Low-Wage Country Competition and the Quality Content of High-Wage Country Exports*

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Abstract

We study how competition from low-wage countries in international markets affects the quality content of high-wage country exports. We focus on aggregate quality changes driven by a reallocation of sales from low- to high-quality producers within industries. Two alternative indicators are used to measure quality changes in firm-level data. Both lead to similar conclusions. Namely, we show that the mean quality of French exports increased by 11% between 1995 and 2005. A 2SLS estimation shows that quality improvement is significantly more pronounced in markets in which the penetration of developing countries has increased the most. The results are consistent with the competition from low-wage countries making developed countries specialize within industries in the production of higher quality goods.
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1 Introduction

This paper shows, based on firm-level data, that tougher competition from low-wage countries (LWC) triggers an increase in the quality content of French exports. The aggregate quality growth is consistent with intra-industry specialization along the quality dimension. Competition from low-wage countries leads rich nations to specialize in high-quality goods with potentially important consequences on their export performances, labor market and growth patterns.[1]

The aggregate quality growth identified in the data is driven by a reallocation of activities, within industries, from low- to high-quality firms. There are several reasons why such a reallocation among heterogeneous qualities is expected to be important in the data. First, the trade literature has emphasized the importance of the inter-firm reallocation of activities as a determinant of aggregate trade patterns.[2] Second, while the early literature assumes firms are heterogeneous in the productivity dimension, recent evidence emphasizes another dimension of heterogeneity, namely differences in the quality of products sold by firms within an industry.[3] Third, indirect evidence discussed by Peter Schott (Schott, 2004, 2008) suggests that international trade increasingly features intra-industry specialization along the quality dimension. Contrary to what standard Ricardian models predict, developed and developing countries now export similar products, but low-wage countries produce and export lower qualities of these products.[4] This suggests that, at the industry-level, LWCs exploit a comparative advantage in the production of low-quality varieties.

These three pieces of evidence can be reconciled into a unified framework in which firms are heterogeneous along the quality dimension and low-wage countries have a comparative advantage in the production of lower qualities.[5] When low-wage countries open up to international trade, countries specialize in the segment of the quality ladder that corresponds to their comparative advantage. Exports of LWCs concentrate on the lower segments while

[1]A specialization of rich countries in high-quality goods is likely to modify the relative demand for skilled and unskilled workers with an end effect on wage inequality and employment rates. In the long run, this could also affect growth potential, as discussed in Hausmann, Hwang and Rodrik (2007). If high quality goods are associated with higher productivity levels, specialization in high quality should increase aggregate prospects.

[2]See Melitz (2003)'s seminal paper. For a review, see Melitz and Trefler (2012).

[3]See among others Crozet, Head and Mayer (2012) on French data, Verhoogen (2008) on Mexican data, Hallak and Sivadasan (2009) on Indian, Chilean, Colombian and US data, and Baldwin and Harrigan (2011) on (product level) US data.

[4]Amiti and Freund (2010) show that emerging economies are becoming competitive not only in labor-intensive sectors, as predicted by the theory, but also in capital-intensive ones. Schott (2008), and Fontagné, Gaulier and Zignago (2008) provide additional evidence that disaggregated products on which developed and less-developed countries compete are sold at heterogeneous prices. Namely, LWCs tend to export lower price products. To the extent that price differences reflect heterogeneity along the quality dimension, this suggests that LWCs export low-quality goods.

[5]Throughout the paper, our definition of quality is based on the consumers' willingness to pay for a specific variety. A variety that consumers are willing to pay for, even at an extra cost, is said to be of good "quality". This can cover various characteristics of the good, including better quality inputs, less standardized technology, larger marketing expenditures at the level of the distribution, etc.

rich countries become increasingly specialized in high-quality goods: Market shares reallocate toward firms producing the highest qualities that are somewhat insulated from LWC low-quality competition.[6] In such a framework, one can expect the competition from low-wage countries to drive the quality content of northern country exports up.

The purpose of this paper is to assess the empirical validity of the mechanism just described. We use French firm-level export data and measure the magnitude of quality changes (driven by inter-firm reallocation) by industry and destination market. In the aggregate, we find that the quality of French exports increased by 11% between 1995 and 2005. This overall quality improvement however hides strong heterogeneity across sectors and destination markets. We exploit this heterogeneity to test for a causal impact of an increased competition from low-wage countries on the magnitude of quality changes. Our estimates suggest that the increase in the quality content of French exports is significantly more pronounced in those markets in which the competition from low-wage producers intensified the most. This feature of the data is consistent with intra-industry specialization inducing a reallocation of market shares across French firms, in favor of the best qualities.

There are two empirical challenges in this exercise. First, we need to measure intra-industry quality changes. We propose two alternative indices that measure aggregate quality changes attributable to a reallocation of market shares across vertically differentiated varieties, composing the basket of exported goods. Both indices are theoretically grounded and built from firm-level data. Importantly, they both lead to the same conclusions.

Our first quality index relies on the methodology proposed by Aw and Roberts (1986) and Boorstein and Feenstra (1987).[7] A nice feature of their measure is that it relies on very few assumptions on the way quality enters preferences. This index has two drawbacks. First, it implicitly assumes that more expensive varieties are of better quality. Second, it is biased by within-firm quality changes. We argue that both biases play against us, and we thus underestimate the effect of LWC competition on the quality of French exports.[8]

To check the robustness of our results, we however provide evidence based on an alternative quality index computed using actual estimates of individual qualities, by destination country. With respect to Boorstein & Feenstra's quality index, the estimation of individual

[6]Reallocation can occur through a net exit of low-quality firms as in Baldwin and Harrigan (2011), or through a reallocation of market shares from low- to high-quality incumbents. This later effect will be at work if the elasticity of substitution with LWC products is lower for high-quality than for low-quality varieties. This is the case in models of vertical differentiation *à la* Gabszewicz and Thisse (1979). Finally, the quality of exports may increase as a result of individual firms improving the quality of their products. As discussed later, we show that such "within-firm" quality upgrading is of limited magnitude in our data.

[7]See Harrigan and Barrows (2009) for a recent application on sectoral data.

[8]If the price of a variety is correlated with the productivity of the firm rather than with the quality of its product, as is the case in the Melitz model, an increase in the Boorstein & Feenstra index reflects a reallocation of market shares toward less productive firms. Since competition from low-wage countries penalizes low-productivity firms, one should observe a decrease in the "quality" index in markets that are more exposed to competitive pressures. We observe the opposite correlation, which favors the interpretation of the index in terms of quality. We further show that our index is downward-biased in the case of within-firm quality upgrading. Given evidence on LWC competition inducing within-firm quality upgrading, see e.g. Bloom, Draca and Van Reenen (2009), such adjustments play against our estimation of a positive link between LWC competition and the quality index.

qualities relies on stronger assumptions. However, it does not assume prices and quality are tightly linked and allows us to control for within-firm quality changes. Namely, we follow Khandelwal, Schott and Wei (2011) and use the between-firm dimension of the data to identify relative quality levels by firm and destination market. Based on these estimates, it is possible to measure changes in the mean quality of aggregate exports and break them down into a between- and a within-firm component. Importantly, the between component attributable to market shares being reallocated among heterogeneous qualities is remarkably close to estimates based on the first approach. Moreover, the component of quality changes attributable to within-firm quality upgrading is also found to increase over time.

