \left[\sum_j \frac{\tau_{ijh}x_{ijh}\lambda_{ijh}^\zeta}{\sum_j \tau_{ijh}x_{ijh}} \right]^{\frac{1}{\zeta}} \left(\frac{1}{\sigma} \eta \kappa_{ih} \right)^{\frac{1}{\zeta}}. \quad (\text{II.7})$$

The resulting price equation corresponds to a markup over the constant marginal cost and the iceberg trade cost. The equation on the right represents the wage premium as a function of the qualities perceived in each destination λ_{ijh} weighted by the export values and a series

10. A rise in wages can be interpreted as an increase in the share of skilled with respect to unskilled workers, as in Brambilla and Porto (2016), or, in the spirit of the O-ring model of Kremer (1993), as employment of more capable workers within the two categories, as in Verhoogen (2008).

11. Here, we consider labor supply shocks as exogenous shifts in the disutility of supplying labor.

of exogenous parameters. Since export product quality may be perceived differently according to the export destination, the relationship between export product quality and the wage premium can be puzzling. To provide a comprehensive and straightforward understanding of the relationship of interest, we define $\bar{\lambda}_{ih}$ as the average level of quality exported from country i for product h to all destinations:

$$\bar{\lambda}_{ih} = \left[\sum_j \frac{\tau_{ijh} x_{ijh} \lambda_{ijh}^{\zeta}}{\sum_j \tau_{ijh} x_{ijh}} \right]^{\frac{1}{\zeta}}. \quad (\text{II.8})$$

We argue that the weighted average quality perceived across all exporters, $\bar{\lambda}_{ih}$, represents a good indicator of the intrinsic quality of products exported with an industry. We define $\rho_{ih} = \frac{w_{ih}}{\bar{w}_i}$ as the industry wage premium. Taking the logs of Equation (II.7) and adding the temporal dimension t , we obtain our empirical model:

$$\ln \rho_{iht} = \frac{1}{\eta} \ln \bar{\lambda}_{iht} + \epsilon_{iht}, \quad (\text{II.9})$$

where the error term $\epsilon_{iht} = \frac{1}{\eta \zeta} \ln \left(\frac{1}{\sigma} \eta \kappa_{iht} \right)$. Equation (II.9) describes the quality provision mechanism, according to which the wage premium is a function of the average export product quality. The effect of quality on the wage premium depends on the elasticity of employee capabilities to the wages offered, η , which represents the responsiveness of worker capabilities to the offered wage. A high value of η implies that firms offering higher wages are more likely to attract more capable employees. Equation (II.9) also provides an understanding of the impact of the other factors included in the error term on the wage premium. Independently of the quality exported, the wage premium for the representative firm is affected by time-varying exogenous labor supply shifts. Our resulting final equation is based on the link between skilled labor, quality and wages, which represents the underlying structure of the quality provision mechanism. An increase in export quality requires the hiring of highly skilled and better-qualified employees, who, in turn, are expected to receive above-average wages.

3 Data and variables

3.1 Data

Data on country-level trade flows have been taken from BACI, a detailed international trade database made available by CEPII that covers a large number of countries and 5 000 products expressed in terms of Harmonized System (HS) (1996 revision) codes at the 6-digit level. The BACI dataset has been obtained by CEPII through a process of data harmoniza-

tion of import and export values reported by the Comtrade database.¹² In addition to import values, the data also record import weights, while prices are not directly reported. Each variety's unit values, calculated as the ratio of the value and weight of the trade flows and deflated using the consumer price index (CPI), are, therefore, used as a proxy for prices.¹³ Supplementary data on GDP, population and distance are taken from the CEPII gravity dataset. Data on industry characteristics are taken from the Industrial Statistics Database (INDSTAT 2) made available by the United Nations Industrial Development Organization (UNIDO). The INDSTAT 2 dataset reports annual data on output, total wages and salaries paid and total number of employees in each manufacturing industry. Overall, the database covers a total of 118 different manufacturing industries defined at the 4-digit level according to the International Standard of Industrial Classification (ISIC) revision 3 nomenclature, over a time range from 1995 to 2010. Although the INDSTAT 2 dataset covers a large number of countries, for many of those countries, the number of industries covered by the database is scant, which results in a highly unbalanced panel. For the current analysis, the panel is restricted to 23 exporting countries that report a balanced panel over at least 8 years between 1995 and 2008. Our sample includes the major exporting countries in the world and represents 60% of total world exports.¹⁴

3.2 Variables of interest

3.2.1 Wage premium

In Section 2, we describe the quality provision mechanism as the effect of export product quality on the wages offered by a representative firm producing a product from a specific country. Our data do not allow us to associate wages with a specific product defined at the 6-digit level. For this reason, we conduct our analysis using the average calculated at the industry level as a reference. Our sample is composed of a panel of 23 different exporters including high- and middle-income countries. Industry average wages run from the lowest of US\$ 2 900, recorded in 1995 in Ecuador, to US\$ 39 000, recorded in the United States (see Table A3 of the Appendix for more details). The objective of the following analysis is to provide an understanding of the main aspects that determine industry-level wages and explain the relevance of the use of the wage premium as our variable of interest. In Table 1, the industry average wage, $\ln w_{ikt}$, is regressed on a combination of exporter-year and industry-year fixed effects to distinguish the contribution of each dimension in determining the wage level.

12. The process of harmonization done by CEPII takes into account the reliability of importer and exporter declarations and allows researchers to work with better data with wide country coverage. See Gaulier and Zignago (2010) for further details.

13. CPI (2010 = 100) data are from the World Bank database.

14. Tables A1 and A2 of the Appendix describe the countries and the number of industries per country included in the analysis.

Table 1: Variance analysis of the average wage per capita at industry level

	Explained variable: $\ln w_{ikt}$		
	(1)	(2)	(3)
Constant	9.654*** (0.002)	9.654*** (0.007)	9.654*** (0.001)
FE exporter-year	Yes	No	Yes
FE industry-year	No	Yes	Yes
R-squared	0.928	0.092	0.969
Observations	25,168	25,162	25,162

Significance levels: ***0.01 **0.05 *0.10. Regressions cluster standard errors by exporter-industry.

The results in Table 1 indicate that 92.8% of the average wage at the industry level is determined by common exporter-year factors. This finding implies that wages follow a common national trend related to country growth as well as the common legislation to which wages are subject. Coherently with our theoretical model presented in Section 2, we derive the industry wage premium as the difference between the log wage at the industry level and its average at the country level $\ln \rho_{ikt} = \ln w_{ikt} - \ln \bar{w}_i t$. While the use of the wage premium allows us to isolate our variable of interest from common factors affecting all wages at the country level, there are also common determinants at the industry level that significantly affect wages. In particular, wages are likely to be correlated with industry technological intensity. Several studies in development economics analyze the impact of specialization on the production of products with high technological content in economic development (Hausmann et al., 2007; Sutton and Trefler, 2016). Technologically intensive industries such as chemical manufacturing are likely to require more qualified workers than, for example, the textile industry. As a consequence, the labor force composition in the case of chemical manufacturing is likely to be more skewed toward high-skilled employees. For this reason, we expect the wage premium to increase with the intensity of technology in the industry. In Table 2, we regress the industry wage premium against different measures of technological intensity.

In Table 2, Column (1) presents the results of the estimation of the industry wage premium on a dummy tech_k , which sorts industries into three categories according to their technological intensity: high, medium and low. The three categories are derived from UNIDO's classification of manufacturing sectors by technology in Van den Anandel et al. (2010). The reference for the regression is the low technological intensity category. We observe that the wage premium increases with the level of technology in the industry. In the second column of Table 2, we analyze the correlation between the average industry wage premium and the PRODY index of sophistication, derived as in Hausmann et al. (2007). The index $\text{prody}_k = \ln \sum_i \frac{x_{ik}/X_i}{\sum_i x_{ik}/X_i} * \text{GDP}/\text{cap}_{i,2000}$ corresponds to the weighted average GDP per capita of countries exporting products from a given industry and thus represents the income level

Table 2: Correlation between industry wage premium and measures of technology sophistication

	Explained variable: $\ln \rho_{ikt}$	
	(1)	(2)
I.medium tech _k	0.213*** (0.005)	
I.high tech _k	0.276*** (0.004)	
prody _k		0.109*** (0.006)
Constant	-0.152*** (0.003)	-1.508*** (0.089)
FE exporter-year	Yes	Yes
R-squared	0.168	0.013
Observations	25,168	25,168

Significance levels: ***0.01 **0.05 *0.10. Independent variable corresponds to the log of the wage premium. Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

associated with that industry.¹⁵ The numerator x_{ik}/X_i represents the average export value of source country i for industry k during the time period over the total export of manufacturing products X_i . The denominator $\sum_i x_{ik}/X_i$ aggregates the value shares across all countries exporting products from industry k . Hence, the PRODY index represents a weighted average of the per capita GDPs of exporters for a given industry k . A high measure of $prody_k$ indicates that for a given industry, a large part of world exports come from high-revenue countries and, therefore, that the industry is likely to be characterized by a high technological endowment. The coefficient of the variable $prody_k$ is positive and significant, which indicates that industries using more sophisticated technologies pay higher wages on average. These findings reveal the extent to which the level of industry wages depends on country and industry factors. As the main objective of this study is to analyze the impact of quality on the average wages offered within an industry, the empirical model that we design in Section 4 takes those elements into account.

3.2.2 Quality estimation

Quality is an intangible element of goods and is very difficult to measure, especially for aggregates of different types of products. Beyond a few studies conducted on the export of specific products,¹⁶ the literature on international trade often relies on different types of proxies for quality. Unit values have been widely used in this context, although they also reflect other characteristics such as differences in pricing strategies and costs due to efficiency

15. The PRODY index has no temporal dimension, as it is intended to measure a generic degree of industry sophistication during the entire period under analysis. The reference year in our case for the measure of GDP per capita is 2000.

16. The works of Crozet et al. (2012) and Chen and Juvenal (2016), for example, use expert wine ratings as a direct measure of quality.

in the production process. While unit values have proved to perform poorly as quality proxies for products with a low scope for quality differentiation, the studies of Khandelwal (2010) and Khandelwal et al. (2013) provide different strategies to estimate quality as a demand residual. In this study, we rely on the methodology proposed by Khandelwal (2010), and we derive the export quality for each variety in each destination. Quality is measured such that conditional on prices, the larger the market share of a product, the higher is the quality. The quality estimated corresponds, therefore, to quality as perceived by consumers. From Equation II.2, we derive the demand for variety ih in country j . Like Berry (1994) and Khandelwal (2010), we complete the demand system with an "outside" variety that has mean utility normalized to zero. The outside variety corresponds in our case to domestically produced goods and allows consumers the possibility of not purchasing any of the imported varieties. We obtain the market share of domestically consumed products by subtracting exports from total production. The demand function is estimated for each market corresponding to an importer-industry pair. The total number of regression runs is equal to 1916. For the sake of clarity, we keep the indexation for importer j and industry k as we aggregate the measure of quality obtained across different importing countries in the following step. The demand function estimated is:

$$\ln(s_{ijht}) - \ln(s_{0kt}) = \lambda_{1,ijkt} + \lambda_{2,jh} + \beta_1 \ln p_{ijht} + \beta_2 \ln(s_{ijht|H}) + \lambda_{3,ijht}. \quad (\text{II.10})$$

The market share of variety ih in destination j is defined as s_{ijht} , while we refer to the market share of the outside variety with s_{0kt} . On the right-hand side of the equation, p_{ijht} corresponds to the price of variety ih , while the term $\ln(s_{ijht|H})$ is a specification that derives from the nested logit structure of the utility and corresponds to the market share of the variety ih within product h . $\lambda_{1,ijkt}$ corresponds to an exporter-year fixed effect, $\lambda_{2,jh}$ is a product fixed effect, and $\lambda_{3,ijht}$ is the error term. The rationale behind the choice of this combination of fixed effects is that the fixed effect $\hat{\lambda}_{1,ijkt}$ represents the industry-year component of quality for exporter i and allows us to capture the quality as perceived in country j of the products of industry k exported by country i . We build our measure of export quality at the industry level on $\hat{\lambda}_{1,ijkt}$. The estimated quality of variety ih in destination j is equal to $\ln \hat{\lambda}_{ijht} = \hat{\lambda}_{1,ijkt} + \hat{\lambda}_{2,jh} + \hat{\lambda}_{3,ijht}$.

Since $\ln p_{ijht}$ and $\ln(s_{ijht|H})$ are likely to be correlated with the error term, we use an IV strategy to obtain consistent estimates of the import demand model. Price is instrumented through the weighted average price of variety ih in other destination countries j . Under the hypothesis that each variety shares common production costs, the price charged for the same type of product in other destinations constitutes a valid predictor of the price of the variety and is likely to be uncorrelated with specific country demand shocks. As in Khandelwal (2010), we instrument the variety market share within its nest $\ln(s_{ijht|H})$ with two count variables: the number of varieties imported within product h by the importer and

the number of destinations to which the exporting country exports variety ih .¹⁷

Starting from the fixed effect exporter-year $\hat{\lambda}_{1,ijkt}$, which is destination-industry specific, as the demand system is estimated for each destination-industry, we obtain a measure of quality at the exporter-industry level as in Equation II.8 in the theoretical section. Following Equation II.8 in Section 2, we set the substitution parameter between industry technology and employee capabilities $\zeta = 1$, and we calculate the average export quality of each exporter-industry-year triplet as $\ln \bar{\lambda}_{ikt} = \ln \sum_{j \in J} \frac{\tau_{ijh} x_{ijkt} \hat{\lambda}_{ijkt}}{\sum_{j \in J} \tau_{ijh} x_{ijkt}}$. The number of countries included in J includes only large exporters for the following reason. The measure of quality $\hat{\lambda}_{ijkt}$ corresponds to the product quality for industry k relative to that of all other varieties imported. An important determinant of quality measured is, therefore, the quality of competing varieties imported from other countries. Assuming that large countries import products from a large number of exporters, the market size in destination countries is crucial for obtaining a measure of quality comparable across markets and not biased by a restricted range of varieties imported. Suppose that quality is estimated in a small importing country such as Slovenia; the number of importing varieties for an industry is likely to be small, and as a consequence, the estimated quality $\hat{\lambda}_{ijkt}$ depends mainly on the characteristics of the few competing varieties. For this reason, we opt to estimate export quality in specific importing markets that represent the largest world exporters during the period under consideration. These countries are Australia, Canada, China, Belgium, Germany, Spain, France, the United Kingdom, Indonesia, India, Italy, Japan, South Korea, Malaysia, Mexico, the Netherlands, Turkey, Ukraine, and the United States and account for 67.8% of total world imports during the period under analysis. We obtain in this way a measure of quality for each exporter and industry in our sample; the measure corresponds to the weighted average quality perceived in the large markets to which a country exports.¹⁸

Trade in high-quality products is characterized by a number of currently acknowledged factors. The objective of the following analysis is to verify that the measure of quality obtained is coherent with well-established trade dynamics reported in several studies. Following the seminal intuitions of Linder (1961) and Alchian and Allen (1964), a considerable number of studies find that richer countries import higher-quality products (Bastos et al., 2018; Hallak, 2006) and that because per-unit transportation costs decrease with product quality, high-quality products are more likely to be exported to more distant destinations Bastos and Silva (2010), Emlinger and Lamani (2020), and Hummels and Skiba (2004). Table 3 displays the correlation between the measure of quality obtained and unit values, export exposure to high-income destinations and average distance of export. In Column (1) of Table 1, we analyze the relationship between export quality and exposure to high-income destinations, measured as $g_{ikt} = \ln \left(\sum_j s_{ijkt} * GDP/cap_{j,1995} \right)$, where s_{ijkt} corresponds to the export share

17. Details on the quality estimation results are reported in Table B1 of the Appendix.

18. The use of actual market shares as weights in the calculation of quality at the exporter-industry level is subject to endogeneity since quality and market shares can be correlated. We discuss this issue in the additional results section.

of destination j for industry k in source country i . The measure of exposure to high-income destinations is obtained as in Brambilla and Porto (2016). As expected, we observe a positive correlation between quality and the share of exports to high-income countries. In Column (2), we analyze the correlation between quality and the weighted average distance that products are exported, calculated as $\ln distance_{ikt} = \sum_{h \in k} \sum_j \ln distance_{ihjt} * \omega_{ijht}$, where ω_{ijht} corresponds to the share of exports of variety ih to country j relative to the total exports of exporter i for industry k . The coefficient of distance is positive and significant, which indicates that industries exporting higher-quality products export to more distant countries on average. We then analyze the correlation between quality and unit values. In Columns (3) and (4), we analyze the correlation between quality and the average unit values of exports. In Column (3), unit values are measured as total exports in terms of value over total exports in terms of weight for the exporter-industry pair. In Column (4), we instead use an index that takes into account unit values at the product level. The index I_{ikt}^{uv} corresponds to the weighted average of deviations between the variety's unit value and the average unit value of competing varieties in the same market and aggregated at the industry-exporter level. It is calculated as $I_{ikt}^{uv} = \sum_j \sum_{h \in k} [(\ln uv_{ihjt} - \ln \bar{uv}_{hjt}) * \omega_{ijht}]$, where ω_{ijht} corresponds to the share of exports of variety ih with respect to total exports within industry k for country i and \bar{uv}_{hjt} is the average unit value of imported varieties ih in country j for product h . When this price measure is positive, the average price of the varieties exported by a country is higher than the average price at which the varieties are sold. We observe that in both Columns (3) and (4), the correlation between unit values and quality is positive and significant.

Table 3: Correlations between quality of exports, income, unit values and distance

	Explained variable: $\ln \hat{\lambda}_{ikt}$			
	(1)	(2)	(3)	(4)
g_{ikt}	0.035*** (0.011)			
$\ln distance_{ikt}$		0.129*** (0.009)		
$\ln uv_{ikt}$			0.102*** (0.011)	
I_{ikt}^{uv}				0.111*** (0.007)
Constant	-0.112 (0.108)	-0.738*** (0.071)	0.267*** (0.005)	0.067*** (0.011)
FE exporter-year	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes
R-squared	0.437	0.440	0.438	0.441
Observations	30,544	30,544	30,544	30,544

Significance levels: ***0.01 **0.05 *0.10. Dependent variable corresponds to the log of the exported quality at industry level. Regressions cluster standard errors by exporter-industry.

4 Empirical analysis and results

In this section, we present our empirical strategy, which aims to assess the causal relationship between export product quality upgrades and the average wage premium at the industry level. Our empirical analysis refers to the theoretical framework presented in Section 2 and, in particular, the findings reported in Equation II.9. We begin with an analysis of the relationship between wages and export quality through an ordinary least squares (OLS) analysis. Then, we propose an IV strategy to assess causality.

4.1 Empirical model

The objective of the empirical model is to capture the effect of export product quality on average wages. We analyze the relationship between wages and quality using first differences, which allows us to control for the time-invariant characteristics of an exporter-industry pair. Motivated by the theoretical finding of Equation II.9, our baseline model analyzes the impact of a quality upgrade in industry k on the average wages paid in the exporting country at the industry level.

$$\Delta premium_{ikt} = \beta_1 + \beta_2 \Delta \widehat{quality}_{ikt} + \Delta \mathbf{X}'_{ikt} \beta_3 + \phi_{it} + \phi_{kt} + \epsilon_{ikt}$$

Here, the dependent variable corresponds to the difference between the log wage premium and its value lagged by one year $\Delta premium_{ikt} = \ln \rho_{ikt} - \ln \rho_{ikt-1}$. The change in quality between year t and year $t - 1$ corresponds to $\Delta \widehat{quality}_{ikt} = \ln \bar{\lambda}_{ikt} - \ln \bar{\lambda}_{ikt-1}$. ϕ_{it} and ϕ_{kt} correspond to industry-year and exporter-year fixed effects. This combination of fixed effects allows us to control for time-varying unobserved factors specific to an industry or an exporting country that may affect the wage premium, such as the spread of new technologies available worldwide and all factors that could impact wages at the country level. The model parameters are therefore identified uniquely by changes at the exporter-industry scale.

The vector \mathbf{X}' includes a set of variables controlling for the relative trade intensity and productivity of an industry. We control for trade intensity motivated by the studies highlighting the impact of sector liberalization on the labor market, which has received particular attention in the case of developing countries (Goldberg and Pavcnik, 2007), while our inclusion of productivity is explained by our theoretical model, which predicts that more productive firms maximize their profits when they produce higher-quality products. In this regard, some studies provide empirical evidence on the interrelation between firm productivity and export product quality (Kugler and Verhoogen, 2012; Verhoogen, 2008). Standard errors ϵ_{ikt} are clustered to control for serial correlation across the same group within the exporter-industry pair.

Table 4 reports the results of the OLS estimation. In Column (1), we report the results of the regression of changes in the wage premium on the first differences of quality, conditional only on the set of fixed effects. The coefficient is positive and significant, which indicates that an industry that upgrades the average quality of its exports across all destinations increases its average wages offered relative to both the national average and the industry average worldwide. In Column (2), we use the difference in the degree of trade openness as a proxy for the degree of protection of the industry. The degree of openness of an industry is measured as $openness_{ikt} = \ln \frac{import_{ikt} + export_{ikt}}{production_{ikt}}$ and is intended to measure industry exposure to international competition. Greater openness has a twofold implication for domestic firms. They are subject to tougher competition from foreign varieties in the domestic market, and at the same time, they have a higher propensity to participate in export activities, which makes them more exposed to competition in international markets. We observe that there is a negative correlation between an industry's degree of openness and the wages it offers on average, which implies that the more protected an industry (or the lower the trade openness), the higher is the wage premium. This is related to the competitive effect of globalization, which leads to a decrease in wage protections (Feliciano, 2001; Goldberg and Pavcnik, 2005; Pavcnik et al., 2004)). In Column (3), we add an interaction term for the difference in industry openness and exporter GDP per capita, and we observe that the negative effect of openness on the industry wage premium decreases with exporter income per capita. In line with the literature, the negative effect of trade openness on the income level is particularly relevant for developing countries. In Column (4), we include the first difference of log exports expressed in log terms. As outlined by Matsuyama (2007) and Brambilla et al. (2012), the activity of exporting includes international marketing, advertising and distribution, which require the hiring of qualified labor. In Column (5), we control for changes in industry productivity, measured as log output per worker. According to the model that we introduced, more productive firms are likely to produce higher-quality products.¹⁹ We observe a positive correlation between the two variables, which implies that the benefits of an increase in productivity are likely to be shared with employees.²⁰ While the effect of productivity is strong and significant, the inclusion of the covariate makes the variable $\Delta \widehat{quality}_{ikt}$ no longer significant. This implies that the changes in product quality and productivity shocks are strongly correlated and that the results obtained in Columns (1) to (4) are likely to be confounded by productivity shocks. In Column (6), we include all covariates and observe that the effects of all other covariates are confounded by industry productivity shocks. There are several other variables that represent potential sources of endogeneity that is likely to bias the results of the OLS regression. To address this endogeneity and obtain more consistent results, we rely on an IV approach.

19. Several studies point out that more productive firms tend to produce higher-quality products (Crinò and Epifani, 2012; Kugler and Verhoogen, 2012).

20. This result is in line with the literature on rent-sharing (Card et al., 2018).

Table 4: Results baseline regression with Fixed Effects

	Explained variable: $\Delta premium_{ikt}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta quality_{ikt}$	0.007** (0.003)	0.010*** (0.004)	0.009** (0.004)	0.007* (0.004)	0.005 (0.003)	0.005 (0.003)
$\Delta openness_{ikt}$		-0.054*** (0.007)	-0.192*** (0.047)			-0.000 (0.009)
$\Delta openness_{ikt} * \ln gdp/cap_{it}$			0.015*** (0.005)			
$\Delta export_{ikt}$				0.007*** (0.003)		0.004 (0.006)
$\Delta productivity_{ikt}$					0.223*** (0.021)	0.223*** (0.024)
Constant	-0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	-0.000 (0.001)	-0.015*** (0.001)	-0.015*** (0.002)
FE exporter-year	Yes	Yes	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.102	0.125	0.129	0.103	0.218	0.218
Observations	23,287	21,586	21,586	21,593	21,586	21,586

Significance levels: ***0.01 **0.05 *0.10. Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

4.2 Instrumental analysis

The OLS-fixed effects (OLS-FE) regression controls for all factors related to the exporter and the industry through fixed effects and for factors related to trade intensity and productivity through covariates. Nonetheless, our empirical model is likely to be subject to problems of endogeneity because of omitted variables and reverse causality issues. As pointed out by Brambilla and Porto (2016), unobserved productivity shocks not captured by labor productivity ($\Delta productivity_{ikt}$) could lead to an increase in firm profits and, when shared with workers, increase wages. As a consequence, this would lead to an upward bias of the estimation of β_2 . Another factor of concern consists of all major common changes in firm fixed or transportation costs, which affect the zero-profit productivity cutoff to export. Assuming that a drastic increase in export duties makes the productivity cutoff to export higher, this would leave firms with lower productivity within an industry out of the export market. The remaining firms would be the most productive ones and, probably, the ones exporting high-quality products and paying higher wages. For this reason, an augmentation of costs to export could at the same time increase the average wages paid within an industry and the average quality of exports because it leaves less productive firms out of the exporting market. In addition, an aspect for which our empirical model does not control is the effect of unions in certain sectors, which could also generate above-market wages and an upward bias of β_2 . Another factor likely to have an impact on wages and export quality is changes in sector-level R&D expenditure. On the one hand, an increase in R&D expenditure leads to an augmentation of the average salary, as R&D tasks are likely to be performed by better-

paid specialized employees. On the other hand, R&D improvements could lead to a quality upgrade without requiring the hiring of higher skilled workers for the production process. Along with omitted variable bias, there could be a reverse causality problem. Suppose that there is a labor market reform that increases the average wages offered in an industry and that as a consequence, more talented and highly skilled workers choose to work in that industry. Thanks to the arrival of better-qualified and more talented workers, the quality of the goods produced and exported could conceivably improve. This would generate a reverse causality effect, as the increase in product quality is an indirect consequence of the increase in wages. Finally, our measure of quality corresponds to the quality perceived by consumers in importing markets and includes factors other than purely intrinsic product quality, such as taste or reliability, which could induce consumers to prefer one variety instead of another. If, for example, an international media scandal related to product safety were to lead to a decline in trust (or confidence) in an industry's export products abroad, this would decrease the quality of those products perceived abroad with no concrete product quality changes.

To determine the causal effect of quality upgrades on wage growth, we follow an instrumental strategy. We need to find an instrument that partially explains the changes in export quality and is independent of changes in the average level of wages offered. The idea behind our instrument for quality upgrades is related to the Linder hypothesis, according to which two countries with similar income levels are more likely to trade with each other because they produce products of similar quality. As highlighted in the works of Schott (2004) and Hummels and Klenow (2005), the Linder hypothesis implies that high-income countries are more likely to produce and export high-quality products.

The instrument that we propose is intended to proxy the *change in demand for quality* of export products in destinations to which country i is already exporting. The instrument corresponds to the weighted average of changes of imports of products competing with those of industry k in each destination j , where the changes in imports are weighted by exporter GDP per capita. We turn to an example to explain the logic behind the choice of this instrument. Suppose that Germany produces cars of good quality that are exported to the US. Based on the Linder hypothesis, we assume that high-income countries export high-quality cars, so when the US increases its imports of cars from high-income countries, its appreciation for quality in the car industry increases as well. In this situation, the change in demand for cars in the US incentivizes car producers in Germany to upgrade the quality of exported cars. In contrast, if the US increases its imports of cars from low-income countries, demand for cars in the low-quality segment increases. In this case, appreciation for high-quality German cars should be stable or decrease, and German exporters would have no incentive to upgrade the quality of their cars.

The instrument is obtained as follows:

$$\Delta \widehat{quality}_{ikt} = \sum_{j \in J} \omega_{ijkt} * \left[(demand_{ijkt} * g_{ijkt}) - (demand_{ijkt-1} * g_{ijkt-1}) \right],$$

where $demand_{ijkt}$ denotes the demand for products of industry k from exporter i in country j and is proxied by the total value of imports of competing varieties. It is measured as $demand_{ijkt} = \ln \sum_{i' \neq i} imports_{i'jkt}$ and corresponds to imports of products belonging to industry k in country j from countries $i' \neq i$. $demand_{ijkt}$ is weighted by $g_{ijkt} = \ln \left(\sum_i s_{ijkt} * GDP/cap_{it} \right)$, which corresponds to the average log GDP per capita of the exporters for a given industry k in country j , weighted by s_{ijkt} , which corresponds to the share of imports from country i over total imports. When country j increases its share of imports from high-income countries, the value of g_{ijkt} increases accordingly. Finally, ω_{ijkt} corresponds to $\frac{x_{ikjt}}{\sum_j x_{ikjt}}$ and represents the share of exports of industry ik to country j over overall industry exports. The instrument proposed is likely to be exogenous, as changes in demand for a product in destination countries are likely to be unrelated to changes in the wages offered in the exporting country.

Table 5 reports the results of the baseline model using the instrumental regression strategy. The results reported replicate the specifications from Table 4. From Columns (1) to (5), we instrument the change in export quality with the change in demand for quality. The results indicate that the coefficient of quality is positive and significant for all specifications, including the case in which we control for productivity changes. The coefficient for $\Delta quality_{ikt}$ is larger than the one obtained through the OLS estimation, which indicates that the OLS regression biased the coefficient downward. The F-statistic and Sanderson-Windmeijer (SW) first-stage χ^2 tests of underidentification and weak identification indicate that the instrument is relevant. The coefficient reported in Column (5) corresponds to $\beta_2 = 0.130$ and indicates that an industry that upgrades its export product quality by moving from the first quartile to the second quartile of the quality distribution shows an increase in the wage premium of 3.5%. In Column (6), we add another instrument that corresponds to the change in the industry average distance of exports and is measured as $\Delta \tilde{\lambda}_{ikt} = \ln distance_{ikt} - \ln distance_{ikt-1}$, where the average distance is calculated as $\ln dist_{ikt} = \sum_{h \in k} \sum_j \ln distance_{ihjt} * \omega_{ijkt}$. The idea of using changes in the distance is based on the Alchian-Allen effect, according to which better-quality products are likely to be exported greater distances. In Column (6), we observe that adding the change in the average distance does not considerably increase the relevance of the instruments, as the χ^2 statistic increases from 30.9 to 32.1. Adding a second instrument, however, allows us to perform the Sargan-Hansen test, also known as the Sargan J test, which is a test of overidentifying restrictions used to ensure the exogeneity of the instruments used. As expected, the p-value of the Sargan J test is well above the critical values, which indicates that we cannot reject the null hypothesis that our instruments are not correlated with the error term.

Table 5: Results of the instrumental variable regression

	Explained Variable: $\Delta premium_{ikt}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta quality_{ikt}$	0.117** (0.052)	0.125*** (0.045)	0.101** (0.047)	0.122*** (0.043)	0.130*** (0.048)	0.134*** (0.049)
$\Delta openness_{ikt}$		-0.059*** (0.007)			-0.000 (0.009)	-0.000 (0.009)
$\Delta export_{ikt}$			-0.004 (0.006)		-0.010 (0.008)	-0.011 (0.008)
$\Delta productivity_{ikt}$				0.220*** (0.021)	0.220*** (0.024)	0.220*** (0.024)
FE exporter-year	Yes	Yes	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	-0.105	-0.083	-0.072	0.016	0.001	-0.006
Observations	23,287	21,586	21,593	21,586	21,586	21,586
F-test	31.437	32.812	27.443	34.267	28.211	14.748
SW χ^2 -test	33.972	35.453	29.652	37.026	30.486	31.876
J stat p-val						0.817

Significance levels: ***0.01 **0.05 *0.10. Two steps least squares regression where change in the quality of exports is instrumented with the change in the demand for quality in importing countries. Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

4.3 Additional results

In this section, we argue that the magnitude of the documented causal effects may be influenced by different factors. For this reason, we provide further insights into the quality provision mechanism, with a focus on the degree of product differentiation and the income level of the exporting country. First, we expect to see a stronger impact of changes in quality on the wage premium for products and industries with a large scope for quality differentiation, as the returns to investing in quality upgrades are higher. Second, we separate the effect of export quality upgrades on wages between high- and low-income countries and analyze in which case the effect is stronger. Since high-income countries are likely to have more rigid labor markets and higher minimum wages than low-income countries, we expect the documented effect to be stronger for the latter. To analyze these effects, we use 3 different dummies that split our sample into two groups. For each dummy generated, the model that we analyze is the following (D indicates a generic dummy):

$$\Delta premium_{ikt} = \beta_1 + \beta_2 \Delta \widehat{quality}_{ikt}(D) + \beta_3 \Delta \widehat{quality}_{ikt}(1 - D) + \Delta \mathbf{x}'_{ikt} \beta_4 + \phi_{it} + \phi_{kt} + \epsilon_{ikt}.$$

The first dummy distinguishes industries with a preponderance of differentiated products and industries where part of their exports include homogeneous products. To identify the two groups, we rely on the classification in Rauch (1999), which separates products into three categories: homogeneous products, products with a reference price on trade markets and differentiated products. For each exporter industry, we are able to calculate the per-

centage of differentiated products exported over the total. The dummy variable D_{ik} is equal to 1 if the percentage of differentiated products exported within industry k by exporter i is above the average. The results of this regression are reported in Column (1) of Table 6 and indicate that the effect is more important for differentiated products. We add evidence on this effect using the quality ladder as a measure of the scope for quality differentiation. For a given industry, the ladder is calculated as the average of the interdecile ranges of quality estimated in each importing country $\hat{\lambda}_{ijkt}$ and has an industry and time dimension.²¹ In Column (2), we report the results of the regression where the dummy $L_{kt} = 1$ when the quality ladder is above the average. The results confirm that when the quality scope is large, the effect of quality upgrades on wage changes is stronger. The third dummy is related to the GDP per capita of the exporting country and is meant to analyze whether the wage effect is more important in low- or high-income countries. The dummy $G_{it} = 1$ when exporter i has a GDP per capita larger than the sample average.²² We observe that the documented effect is stronger for low-income countries, which indicates that when low-income countries increase their export product quality, the extent to which wages increase is larger than that in high-income countries. This effect is probably because low-income countries often exhibit less regulated labor markets and that the salary differences between unskilled and skilled workers are more pronounced. To substantiate the findings in Column (3), in Column (4), we add the $\ln \text{gdp/cap}$ in interaction with $\Delta \widehat{quality}_{ikt}$ instead of using a dummy variable. The result confirms our findings in Column (3).