The second challenge concerns the identification of a causal impact from LWC competition to quality changes. To that aim, we use the heterogeneity in quality adjustments across industries and destination markets. Using sector and country fixed effects in our regression framework allows us to control for a large number of unobserved determinants of quality changes, which may be correlated with the penetration of LWC exports. Once these fixed effects are controlled for, the impact of LWC competition on quality changes is entirely identified using the heterogeneity within sectors across destinations, which we relate to the heterogeneous penetration of LWCs. We are also concerned with potential endogeneity. In addition to measurement errors and omitted variable biases, our specification may suffer from reverse causality.[9] We thus develop a 2SLS strategy and find that the impact of LWC competition on quality is stronger, once endogeneity is controlled for. The effect is robust to controlling for various determinants of quality changes. We also show that competition from high-wage countries has the opposite effect on aggregate quality. This supports how we interpret the result, namely that it is explained by intra-industry specialization.

Our paper is related to a growing literature analyzing the impact that competition from low-wage countries has on individual firms and workers in developed countries. Bernard and Jensen (1997) show that competition from low-wage countries reallocates production towards capital-intensive plants, while labor-intensive ones are pushed out of the market. This is consistent with evidence discussed in this paper if the production of better qualities is more capital-intensive.[10] Holmes and Stevens (2010) also emphasize the role of inter-firm reallocations. In their theory however, the heterogeneity is not explained in terms of low- and high-quality firms, but in terms of firms producing standardized versus specialized goods. Using Census data, they show that Chinese competition has mainly hurt large-scaled standardized plants in the US. Finally, Amiti and Khandelwal (forthcoming) evaluate the quality effect of import competition. Using product-level data and the methodology developed in Khandelwal (2010), they find a non-linear impact of competition on quality upgrading which depends on how far a country is from the quality frontier. Our results suggest that France is sufficiently close to the frontier for the effect of competition to be positive. We further stress that the effect of foreign competition depends on the nature of competitive pressures that the producing country faces in *each destination market*. More

[9] In sectors and toward destinations where France increases quality, LWCs have more room to enter, and so increase their market shares.

[10] Verhoogen (2008) provides evidence of a positive link between the capital intensity of a firm and the quality of its output.

specifically, the quality content of exports increases with LWC competition but tends to decrease when the competition comes from high-wage, high-quality countries.

There are other mechanisms through which LWC competition may affect the aggregate level of quality/innovation. Most notably, the literature has pointed out *within-firm* technology upgrading induced by Chinese competition (Bloom et al., 2009; Mion and Zhu, 2011, see). These papers show that increased competitive pressures from China make firms adopt production processes that are more intensive in skilled and non-production workers (Mion and Zhu, 2011) and rely more on innovation (Bloom et al., 2009). The within-firm quality upgrading that we observe in our data is consistent with evidence in those papers. When we apply the same identification strategy as with the between indicators, we however find no evidence that within-firm quality changes are positively correlated with the magnitude of competitive pressures exerted by low-wage countries. This does not necessarily contradict previous results though, since our observation period is relatively short and our identification is in the cross-section of markets.[11] We consider rather that our "between" results and the "within" evidence in the above-mentioned papers are consistent. Both lines of research suggest that LWC competition affects the quality content of aggregate exports.

The rest of the paper is organized as follows. Section 2 describes the mechanism we have in mind to explain the link between the competition from low-wage countries and the aggregate quality of exports. Section 3 presents the strategy and data we use to test the prevalence of this mechanism. We discuss the results in Section 4. Finally, Section 5 concludes.

2 Theoretical Background

The mechanism tested in this paper is related to the notion of intra-industry specialization first discussed by Schott (2004). Based on product-level US import data, he shows that the US increasingly sources the same products from both high- and low-wage countries. These trade patterns contradict the neo-classical theory of international trade that predicts countries should specialize in the type of products for which they have a comparative advantage. Based on the simplest HOS model, one expects low-wage countries to specialize in the production of labor-intensive products. In that sense, the growth of these countries' exports in capital-intensive sectors is puzzling.[12]

According to Schott (2004), the puzzle can be explained by factor-proportion specialization occurring *within* rather than *across* products. His argument is based on the fact that, at the disaggregated level, unit values vary systematically with exporter relative factor endowments and exporter production techniques. This holds true in the cross-section, with

[11] Improving the quality of a product is a process that takes time since investments in R&D or marketing are not immediately efficient. Moreover, the firm is likely to increase the quality of its product in *all* the markets it serves, which cannot be identified with our strategy that relies on the variability across markets within sectors.

[12] See Amiti and Freund (2010) for additional evidence of emerging economies becoming competitive in capital-intensive sectors.

capital- and skill-abundant countries exporting goods at higher unit values, and over time, skill- and capital-deepening countries experiencing an increase in unit values relative to the countries they leave behind. In the words of Schott, "the relationship between unit values, exporter endowments and exporter production techniques supports the view that capital- and skill-abundant countries use their endowment advantage to produce vertically superior varieties, i.e. varieties that are relatively capital or skill intensive and possess added features or higher quality, thereby commanding a relatively high price." To put it differently, specialization occurs *within* industries along the quality dimension.

Our paper investigates the microeconomic underpinnings of such specialization patterns. We consider a world in which firms producing a specific good are heterogeneous in terms of the quality they produce. We ask how competition in international markets affects the mean quality of goods exported by a given country. In line with Schott, we expect competition among countries with different factor endowments to make high-wage, capital-abundant countries specialize in high-quality varieties.

Intuitively, there are two channels through which international trade may trigger such an increase in the mean quality of high-wage country exports. The first one is the "within-firm" channel, namely an increase in the quality content of the exports of individual firms. Such within-firm quality upgrading has been documented by Bloom, Draca and Van Reenen (2009) and Mion and Zhu (2011). Both papers show that increased competitive pressures from China have an impact on the production decisions of firms. Namely, they adopt production processes that are more intensive in skilled and non-production workers (Mion and Zhu, 2011) and rely more on innovation (Bloom et al., 2009). To the extent that such technological upgrading makes it possible for firms to sell goods at a higher unit value, it may explain Schott's evidence of unit values increasing in high-wage, capital-intensive countries over the last two decades.

In this paper, we mainly focus on a different, though complementary, mechanism by which competition from low-wage countries may trigger the rise of unit values in high-wage countries. Namely, we quantify the "between-firm" channel, i.e. adjustments *between* firms producing heterogeneous qualities of the same product. Taking the distribution of individual qualities as given, we quantify the effect on the mean quality of exported goods of the reallocation of market shares among heterogeneous producers.[13] Our empirical strategy makes it possible to compare the magnitude of the "within-firm" effect underlined in the rest of the literature and the "between-firm" effect just described. In our data, an increase in the intensity of competitive pressures in international markets has an effect on the "between" component of quality improvements, while being uncorrelated with within-firm quality changes.

The recent literature in international trade offers a first theoretical framework consistent with evidence of between-firm quality adjustments. Following Baldwin and Harrigan (2011), several papers have discussed how market integration affects aggregate trade patterns when firms produce heterogeneous qualities of the same product. In the simplest of these models, in which varieties combine into a CES function, with quality playing the role of a demand

[13] While we implicitly assume that quality is constant at the firm-level, our empirical approach accounts for the possibility that quality also varies within firms. See details in Section 3.

shifter, trade integration between countries with different wage levels leads to a reallocation of market shares within countries. Namely, increased competitive pressures from firms located in low-wage countries reduce the revenue of all firms in high-wage countries. As in the Melitz model, this shifts the quality thresholds above which firms can produce and export. Some low-quality firms are pushed out of the market and some producers of medium quality goods stop exporting. Those selection mechanisms imply that the mean quality of production and exports increases, together with the unit value of exports. This model is thus consistent with the mean quality of high-wage country exports rising as a result of increased competitive pressures in international markets.

In this model, the product-level quality improvement is explained by the exit of lower qualities from export markets. Moreover, the selection mechanism is not affected by the quality level of competing firms. While we find evidence of such a selection in our data, entries and exits are not the sole drivers of the quality improvement observed in the data. A large contribution to quality upgrading is attributable to the reallocation of market shares across incumbents, with low-quality varieties losing to the benefit of high-quality ones.

To explain such patterns in the data, it is necessary to depart from Baldwin & Harrigan's CES model and assume that the elasticity of the export revenue of firms to the shock in international markets is itself heterogeneous among quality producers. This type of asymmetry appears in a model of quality differentiation *à la* Gabszewicz and Thisse (1979).[14] In such a model, the reason why LWC competition induces a reallocation of market shares among qualities exported by high-wage countries is the asymmetric impact it has on different segments of the quality ladder. If low-wage countries position themselves in the bottom part of the quality ladder, they exert stronger competitive pressures on low-quality producers than on high-quality ones in international markets. This can explain the reallocation of market shares across heterogeneous producers that we observe in our data.

3 Measuring Quality Changes in the Data

3.1 Data

Our empirical analysis is based on quality indices established using a detailed data set of French exports. Namely, we use annual export flows which are disaggregated by firm, product (defined at the 8-digit level of the combined nomenclature) and destination for the 1995-2005 period. The empirical analysis is restricted to the sub-sample of partner countries that represent at least 1% of French exports, minus Taiwan, Nicaragua, Kuwait, and Kazakhstan. This restriction insures that our sample contains destination markets that are served by a large enough number of French firms, even at the disaggregated product level. Together, those markets represent 85% of French exports.

The empirical exercise neglects non-manufacturing industries, mainly agricultural goods in the customs data, since they are less likely to be vertically differentiated. We also drop the tobacco industry, which is very concentrated in France, and the industries of "Other food

[14] See also Auer and Sauré (2011).

products, not elsewhere classified" and "Miscellaneous products of petroleum and coal." These restrictions leave us with a sample of 49 countries and 24 ISIC sectors that covers 65% of French exports. In this sample, observations are identified by a firm identifier (f), a product category (p), a destination market (c) and a time period (t). We call "variety" a firm $\times$ product $\times$ destination triplet. For each variety, we have information on the "free-on-board" value in euros (v_{fpct}), as well as the exported quantity in tons (q_{fpct}). This can be used to compute firm-level unit values, $p_{fpct} \equiv \frac{v_{fpct}}{q_{fpct}}$, which serve as a proxy for individual prices.

As noted by Kravis and Lipsey (1974), unit values are a biased measure of prices because of quality composition effects. Given the very high level of disaggregation, we expect such within-firm$\times$product composition effects to be small. As detailed later, one of our quality indices however takes into account the possibility that the quality of bilateral exports *within firms and products* adjusts over time. Measurement errors in either values or quantities can also affect unit values, which we control for by using a trimming procedure. Namely, we drop annual growth rates in unit values larger than 300% (in absolute value) from the sample. The number of observations shrinks by less than 3% as a consequence.

Data are aggregated across firms selling the same good in a given market to compute a sector- and market-specific quality index called Q_{kct}. The index measures changes over time in the quality of French exports in sector k and country c due to a reallocation of demand across "varieties" (i.e. across firms and/or products). As the measure of quality upgrading is an index, it can be compared across sectors and/or destination countries. It has to be noted however that it does not say anything about the absolute quality level in market (k, c). As detailed in section 3.2, we use two alternative quality indices, one based on Boorstein and Feenstra (1987) (BF) and the other one inspired from the methodology described in Khandelwal, Schott and Wei (2011) (KSW).

For varieties to be comparable in terms of the utility they induce and the quantity consumed, they have to be similar enough. In what follows, quality indices are computed at the 6-digit level of the harmonized system (hs6). A "good" is thus an hs6 sector, while a variety is a product sold by a particular firm in that sector.[15] Since the analysis uses the time dimension of the panel, particular attention has to be paid to potential changes in the nomenclature. Before computing the quality indices, product data are harmonized over time using a procedure similar to the one used by Pierce and Schott (2011) for the US "TS" nomenclature. After the harmonization, the data covers 238,842 firms producing goods in 7,741 cn8 categories. Finally, hs6-specific quality indices are aggregated at the ISIC (3 digits) level using a Tornqvist formula. This allows to smooth any remaining noise in our measure of quality while retaining a sector dimension.

[15] The same firm may serve the same market with several cn8 varieties within the same hs6 "sector". These varieties are assumed to be substitutable to each other as two varieties produced by different firms. These "multi-product" companies represent a very small share of our sample, however. More than 90% of the firms we consider produce a single product within a given hs6 category.

3.2 Measuring Quality Changes

3.2.1 First Method

Our first index quantifies quality changes using the approach developed by Aw and Roberts (1986) and Boorstein and Feenstra (1987), and recently used by Harrigan and Barrows (2009). Boorstein and Feenstra (1987) define the "quality" of a basket of goods as the mean utility its consumption induces per unit of goods:

$$\mathrm{Q}_{kct} = \frac{g_{kc}(\{q_{fpct}\})}{\sum_{f,p} q_{fpct}},$$

where Q_{kct} is the quality index for country c and sector k, q_{fpct} is the quantity consumed of variety (f, p), $g_{kc}(.)$ is an aggregate of the varieties consumed, and $\sum_{f,p} q_{fpct}$ is the aggregate volume of consumption. This definition is general in the sense that it does not associate the "quality" of a variety to any specific observable characteristic. Instead, it relies on revealed preferences and considers a variety that induces more utility for consumers, conditional on the quantity consumed, as being of better quality.