21. The results are robust when we use the range calculated as the difference between the maximum and the minimum to define the quality ladder.

22. The results are also robust to use of the median as the cutoff.

Table 6: Results of the instrumental variable regression - Additional results

	Explained variable: $\Delta premium_{ikt}$			
	(1)	(2)	(3)	(4)
$\Delta quality_{ikt} * diff_k$	0.143** (0.058)			
$\Delta quality_{ikt} * homog_k$	0.108** (0.047)			
$\Delta quality_{ikt}(L)$		0.130** (0.057)		
$\Delta quality_{ikt}(1-L)$		0.119** (0.051)		
$\Delta quality_{ikt}(G)$			0.097** (0.044)	
$\Delta quality_{ikt}(1-G)$			0.146*** (0.056)	
$\Delta quality_{ikt}$				0.456** (0.226)
$\Delta quality_{ikt} * \ln gdp/cap_{it}$				-0.035* (0.021)
$\Delta export_{ikt}$	-0.010 (0.008)	-0.009 (0.008)	-0.008 (0.008)	-0.008 (0.008)
$\Delta openness_{ikt}$	0.000 (0.009)	-0.000 (0.009)	0.001 (0.009)	0.002 (0.009)
$\Delta productivity_{ikt}$	0.220*** (0.024)	0.220*** (0.024)	0.221*** (0.024)	0.221*** (0.024)
FE exporter-year	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes
R-squared	0.006	0.022	0.013	-0.016
Observations	21,586	21,586	21,586	21,586

Significance levels: ***0.01 **0.05 *0.10. Two steps least squares regression where change in the quality of exports is instrumented with the change in the demand for quality in importing countries. The instrument is interacted with the dummies in columns (1) to (3) and with the interaction variable in column (4) in the same way as the variable $\Delta quality_{ikt}$. Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

5 Robustness

In the following section, we provide additional support for the quality provision mechanism through different robustness tests.

5.1 Alternative instruments

In this part, we perform the same IV regression but instrument the variable $\Delta \widehat{quality}_{ikt}$ with a different set of variables to verify the robustness of our results to alternative instruments. We refer to the instrument used in the main section as the preferred instrument. Table 7 reports the results of the regressions using the alternative instruments. In Column (1), we use our preferred instrument, with the difference that the changes in imports for country j are

weighted by the GDP per capita of the exporter for 1995. In other words, the weights g_{ijkt} are obtained using $g_{ijkt} = \ln\left(\sum_i s_{ijkt} * GDP/cap_{i,1995}\right)$. In this way, the instrument is built such that it is not affected by changes in exporters' GDP per capita but only by changes in the share of imports. Our results are not affected by this alternative definition of g_{ijkt} . In the previous section, we assume that the change in demand for quality in the importing countries and the change in export quality occur during the same year. We can imagine that firms need time to adapt to changes in demand from abroad and that the upgrading of product quality could be a process that requires more than one year. In line with this intuition, in Column (2), we instrument the change in export quality with the change in demand for quality from the previous year, which corresponds to the preferred instrument lagged by one year. We observe that the SW first-stage χ^2 and F-statistics are significantly lower than those for the instrument presented before, while the results of the coefficients seem to be larger. This indicates that the lagged instrument is less relevant but is still capable of capturing part of the changes in export quality. In Columns (3) and (4) of Table 7, we instead use a variant of the proposed instrument that is also inspired by the Linder hypothesis and successive studies pointing out that high-income countries tend to import high-quality products because their population values quality more (Bastos et al., 2018; Hallak, 2006). In this case, we measure the change in demand for export product quality with the change in demand in destination countries weighted by their income. This variant of the instrument basically assumes that high-income countries import high-quality products and that when demand for exports increases more in high-income countries than in low-income countries, firms are incentivized to upgrade their export quality. The instrument is obtained as follows:

$$\text{Variant: } \Delta \widehat{quality}_{ikt} = \sum_{j \in J} \left(\omega_{ijkt} * (\ln demand_{jkt} - \ln demand_{jkt-1}) * \ln GDP/cap_{jt} \right).$$

For our preferred instrument presented in Section 4, $demand_{ijkt}$ denotes demand for products of industry k from exporter i in country j and is measured as $demand_{ijkt} = \ln \sum_{i' \neq i} imports_{i'jkt}$. The variable GDP/cap_{jt} corresponds to the GDP per capita of importer j . In Column (4), we use the same instrument with the difference that income per capita is fixed to that in the first year of our analysis, namely, 1995. The change in demand for an industry is therefore weighted by $\ln GDP/cap_{j,1995}$ in Column (4). Conceptually, the instruments used in Columns (3) and (4) represent the change in demand for exports from industry k for exporter i weighted by the income per capita of importer j . The underlying mechanism that relates the change in export quality and the instrument is that if demand for exports for country i increases in high-income destinations, relative demand for quality also increases. The results obtained in Columns (3) and (4) indicate that the instrument is relevant, as the F-statistic and the SW first-stage χ^2 tests are both approximately 10, but less relevant than our preferred instrument. The coefficient obtained for $\Delta \widehat{quality}_{ikt}$ is significantly higher than that obtained in the previous section. Finally, in Column (5), the two

instruments—the preferred instrument and the variant used in Column (3)—are used simultaneously. The result on the coefficient is slightly affected with respect to the results obtained in the main section, while the Sargan J test indicates that both instruments are likely to be exogenous.

Table 7: Results with alternative instruments

	Explained variable: $\Delta premium_{ikt}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta quality_{ikt}$	0.130*** (0.048)	0.214* (0.130)	0.198** (0.098)	0.192** (0.096)	0.094** (0.042)
$\Delta export_{ikt}$	-0.010 (0.008)	-0.020 (0.016)	-0.018 (0.013)	-0.017 (0.013)	-0.006 (0.008)
$\Delta openness_{ikt}$	-0.000 (0.009)	-0.000 (0.010)	-0.000 (0.010)	-0.000 (0.010)	-0.000 (0.009)
$\Delta productivity_{ikt}$	0.220*** (0.024)	0.217*** (0.024)	0.218*** (0.024)	0.218*** (0.024)	0.221*** (0.024)
FE exporter-year	Yes	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes	Yes
R-squared	0.001	-0.227	-0.173	-0.154	0.064
Observations	21,586	21,586	21,586	21,586	21,586
F-test	28.211	5.044	9.384	9.676	16.674
SWChi-test	30.486	5.451	10.141	10.457	36.038
J stat-pval					0.154

Significance levels: ***0.01 **0.05 *0.10. Two steps least squares regression where change in the quality of exports is instrumented with the change in the demand for quality measured through alternative methodologies. In column (1) the instrument is similar to the preferred one with the difference that the imports are weighted with the GDP/cap of exporter in 1995. In column (2) we use the same instrument with a lagged of one year $inst_{ikt-1}$. In column (3) and (4) the change in quality is instrumented with the change in the demand from exports weighted by the actual income per capita of importers in column (3) and the income per capita in 1995 in column (4). In column (5) change in quality is instrumented with both, the preferred instrument used in the main sections and the alternative instrument used in columns (3). Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

5.2 Alternative measures of quality

In the results section, the measure of export product quality used to analyze the documented effect corresponds to the weighted average quality estimated through the methodology proposed by Khandelwal (2010), where the weights are the share of total exporter-industry exports. This calculation is likely to suffer from an endogeneity issue, as the market shares used as weights are likely to be positively correlated with the quality estimated in the destination country.²³ We propose different weights for average quality at the exporter-industry level, where the weights correspond to the share of exporter-industry exports in the first

23. Upgrades to the quality of varieties exported to a destination are likely to increase the prices of those varieties with respect to varieties sold to other destinations. Conditional on quantities, the price increase makes the value of exports to the destination grow with respect to the value of exports toward other destinations.

year that they record positive exports toward a specific destination. This measure has the flaw of not being precise, as the set of destinations to which a country exports varies over time. Thus, while we acknowledge the potential endogeneity problem, our preferred measure remains the average weighted with the corresponding shares of exports. In Column (1) of Table 8, we report the results of the empirical model using the alternative measure of quality. We observe that the result is very close to our main result. Column (2) reports the results of the regression where quality is estimated following the methodology proposed by Khandelwal et al. (2013). The estimation procedure for quality is conceptually similar, as quality is estimated as the residual of a constant elasticity of supply (CES) demand system.²⁴ Our results indicate that the effect is robust to the alternative measure of quality. In Column (3), we use the difference in the average unit value measured as total export value over total export quantity. In this case, the F-test indicates that the change in demand for quality in the importing countries is not a good instrument for the changes in unit values. This is because there are many other factors not related to quality that are likely to influence the change in unit values, such as pricing-to-market strategies and changes in costs. Another major problem with the use of unit values in dealing with industries is that at this scale, unit values are mainly influenced by the product composition of exports within the industry instead of export product quality. An increase in unit values may reflect an increase in the unit values of each product exported or a change in the composition of exports toward products characterized by higher unit values. For these reasons, we are not perturbed by the results in Column (3). Finally, in Column (4), we perform the standard IV regression using the difference in wages per capita instead of the wage premium as the dependent variable. There are no significant differences in the results when we use the difference in wages instead of the wage premium.

24. See Appendix C for more details on the procedure for quality estimation in this case.

Table 8: Results with alternative measures for quality

	(1)	$\Delta premium_{ikt}$ (2)	(3)	$\Delta \ln w_{ikt}$ (4)
$\Delta quality(1995)_{ikt}$	0.123** (0.049)			
$\Delta quality(KWS)_{ikt}$		0.061** (0.031)		
ΔUV_{ikt}			-0.909 (1.192)	
$\Delta quality_{ikt}$				0.119** (0.047)
$\Delta export_{ikt}$	-0.008 (0.008)	-0.021 (0.016)	0.123 (0.154)	-0.009 (0.008)
$\Delta openness_{ikt}$	-0.001 (0.009)	0.004 (0.011)	0.006 (0.019)	-0.000 (0.009)
$\Delta productivity_{ikt}$	0.220*** (0.024)	0.230*** (0.026)	0.238*** (0.035)	0.220*** (0.024)
FE exporter-year	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes
R-squared	0.013	-0.577	-2.956	0.022
Observations	21,586	21,202	21,586	21,586
F-test	31.508	5.839	0.647	28.478
SWChi-test	34.049	6.319	0.699	30.774

Significance levels: ***0.01 **0.05 *0.10. Dependent variable corresponds to the difference of the wage premium in column (1) to (3) and to the difference in wage per capita in column (4). Two steps least squares regression where change of quality are instrumented with the change in the demand for quality in importing countries. Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

5.3 Excluded countries

Our analysis is conducted on a sample of 23 countries. We choose our sample of countries following two criteria:²⁵

1. Countries must have a balanced panel of data on wages per capita over at least 8 years available.
2. Countries must have a population of at least 6 million in 1995. This is because many small countries record exports for only a few industries, and their export volumes are characterized by large fluctuations.

For completeness and robustness, we perform the regressions including the excluded countries. Table 9 reports the results of the IV regressions. In Column (1), we include the countries for which a balanced panel of data on wages is available only for a short period, namely, China, Romania and Poland. In Column (2), we include the countries with a population of less than 6 million in 1995, namely, Lithuania, Latvia, Finland, Norway, Slovakia and Slovenia. Finally, in Column (3), we include all countries included in the two previous regres-

25. See Table A2 of the Appendix for more details.

sions. While the instruments seem to perform slightly worse when we add small countries to the sample, the results remain robust. Moreover, we observe that the coefficient of quality increases, especially when we add small countries. This can be explained by the fact that over the six small countries added, four are low- to medium-income countries and that as reported in Table 6, the documented effect is stronger for low-income countries.

Table 9: Robustness tests

	Explained variable: $\Delta premium_{ikt}$		
	short panel	small	all
$\Delta quality_{ikt}$	0.115** (0.046)	0.191*** (0.065)	0.183*** (0.062)
$\Delta export_{ikt}$	-0.009 (0.008)	-0.019** (0.009)	-0.018** (0.009)
$\Delta openness_{ikt}$	-0.001 (0.009)	0.001 (0.009)	-0.001 (0.008)
$\Delta productivity_{ikt}$	0.216*** (0.023)	0.217*** (0.019)	0.214*** (0.019)
FE exporter-year	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes
R-squared	0.022	-0.159	-0.145
Observations	23,228	26,589	28,231
F-test	26.604	20.348	19.864
SW Chi-test	28.619	21.721	21.141

Significance levels: ***0.01 **0.05 *0.10. Two steps least squares regression where change in the quality of exports is instrumented with the change in the demand for quality in importing countries. Standard errors are clustered at the exporter-industry level and are reported in parenthesis.

6 Conclusion

The literature on international trade has investigated the impact of commerce on labor markets. Several studies find evidence of wage increases due to increases in the quality of export products (Brambilla et al., 2012; Fieler et al., 2018; Verhoogen, 2008). The objective of the current chapter is to generalize the results obtained in these previous studies and to establish a causal link between upgrades to export product quality and variations in average wages at the industry level on a global scale. This study is conducted at the country-industry level on the manufacturing sector over a set of 23 countries and analyzes how export quality upgrades affect the wages of exporting countries. Export quality is estimated as a residual of a demand function following the methodology proposed by Khandelwal (2010), while we establish a causal relation through an IV strategy. Our results show that ahead of an upgrade in export quality in a specific industry, the average wages offered within the industry also increase. Our results indicate that an industry that upgrades its export product quality by moving from the first quartile to the second quartile

of the quality distribution shows an increase in its wage premium of 3.5%.

There are multiple implications of our findings. Low-income countries are characterized by lower export product quality and a scarcity of skilled labor due to the lack of efficient education systems and migration of the most qualified workers. A rise in demand for skilled labor among industries aiming to upgrade their export product quality could have beneficial effects for the economic development of such countries. Although we find that the effect is stronger for low-income countries, the causal effect of export product quality upgrades on industry wage premia is also significant for developed countries. Industries in high-income countries facing competition from cheap varieties exported from low-income countries are more inclined to upgrade the quality of their export products and therefore to attract skilled labor. As a consequence, reallocation of the workforce could generate wage inequality across industries.

Appendix A – Data

Since trade data are known to be noisy, we employ two trimming procedures to eliminate aberrant values: First, for each exporter-product pair, observations with unit values 10 times larger or smaller than the median unit value are dropped. Likewise, for each importer-product pair, observations with unit values 10 times larger or smaller than the median unit value are dropped. As in Sutton and Trefler (2016) and Benkovskis and Wörz (2018), countries with fewer than 2 million people in 2008 are excluded from the analysis. Table A1 reports the list of countries and the number of industries for which we conduct the analysis. The whole sample includes 118 industries, and the period under analysis is 1995-2008, consisting of 14 years. The selection of countries is constrained by data availability in UNIDO's INDSTAT 2 database, which reports the annual number of employees and wages by industry. Although INDSTAT 2 covers a larger number of countries, there are large numbers of missing observations for many countries. We choose, therefore, to include in the analysis only countries for which data on wages and employees are reported for at least 8 consecutive years and at least 70 industries. Moreover, we do not include small countries with a population of less than 6 million in 1995, as these countries record positive export values for a small number of industries only. Table A2 reports the countries excluded from the analysis for being too small or reporting too many missing years. These countries are included in the robustness analysis.

Finally, Table A3 reports the distribution and means of the main variables used.

Table A1: Period and number of industries available by country

country	period	number of industries
Austria	1995-2008	102
Belgium	1995-2008 (2002)	109
Canada	1995-2008	100
Denmark	1995-2008	85
Ecuador	1995-2008	70
France	1996-2008	114
Germany	1995-2008	112
Hungary	1995-2008	92
Indonesia	1995-2008	108
Ireland	1995-2008	74
India	1998-2007	116
Iran	1995-2008	75
Italy	1995-2008	113
South Korea	1995-2006	118
Malaysia	2000-2008	112
Netherlands	1995-2008	92
Portugal	1996-2008	110
Spain	1995-2008	115
Sweden	1995-2008	95
Turkey	1995-2008	106
Ukraine	2000-2008	115
United Kingdom	1995-2007	114
United States	1997-2008	108

Table A2: Countries included in the robustness analysis

Countries with a short recorded period		
country	period	number of industries
China	2003-2008	106
Poland	2002-2008	100
Romania	2003-2008	100
Small countries		
Finland	1995-2008	89
Lithuania	1995-2008	85
Latvia	1995-2008	43
Norway	1995-2008	87
Slovakia	1996-2008	75
Slovenia	1995-2008	85

Table A3: Summary statistics of main variables

	Mean	p25	p50	p75
quality _{ikt}	0.181	-0.184	0.0832	0.427
Δ quality _{ikt}	0.0216	-0.164	0.0292	0.218
wage/employees	22646	5786	21279	34518
Δ wages _{ikt}	0.0686	-0.0122	0.0672	0.154
wage premium _{ikt}	0.000729	-0.0377	0.000356	0.0377

Appendix B – Quality estimation results

Table B1 reports the summary of the results of the quality estimation. Equation II.10 is regressed separately on groups of observations belonging to different industry-importer pairs using an IV strategy for a total of 1996 regressions. We compare the OLS estimation with the two-stage least squares (2SLS) estimation. The OLS estimation is likely to underestimate the coefficient of price, as price and quality are positively correlated, and to overestimate the coefficient of the nest share. As reported in Table B1, the distribution of the coefficients of price for the IV regression is lower than that of the coefficients for the OLS regression, and the distribution of the coefficients of the nest share variable is lower in the case of the IV regression. These results indicate that the instruments move the coefficients in the expected direction. Lines 5 to 8 report the p-value of the first-stage F-test and χ^2 statistic; both tests indicate that the instruments are relevant for both price and nest share.