A nice feature of Boorstein and Feenstra's quality index (called the BF quality index later on) is that its computation requires little information on the considered set of varieties. Namely, changes in the aggregate quality index can be inferred from the comparison of the unit value and ideal price indices computed over the set of varieties under consideration:

$$\Delta \ln \mathrm{Q}_{kct} = \Delta \ln \mathrm{UV}_{kct} - \Delta \ln \pi_{kc}(\{p_{fpct}\}), \tag{1}$$

where Δ is the first-order difference operator. $\Delta \ln \mathrm{Q}_{kct}$ is a percentage change in the quality composition of the considered basket of goods, $\Delta \ln \mathrm{UV}_{kct}$ is the growth of its unit value and $\Delta \ln \pi_{kc}(\{p_{fpct}\})$ denotes changes in the ideal price index as a function of the vector of prices.[16]

The intuition surrounding equation (1) is the following. The unit value computed across a basket of varieties can be written as the weighted average of individual prices: $\mathrm{UV}_{kct} = \sum_{f,p} w_{fpct} p_{fpct}$, where w_{fpct} is the share of variety (f, p) in aggregate consumption (in real terms). Thus, a change in the unit value either reflects price adjustments (changes in p_{fpct}) or a change in the relative weight of each variety in aggregate consumption (changes in w_{fpct}). With a well-defined ideal price index, price adjustments are captured by the $\Delta \ln \pi_{kc}(\{p_{fpct}\})$ term in equation (1). The remaining changes in the composition of the consumption basket are then assigned to quality changes ($\Delta \ln \mathrm{Q}_{kct}$). Thus, according to this breakdown, any increase in the unit value index that is not matched by an equivalent price increase is the result of consumption being reallocated toward more expensive varieties. From the point of

[16] The breakdown is detailed in Boorstein and Feenstra (1987). It crucially relies on two assumptions. First, $g_{kc}(.)$ must be homogeneous of degree one. Second, the considered basket of goods has to be separable from other consumptions in the aggregate utility function. More specifically, the consumption of varieties produced in France is assumed to be separable from the consumption of goods produced in other countries. This (strong) assumption is necessary in the absence of firm-level data on non-French export flows.

view of consumers, the reallocation is optimal if these varieties are of better quality. The aggregate quality index increases as a consequence.

In equation (1), the unit value index can be observed directly, by the aggregation of values and quantities across firms within a sector/destination market:

$$\Delta \ln UV_{kct} \quad = \quad \Delta \ln \frac{\sum_{(p,f)\in I_{kct}} v_{fpct}}{\sum_{(p,f)\in I_{kct}} q_{fpct}} \tag{2}$$

where I_{kct} is the set of varieties of good k exported to country c in year t.

The price index is in turn obtained by aggregating individual prices. This creates an additional difficulty since the functional form of the price index varies depending on the underlying assumption on the consumer's preferences across the set of varieties (the assumption on $g_{kc}()$). In the empirical exercise, we use two alternative assumptions, namely that $g_{kc}()$ is either a CES or a translog function.[17] In the CES case, the corresponding price index is the Sato-Vartia-Feenstra index (see Sato, 1976, Vartia, 1976 and Feenstra, 1994). With translog preferences, the price index is the one defined by Feenstra and Weinstein (2010). Appendix A provides details on the definition of those indices. Both can be calculated based on our data, using the changes observed in individual unit values ($\Delta \ln(p_{fpct})$) and the weighting parameters consistent with the underlying utility function. In the CES case, the calculation involves the elasticity of substitution (σ_{kc}) which we calibrate. Namely, we either use a homogenous value of 5, consistent with mean estimates found in the trade literature (Anderson and van Wincoop, 2004), or hs6-specific estimates taken from Imbs and Mejean (2009). In the translog case, the structural parameter determining the magnitude of the own price and cross-price elasticities (δ_{kc} in equation (A.2)) is calibrated to 0.5 which is consistent with the median estimate obtained by Feenstra and Weinstein (2010).

Quality improvements captured by the Boorstein and Feenstra (1987) index are thus the result of consumption being reallocated across varieties. The assumption that individual qualities are exogenously given is implicit in their theoretical framework. It may well be the case, however, that within-firm quality changes, notably as a result of increased competition from low-wage countries. This would be consistent with Mion & Zhu (2011) and Bloom et al. (2009). The final impact of such within-firm quality adjustments on the quality index is ambiguous. On the one hand, within-firm quality adjustments put upwards pressures on prices, and thus on the price index, with a negative end effect on the quality index. On the other hand, quality adjustments should reallocate demand in favor of those better qualities which, given the definition of the BF index, increases aggregate quality. Since the first effect through the price index plays against the second reallocation effect, our measure of quality is downward-biased in the case of within-firm quality improvements. In the econometric analysis, such a bias will play against the mechanism we are looking for. This means that the estimated effect of LWC competition on quality, identified with BF, is a lower bound.

Finally, it has to be noted that this definition of quality changes relies crucially on the assumption that goods are vertically differentiated. If the only source of heterogeneity is

[17] Harrigan and Barrows (2009) use a CES utility function.

instead the productivity dimension, increases in the quality index reflect a reallocation of consumption in favor of more expensive, less productive varieties. Once again, this plays against the empirical relationship we are looking for. If the changes in our index are entirely driven by a reallocation along the productivity dimension, one should expect more competition from low-wage countries to drive the reallocation in favor of more productive firms, with a negative end effect on the quality index.[18]

3.2.2 Second Method

As the previous section should have made it clear, the BF quality index relies on two assumptions, constant quality within firms and vertical differentiation between varieties, which may well be counterfactual. We thus test that our results are robust using an alternative methodology.

The second quality index is built in two steps. First, we estimate quality at the firm-product-destination-year level. Second, we calculate how the observed reallocation of market shares among those heterogeneous (estimated) qualities modifies the mean quality of aggregate exports. This measure should be comparable with changes in the BF quality index. As a side product, it is also possible to use quality estimates to measure the change in the aggregate quality of exports that is attributable to individual varieties adjusting their quality. This "within-firm" quality index can then be compared to the former "between-firm" quality indicator.

To measure individual qualities, we build upon the methodology described in Khandelwal, Schott and Wei (2011). They show how to estimate the quality of a variety, as defined by a specific product produced in a given country. We adapt their strategy to varieties defined as a specific good produced by a given firm. The identification is based on a CES demand equation that takes the following form:

$$q_{fpct} = p_{fpct}^{-\sigma_{kc}} \Lambda_{fpct}^{\sigma_{kc}-1} P_{kct}^{\sigma_{kc}-1} Y_{kct} \tag{3}$$

where Λ_{fpct} is the quality level of good p sold by firm f in country c, P_{kct} is the price index in sector k of country c and Y_{kct} is the nominal demand of country c in sector k. q_{fpct}, p_{fpct} and σ_{kc} are defined as in Section 3.2.1. The estimation relies on a functional form assumption, namely that preferences are CES and individual qualities play the role of a demand shifter.

Taking the log of equation (3) and applying a within transformation to remove variables that are not variety-specific (P_{kct} and Y_{kct}), we obtain the following equation:

$$(\ln q_{fpct} + \sigma_{kc} \ln p_{fpct}) - (\ln q_{kct} + \sigma_{kc} \ln p_{kct}) = (\sigma_{kc} - 1)(\ln \Lambda_{fpct} - \ln \Lambda_{kct}) \tag{4}$$

where q_{kct}, p_{kct} and Λ_{kct} respectively denote the mean quantity, price and quality at which good k is sold in market c. Based on prices and quantities observed at the variety level, and a calibration of the elasticity of substitution σ_{kc}, it is thus possible to estimate, for each variety available in a given market, the relative level of its quality, with respect to the market

[18] We are thankful to Amit Khandelwal for pointing this out to us.

average.[19]

The aggregation of individual quality estimates (4) makes it possible to define a quality index. The definition of such an index is tricky, however, since the "aggregate quality" we are after is a conceptual object that does not have any theoretically grounded equivalent in models. The first approach described in section 3.2.1 uses one of many possible ad hoc definitions, namely the mean utility per unit of consumption. In the second approach, we do not try to define aggregate quality and just posit an ad hoc breakdown for quality changes. In doing so, we follow the approach used in macroeconomics to study the microeconomic underpinnings of aggregate TFP changes (Foster et al., 2008, e.g.).

As we want to compare the relative behavior of the "between" and "within" components of quality improvements, we first define changes in the aggregate "quality" attributable to between-firm adjustments:

$$\Delta \ln Q_{kct} = \sum_{f,p \in I_{kc}} \Delta s_{fpct} (\ln \bar{\hat{\Lambda}}_{fpc} - \ln \bar{\hat{\Lambda}}_{kc}) + \sum_{f,p \in N_{kct}} s_{fpct} (\ln \hat{\Lambda}_{fpct} - \ln \hat{\Lambda}_{kct}) - \sum_{f,p \in X_{kct-1}} s_{fpct-1} (\ln \hat{\Lambda}_{fpct-1} - \ln \hat{\Lambda}_{kct-1}) \quad (5)$$

s_{fpct} and I_{kc} are defined as in Section 3.2.1. $N_{kct} \equiv I_{kct} - I_{kc}$ is the set of firms entering the export market between periods $t-1$ and t and $X_{kct-1} \equiv I_{kct-1} - I_{kc}$ is the set of firms leaving the export market between $t-1$ and t. $\ln \bar{\hat{\Lambda}}_{fpc} - \ln \bar{\hat{\Lambda}}_{kc}$ measures the estimated relative quality of variety (f,p) on average for periods $t-1$ and t. The first term in equation (5) captures aggregate quality effects of market shares being reallocated between incumbents of heterogeneous quality levels. The last two terms measure the aggregate effect of net entries.

As in the BF index, this neglects within-firm quality adjustments. However, since equation (5) takes the actual level of quality of each variety into account, estimates of "between-firm" quality changes obtained using this definition are not biased in the case of within-firm quality adjustments. Moreover, the method makes it possible to compare the magnitude of the above-mentioned "between" quality adjustments with the impact of firms improving the quality they offer. Namely, the aggregate quality index attributable to within-firm adjustments is defined as:

$$\Delta \ln \tilde{Q}_{kct} = \sum_{f,p \in I_{kc}} \bar{s}_{fpc} \Delta (\ln \hat{\Lambda}_{fpct} - \ln \hat{\Lambda}_{kct}) \quad (6)$$

where $\bar{s}_{fpc}$ is the mean market share of variety (f,p) and $\Delta(\ln \hat{\Lambda}_{fpct} - \ln \hat{\Lambda}_{kct})$ the change in its relative quality level between periods $t-1$ and t.

With respect to the first methodology, using the KSW strategy makes it possible to compare the between and within components of aggregate quality changes (respectively $\Delta \ln Q_{kct}$ and $\Delta \ln \tilde{Q}_{kct}$) and ask how they correlate with competitive pressures in international markets. This is done in Section 4.4.

[19] As in the first approach, σ_{kc} is either assumed equal to 5, or calibrated using hs6 estimates from Imbs and Mejean (2009).

4 Results

4.1 Patterns in the Quality of French Exports

At the ISIC level, our sample contains 1,170 (destination- and sector-specific) time-series. Table 1 gives summary statistics on the corresponding end-period quality indices. The first two panels correspond to quality indices computed using the BF formula, either under a CES assumption or with translog preferences. The next two panels are obtained based on the KSW definition, first for between-firm quality adjustments, then for within-firm quality changes. For each "between" index, it is possible to distinguish between quality adjustments occurring at the intensive and at the extensive margins. In the BF case, an "intensive" index is calculated from the comparison of the unit value index computed on the subset of intensive flows (I_{kc}) and the intensive component of prices indices (the first term in equations (A.1) or (A.2)). In the KSW case, the intensive component corresponds to the first term in equation (5). Table 1 makes the distinction between those two margins.

The comparison of the first three panels illustrates the robustness of our results to the definition of aggregate quality. It suggests that, over the 1995-2005 period, the mean quality increased by 14 to 16% on average. This breaks down into a 5% increase at the intensive margin, and an 8-11% rise attributable to the net entry of firms into export markets.[20] While the means are very similar across indices, we find a greater variance of quality changes across markets with the BF index than with the KSW one.

The comparison of these figures with the fourth panel in Table 1 further allows to assess the relative magnitude of aggregate quality adjustments attributable to a reallocation of market shares between firms and to the adjustment of individual qualities. The average within-firm quality growth is 20%, which is slightly greater than the between-firm adjustment. While the increase in the between-firm quality index is monotonous over time, the within-firm adjustment is triggered by a strong increase occurring between 1996 and 1997.

The summary statistics in Table 1 do not account for the composition of the French export basket across sectors and destinations. Figure 1 aggregates the 1,170 series into a multilateral quality index, using a weighting scheme that reflects the specialization of French exports. The graph allows to compare quality changes obtained with all three indices (the BF index assuming either CES or translog preferences and the KSW-between index), in the whole sample (panel (a)) and in the restricted sample of intensive flows (panel (b)). Despite different underlying assumptions, the aggregate evolutions are remarkably similar. They show a monotonous improvement in the quality of French exports over the period, both at the intensive and at the extensive margins. The cumulative growth rate over the 1995-2005 period is equal to 11%. It is somewhat lower at the intensive margin, especially when quality is measured using the BF formula. The similarity of results across estimation methods is also apparent at the sectoral level, as illustrated in Figure 2. While the measured changes in quality are somewhat different with the BF and KSW indices in some sectors, most notably for "Leather products", the sectoral patterns are consistent, on average.

[20]The evolution in the number of French flows is depicted in Figure A.1.

These aggregate evolutions hide a strong degree of heterogeneity, however, as shown by the large distribution of quality growth rates around the mean (first row of each panel in Table 1). Despite the average upward trend, the quality of the French export basket thus decreases in about 40% of the 1,170 markets under consideration. A variance breakdown based on the sector- and country-specific quality indices reveals that more than 75% of the total sum of squares is due to determinants that have the double geographic *and* sectoral dimension. The role of sector-specific determinants is consistent with the IO literature, which explains vertical differentiation by structural features related to the production technology. However, our results suggest that quality changes are also affected by determinants that are market-specific within a given sector. This either means that firms serve different markets with different qualities or that composition effects among firms with heterogeneous qualities explain differences in the mean quality within sectors across destinations.