Table B1: Quality estimation results

	mean	p25	p50	p75
OLS coefficient price	-0.247	-0.336	-0.201	-0.108
IV coefficient price	-0.637	-0.933	-0.454	-0.148
OLS coefficient nest share	0.849	0.794	0.877	0.935
IV coefficient nest share	0.675	0.486	0.781	0.929
First stage F-stat p-value, price	0.014	0.000	0.000	0.000
First stage χ^2 -stat p-value, price	0.021	0.000	0.000	0.000
First stage F-stat p-value, nest share	0.008	0.000	0.000	0.000
First stage χ^2 -stat p-value, nest share	0.017	0.000	0.000	0.000
Number of observation per estimation	5609	1056	2716	6448

Appendix C – The Khandelwal et al. (2013) method of quality estimation

The estimation of quality according to the methodology proposed by Khandelwal et al. (2013) is increasingly adopted to infer quality as the residual of a demand function. While this estimation is practical, as it requires only information on volumes and quantities of trade flows, the methodology needs to assume a value for the CES elasticity of substitution between varieties. Product quality is inferred from the demand function derived by the classic CES utility function of Dixit and Stiglitz (1977):

$$\ln q_{ihjt} + \sigma p_{ihjt} = FE_{jt} + FE_h + \epsilon_{ihjt}, \quad (\text{II.11})$$

where q_{ihjt} corresponds to quantity exported and σ corresponds to the elasticity of substitution between varieties. In the estimation, we use the country-product-specific elasticity of substitution estimated by Broda and Weinstein (2006). Quality is then obtained as:

$$\text{quality(KWS)}_{ihjt} = \frac{\hat{\epsilon}_{ihjt}}{\sigma-1}.$$

For the country-product pairs for which the elasticity of substitution is not available, we used the median σ across all products. Quality is estimated for each exporter-product-importer-year. Similarly to how we estimate quality following the methodology of Khandelwal (2010), we obtain a measure of quality at the exporter-industry-year level as the weighted average of qualities estimated: $\text{quality(KWS)}_{ikt} = \sum_j s_{ijkt} \sum_{h \in k} \text{quality(KWS)}_{ihjt}$, where s_{ijkt} corresponds to the market share of exports to destination j over the total exports of country i for industry k .

Chapter III

How taste proximity affects consumer quality valuation of imported varieties: Evidence from the French agri-food sector ¹

1 Introduction

The literature on international trade identifies productivity as the most relevant attribute ensuring a firm's success in its export activity. Nonetheless, the economic environment and other characteristics of destination markets are likely to affect a firm's export performance in various ways. A number of studies find that consumer preferences play a major role in determining the demand for imported products.² Countries that do not share similar cultural features are likely to differ in their demand for goods produced abroad. Differences in consumer attitudes and preferences may not only represent a generic barrier to trade but can also distort the perception of the appeal of imported varieties from a specific origin country.

In this study, we analyze whether differences in consumer tastes between trading partners affect the export performance of vertically differentiated varieties in a different manner. The objective of this paper is to examine whether consumers' valuation of the quality of exported products is stronger in destination markets where tastes are similar. The idea of our study is inspired by the paper of Jäkel (2019), which shows that varieties with higher domestic appeal perform relatively better in markets where consumer taste is similar to that of domestic consumers. We conduct our analysis on the agri-food sector, which is recognized as particularly influenced by national and cultural factors. Indeed, consumer

1. A version of this chapter was presented at the 37th JMA (Journées de Microéconomie Appliquée) 2021 in Annecy (FR). In preparing this chapter, I have benefited from discussions with Stéphane Turolla, Carl Gaigné and Angela Cheptea.

2. See Disdier and Mayer (2007), Disdier et al. (2010) and Guiso et al. (2009).

tastes for food products can differ substantially across countries and represent a major determinant of trade flows in the agri-food sector.³

In this study, we propose a theoretical framework where firms produce vertically differentiated products with marginal costs depending on the cost of producing quality. Taste proximity enters the utility function as a factor that increases consumer propensity to pay for quality. Under the hypothesis of a positive correlation between quality and export prices, consumer willingness to pay for quality increases with taste proximity and positively affects the sales of varieties exported at higher prices. Conversely, at destinations where taste proximity is low, consumers have a lower valuation for quality, and varieties exported at lower prices gain relatively larger market shares. To identify taste proximity between countries, we rely on data gathered from the online travel company TripAdvisor, which reports information about the type of cuisine offered in restaurants all over the world. We build a database that describes the distribution of restaurants in each country according to the type of cuisine offered. Our database includes 2 395 518 restaurants reported in 107 countries. As we are interested in estimating taste proximity between trading countries, we associate each type of cuisine with an origin country. Assuming that the strong presence of restaurants offering culinary specialties from abroad is determined by consumer appreciation for this type of cuisine, we derive a measure of taste proximity between countries from the information on the cuisine distribution across restaurants. The measure of taste proximity is derived using a control function approach in a gravity model in which we embed a set of variables derived from the cuisine distribution in each country. According to this method, we estimate the taste proximity as part of the residual of a gravity equation. Hence, in our formulation, taste proximity corresponds to an unobserved affinity in taste for food products between consumers that promotes trade. Once the measure of taste proximity has been obtained, we analyze whether it explains the variation in export revenues for different qualities of exported varieties across destination markets. The analysis is conducted using firm-product level data on exports and imports for French firms in the agri-food sector. The case of French exports in the agri-food sector is particularly interesting and informative because, in addition to being one of the major European exporters of food products, France is also widely recognized for its gastronomic culture. Our preliminary analysis reveals that export prices are highly correlated with imported input prices, which suggests a positive association between export prices and product quality. To address our main question, we use a reduced-form approach and empirically analyze how differences in destination-specific taste proximity affect the intensive margin of exports relative to the price of varieties.

Our results indicate that firms earning larger revenues sell products at lower prices. This

3. A study by Atkin (2013) shows how taste for food explains differences in prices between Indian regions, while the work of Dubois et al. (2014) highlights how national consumer preferences influence the consumption basket.

implies that for French exports in the agri-food sector, price competition prevails. Taste proximity positively affects the export volume of varieties sold at higher prices. Overall, our findings indicate that French firms selling high-quality products perform better in countries where food preferences are closer to those of French consumers relative to other destination countries. The documented effect is robust to the inclusion of other explanatory factors that could be correlated with taste proximity, such as geographical distance or the income level of the importing country. Our results confirm the findings of Jäkel (2019), according to which the product appeal of exported products decreases as consumer tastes diverge from those of domestic consumers.

The main contribution of this study is to propose a new innovative way to derive an estimation of taste proximity between countries. While the use of information gathered from the TripAdvisor website is not novel in international trade,⁴ we use data on cuisine distribution in an innovative way to derive a measure of taste proximity. Using a control function approach to derive a measure of taste proximity recalls the method used by Aw-Roberts et al. (2020), who estimate taste preference at the firm-product level but with a different connotation. They derive their estimation of taste as part of the residual of a demand function and regard taste as a preference for the horizontal attributes (nonqualitative attributes) of a variety. In contrast, we derive a measure of taste proximity between two countries that captures the average consumer's appreciation for food products from an origin country and is common to all products and firms. Another contribution of this chapter is to provide evidence on the role that consumer taste plays in export dynamics in the food sector. In our study, we go beyond the consideration of taste proximity as a factor that promotes trade between countries and analyze its impact on the sales of products according to their quality.

This study contributes to the literature on the determinants of the export dynamics of vertically differentiated products. In compliance with the hypothesis formulated by Linder (1961), the level of income of destination countries is a determinant of the demand for quality. A higher level of income implies a higher valuation of quality, and consumers in wealthy countries have a higher propensity to spend on quality. The study of Hallak (2006) is one of the first to observe that the level of income of export destinations is positively related to the unit value of exported products. More recent studies conducted at the firm level corroborate its findings (Bastos and Silva, 2010; Bastos et al., 2018; Görg et al., 2017; Johnson, 2012). Another notorious element that affects the trade of high-quality products is the distance between trading partners. The Alchian and Allen (1964) effect stipulates that because of per-unit trade costs, the relative demand for higher quality goods is stronger in more distant destinations. Empirical proofs of the Alchian-Allen effect include Hummels and Skiba (2004), Martin (2012), Martin and Mayneris (2015) and Emlinger and Lamani

4. Waldfogel (2019) consider food prepared at restaurants as a cultural good and use TripAdvisor data on restaurants to analyze trade patterns in global cuisines.

(2020). Other studies find that the scope of product differentiation and the market size of the destination country affect the volume of sales and the selection into the export of varieties according to their quality (Baldwin and Harrigan, 2011; Kneller and Yu, 2016; Manova and Yu, 2017).

This paper also contributes to the literature on the impact of consumers' attitudes on the demand for imported products. Several studies investigate bilateral affinity as an element that influences the preferences of consumers and represents a source of trade promotion. As illustrative examples, the paper of Guiso et al. (2009) examines the relative trust of European citizens in citizens of other countries, while Disdier and Mayer (2007) analyzes proximity in public opinions. Along the same line of thought, Disdier et al. (2010) analyzes cultural proximity, measured as the bilateral trade in cultural goods, as a trade determinant. All these studies agree on the importance of bilateral affinity as a determinant of consumer preferences and, in turn, of trade exchanges.

Finally, we also contribute to the broader literature that analyzes product quality as a determinant of a firm's export performance. Standard trade models assess that most efficient firms are more likely to export and to earn larger revenues in domestic and foreign markets. While, in its standard formulation, the Melitz model indicates that firm efficiency translates into lower prices, extended versions of the Melitz framework that include costly quality on the production side and a propensity to pay for quality on the demand side suggest that this relationship between prices and sales is not at all straightforward.⁵ The majority of empirical studies identify quality as a major determinant of firm export status and report that quality allows exporters to charge higher prices than non-exporters (Hallak and Sivadasan, 2013; Iacovone and Smarzynska Javorcik, 2012; Kugler and Verhoogen, 2012).⁶ Similarly, the study of Manova and Zhang (2012) focuses on variations between exporting firms and observes that firms that charge higher export prices earn larger revenues, especially in the case of highly differentiated products. With respect to these studies, which highlight the better performance of firms exporting high-quality products, we argue that, for the food sector, quality may represent an imperfect predictor of success in markets characterized by low taste proximity.

The remainder of this study is organized as follows: Section 2 introduces the theoretical framework; Section 3 describes the data used; Section 4 explains the methodology used for the estimation of taste proximity; Section 5 presents the empirical model and the results; and Section 6 concludes the study.

5. Theoretical models include Gaigné and Larue (2016), Hallak and Sivadasan (2013), Kugler and Verhoogen (2012), and Verhoogen (2008)

6. With the exception of Jäkel and Sørensen (2020), which instead finds that, for the case of Danish manufacturing firms, cheaper varieties have a higher probability of being exported.

2 Theoretical framework

In this section, we present the theoretical underpinnings explaining the impact of the taste proximity of destination countries on the intensive margin of vertically differentiated products. We assume that consumer propensity to spend on quality varies according to the origin of imported varieties and is positively related to taste proximity. In this way, the demand for high-quality varieties is specific to each origin country and increases with the degree of appreciation of products from the exporting country. Because product quality is often unobserved in international trade, we propose a theoretical framework that illustrates how taste proximity affects the relationship between export prices and export revenues through a quality valuation mechanism. Our conceptual framework is presented with reduced assumptions about the underlying production technology and demand structure. Firms produce vertically and horizontally differentiated products and export to different destinations. Each destination differs from the others in the proximity of consumer taste with respect to the exporting country. The crucial feature of our model is that consumers are more willing to spend on quality in countries where taste proximity is higher. We obtain a general framework in which the cost of producing quality depends on the relative cost of input quality, while on the demand side, consumer willingness to pay for quality depends on taste proximity. As a result, the relationship between export prices and export revenues in each destination market is determined by product-specific characteristics, which determine the correlation between a variety's price and quality, and by taste proximity, which determines the consumer propensity to spend on quality. The model we propose is related to the theoretical framework in Manova and Yu (2017), in which the authors distinguish between two environments: a *quality sorting* environment where varieties sold at higher prices acquire larger market shares because of quality and an *efficiency sorting* environment where varieties sold at lower prices have larger market shares because of price competition. While in Manova and Yu (2017) the sorting environment depends on the degree of product differentiation, in our theoretical framework, it also depends on taste proximity, which is destination specific. This implies that for a given variety, one can observe an efficiency sorting environment in destinations where taste proximity is low and a quality sorting environment in destinations where consumer tastes are close to those of the exporter.

2.1 Setup

The model is relative to the firm problem; we use f to indicate the firm, h to indicate the product and i to indicate the exporting country. As firms can belong to different exporting countries, the indexation for exporters i is disregarded when the indexation for firms f is used. We assume that each firm produces only one type (quality) of product. Therefore, each variety is identified by the firm-product combination fh . The utility of consumers in country j increases with product quantity, product quality, and the number of available

varieties. The demand for a variety $x_{fhj} = x(\frac{p_{fhj}}{\lambda_{fhj}}, P_{jh}, E_{jh})$ is decreasing in quality-adjusted prices $\frac{p_{fhj}}{\lambda_{fhj}}$ and increasing in aggregate demand E_{jh} and a quality-adjusted price index P_{jh} . The demand function is assumed to be isoelastic, which makes its implicit form adaptable to different standard frameworks, such as CES or Cobb-Douglas. The parameter $\lambda_{fhj} = \theta_{fh}^{\beta_{ij}}$ represents the quality of variety fh as perceived by consumers in country j . It is a function of the intrinsic quality of this variety, θ_{fh} , and of the taste proximity between origin country i and destination j , $\beta_{ij} > 0$.⁷ Taste proximity enters the demand function as a factor that increases consumer preference for quality. This specification implies that consumers have a higher preference for quality for varieties imported from countries for which they exhibit a high taste proximity. In contrast, for imported varieties from countries with low taste proximity, consumers tend to value quality less and be more sensitive to price.

Firms are assumed to be heterogeneous in efficiency A_{fh} and produce only one type of product h . Each variety fh can be exported to multiple countries j . The unit cost of production is independent of the quantity produced. The marginal cost is, therefore, constant and corresponds to $c_{fh} = \frac{\omega_{fh}}{A_{fh}}$, where ω_{fh} represents the price index of production factors and is a function of the cost of inputs and labor used for the production of variety fh . As the production of higher quality products requires hiring skilled labor, which is costly, and the use of high-quality inputs, which are more expensive (Bastos and Silva, 2010; Verhoogen, 2008), we assume that the price index of production factors depends on the quality of the input $\omega_{fh}(\theta_{fh})$. Following Kugler and Verhoogen (2012), we assume that most productive firms endogenously choose to produce high-quality products $\theta_{fh}(A_{fh})$. Such a complementarity between efficiency and quality could be attributed to the need to ensure quality control when processing more sophisticated intermediates. We assume iceberg trade costs to export $\tau_{ijh} > 1$. Firms maximize their profits independently of each destination. The profit maximization problem defines the optimal price:

$$p_{fhj} = \frac{\eta_{x,p}}{\eta_{x,p} - 1} * \frac{\omega_{fh}}{A_{fh}} * \tau_{ijh},$$

where $\eta_{x,p}$ corresponds to the price elasticity of demand and the term $\frac{\eta_{x,p}}{\eta_{x,p} - 1}$ represents the markup over the marginal cost.⁸

2.2 Implications for the price of varieties

As a preamble to the analysis of the interaction between the price of a variety and its intensive margin, we analyze the behavior of prices with respect to firm efficiency and the

7. This specification recalls the demand system developed in Hallak (2006), where β_{ij} is instead a function of the level of income of the destination country.