Before turning to the determinants of such quality changes, it is interesting to further discuss the way such adjustments affect export performances. To that aim, we take advantage of the BF breakdown to study how changes in the value of exports are distributed between volume, value and quality effects. In Boorstein & Feenstra's setting, the growth rate of aggregate exports can be written as:

$$\Delta \ln \mathrm{V}_{kct} = \Delta \ln \mathrm{Qy}_{kct} + \Delta \ln \pi_{kc}(\{p_{fpct}\}) + \Delta \ln \mathrm{Q}_{kct}, \tag{7}$$

where $\Delta \ln \mathrm{V}_{kct}$, $\Delta \ln \mathrm{Qy}_{kct}$, $\Delta \ln \pi_{kc}(\{p_{fpct}\})$ and $\Delta \ln \mathrm{Q}_{kct}$ respectively denote the growth rates of the value, quantity, price and quality of exports to market (k, c). Based on this breakdown, an increase in the value of French exports can be explained by French firms exporting a larger quantity, by their prices increasing, or by demand being reallocated in favor of more expensive, better qualities. Based on this equation, Figure 3 breaks down the export growth by destination country (panel a) and by sector (panel b).[21] The size of the quality component reflects the magnitude of the quality changes over the 1995-2005 period. Its *relative* size with respect to the overall growth rate of exports, reported between parentheses in Figure 3, further conveys information on the contribution of quality to export performances. This contribution is especially important for richer countries, most notably Switzerland, Germany and Japan. On the other end of the spectrum, quality is relatively less important in explaining France's export performance in poorer countries like Poland, Spain, Portugal and Greece. For these countries, the growth of exports is mainly due to French firms increasing the quantity they export. At the industry level, quality is especially important in explaining the growth of French exports in electrical machinery, other machinery, glass and rubber products and footwear. In these sectors, the quality component explains more than 50% of export growth. Incidentally, the competition from China and other low-wage countries is intense in these sectors.

[21] For the sake of conciseness, panel a is restricted to France's 14 main partners. The results covering the rest of the sample are available upon request.

4.2 Quality and Low-Wage Country Competition

In a world of within-industry specialization, the previously described increase in the quality of French exports is driven by changes in the competitive environment faced by French firms in international markets. To test whether this mechanism prevails in the data, we now use the heterogeneity in the intensity of quality changes across sectors and destination countries. We ask how it relates to measures of the quality competition. If countries indeed specialize within industries, it must be true that the quality growth is stronger in those markets in which France faces stronger competitive pressures from low-quality producers.

Our measure of "quality competition" relies on the growing penetration of goods produced in low-wage countries. Over the last two decades, the share of low-wage countries in world trade has dramatically increased, from less than 8% of world exports in 1995 to more than 16% in 2005.[22] If, on average, low-wage countries produce lower qualities, as evidence in the literature suggests, the increased penetration of their products should put competitive pressures on the lowest segment of the quality ladder. This should eventually lead to an aggregate growth in the quality of exports for countries with a comparative advantage in higher-quality goods, potentially including France.

As preliminary evidence, Figure 4 plots the change in the quality of French sectoral exports (averaged across destination markets) against the change in the market share of low-wage countries. It shows a positive relationship between quality growth and increased competition from low-wage countries, when quality is measured using the BF index (panel (a)) and with the KSW method (panel (b)). The positive relationship suggests that the mean quality of French exports increased more over the period in those industries that were more exposed to low-wage countries.

We now use an econometric model to ask whether the previous correlation reflects a causal impact from changes in competitive pressures exerted by low-wage countries on the quality of French exports in each destination market. Our baseline estimated equation is:

$$\Delta_{95-05} \ln Qlty_{kc} = \alpha \, \Delta_{95-05} Msh_{kc}^{lwc} + X_{kc} + \epsilon_{kc}, \tag{8}$$

where k and c refer to the sector and the destination country, respectively, and Δ_{95-05} denotes the first difference between 1995 and 2005. $\Delta_{95-05} \ln Qlty_{kc}$ is the log change in the quality of French exports toward country c in sector k over the 1995-2005 period. $\Delta_{95-05} Mks_{kc}^{lwc}$ is the variation in the market share of low-wage countries. Finally, X_{kc} is a vector of controls. The baseline regression uses sector- and country-specific fixed effects. Country fixed effects control for all macroeconomic evolutions that may explain an aggregate improvement in the demand for quality expressed by market c. For instance, these effects capture the possibility that the country has become richer, which tends to increase its aggregate demand of high-quality goods. Sectoral fixed effects control for overall quality changes in some specific

[22] We follow Bernard, Jensen and Schott (2006) and define low-wage countries as countries whose GDP per capita is less than 5% of the US one. The above mentioned market shares are computed using the information on bilateral trade flows from the UN-ComTrade database. China alone accounts for two-thirds of the increase.

sectors. If, for instance, France was outsourcing the low-quality-intensive tasks in low-wage countries, while maintaining a local production of quality-intensive components, an increase in the quality of sectoral exports, together with a rise in the amount exported by LWCs would be observed. This tendency would however be common across all destinations within a given sector. With country *and* sector fixed effects, the α coefficient is identified *within* sectors *between* countries. On top of this (demanding) structure of fixed effects, some sectoral and country-specific variables are also used as controls in some regressions. We describe them later on.

A potential caveat of the previous regression framework is that changes in market shares may be endogenous to the evolution in the mean quality of French exports because of reverse causality or omitted variables. Reverse causality may arise if positive changes in the quality composition of French exports allow firms located in low-wage countries to increase their market shares abroad. Omitted variables may also create endogeneity if these determinants of quality changes are also correlated with the market shares of low-wage countries.[23]

To reduce the risk of reverse causality, the market share of low-wage countries is computed using the rest of the world minus French exports as a reference:

$$Mks^i_{kct} \equiv \frac{IMP_{ikct}}{\sum_{l \neq France} IMP_{lkct}} \text{ and } Mks^{lwc}_{kct} = \sum_{i \in lwc} Mks^i_{kct},$$

where IMP_{lkct} is the value of good k imported by country c from country l at time t. Based on the assumption that the evolution of these market shares is exogenous to quality changes in France, we estimate equation (8) using OLS.

Changes in market shares may still be endogenous, however. We thus run a set of 2SLS estimations. We first estimate the values predicted for changes in bilateral market shares for exporters from emerging countries (i.e. we instrument $\Delta_{95-05} Msh^i_{kc},\ i \in lwc$). We use five instruments. The first one measures changes in the market share of the considered exporting country i in other destinations (i.e. it averages $\Delta_{95-05} Mks^i_{kd}$ across all destinations d except c). This instrument conveys information about the aggregate "performance" of the low-wage country in sector k over the period under consideration. Since the variable does not use information on sales in country c, it is independent from changes affecting the market structure in that country, notably due to France increasing the quality of its exports. The second instrument measures the initial market share of country i in the destination market considered ($Mksh^i_{kc95}$), which is negatively correlated in the data to the market share change. The third instrument makes the previous two variables interact. The fourth instrument measures the distance between a country and its destination market, in relative terms with respect to competitors:

$$RelDist^i_{kc} = \frac{Dist^i_c}{\frac{1}{N_{kc}} \sum_{l=1}^{N_{kc}} Dist^l_c},$$

where i and c are the low-wage country and the destination market. $Dist_{ic}$ is the distance

[23]It must be noted that the limited share of France in world exports strongly reduces the chances that the market share of low-wage countries could be endogenous to the quality of French exports.

between i and c and N_{ck} is the number of countries serving country c in good k.[24] Finally, a fifth instrument makes the relative distance variable interact with the change in a country's market shares. The results for the first-stage regressions are reported in Table A.1.