8. In monopolistic competition, $\eta_{x,p}$ depends on the elasticity of substitution between varieties; in the case of oligopolistic competition, $\eta_{x,p}$ depends on the elasticity of substitution between varieties and the variety's market share.

cost of inputs. Efficiency A_{fh} has a twofold effect on prices. First, there is a *direct effect* that decreases the cost of production, as efficiency reflects a firm's capability to produce output using few variable inputs. Second, we have an *indirect quality effect* that increases the marginal costs because more efficient firms use higher quality inputs. We compute the derivative of the export price with respect to efficiency to delineate the elements conditioning the relationship between efficiency and price:

$$d \ln p_{fhj} = (-1 + \eta_{\omega, \theta} \times \eta_{\theta, A}) d \ln A_{fh} \quad (\text{III.1})$$

Equation (III.1) indicates that the effect of efficiency on output prices depends on two parameters: $\eta_{\omega, \theta} \equiv \frac{\partial w_{fh}}{\partial \theta_{fh}} \frac{\theta_{fh}}{w_{fh}} > 0$, which corresponds to the elasticity of input prices to the quality of output and indicates the cost of producing the quality of variety fh , and $\eta_{\theta, A} \equiv \frac{\partial \theta_{fh}}{\partial A_{fh}} \frac{A_{fh}}{\theta_{fh}} > 0$, which corresponds to the elasticity of output quality to efficiency and indicates the actual incentive of most efficient firms to invest in quality. The term $\eta_{\omega, \theta} \times \eta_{\theta, A}$ determines the sign of the correlation and can be interpreted as the sensitivity of production costs to firm efficiency. We derive the relationship between the export price and the cost of inputs by replacing $d \ln A_{fh}$ in Equation (III.1) with the derivative of the cost of inputs over efficiency $d \ln \omega_{fh} = (\eta_{\omega, \theta} \times \eta_{\theta, A}) d \ln A_{fh}$. We obtain the following relationship between the export price and the cost of inputs:

$$d \ln p_{fhj} = \left(\frac{\eta_{\omega, \theta} \times \eta_{\theta, A} - 1}{\eta_{\omega, \theta} \times \eta_{\theta, A}} \right) d \ln \omega_{fh} \quad (\text{III.2})$$

In the same way, we derive the relationship between the export price and the intrinsic quality of a variety:

$$d \ln p_{fhj} = \left(\frac{\eta_{\omega, \theta} \times \eta_{\theta, A} - 1}{\eta_{\theta, A}} \right) d \ln \theta_{fh} \quad (\text{III.3})$$

As in the case of Equation (III.1), the term $\eta_{\omega, \theta} \times \eta_{\theta, A}$ determines the sign of the correlation between input costs and export prices and between intrinsic quality and export prices. Based on how the export price varies with respect to efficiency and input costs, we can distinguish two situations:

- When $\eta_{\omega, \theta} \times \eta_{\theta, A} > 1$. This means that the indirect quality effect prevails over the direct effect of efficiency on prices. This condition reflects a situation in which, although high-quality products are produced by most efficient firms, the costs of high-quality inputs outweigh the benefits of efficiency for costs. As a consequence, the export price reflects the cost of producing quality.
- When $\eta_{\omega, \theta} \times \eta_{\theta, A} < 1$. This indicates that prices decrease with efficiency because of the direct effect of efficiency. In this case, highly efficient firms produce high-quality products, and because of these firms' capacity to reduce the overall costs of production, high-quality products are produced at lower prices. In this case, the cost of producing quality and the output price are negatively correlated.

The two situations presented above recall in part the distinction made by Manova and Yu (2017) between the quality sorting environment, where export prices are positively correlated with quality and efficiency, and the efficiency sorting environment, where export prices decrease with quality and efficiency. Manova and Yu (2017) assume no differences in the demand for imported varieties across importers, obtaining the result that high-quality varieties gain larger market shares in each destination. The introduction of taste proximity as a factor that shapes consumers' valuation of quality means that the sorting environments also depend on demand characteristics. In the next section, we analyze how differences in taste proximity across destinations can affect the relationship between the quality of exported varieties and the intensive margin.

2.3 Export prices and firm revenues

In this section, we provide an understanding of the impact of taste proximity β_{ij} on the intensive margin via the quality valuation mechanism. The derivative of sales with respect to the intrinsic quality of variety θ_{fh} is equal to:

$$d \ln x_{ijh} = -\eta_{x,p} (\beta_{ij} - \eta_{\omega,\theta}) d \ln \theta_{fh}, \quad (\text{III.4})$$

where the price elasticity $\eta_{x,p}$ is negative. Equation (III.4) indicates that the relationship between quality and sales depends positively on taste proximity β_{ij} , which increases the quality valuation of varieties exported by country i , and negatively on the cost of producing quality $\eta_{\omega,\theta}$, which is product specific. The term $(\beta_{ij} - \eta_{\omega,\theta})$ can be interpreted as the destination-specific return to product quality. Equation (III.4) ideally represents the empirical model we refer to when we estimate the impact of taste on consumers' valuation of quality (Section 5). Nonetheless, except for a few studies in international trade that use direct measures of product quality,⁹ information about product quality is generally unavailable, which makes Equation (III.4) empirically difficult to estimate. For this reason, we rely on Equation (III.3), which defines the determinants of the relationship between quality and output prices, and examine the impact of taste proximity on the demand for quality by analyzing the correlation between export revenues and prices. We derive the volume of sales with respect to export prices and obtain:

$$d \ln x_{fhj} = -\eta_{x,p} \left[-1 + \frac{\overbrace{\beta_{ij} \times \eta_{\theta,A}}^{\text{sensitivity of quality perceived to efficiency}}}{\underbrace{\eta_{w,\theta} \times \eta_{\theta,A}}_{\text{sensitivity of production costs to efficiency}} - 1} \right] d \ln p_{fhj} \quad (\text{III.5})$$

9. The works of Crozet et al. (2012), Chen and Juvenal (2016) and Emlinger and Lamani (2020) propose an analysis of exports for a limited range of products for which they have direct information on quality.

Equation (III.5) indicates that the sign and extent of the relationship between sales and prices depends on the sensitivity of production costs to efficiency $\eta_{w,\theta} \times \eta_{\theta,A}$ and on the term $\beta_{ij} \times \eta_{\theta,A}$, which can be interpreted as the sensitivity of the quality perceived in the destination country to firm efficiency. From the previous analysis, we know that when $\eta_{w,\theta} \times \eta_{\theta,A} < 1$, the quality of products decreases with export prices. In this case, independent of the value of β_{ij} , the coefficient of $d \ln p_{fhj}$ is always negative, which implies a negative correlation between intensive margins and prices. Higher values of taste proximity amplify the negative correlation between the variety's export value and its export price. On the other hand, when $\eta_{w,\theta} \times \eta_{\theta,A} > 1$ and prices reflect the quality of varieties, the type of relationship between sales and prices is determined by both the sensitivity of production costs to efficiency and the interaction between taste proximity and the elasticity of the intrinsic quality to firm efficiency. In this case, taste proximity increases the valuation of quality and, therefore, the propensity to spend on expensive varieties. Note that in this case, the correlation between export prices and sales can be positive in countries with high taste proximity and negative elsewhere. A negative coefficient of $d \ln p_{fhj}$ implies that lower quality varieties have higher export revenues because taste proximity is not high enough to make high-quality varieties attractive to the importing market. Whatever the correlation between export prices and quality, our theoretical framework assumes that taste proximity augments the valuation of quality and, as a consequence, increases the export revenues of high-quality varieties. In contrast, the effect of taste proximity on prices depends on the sensitivity of production costs to efficiency and can be negative when high-quality varieties are exported at lower prices. An important difference from the model proposed by Manova and Yu (2017) is that a negative correlation between export prices and export revenues does not necessarily imply that higher quality is associated with lower export prices. Instead, it could be due to weak taste proximity, which reduces the consumer propensity to spend on more expensive high-quality varieties.

3 Data

3.1 Data on trade

Our empirical analysis focuses on French exporters of agri-food products. Data on the foreign trade of French firms come from French customs. Customs reports the monetary value and the volume (in physical weight) of export and import trade flows for each firm at the 8-digit level of the Combined Nomenclature (CN8). Firms are identified according to their SIREN number, and for each export (import) flow, French customs reports the destination (origin) country. Since the objective of our analysis is to estimate the impact of consumer tastes on trade in food products, we restrict the analysis to consumer products related to the food sector.¹⁰ We distinguish consumer products from intermediary products using the

10. The food sector corresponds to HS2 chapters 1 to 24

BEC classification.¹¹ Observations with missing quantity are dropped, as are observations with a value below 1 000 euros. We obtain in this way a database on the trade flows of 51 380 exporting firms and 2 586 traded food products for a period that spans from 2000 to 2014. Data on country-level trade flows are from BACI, a detailed international trade database provided by CEPII that covers a large number of countries and more than 5000 products expressed in terms of the Harmonized System (HS) classification revision 1996 at the 6-digit level. Concordance between CN8 and HS6 nomenclature is obtained following the methodology proposed by Van Beveren et al. (2012). Data on GDP and population have been obtained from the World Bank's database WDI available as open data,¹² while standard gravity variables have been taken from the Gravity dataset provided by CEPII.¹³ For tariffs, we use the TRAINS database provided by the World Integrated Trade Solution (WITS) software of the World Bank.¹⁴ Annual tariffs are reported at the HS 6-digit level for each bilateral trade relationship between countries for the period 2000-2016.¹⁵ Data on the stock of migrants are taken from the United Nations, Department of Economic and Social Affairs (2020).¹⁶ Data on migrants are reported every 5 years and are available between 1990 and 2018. We used linear interpolation to obtain annual data on migration.

3.2 Data on restaurants

To obtain a measure of taste proximity between two countries, we use data on the country-level distribution of restaurants offering the cuisine of the trading partner. We assume, therefore, that consumers' appreciation for a cuisine is directly related to the distribution of restaurants offering that cuisine. To obtain the number of restaurants and the types of cuisine offered in each country, we rely on data gathered from the online travel company TripAdvisor, which reports information on restaurants, hotels, and attractions in cities around the world. On TripAdvisor, restaurant owners or managers fill out information about their restaurants and report the price range, the type of cuisine and the special diets available, while clients are able to rate the restaurant and provide comments. The website is popular worldwide and attracts approximately 350 million visitors per month. We collect information on restaurant cuisine through a web-scraping technique on the top 100 cities in a panel of 107 destination countries. For each type of cuisine, we obtain the distribution of restaurants that offer it in each country. By collecting data on so many cities, we include not only

11. Broad Economic Categories; see the document published by the Department of Economic and Social Affairs of the UN: United Nations (2018)

12. Source: <https://data.worldbank.org/>

13. Source: http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp

14. Source: <https://wits.worldbank.org/>

15. The TRAINS database provides three types of tariffs at the 6-digit level for each bilateral relation: most favored nation (MFN) tariffs, which are what countries promise to impose on imports from other members of the WTO, bound tariffs (BND), which correspond to the bound tariff-specific commitments made by individual WTO member governments, and effectively applied (AHS) tariffs assessed by the WITS-TRAINS database developers as the level of tariffs actually applied. In this study, we use effectively applied (AHS) tariffs.

16. Trends in International Migrant Stock: Migrants by Destination and Origin (United Nations database, POP/DB/MIG/Stock/Rev.2015)

Number of restaurants

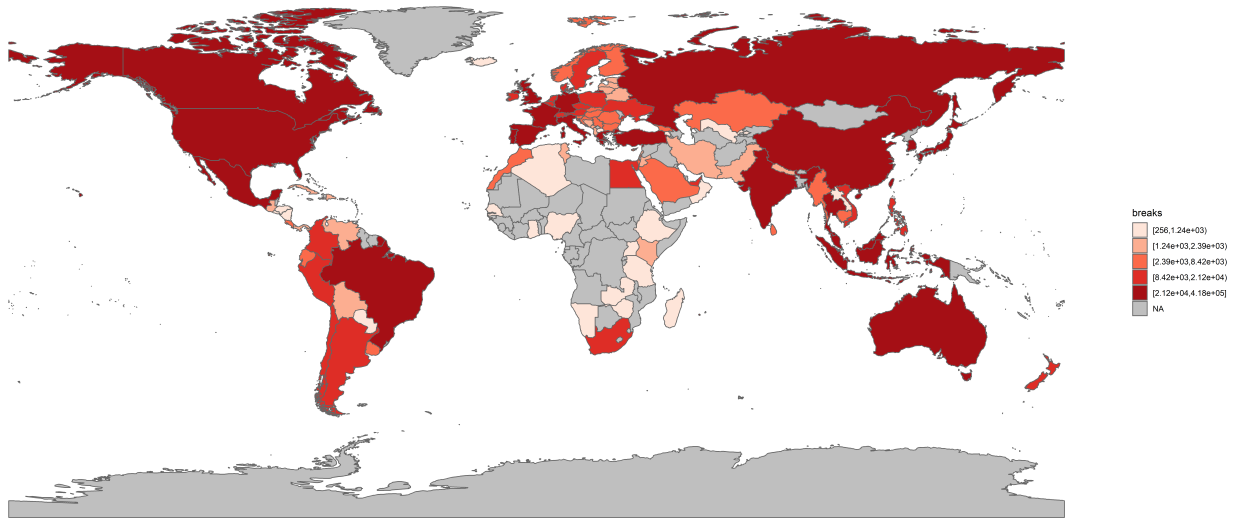


Figure 1: The number of restaurants in the first 100 cities for each country

Source: Computations by author using data from TripAdvisor.

the most prominent tourist destinations and most cosmopolitan areas but also a much larger range of metropolitan areas. With such broad coverage, we argue that the effect of tourism on the distribution of the type of cuisine across restaurants is negligible. The advantage of using the data collected from TripAdvisor is that the website maintains lists of restaurants classified into 183 different cuisine categories, most of which can be identified with particular origin countries.¹⁷ Overall, the data gathered from TripAdvisor cover a total of 2 395 518 restaurants. Figure 1 displays the number of countries covered.

From the data on restaurants, our aim is to obtain the distribution of the type of cuisine in each country. Many restaurants do not necessarily offer dishes from a foreign country. Since we are interested in measuring taste proximity between countries, in this analysis, we consider only the restaurants listing at least one cuisine that can be associated with a foreign country. Our sample is therefore reduced to 1 190 742 restaurants around the world. Because restaurants can report more than one cuisine type, the sum of the number of restaurants offering each cuisine does not equal the total number of restaurants. If each restaurant had only one cuisine, then the number of listings for a particular cuisine would provide a direct measure of the number of restaurants offering that cuisine. Because restaurants can list multiple cuisines, estimating each cuisine's share of restaurants in a country requires the use of a system of weights. When a restaurant reports multiple types of cuisine, we attribute equal shares to the different types listed. An example will provide some insights into the procedure. If a restaurant lists only one type of cuisine, let us suppose Japanese, it will count as one Japanese cuisine. If a restaurant lists Chinese and Japanese cuisine, it will count as 0.5 Japanese cuisine and 0.5 Chinese cuisine. We derive in

17. Further details on the association of each type of cuisine with the corresponding origin country can be found in Table A1 in the Appendix.

this way n_j^i , which corresponds to the number of restaurants in country j offering a cuisine from country i .

The use of data gathered from TripAdvisor may not provide a consistent perspective of the actual distribution of restaurants in a country. Concerns can arise especially in less developed countries where the total number of reported restaurants is small and TripAdvisor is mainly used by tourists. In these cases, our measure of cuisine distribution does not always represent a sound indicator of consumer taste. For this reason, we consider only countries for which we have information on at least 1000 restaurants offering a cuisine from a foreign country. This choice led us to limit the analysis to 55 countries.

4 Estimation of taste proximity

In this section, we explain the procedure to derive a measure of taste proximity intended to capture consumer tastes for food products of a specific origin country. We use a control function approach in a gravity model integrating variables on cuisine distribution as proxies for taste proximity. Gravity models have long been used to estimate the impact of trade barriers and cultural proximity on trade flows between countries. As outlined by Head and Mayer (2013), localized taste is one of the forces that can promote, as well as reduce, trade between two countries. The rationale behind the use of a control function approach is that it allows us to tease out the part of the residual of the gravity equation that captures unobserved taste proximity. We estimate the gravity equation using data on country-level trade flows from the BACI database on the 55 countries for which information about the restaurant distribution is available. Since we use data on trade at the country level, a country is treated as a representative consumer, which might conceal within-country heterogeneity across consumers. In this way, the obtain a measure of taste proximity captures the taste similarity of consumers in importing country j for food products from origin country i . We start by counting the number of restaurants offering a foreign cuisine, n_j^i , from TripAdvisor and define two observable variables that can be used as proxies for taste proximity. Then, we define the form of the control function for consumer taste proximity, which includes these proxies. Finally, the control function is embedded in the gravity equation and estimated jointly with other parameters. The variables used as proxies for taste proximity are as follows:

1. A measure of cuisine popularity in a given country relative to the average popularity of that cuisine across all destinations. This measure is derived as the log of the share of restaurants offering a cuisine from country i in destination country j over the average share of restaurants offering a cuisine from i across all countries: $\text{popularity}_{ij} = \ln \frac{s_{ij}}{\bar{s}_i}$.

The variable $s_{ij} = \frac{n_j^i}{\sum_{i \neq j} n_j^i}$ corresponds to the share of cuisine from country i over the total of foreign cuisines in country j , while \bar{s}_i corresponds to the simple average of s_{ij} across all countries. The measure of cuisine popularity represents an indicator of

relative consumer appreciation of food products exported from the reference country of the cuisine. The higher the degree of appreciation for a type of cuisine is, the higher the consumer taste proximity to the origin country of that cuisine. We divide the share of cuisine s_{ij} by the average share \bar{s}_i because few origin countries have very popular cuisines spread across all destination countries, and the cuisines of the rest of the countries are much less represented worldwide.¹⁸

2. An index of similarity in the distribution of the type of foreign cuisines offered by two countries. To measure similarity, we compare the distribution of the different types of foreign cuisine in countries i and j excluding the cuisines associated with the two countries. For this purpose, we use the Finger-Kreinin (FK) index, which measures the similarity between two countries i and j as $FK_{ij} = 1 - \frac{1}{2} \sum_{l \neq i, j} |s_{lj} - s_{li}|$. The FK index compares the shares of each type of cuisine in each country and takes values between zero and one. A high value of the FK index indicates a high degree of similarity in the distribution of the types of cuisine in the two countries.