The results of the baseline estimation are presented in Table 2, for each quality index described in Section 3.2.[25] The only controls, in addition to the change in LWC market shares, are country and sector fixed effects. The first two columns use sector fixed effects defined at the 2-digit level of aggregation, while columns (3) and (4) have 3-digit fixed effects. Since quality changes are defined at the 3-digit level, the second set of estimates is more demanding and solely uses the within-sector/across-country dimension to identify the impact of LWC competition. Results in column (1) and (3) correspond to OLS; columns (2) and (4) report 2SLS estimations.

The results in Table 2 show a positive coefficient on the variable measuring changes in LWC market shares. The growth in quality described in Section 4.1 is stronger in those sectors and destinations that are more strongly exposed to competition from low-wage countries. Unsurprisingly, the t-statistics are always lower when 3-digit fixed effects are used as controls, since this reduces the degrees of freedom available for identification. However, the magnitude of the coefficient estimated on the LWC competition variable is very comparable in both cases. This suggests that the lower significance of the results in columns (3) and (4) is mainly explained by the lack of variability within industries across countries. With all three indices, the comparison of OLS results with 2SLS ones (columns (1) and (2) with 2-digit sector fixed effects and columns (3) and (4) with 3-digit effects) shows a magnified effect of LWC competition on the quality of French exports, once endogeneity is controlled for. With 2SLS the impact of LWCs increasing their market share on the quality content of French exports is positive, significant in most cases and sizeable.

The positive sign means that the quality of French exports has increased the most in markets in which competitive pressures from low-wage countries have been the strongest. This is consistent with within-industry specialization. In quantitative terms, we find that an increase in LWC market share of 10 percentage points leads to a growth in the quality content of French exports ** of 0.4 to 1.9%, depending on the specification.

Table 3 presents various robustness checks on the baseline estimation presented in Table 2. Columns (1) to (4) test the robustness to additional control variables, while columns (5) and (6) focus on the intensive component of (between-firm) quality adjustments. Given the structure of fixed effects, the only conceivable omitted variables that may bias the results in Table 2 have the double sector and country dimension. In columns (1) and (2), we ask whether the degree of competition in the destination market, as measured by the Herfindahl index, affects the magnitude of quality changes. If this is the case, it may be that the effect of competition from low-wage countries identified in Table 2 is related to the penetration of

[24] The distance variable is a population-weighted mean of city-to-city bilateral distances, downloaded from the CEPII's website ($http://www.cepii.fr/anglaisgraph/bdd/distances.htm$).

[25] The results in table 2 use a calibration of the elasticity of substitution entering the BF-CES and the KSW indices with a uniform value of 5. The results based on sector-specific estimated elasticities taken from Imbs and Mejean (2009) are provided in Table A.2. They are very comparable to the results based on homogeneous elasticities.

LWCs in foreign markets reducing the geographical diversification of imports. The Herfindahl index is computed using ComTrade data and defined as: $Herf_{kct} = \sum_i s_{ikct}^2$ where s_{ikct} is the share of exports from i in the total value of good k imported by country c in year t and the summation is done on all countries exporting to destination c. It is introduced in first difference between 1995 and 2005 in the estimated equation. We further make this variable interact with a sector-specific measure of vertical differentiation to allow for the possibility that the previous competition effect is limited to sectors that display a large enough degree of quality heterogeneity. Our measure of vertical differentiation is taken from Khandelwal (2010) and is denoted "Ladder" in Table 3.[26]

As expected, the effect when the Herfindahl index increases is positive, meaning that quality growth is triggered by changes in the competitive environment. The effect is marginally smaller in sectors with a longer quality ladder. This result is less intuitive, but is very small. Most importantly, the impact of LWC competition is hardly affected by the introduction of these additional control variables. This is true with 2-digit sector fixed effects, as well as with the most disaggregated ones.

Columns (3) and (4) consider the case for the effect of a country getting richer on the quality content of French exports. The overall effect of such wealth improvement is already taken into account in the country fixed effects. However, there is no doubt that the demand of quality expressed by richer consumers should concentrate in those sectors that are vertically differentiated. We account for this possibility in the estimated equation by introducing an interaction between the growth rate of the destination country's GDP per capita, and the quality ladder of the sector under consideration. The coefficient on this variable should be positive, which it is, but at a very low level that is not significantly different from zero. Once again, the impact of LWC competition is unchanged, with respect to the baseline results.

Finally, columns (5) and (6) display results for quality indices constructed using the information contained in the intensive sample. These indices capture reallocation across incumbents, but neglect quality shifts driven by entries to or exits from a market. The impact of low-wage country competition on quality is slightly reduced in this sample. However, it remains positive and significant most of the time, whatever the specification or the definition of the quality index.

Overall, the robustness analysis conducted in Table 3 suggests that the effect emphasized in Table 2 is robust to various definitions of quality and to various specifications of the estimated equation. It confirms the significant and positive effect that the increasing penetration of low-wage countries exerts on the mean quality of French exports. We interpret this result as evidence of intra-industry specialization.

[26] Khandelwal uses a cross-country identification method to estimate the mean quality of a country's exports to the US, at the highly disaggregated product-level. He then assimilates the maximum quality gap across exporting countries within a given sector to a measure of quality differentiation. A longer "quality ladder" thus corresponds to a sector that is more prone to vertical differentiation.

4.3 Quality and High-Wage Country Competition

For the positive effect of LWC competition on the quality content of French exports to be interpretable in terms of within-industry specialization, it must not be related to an overall increase in competitive pressures faced by French firms in international markets. Instead, it must be true that quality growth is driven by the fact that these pressures come from low-quality firms, on average. In the previous section, we favored the second interpretation after having posited that low-wage countries do export low quality varieties. If this is the case, the reverse effect must hold true as well. Namely, in those markets in which French firms face high-quality competition, the reallocation should favor low-quality producers, and the mean quality of French exports should decrease as a consequence.

To allow for this possibility, Table 4 introduces another control variable measuring the rise in the market share of *high-wage countries*, by destination and sector. This variable is constructed in a symmetric way to the LWC competition measure, using the same instruments as predictors of bilateral market shares, but on the subset of countries whose GDP per capita is above 90% of the US one. We expect the coefficient on this variable to be negative if increased competition from high-quality producers implies a reallocation of market shares toward low-quality producers in France.

Whatever way quality is measured, Table 4 shows a negative effect of high-wage countries increasing their market share on the quality content of French exports. This effect does not offset the positive impact of LWCs whose magnitude remains comparable to the baseline results. The high-wage country effect is often non-significant, though. This can probably be explained by the amount of variability being small, in comparison with sectoral changes in LWC market shares.

In any case, the negative coefficient is consistent with intra-industry specialization patterns. It suggests that the quality content of French exports has not increased, and may even have decreased, in those markets in which competitors for French firms had a comparative advantage in high-quality varieties. This validates our interpretation of the positive LWC effect, namely that it exerts pressures on the low-quality segment of French exports and triggers a reallocation which drives aggregate quality up.