Once the measure of popularity and the FK index are obtained, we embed the two proxies for consumer taste into a gravity model:

$$x_{iht} = \exp[\gamma_0 + \mathbf{X}'\gamma_1 + \ln taste_{ij}(\mathbf{Y}') + FE_{iht} + FE_{jht}] * \epsilon_{ijht}, \quad (\text{III.6})$$

where \mathbf{Y}' represents the vector of variables used as proxy for taste, FE_{iht} and FE_{jht} are product-specific time-varying exporter and importer fixed effects, and \mathbf{X}' is a vector of gravity variables, which includes distance and ad valorem tariffs¹⁹, the bilateral stock of migrants, a "Linder term" of income dissimilarity, contiguity, common official language, common currency, common colonial past, common religion and the presence of free trade agreements. While many of the gravity variables used here are commonly used in the estimation of gravity equations, we highlight the importance of controlling for the presence of migrants and income dissimilarities. Several studies indicate that migrants impact trade through two main channels (Felbermayr et al., 2015; Steingress, 2018). First, migrants bring with them the preference for products from their origin country and are likely to spread their preferences within the local population. Second, the presence of migrants reduces transaction costs, as it mitigates incomplete information on origin markets. Controlling for the presence of migrants is, therefore, critical. Their presence is likely to be correlated with taste proximity but also with other elements affecting trade. In the same way, similarities in the level of income could also be correlated with taste proximity and represent an essential element for which we need to control. We control for income dissimilarities through the so-called Linder term, which is equal to $|\ln gdp/cap_{it} - \ln gdp/cap_{jt}|$. The gravity Equation (III.6) is estimated using the PPML regressor. We replace the unobservable $\ln taste_{ij}(\mathbf{Y}')$

18. Table B1 in the Appendix reports in detail the average share of cuisines around the world by origin country.

19. To deal with zero duties, we take $\text{tariff}_{ijht} = \ln(1 + adv_{ijht})$ as in Emlinger and Lamani (2020)

with the two proxies, $popularity_{ij}$ and FK_{ij} . We use a polynomial function of order one to estimate the coefficients, which are then used to predict a measure of taste proximity:

$$\ln \widehat{taste}_{ij} = \alpha_1 popularity_{ij} + \alpha_2 FK_{ij} \quad (III.7)$$

Table 1 reports the coefficients of the proxy variables when included in the gravity estimation. In columns (1) and (2), the two proxies are embedded separately, while in Column (3), they are embedded jointly. We observe that in all three specifications, the coefficients of the popularity index and the FK index are always significant and positive. The estimated parameters of all the other gravity variables are in line with the literature.

Table 1: Gravity estimation with country-level data

	Explained variable: x_{ijht}		
	(1)	(2)	(3)
popularity _j	0.069*** (0.003)		0.067*** (0.003)
FK index _{ij}		0.745*** (0.058)	0.648*** (0.058)
ln distance _{ij}	-0.778*** (0.008)	-0.763*** (0.008)	-0.757*** (0.008)
tariff _{ijht}	-1.004*** (0.052)	-1.014*** (0.051)	-1.012*** (0.051)
ln immigrants _{ijt}	0.085*** (0.004)	0.113*** (0.004)	0.083*** (0.004)
ln emigrants _{ijt}	0.063*** (0.004)	0.060*** (0.004)	0.058*** (0.004)
linder _{ijt}	-0.222*** (0.007)	-0.197*** (0.007)	-0.209*** (0.007)
FTA _{ijt}	0.245*** (0.015)	0.198*** (0.015)	0.248*** (0.015)
contiguity _{ij}	0.397*** (0.008)	0.387*** (0.008)	0.393*** (0.008)
language _{ijt}	0.186*** (0.010)	0.181*** (0.011)	0.148*** (0.011)
colony _{ijt}	0.193*** (0.011)	0.149*** (0.011)	0.185*** (0.011)
currency _{ijt}	0.196*** (0.011)	0.196*** (0.011)	0.190*** (0.011)
religion _{ijt}	0.227*** (0.017)	0.170*** (0.016)	0.237*** (0.017)
Constant	14.312*** (0.084)	13.466*** (0.094)	13.776*** (0.095)
FE exporter-prod-year	Yes	Yes	Yes
FE importer-prod-year	Yes	Yes	Yes
Observations	2,003,031	2,072,505	2,003,031

Significance levels: ***0.01 **0.05 *0.10. Dependent variable is product level bilateral exports. Estimation method: PPML.

In Table 2, we report the values of the two proxies, popularity and the FK index, and the resulting estimate of taste proximity with respect to French cuisine. We observe that taste proximity is correlated with distance and that countries that share a common land border with France exhibit a higher taste proximity. Nonetheless, consumer taste proximity is not explained by geographical distance alone. Some countries have a relatively high taste proximity, although they are located far from France, such as Israel and Thailand.

Table 2: Proxies and estimate for taste proximity with France

Country	Popularity _{FR,j}	FK index _{FR,j}	ln taste _{FR,j}	Country	Popularity _{FR,j}	FK index _{FR,j}	ln taste _{FR,j}
Belgium	1.600	0.787	1.180	Rep. of Korea	-0.443	0.691	0.629
Switzerland	1.100	0.765	0.949	Canada	-0.387	0.685	0.628
Netherlands	0.752	0.794	0.875	Brazil	-0.572	0.723	0.628
Denmark	0.503	0.827	0.850	Argentina	-0.166	0.648	0.617
Czech Rep.	0.222	0.794	0.779	Australia	-0.950	0.704	0.611
Israel	0.168	0.771	0.753	Ireland	-0.381	0.657	0.606
Germany	-0.686	0.827	0.723	Russia	-0.633	0.677	0.605
Italy	-0.598	0.815	0.714	USA	-0.749	0.671	0.594
Norway	-0.202	0.764	0.707	Kazakhstan	-1.030	0.684	0.591
Portugal	-0.208	0.763	0.706	United Kingdom	-0.657	0.661	0.591
Spain	-0.760	0.809	0.705	Japan	-0.679	0.626	0.588
Poland	-0.669	0.794	0.698	Colombia	-0.148	0.586	0.569
Sweden	-0.132	0.736	0.691	New Zealand	-0.748	0.624	0.556
Thailand	0.190	0.690	0.691	Chile	-0.486	0.599	0.551
Finland	-0.453	0.766	0.689	Costa Rica	-0.303	0.568	0.541
Peru	-0.322	0.751	0.687	Philippines	-0.672	0.592	0.534
Egypt	-0.130	0.728	0.685	Indonesia	-0.791	0.589	0.525
Vietnam	0.444	0.633	0.684	China	-0.191	0.537	0.524
Hungary	-0.137	0.727	0.683	Singapore	-0.545	0.561	0.517
Ukraine	0.246	0.671	0.683	Ecuador	-0.149	0.515	0.511
Turkey	0.134	0.678	0.673	Croatia	-0.987	0.578	0.508
Dominican Rep.	0.272	0.650	0.670	Sri Lanka	-0.739	0.528	0.479
Mexico	0.054	0.678	0.664	Malaysia	-1.052	0.517	0.456
Austria	-1.070	0.765	0.656	Slovenia	-1.725	0.487	0.413
Romania	0.302	0.619	0.649	India	-1.356	0.429	0.375
Greece	-0.364	0.685	0.634	Georgia	-1.557	0.426	0.367

Source: Computation by authors based on data from TripAdvisor.

5 Empirical analysis

In this section, we empirically examine how taste proximity affects the valuation of product quality and consequently the export revenues of high-quality products. The theoretical framework presented in Section 2, and in particular the findings reported in Equation (III.5), delivers a testable prediction that makes it possible to empirically examine this effect through an analysis of the correlation between export prices and sales.

5.1 Empirical model

The purpose of our empirical model is to examine whether, within a given product category, the correlation between price and revenue across firms depends on the taste proximity of importing countries with respect to France. As French customs data do not report the prices of the exported varieties, we instead use the unit values computed as the ratio of export

value to weight. The analysis proposed in this section is based on a reduced-form approach and is not intended to identify a causal relation. To test our main hypothesis, we regress the log of export sales on the log of unit values for a variety fh exported to destination j at year t . To capture the effect of taste proximity on the relationship between sales and prices, we add the variable $\ln \widehat{taste}_{FR,j}$ obtained in the previous section, interacted with the log of sales:

$$\ln sales_{fhjt} = \delta_0 + \delta_1 \ln uv_{fhjt} + \delta_2 (\ln uv_{fhjt} * \ln \widehat{taste}_{FR,j}) + \mathbf{Z}' \delta_3 + \varphi_{jt} + \varphi_{ht} + \epsilon_{fhjt} \quad (\text{III.8})$$

Parameters φ_{jt} and φ_{ht} correspond to destination-year and product-year fixed effects. φ_{jt} controls for time-varying importer-specific characteristics that may explain the variation of sales at a given destination, such as the level of income, population size, or any other demand shock. Moreover, since the analysis is based on exporting firms located in France, φ_{jt} allows us to control for all bilateral characteristics between France and the importing country, such as distance, transportation costs, or the presence of free trade agreements. φ_{ht} instead controls for the yearly average unit value at which a product is exported by France, as well as for changes in worldwide conditions in the market for this product. \mathbf{Z}' corresponds to a vector of control variables and includes the product scope within a firm, measured as the total number of products exported by a firm to a destination, and the Herfindal index, measured as $HHI_{jht} = \sum_n^N s_{fhjt}^2$, where s_{fhjt} is the market share of firm f in the market and N is the number of firms. The rationale behind the use of the HHI_{jht} is to control for the degree of competition in a market, which could influence the relationship between prices and sales. We also control for the scope of exported products to a destination. For multiproduct firms, a larger number of exported products implies that many of them are outside the firm's core competencies. The coefficients of interest are the sum $\hat{\delta}_1 + \hat{\delta}_2 \ln \widehat{taste}_{FR,j}$, which determines the sign and the extent of correlation between sales and export prices, and δ_2 , which determines how taste proximity affects this correlation. Given the set of fixed effects introduced in Equation (III.8), we estimate how variations in unit values explain the variation in revenues across firms exporting the same CN8 product to the same country in a given year. A positive value of $\hat{\delta}_1 + \hat{\delta}_2 \ln \widehat{taste}_{FR,j}$ indicates that the intensive margin of varieties increases with the export price. According to our theoretical framework, this scenario implies that despite higher prices, higher quality products perform better than low-quality products because of consumers' valuation of quality. In this case, a positive value of δ_2 indicates that for destinations with strong taste proximity, varieties of higher quality have relatively larger revenues. A negative value of $\hat{\delta}_1 + \hat{\delta}_2 \ln \widehat{taste}_{FR,j}$ denotes, instead, a negative correlation between the intensive margin and export prices and could indicate two different scenarios. Because export prices and quality may be negatively correlated in this case, the interpretation of the effect depends on the

sensitivity of production costs to efficiency.²⁰ On the one hand, when the sensitivity of production costs to efficiency is below 1, quality is negatively correlated with export prices, and higher quality varieties are characterized by larger market shares because of their lower prices. On the other hand, when the sensitivity of production costs to efficiency exceeds 1, quality and export prices are positively correlated, and low-quality varieties have larger market shares because of their lower prices.

To address these last considerations, our empirical model in Equation (III.8) explains how taste proximity affects the relationship between sales and prices, but in the case in which prices and sales are negatively correlated, it cannot provide a comprehensive interpretation of the link between taste proximity and consumer valuation of quality. To address this issue, we analyze whether production costs increase with quality. Ideally, to establish whether prices and quality are positively associated, we should verify the correlation between export prices and the cost of inputs, as indicated by Equations (III.2) and (III.3) in Section 2. Assuming that the price of imported inputs reflects the costs of inputs used in production, we analyze the correlation between export prices and the price of imported inputs. Since we are not able to identify the exact inputs used for the production of each output, we follow Jäkel and Sørensen (2020) and estimate two different averages:

- $\ln uv_{fht}^{m,HS3}$ calculated at the firm-product (output) level, which corresponds to the weighted average of the unit values of imported inputs for the inputs within the same category (HS3) as the product.
- $\ln uv_{ft}^m$ calculated at the firm level, which corresponds to the weighted average of the unit values of overall inputs imported by the firm.

Table 3: Relationship between export unit values and unit values of imported inputs

	Explained variable: $\ln uv_{fjht}$	
	(1)	(2)
$\ln uv_{fht}^{m,hs3}$	0.295*** (0.008)	
$\ln uv_{ft}^m$		0.342*** (0.009)
Constant	8.239*** (0.003)	8.245*** (0.003)
FE destination-year	Yes	Yes
FE product-year	Yes	Yes
R-squared	0.737	0.737
Observations	1,845,993	1,845,993

Significance levels: ***0.01 **0.05 *0.10. Regressions cluster standard errors by firm-year.

20. In our theoretical framework, the sensitivity of production costs to efficiency is represented by the term $\eta_{\omega,\theta} \times \eta_{\theta,A}$, which corresponds to the product of the elasticity of input prices to quality and the elasticity of output quality to efficiency.

Table 3 reports the results of regressing export unit values on imported input prices. As the coefficient of input prices is significant and positive in both columns, we are likely to be in a situation in which the production of high-quality products implies higher marginal costs, which are translated into higher prices. This finding is not surprising since it is well known that in the agri-food sector, the quality of output derives mainly from the ingredients used in processing and that high-quality inputs cost more. With reference to Equation (III.3) in the theoretical section, our results suggest that the sensitivity of production costs to efficiency $\eta_{\omega,\theta} \times \eta_{\theta,A}$ is larger than one, which implies a positive correlation between prices and quality.

Table 4: Impact of taste proximity on the relationship between sales and export unit values

	Explained variable: $\ln \text{sales}_{fjht}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln uv_{fjht}$	-0.196*** (0.004)	-0.212*** (0.004)	-0.221*** (0.008)	-0.216*** (0.008)	-0.184*** (0.008)	-0.121*** (0.007)
$\ln uv_{fjht} * \ln \text{taste}_{FR,j}$			0.042*** (0.008)	0.038*** (0.008)	0.038*** (0.008)	0.059*** (0.007)
$\ln N \text{ products}_{fjt}$				-0.019*** (0.005)	0.485*** (0.008)	0.094*** (0.003)
HHI_{jht}				-0.298*** (0.012)	-0.083*** (0.011)	-0.319*** (0.010)
$\ln \text{product rank}_{ft}$					-0.838*** (0.008)	
Constant	11.150*** (0.034)	11.280*** (0.034)	11.216*** (0.040)	11.323*** (0.039)	11.197*** (0.039)	10.202*** (0.034)
FE destination-year	No	Yes	Yes	Yes	Yes	Yes
FE product-year	Yes	Yes	Yes	Yes	Yes	Yes
FE firm	No	No	No	No	No	Yes
R-squared	0.127	0.169	0.156	0.157	0.287	0.349
Observations	2,957,205	2,957,120	2,090,834	2,090,834	2,090,834	2,079,611
$\delta^j(\ln \text{taste}_{max})$			-0.171	-0.170	-0.139	-0.051
$\delta^j(\ln \text{taste}_{min})$			-0.205	-0.202	-0.170	-0.099
F-test diff.			25.24	21.58	22.83	68.18
p-value F-test			0.000	0.000	0.000	0.000

Significance levels: ***0.01 **0.05 *0.10. Regressions cluster standard errors by firm-year.

Table 4 reports the results of the baseline model. In Columns (1) and (2), we regress the log of sales on the log of unit values conditional on a vector of control variables, and we introduce product-year and destination-year fixed effects in each column. We observe a negative correlation between prices and sales, which indicates that overall, export revenues decrease with the unit value and quality of varieties. This result seemingly contradicts the main findings of the literature, which observes, in general, a positive correlation between prices and sales. Note that the vast majority of studies investigating firms' export performance are conducted on developing countries characterized by limited domestic demand for high-quality products and systematically outline the fact that an essential prerequisite to successfully export is to upgrade the quality of products above the average level offered in the domestic market (Kugler and Verhoogen, 2012; Manova and Zhang, 2012; Manova and

Yu, 2017). France is a highly developed country characterized by high quality standards and a domestic demand that drives the production of high-quality products. Our setting is, therefore, different from that of developing countries, and the efficiency sorting mechanism is likely to be driven by other factors. This result is, however, in line with the findings of Jäkel and Sørensen (2020), who observe a negative price premium for exporting firms with respect to non-exporters. In Column (3), we include the log of taste as estimated in Section 4, interacted with the log of unit values. The coefficient δ_2 is positive, which indicates that in countries with high taste proximity, varieties sold at higher prices have relatively higher intensive margins. A positive estimate for δ_2 is consistent with our hypothesis that taste proximity increases the quality valuation of imported varieties. The result also holds when we add our control variables in Column (4). This indicates that the effect of taste proximity on the correlation between unit values and sales is not affected by the scope of products exported within the firm or by the degree of competition in the importing country. In Column (5), we add the rank of the product within the firm computed across all destinations (also referred to as the global rank) as an additional control. The purpose is to control for the rank of the product within a firm's portfolio, as we assume that export revenues from a product are higher for firms exporting more varieties and products closer to their core competences (Bernard et al., 2010; Manova and Yu, 2017). This additional control, therefore, allows us to compare the effect of taste proximity on the correlation between sales and unit values for varieties located at the same distance from the firm's core competence. We observe that this additional control does not change our estimated effect of taste proximity. Nonetheless, as the global rank of a product is likely to be correlated with the quality of the product, we retain the specification in Column (4) as the preferred one. In Column (6), we add an additional firm-level fixed effect, which allows us to verify whether the positive effect of taste proximity on the price-sales correlation holds within the products exported by the same firm. The result is robust to the addition of firm fixed effects.

In Columns (3) to (6) of Table 4, we also report the prediction of the effect of export unit values on export revenues $\delta^j = \delta_1 \ln uv_{fhjt} + \delta_2 (\ln uv_{fhjt} * \ln \widehat{taste}_{FR,j})$ for the minimal and the maximal levels of taste proximity with France.²¹ We observe that, in all specifications, the null hypothesis that $\delta^j(\ln taste_{max}) = \delta^j(\ln taste_{min})$ is rejected. We observe that the effect of unit values on export revenues also remains negative for the highest value of taste proximity. This result implies that taste proximity tends to attenuate price competition. Consumers' valuation of quality is stronger, but the negative correlation between export prices and sales persists even in countries with high taste proximity. Therefore, high-quality varieties are unlikely to register the highest sales in destination markets, but they perform relatively better in countries where taste proximity is high.

21. As reported in Table 2, the country with the highest level of taste proximity reported is Belgium with $\ln taste_{FR,BE} = 1.180$ while the country with the lowest is Georgia with $\ln taste_{FR,GE} = 0.367$

In Table 5, we test our empirical model on a range of different industries within the agri-food sector. Panel A of Table 5 reports the results of the baseline model without the interaction term $\ln uv_{fhit} * \ln \widehat{taste}_{FR,j}$; Panel B reports the results when including the interaction term between taste proximity and unit values.²² France is renowned for being a world-leading exporter of wine. In fact, 27.82% of total exports in our data are in the HS2 class "Beverages, spirits and vinegar", covering a total of 25 122 firms. The wine industry is one of the most export-oriented industries. In the first two columns of Table 5, we run the estimation separately on the beverage industry (Column 1) and on the rest of the agri-food sector (Column 2). Surprisingly, we observe that the results in these two columns diverge tremendously. In Panel A, we observe a negative correlation between export sales and unit values in both cases, but the coefficient δ_1 is much lower for the beverage industry. In Panel B, the coefficient of sales interacted with taste proximity yields the opposite results. While the results in Column (2) confirm our findings in Table 4, for the beverage industry, the correlation between sales and unit values decreases with taste proximity. In Columns (3) to (6), we run the regression separately for dairy products, meat, preparations of cereals and fruits. For meat and dairy products, we observe an efficiency sorting situation, with a strong effect of taste proximity on the correlation between unit values and sales. For preparations of cereals and fruits, the effect is positive but nonsignificant. This difference in terms of magnitude and significance of the effect of taste proximity is most likely because for dairy and meat products, the scope for vertical differentiation is larger than for fruits and preparations of cereals. While the results for nonbeverage industries (Columns (2) to (6)) are in line with our expectations, the findings reported in Column (1) regarding the beverage industry require further comment. French exports in the beverage industry are dominated by wine, which represents 82% of the exported value. A possible explanation for the different result for this industry is that, similar to other alcoholic beverages, wine is mainly consumed and traded in countries in which wine is produced. These countries are likely to share a similar consumption culture and consumer taste with France and to import wine of different qualities to satisfy heterogeneous demand. In countries in which the consumption of wine is not popular, the consumption of wine is limited to the wealthy part of the population. For this reason, the demand for high-quality varieties is stronger in countries in which wine is not popular. Another possible interpretation is that in countries with high taste proximity, consumers prefer high-quality wines produced domestically. Finally, the result for the beverages industry could be because our variable $\ln taste_{FR,j}$ captures the taste proximity for food products but does not truly reflect the taste proximity for beverages.

22. In both cases, we run the regressions when including the control variables mentioned above. The coefficients of the control variables are not reported.

Table 5: Results for most relevant industries

	Explained variable: $\ln \text{sales}_{fjht}$					
	Beverages (1)	Non-Bev. (2)	Diary (3)	Meat (4)	Cereals (5)	Fruits (6)
Panel A						
$\ln uv_{fjht}$	-0.043*** (0.006)	-0.290*** (0.005)	-0.697*** (0.020)	-0.233*** (0.010)	-0.458*** (0.012)	-0.154*** (0.014)
Panel B						
$\ln uv_{fjht}$	0.015 (0.013)	-0.348*** (0.010)	-1.050*** (0.042)	-0.437*** (0.027)	-0.440*** (0.037)	-0.184*** (0.028)
$\ln uv_{fjht} * \ln \text{taste}_{FR,j}$	-0.097*** (0.016)	0.117*** (0.010)	0.433*** (0.045)	0.322*** (0.031)	0.037 (0.045)	0.047 (0.029)
Observations	627,819	1,462,948	154,905	170,205	107,008	196,510
$\delta^j(\ln \text{taste}_{max})$	-0.099	-0.209	-0.539	-0.057	-0.396	-0.129
$\delta^j(\ln \text{taste}_{min})$	-0.021	-0.305	-0.891	-0.319	-0.426	-0.166
F-test diff.	37.32	148.06	94.19	110.54	0.66	2.54
p-value F-test	0.000	0.000	0.000	0.000	0.415	0.113

Significance levels: ***0.01 **0.05 *0.10. The industries are defined at HS2 digits level. Beverages corresponds to the HS2 class "22 - Beverages, spirits and vinegar", Dairy to "04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included", Meat to "02 - Meat and edible meat offal", Cereals to "19 - Preparations of cereals, flour, starch or milk; pastrycooks' products", Fruits to "08 - Fruit and nuts, edible; peel of citrus fruit or melons". Regressions cluster standard errors by firm-year. All estimations include destination-year and product-year fixed effects and the full set of control variables.

5.2 Additional controls

Taste proximity is not the only element affecting the quality valuation of products. The literature on international trade has outlined that the demand for high-quality products can be determined by other factors that differ across countries. If preferences are nonhomothetic, consumer propensity to spend on high-quality products increases with the level of income (Fajgelbaum et al., 2011; Hallak, 2006). In the same way, the Alchian and Allen (1964) effect stipulates that because of per-unit trade costs, relative demand for higher quality goods increases to more distant destinations. While we control for these two elements through the country-year fixed effect φ_{jt} , concerns can arise when these variables are correlated with taste proximity. If taste proximity for French food is particularly strong in wealthy countries, the coefficient δ_2 also captures the effect of similarity in the level of wealth. Moreover, taste proximity is likely to be inversely correlated with geographical proximity, and if not properly controlled for, δ_2 is likely to underestimate the effect of taste proximity. To address these potential biases, we control for interactions of unit values with per capita GDP, distance and taste computed separately. Note that in this case, we predict the effect of export prices on export revenues according to the degree of taste proximity as:

$$\delta^j(\ln \text{taste}_{FR,j}) = \delta_1 \ln uv_{fjht} + \delta_2 (\ln uv_{fjht} * \ln \widehat{\text{taste}}_{FR,j}) + \delta_3 (\ln uv_{fjht} * \ln \bar{y}_{jt}) + \delta_4 (\ln uv_{fjht} * \ln \overline{\text{dist}}_{FR,j}),$$

Table 6: Additional controls for non-homothetic preferences and the Alchian-Allen effect

	Explained variable: $\ln \text{sales}_{fjht}$		
	(1)	(2)	(3)
$\ln uv_{fjht}$	-0.373*** (0.018)	-0.072*** (0.015)	-0.445*** (0.036)
$\ln N \text{ products}_{fjt}$	-0.020*** (0.004)	0.002 (0.004)	-0.019*** (0.005)
HHI_{jht}	-0.326*** (0.011)	-0.334*** (0.010)	-0.294*** (0.012)
$\ln uv_{fjht} * \ln \text{gdp/cap}_{jt}$	0.018*** (0.002)		0.014*** (0.002)
$\ln uv_{fjht} * \ln \text{dist}_{FR,j}$		0.018*** (0.002)	0.011*** (0.002)
$\ln uv_{fjht} * \ln \text{taste}_{FR,j}$			0.053*** (0.009)
Constant	11.340*** (0.036)	11.349*** (0.035)	11.326*** (0.040)
FE destination-year	Yes	Yes	Yes
FE product-year	Yes	Yes	Yes
R-squared	0.172	0.170	0.157
Observations	2,523,243	2,929,708	2,090,834
$\delta^j(\ln \text{taste}_{max})$			-0.179
$\delta^j(\ln \text{taste}_{min})$			-0.223
F-test diff.			33.51
p-value F-test			0.000

Significance levels: ***0.01 **0.05 *0.10. Regressions cluster standard errors by firm-year.

where $\overline{\text{dist}}_{FR,j}$ and \bar{y}_{jt} correspond to the simple average of the per capita GDP and distance across importers. The results are reported in Table 6. In Column (1), we regress our baseline model augmented with the interaction between per capita GDP and unit value, while in Column (2), we use the interaction of unit value with distance. We observe that the coefficient of the interaction terms in both specifications is positive and significant. This implies that sales of more expensive varieties increase with the distance and the level of income of importing markets. These results confirm the expectations expressed by the Linder hypothesis and the Alchian-Allen effect. In Column (3), we simultaneously include both interaction terms and add the interaction between taste and unit values. We observe that when we control for the income level of importers and distance, the effect of taste remains significant and positive. When comparing our findings in Table 4 with the results in Column (3) of Table 4, we observe that the coefficient of the interaction term between taste and unit value is higher in the second case. This indicates that the downward bias on δ_2 due to the negative correlation between unit values and distance is stronger than the upward bias due to the positive correlation between taste proximity and the level of income.

5.3 Robustness

Table 7: Relationship between proxies of intrinsic variety quality and sales

	Explained variable: $\ln \text{sales}_{fjht}$					
	All industries				Non-beverages	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln uv_{fht}^{m,hs3}$	-0.172*** (0.009)		-0.196*** (0.022)		-0.377*** (0.027)	
$\ln \bar{uv}_{fjht}$		-0.153*** (0.007)		-0.193*** (0.014)		-0.260*** (0.016)
$\ln uv_{fht}^{m,hs3} * \ln \text{taste}_{FR,j}$			0.014* (0.010)		0.114*** (0.011)	
$\ln \bar{uv}_{fjht} * \ln \text{taste}_{FR,j}$				0.040*** (0.014)		0.089*** (0.016)
$\ln N \text{ products}_{fjt}$	-0.046*** (0.005)	-0.026*** (0.004)	-0.094*** (0.005)	-0.053*** (0.005)	-0.109*** (0.005)	-0.125*** (0.005)
HHI_{jht}	-0.299*** (0.012)	-0.352*** (0.010)	-0.255*** (0.015)	-0.310*** (0.012)	-0.274*** (0.016)	-0.328*** (0.014)
Constant	9.852*** (0.010)	10.921*** (0.059)	10.078*** (0.011)	11.150*** (0.055)	10.106*** (0.012)	11.623*** (0.064)
FE destination-year	Yes	Yes	Yes	Yes	Yes	Yes
FE product-year	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.181	0.170	0.171	0.158	0.180	0.172
Observations	1,845,993	2,893,006	1,267,498	2,044,142	1,052,773	1,438,024

Significance levels: ***0.01 **0.05 *0.10. In Columns (5) and (6) the sample is reduced to the non-Beverages products. Regressions cluster standard errors by firm-year.

Our investigation is based on the theoretical assumption that constant markups exceed marginal costs for all varieties. Some concerns may rise when considering eventual pricing-to-market strategies, which could bias the interpretation of δ_2 in the empirical model presented in Equation (III.8). In Table 7, we replace the unit values of exports in the baseline model with two different proxies for quality, which are independent of pricing-to-market strategies relative to destination markets. In Columns (1), (3) and (5) of Table 7, we analyze the correlation between the unit values of imported inputs, $\ln uv_{fht}^{m,HS3}$, and sales, while in Columns (2), (4) and (6), we use the weighted average of unit values of the variety on the other destination markets calculated as $\ln \bar{uv}_{fjht} = \frac{\sum_{l \neq j} \ln uv_{fjht} * \text{quantity}_{fjht}}{\sum_{l \neq j} \text{quantity}_{fjht}}$. Although these proxies share the advantage of being independent from pricing-to-market strategies, they correspond to imperfect measures of quality. In fact, only a small part of inputs used in the agri-food sector are imported, and imported inputs may not reflect the actual quality of inputs used. However, the weighted average of unit values of a variety on the other markets may also capture differences in the varieties exported to each destination.²³ The results in Table 7 confirm that on average, varieties produced with cheaper imported inputs (Column 1) and varieties sold on average at lower prices (Column 2) are characterized by higher ex-

23. Within a given 8-digit product category, there could be differences between products. The literature often refers to these unobserved varieties within a product category as hidden varieties (Khandelwal, 2010).

port revenues. This result is in line with our interpretation that low-quality products are characterized by a higher intensive margin because of their lower prices. In Columns (3) and (4), we add the log of taste interacted with the proxies for quality. We find a positive coefficient for these interaction variables, which indicates that high-quality products perform relatively better in countries with higher taste proximity. Nonetheless, when we use the unit values of imported inputs, the statistical significance of the coefficient is lower than in Table 4. In Columns (5) and (6), we repeat the estimation on the subpanel without the HS2 22 industry "Beverage, spirits and vinegar" and find a higher and more significant effect of taste proximity on the intensive margin of high-quality products. This result corroborates our previous findings in Tables 4 and 5, according to which quality valuation increases with taste proximity, except in the beverage industry.

6 Conclusion

In this study, we investigate the impact of consumer taste proximity on export revenues of French firms in the agri-food sector. Our main objective is to analyze how consumer tastes for food products from France affect the propensity of different destination countries to spend on high-quality French varieties. For this purpose, we introduce a novel methodology for estimating taste proximity based on data collected from the online travel company TripAdvisor, which reports information on the type of cuisine offered in restaurants for a large number of countries. Through the use of these data, we derive a measure of cuisine popularity for each country and an index of the similarity between the distribution of restaurants offering a cuisine for each pair of countries. To obtain the measure of taste proximity, we use a control function approach where the two measures are embedded into a gravity equation. Conceptually, taste proximity corresponds to the unobserved affinity in taste for food products between consumers that promotes trade. After obtaining the measure of taste proximity, we empirically investigate the effect of the taste proximity of different countries with France on the sales of high-quality French varieties in these markets. To do so, we analyze the relationship between unit values and export sales and how this relationship is affected by consumer taste for French food in the destination country. Because of the strong positive correlation between the prices of imported inputs and the export prices of output, export unit values are likely to represent a sound proxy for product quality. Our results indicate that, in general, French food varieties exported at lower prices earn larger revenues in foreign markets. In addition, we find that the negative correlation between sales and export prices is attenuated in countries with high taste proximity. Our findings indicate that although high-quality varieties are characterized by lower export revenues, firms exporting high-quality products perform relatively better in countries with high taste proximity. Our findings suggest that for countries where tastes are similar to those of French consumers, the degree of appreciation of quality is high and consumers are more willing to spend on high-quality products. Our result is robust

to controlling for possible correlations between taste proximity, geographical distance, countries' level of income and pricing-to-market strategies. The effect of taste proximity on the sales of high-quality products is confirmed for the majority of food industries except beverages, which are dominated in France by wine exports. We argue that the difference in results between beverages and the other products may be due to peculiarities of the demand for wine in countries where wine consumption is not present or to the fact that the measure of taste proximity does not truly reflect the taste proximity for beverages.

In general, our results suggest that taste differences between France and other countries make firms exporting at lower prices more successful. This result can be explained by the fact that, especially in the agri-food sector, firms upgrade product quality mainly to accommodate the demands of domestic consumers. When firms export to countries with low taste proximity, differences in taste 'cancel out' consumers' willingness to pay for quality. This is because foreign consumers do not perceive the quality of a product in the same way as domestic consumers, and for this reason, their purchases are mainly driven by price competition, which favors low-quality varieties. Nonetheless, firms exporting high-quality varieties may find it more profitable to export to countries where tastes are closer to domestic ones and consumer willingness to spend on quality is higher.

Appendix A – Data on restaurant cuisine

Table A1: Concordance between type of cuisine and iso2 code of origin country

CUISINE	ISO2	CUISINE	ISO2	CUISINE	ISO2	CUISINE	ISO2
Afghani	AF	Contemporary	N/A	Izakaya	JP	Pub	N/A
African	N/A	Costa Rican	CR	Jamaican	JM	Puerto Rican	PR
Albanian	AL	Croatian	HR	Japanese	JP	Romagna	IT
Algerian	DZ	Cuban	CU	Japanese-Other	JP	Romana	IT
American	US	Czech	CZ	Japanese - Other	JP	Romanian	RO
Anhui	CN	Danish	DK	Japanese - Traditional	JP	Russian	RU
Apulian	IT	Deli	N/A	Japanese Fusion	JP	Salvadoran	SV
Arabic	N/A	Diner	N/A	Japanese sweets parlour	JP	Sardinian	IT
Argentinian	AR	Dining bars	N/A	Jiangsu	CN	Scandinavian	multiple6
Armenian	AM	Dutch	NL	Jiangxi	CN	Scottish	GB
Asian	N/A	Eastern European	N/A	Kaiseki	JP	Seafood	N/A
Assyrian	N/A	Ecuadorian	EC	Kappo	JP	Shandong	CN
Australian	AU	Egyptian	EG	Korean	KR	Shanghai	CN
Austrian	AT	Emilian	IT	Kyoto cuisine	JP	Shojin	JP
Azerbaijani	AZ	Ethiopian	ET	Kyushu cuisine	JP	Sicilian	IT
Bahamian	BS	European	N/A	Latin	N/A	Singaporean	SG
Balti	IN	Fast Food	N/A	Latvian	LV	Slovenian	SI
Bangladeshi	BD	Filipino	PH	Lazio	IT	Soups	N/A
Bar	N/A	French	FR	Lebanese	LB	South American	N/A
Barbecue	N/A	Fruit parlours	N/A	Ligurian	IT	Southern-Italian	IT
Basque	ES	Fujian	CN	Lombard	IT	Southwestern	US
Beer restaurants	N/A	Fusion	N/A	Malaysian	MY	Spanish	ES
Beijing cuisine	CN	Gastropub	N/A	Medicinal foods	N/A	Sri Lankan	LK
Beijing Specialities	CN	Georgian	GE	Mediterranean	N/A	Steakhouse	N/A
Belgian	BE	German	DE	Mexican	MX	Street Food	N/A
Brazilian	BR	Greek	GR	Middle Eastern	N/A	Sushi	JP
Brew Pub	N/A	Grill	N/A	Mongolian	MN	Swedish	SE
British	GB	Guangxi	CN	Moroccan	MA	Swiss	CH
Burmese	MM	Guatemalan	GT	Native American	US	Szechuan	CN
Cafe	N/A	Guizhou	CN	Neapolitan	IT	Taiwanese	TW
Cajun & Creole	N/A	Hangzhou	CN	Nepali	NP	Thai	TH
Calabrian	IT	Hawaiian	US	New Zealand	NZ	Tibetan	CN
Cambodian	KH	Healthy	N/A	Nigerian	NG	Tunisian	TN
Campania	IT	Henan	CN	Nonya	MY	Turkish	TR
Canadian	CA	Hokkaido cuisine	JP	NorthEastern Chinese	CN	Tuscan	IT
Cantonese	CN	Hong Kong	CN	Northern-Italian	IT	Ukrainian	UA
Caribbean	multiple1	Hubei	CN	NorthWestern Chinese	CN	Uzbek	UZ
Catalan	ES	Hunan	CN	Norwegian	NO	Venezuelan	VE
Caucasian	multiple2	Hungarian	HU	Okinawan Cuisine	JP	Vietnamese	VN
Central American	multiple3	Imperial Chinese	CN	Pakistani	PK	Welsh	GB
Central Asian	multiple4	Indian	IN	Persian	IR	Wine Bar	N/A
Central European	multiple5	Indonesian	ID	Peruvian	PE	Xinjiang	CN
Central-Italian	IT	International	N/A	Pizza	N/A	Yunnan	CN
Chilean	CL	Irish	IE	Polish	PL	Zhejiang	CN
Chinese	CN	Israeli	IL	Polynesian	N/A		
Colombian	CO	Italian	IT	Portuguese	PT		

On TripAdvisor, the type of reported cuisine is selected from a list provided by the website. The total number of cuisines proposed by TripAdvisor is 182, and each restaurant can register up to 4 different types. We associate each type of cuisine with the origin country that offers the cuisine. From the 182 listed cuisines, 151 were associated with 93 different origin countries. Table A1 reports the combination between the type of cuisine and the corresponding origin country. There are types of cuisines that cannot be directly associated with a specific origin country because they are simply ageographic, such as "sea food", or because they refer to wide geographic regions, such as "European". We do not take into account these types of cuisine because the provided information is not useful to the scope of the study or

is too generic. For these types of cuisine, the corresponding exporter is reported as N/A in Table A1. In contrast, some types of cuisine refer to restricted geographic regions such as "Caucasian" or "Central American". In these cases, we assign the cuisine to all countries in the region according to their weight in terms of the total population as measured in 2019. In Table A1, we designate these cuisines as "multiple". We have 6 "multiple" cuisines that we allocate to origin countries as follows:

- multiple1: Caribbean \Rightarrow 31% Cuba (CU) - 30% Dominican republic (DO) - 31% Haiti (HT) - 4% Trinidad and Tobago (TT) - 2% Guyana (GY) - 2% Suriname (SR)
- multiple2: Caucasian \Rightarrow 18% Armenia (AM) - 22% Georgia (GE) - 60% Azerbaijan (AZ)
- multiple3: Central America \Rightarrow 10% Costa Rica (CR) - 34% Guatemala (GT) - 13% El Salvador (SV) - 20% Honduras (HN) - 14% Nicaragua (NI) - 9% Panama (PA)
- multiple4: Central Asia \Rightarrow 25% Kazakhstan (KZ) - 9% Kyrgyzstan (KG) - 13% Tajikistan (TJ) - 8% Turkmenistan (TM) - 45% Uzbekistan (UZ)
- multiple5: Central Europe \Rightarrow 7% Czech Republic (CZ) - 23% Poland (PL) - 50% Germany (DE) - 3% Slovakia (SK) - 1% Slovenia (SI) - 6% Hungary (HU) - 5% Switzerland (CH) - 5% Austria (AT)
- multiple6: Scandinavian \Rightarrow 21% Denmark (DK) - 38% Sweden (SE) - 20% Norway (NO) - 20% Finland (FI) - 1% Iceland (IS)

Appendix B – Average shares of cuisine across countries

Table B1 describes the average share of cuisine from each origin country computed as the average of its share in each destination relative to other nondomestic cuisines, \bar{s}_i . The most popular cuisine in the world is Italian cuisine, with an average share of 26.4%, followed by Chinese cuisine, with a share of 16%, and Japanese cuisine, with a share of 13%. French cuisine is one of the most highly appreciated cuisines in the world, with an average share of 5.71%. In contrast, for the majority of cuisines, the average share destination countries is below 1%.

Table B1: Average share of cuisine across destination countries

Country	Average share %	Country	Average share %
Argentina	0.601	Japan	13.0
Australia	0.203	Kazakhstan	0.0150
Austria	0.353	Malaysia	0.215
Belgium	0.325	Mexico	3.89
Brazil	0.568	Morocco	0.403
Cambodia	0.0244	Netherlands	0.246
Canada	0.0531	New Zealand	0.0205
Chile	0.0364	Norway	0.0150
China	16.0	Peru	0.965
Colombia	0.0990	Philippines	0.0939
Costa Rica	0.0103	Poland	0.238
Croatia	0.0983	Portugal	0.253
Czech Republic	0.101	Rep. of Korea	1.73
Denmark	0.0383	Romania	0.0268
Dominican Rep.	0.135	Russia	0.442
Ecuador	0.0107	Singapore	0.0776
Egypt	0.0540	Slovenia	0.0210
Finland	0.007	Spain	3.46
France	5.71	Sri Lanka	0.0422
Georgia	0.323	Sweden	0.102
Germany	1.49	Switzerland	0.187
Greece	1.37	Taiwan	0.253
Hungary	0.116	Thailand	3.44
India	4.82	Turkey	1.78
Indonesia	0.256	USA	13.3
Ireland	0.371	Ukraine	0.0451
Israel	0.151	United Kingdom	0.802
Italy	26.4	Vietnam	1.53

General Conclusion

Theoretical and empirical studies increasingly point to the importance of product quality in international trade. The first insights into the role of quality in international trade appeared with the theory known as the Linder hypothesis, formulated by Linder (1961), who emphasized the importance of domestic demand conditions in the delineation of trade patterns. Since the formulation of the Linder hypothesis, a diverse body of literature has established strong and extensive evidence of the role played by product quality differentiation in shaping trade dynamics. This Ph.D. thesis is a collection of three essays on international trade in which product quality represents the common thread. Each chapter describes a distinct contribution that represents a step forward from the current state of research and includes suggestions for future studies. Nonetheless, the findings of this thesis have to be considered in light of some limitations.

In the first chapter, we examine whether the quality of a product affects the volatility of the product's trade flows, focusing on a demand-driven mechanism. We argue that under the hypothesis of non-homothetic preferences, the variability of income leads to larger fluctuations of demand for high-quality imported products. We propose an analysis of the relationship between export volatility and product quality on cross-country panel data. Our results indicate that exports of high-quality products are characterized by a higher volatility. In addition, we observe that export volatility increases with product quality as the variability of the income per capita in the destination markets is higher. Our results are consistent with our hypothesis, according to which high-quality products are more income-elastic and the demand for high-quality products is more responsive to income shocks. Our findings emphasize the higher exposure to income variability of destination countries as a possible drawback of exporting high-quality products. Nonetheless, we have gone no further in our analysis to consider a geographic diversification of exports as an effective strategy for reducing market-specific idiosyncratic shocks. Since different studies have observed a positive correlation between product quality and the number of markets served (Crozet et al., 2012; Manova and Zhang, 2012; Martin and Mayneris, 2015), it would be interesting to test whether the geographical diversification of high-quality products can reduce the exposure of exports to market-specific demand fluctuations. The current study is performed at the country-product level and hence entails some limitations, as it does not account for heterogeneity across firms exporting the same product. While using

cross-country panel data allows us to generalize our research findings, we are unable to control for firm-specific factors related to product quality, which could represent a source of export volatility.

The second chapter provides insights on the quality provision mechanism according to which production of high-quality products requires employing skilled labor that, in turn, demands higher wages. We present a theoretical model where the upgrade of product quality is conditional on the employment of skilled labor, while the ability of a firm to attract higher-skill employees is determined by the level of wages it offers. We then set up an empirical strategy to test our theoretical prediction on cross-country panel data. Using an instrumental variable strategy, we determine the causal effect of an upgrade of exports' quality on wages offered at the industry level. Our results confirm our theoretical predictions and indicate that industries that upgrade the quality of exports raise the average level of wages paid, implying a change in the workforce composition towards categories of better-paid jobs. While other studies have provided evidence of a positive association between exports' quality and wages through the use of indirect proxies of quality (Brambilla et al., 2012; Brambilla and Porto, 2016; Verhoogen, 2008), we substantiate these findings using a more appropriate measure of quality and considering a large number of countries and industries. Our findings lead to several suggestions that could be subjects of future research. We observe that the documented effect is stronger for less developed countries that are often portrayed as lacking a skilled workforce. The presence of workers with advanced education and in possession of knowledge and skills needed to perform complicated tasks represents a crucial source of countries' economic growth. A rise in demand for skilled labor by industries upgrading the quality of exported products could have beneficial effects on the economic development of the respective country. While several studies have focused on specialization across products as a determinant of long-term economic growth (Hausmann et al., 2007, 2014), our findings suggest that within-product specialization along quality segments may have positive spillovers for economic growth. We hope that this study inspires further research efforts, which could advance the current understanding of the effect of within-product specialization on economic development.

The third chapter focuses on consumer taste proximity as a factor influencing trade of vertically differentiated products in the case of the agri-food sector. In this chapter, we examine whether consumers' valuation of quality of imported French products is higher in countries where consumers' tastes are similar to those of the French. To do so, we perform an empirical analysis to estimate the impact of taste proximity on export revenues of vertically differentiated varieties. To identify taste proximity, we rely on information collected from the online travel company TripAdvisor on the type of cuisine advertised by restaurants for a large number of countries. Using a control function approach, we embed the information on the cuisine distribution across countries in a gravity model to estimate taste proximity as

part of the residual of a gravity equation. We observe that the quality of exported products and their prices are positively correlated and that low-quality varieties are associated with larger revenues in destination markets because of their competitive prices. The main results of the empirical analysis indicate that firms exporting high-quality products earn greater export revenues in countries with a strong taste proximity. Our findings suggest that consumer valuation of product quality depends on the origin of imports and is higher for products imported from countries with similar tastes. Our analysis could be enhanced by considering how taste proximity affects the probability of exporting. In the theoretical model presented in this chapter, we do not include the fixed costs of exports, incurred by each firm exporting to each destination regardless of its level of productivity, product quality and destination characteristics. Similarly, our empirical analysis focuses on export revenues but is silent on the effect of taste proximity on the probability of market entry for vertically differentiated products. An interesting deeper extension of our current study would be to complement it with an analysis of the effect of consumer preferences on the probability of market entry from the theoretical and empirical points of view. The empirical results reported herein should be considered in the light of several limitations that could also represent starting points for future research. First, our measure of taste proximity is time-invariant, as it is obtained from data on cuisine distribution across countries at a given time. While the literature generally indicates a strong persistence in food consumption habits (Atkin, 2013), in our analysis we are unable to account for possible changes in consumer preferences for food products. Second, in the absence of a direct measure of the quality of exported varieties, our empirical analysis relies on the use of export unit values. Given the justification based on our theoretical findings and on the positive correlation between the unit values of imported inputs and exported output, we consider the use of unit values to be appropriate for the scope of the research. Nonetheless, it would be interesting to test our empirical findings by using alternative measures of quality. Finally, it must be noted that our estimation of taste proximity is well suited to measuring differences in consumer taste for the agri-food sector but is inappropriate for capturing generic consumer preferences. Therefore, our measure of taste proximity cannot be used for an extended analysis including other sectors.

List of Figures

C1	Example of nests structure	37
D1	Distribution of coefficients and p-values demand regressions	38
E1	Distribution of quality of imported products for industry "1520 - Manufacture of dairy products"	38
E2	Quality, price and quantity imported of "hs6 020110 - Carcasses or half-carcasses of bovine animals, fresh or chilled" for year 2005	39
E3	Quality and prices of exports to France. Data are relative to imported products of bovine meat (6-digit code: 020110)	40
1	The number of restaurants in the first 100 cities for each country	83

List of Tables

1	Sources of variations in volatility	20
2	Summary statistics	24
3	Distribution of tests for relevance and exogeneity of the instruments	25
4	Correlation between the value of quality and other related factors	26
5	Baseline regression with volatility measured in terms value	28
6	Baseline regression with volatility measured in terms quantity	29
7	Results with interaction variable	31
8	Results with alternative measure of quality	33
B1	Summary statistics of the main variables	36
1	Variance analysis of the average wage per capita at industry level	50
2	Correlation between industry wage premium and measures of technology so- phistication	51
3	Correlations between quality of exports, income, unit values and distance	54
4	Results baseline regression with Fixed Effects	57
5	Results of the instrumental variable regression	60
6	Results of the instrumental variable regression - Additional results	62
7	Results with alternative instruments	64
8	Results with alternative measures for quality	66
9	Robustness tests	67
A1	Period and number of industries available by country	70
A2	Countries included in the robustness analysis	70
A3	Summary statistics of main variables	70
B1	Quality estimation results	71
1	Gravity estimation with country-level data	86
2	Proxies and estimate for taste proximity with France	87
3	Relationship between export unit values and unit values of imported inputs	89
4	Impact of taste proximity on the relationship between sales and export unit values	90
5	Results for most relevant industries	93
6	Additional controls for non-homothetic preferences and the Alchian-Allen ef- fect	94
7	Relationship between proxies of intrinsic variety quality and sales	95

LIST OF TABLES

A1	Concordance between type of cuisine and iso2 code of origin country	98
B1	Average share of cuisine across destination countries	100

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Titre : Trois essais sur le rôle que la qualité des produits joue dans le commerce international

Mots clés : Commerce international, qualité des produits, gout des consommateurs, dynamiques d'exportation

Résumé : Cette thèse se compose de trois chapitres qui représentent une contribution à la recherche sur le rôle de la qualité des produits dans le commerce international. Le premier chapitre présente une analyse empirique de la relation entre la volatilité des flux commerciaux bilatéraux et la qualité des produits exportés. Nous argumentons que, sous l'hypothèse de préférences non-homothétiques, la variabilité du revenu génère des fluctuations plus importantes sur la demande de produits importés de haute qualité. Nos résultats indiquent que l'exportation de produits de haute qualité pourrait être désavantagée par une plus grande sensibilité à la variabilité des revenus du pays de destination. Le deuxième chapitre met en place une analyse empirique sur des données de panel entre pays pour estimer l'effet de l'amélioration de la qualité des produits exportés sur le changement de la prime salariale mesurée au niveau de l'industrie.

Nos résultats indiquent que les industries qui améliorent la qualité de leurs exportations augmentent le niveau moyen des salaires versés, ce qui implique un changement dans la composition de la main-d'œuvre vers des catégories d'emplois mieux rémunérées. Dans le troisième chapitre, nous examinons si l'évaluation de la qualité des produits français par les consommateurs étrangers est plus forte dans les pays où les goûts des consommateurs sont similaires à ceux des Français. Pour identifier la proximité des goûts, nous nous appuyons sur des données recueillies auprès de la société de voyage en ligne TripAdvisor. Les résultats de notre analyse empirique suggèrent que l'évaluation de la qualité des produits par les consommateurs dépend de l'origine des importations et qu'elle est plus forte pour les produits importés de pays ayant des goûts similaires à ceux des consommateurs Français.

Title: Three essays on the role of product quality in international trade.....

Keywords: International trade, product quality, consumer taste, export dynamics.

Abstract: This dissertation consists of three chapters that represent a contribution to the research on the role of product quality in international trade. The first chapter presents an empirical analysis of the relationship between the volatility of bilateral trade flows and the quality of products exported. We argue that, under the hypothesis of non-homothetic preferences, the variability of income generates larger fluctuations of the demand of high-quality imported products. Our findings indicate that a possible drawback of exporting high-quality products is represented by the higher exposure to income variability of destination countries. The second chapter sets up an empirical analysis on cross-country panel data to estimate the effect of the quality up-grade of exported products on the change of the wage premium measured at industry level.

Our findings show that industries which up-grade the quality of exports, increase the average level of wages paid, implying a change in the workforce composition towards categories of better paid jobs. In the third chapter, we examine whether consumer's valuation for quality of French imported products is stronger in countries where consumers' tastes are similar to the French ones. To identify taste proximity, we rely on information collected from the online travel company TripAdvisor. The findings of our empirical analysis suggest that consumer's valuation for product quality depends on the origin of imports and is stronger for products imported from countries with similar tastes to that of French consumers.