4.4 Within-Firm Quality and Low-Wage Country Competition

Before concluding, we run a last set of regressions to compare the behavior of the between-firm and the within-firm quality indices. As explained in Section 3.2, this can only be done using the index derived from estimates of individual qualities based on Khandelwal, Schott and Wei (2011). It is nonetheless useful to compare our results for within-firm quality upgrading to the results from the previous literature emphasizing technology upgrading by firms facing competitive pressures from emerging markets.

Table 5 replicates the regressions displayed in Table 2. Here, as dependent variable we use either the between-firm KSW index, measuring quality changes attributable to a reallocation of market shares across heterogeneous qualities, or the within-firm KSW quality index, measuring the aggregate impact of firms upgrading the quality they produce. As already commented in Section 4.2, the between-firm quality index is found positively correlated with changes in LWC market shares. However, the results look quite different once we focus on quality adjustments driven by within-firm quality upgrading. Namely, we find that low-wage country competition has no significant effect on the within-firm quality index.

At first glance, this result seems to contradict evidence of within-firm technology upgrading in reaction to Chinese competition found in Bloom, Draca and Van Reenen (2009) and Mion and Zhu (2011). Those papers indeed show that firms entering in competition with Chinese products tend to adopt more capital-intensive processes. The comparison between our results and theirs is however tricky for at least two reasons. First, the dependent variable in Bloom, Draca and Van Reenen (2009) and Mion and Zhu (2011) is directly related to the technology of the firm. Namely, Bloom, Draca and Van Reenen (2009) study the patenting activity and use of information technologies, while Mion and Zhu (2011) have information on the share of skilled workers in total employment. We focus our attention instead on the quality of the product, *as perceived by the consumer*, measured by the price premium that he/she is able to pay to consume the variety. Investing in better technologies in order to improve the quality of a product is a long-run, risky investment. It is not necessarily contradictory to say that firms facing competitive pressures from China react by investing in better technologies, but are not immediately able to raise their price. To put it differently, our observation period (1995-2005) is perhaps too short for our estimation procedure to capture the consequences of the technology upgrading identified in Bloom, Draca and Van Reenen (2009) and Mion and Zhu (2011).

The second reason why our results may not be consistent with those in Bloom, Draca and Van Reenen (2009) and Mion and Zhu (2011) is that our identification uses the heterogeneity in quality changes across countries within a sector. The rest of the literature focuses instead on the choice of an individual firm to invest in better technologies that will potentially improve the quality of its good. Even if technology upgrading indeed improves the quality of the product, there is no reason to believe that this improvement is heterogeneous across markets. To put it differently, it may well be that individual firms improve the quality of their products. But this improvement explains the overall rise in the quality level, not the heterogeneity in the magnitude of quality changes across markets within sectors.

5 Conclusion

In a world of within-product specialization along the quality dimension, competition in international markets has a heterogeneous impact on vertically differentiated producers located in a given country. Competitive pressures exerted by standardized good producers in low-wage countries are felt more strongly by low-quality producers than by high-quality firms located in rich countries. This asymmetry triggers a reallocation of demand within a country between firms.

Our paper discusses the impact that the asymmetry has on the quality composition of French exports. Namely, we estimate how competition from low-quality producers affects the quality content of aggregate exports. The empirical analysis uses bilateral export data covering the world of French manufacturing firms.

We show that the quality of the French export basket increased by 11% between 1995 and 2005. The quality growth is particularly marked in sectors and countries where French firms faced increased competitive pressures from low-quality producers. Interestingly, higher competition from high-wage countries led to a decrease in the quality content of French exports. Moreover, the effect was triggered by the reallocation of market shares among heterogeneous producers, not a change in the quality produced by individual firms. This "flight to quality" is consistent with within-industry specialization along the vertical dimension.

The quality growth identified in the data has important consequences, notably from a policy standpoint. The fear of Chinese products dominating the world production of manufacturing goods has been an important concern in most developed countries over the last two decades. Evidence in favor of within-industry specialization suggests that investing in high-quality production could be a way for countries to insulate themselves from the competition of low-wage countries and maintain their market shares in international markets.

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A Definition of the Price Index for the BF Quality Measure

In Boorstein & Feenstra's setup, the only functional form assumption that must be taken concerns the form of preferences ($g_{kc}()$) determining the price index used in the breakdown (1). We use two alternative assumptions, namely that preferences across varieties are CES or translog.

In the CES case, the corresponding price index is the Sato-Vartia-Feenstra index (see Sato, 1976, Vartia, 1976 and Feenstra, 1994):

$$\Delta \ln \pi_{kc}(\{p_{fpct}\}) = \sum_{(p,f)\in I_{kc}} w_{fpct}(I_{kc})\Delta \ln(p_{fpct}) + \frac{1}{\sigma_k - 1}\Delta \ln \lambda_{kct} \tag{A.1}$$

$$\text{where} \quad w_{fpct}(I_{kc}) \equiv \frac{\left(\frac{s_{fpct}(I_{kc})-s_{fpct-1}(I_{kc})}{\ln s_{fpct}(I_{kc})-\ln s_{fpct-1}(I_{kc})}\right)}{\sum_{(p,f)\in I_{kc}}\left(\frac{s_{fpct}(I_{kc})-s_{fpct-1}(I_{kc})}{\ln s_{fpct}(I_{kc})-\ln s_{fpct-1}(I_{kc})}\right)}$$

$$\text{with} \quad s_{fpct}(I_{kc}) \equiv \frac{v_{fpct}}{\sum_{(p,f)\in I_{kc}} v_{fpct}}$$

$$\text{and} \quad \lambda_{kct} \equiv \frac{\sum_{(p,f)\in I_{kc}} v_{fpct}}{\sum_{(p,f)\in I_{kct}} v_{fpct}}$$

I_{kc} is the subset of varieties sold in country c in both periods t and $t-1$ (the "intensive" sample) and σ_{kc} is the CES elasticity of substitution.

The first term in equation (A.1) is a weighted average of price changes, computed on the intensive sample. The second term measures the contribution of net entries. It is stronger when the share of new goods in aggregate expenditures is larger, less so when varieties are more substitutable.

With translog preferences, the price index is written as (see Feenstra & Weinstein, 2010):

$$\begin{aligned}\Delta \ln \pi_{kc}(p_t) = &\sum_{(p,f)\in I_{kc}} \frac{1}{2}(s_{fpct}(I_{kc}) + s_{fpct-1}(I_{kc}))\Delta \ln(p_{fpct}) \\ &+\frac{-1}{2\delta_{kc}}\left\{\sum_{(p,f)\notin I_{kc}}\left[s^2_{fpct}(I_{kct}) - s^2_{fpct-1}(I_{kct-1})\right]\right. \\ &\left.+\frac{1}{I_{kc}}\left[\left(\sum_{(p,f)\notin I_{kc}} s_{fpct}(I_{kct})\right)^2 - \left(\sum_{(p,f)\notin I_{kc}} s_{fpct-1}(I_{kct-1})\right)^2\right]\right\}\end{aligned} \tag{A.2}$$

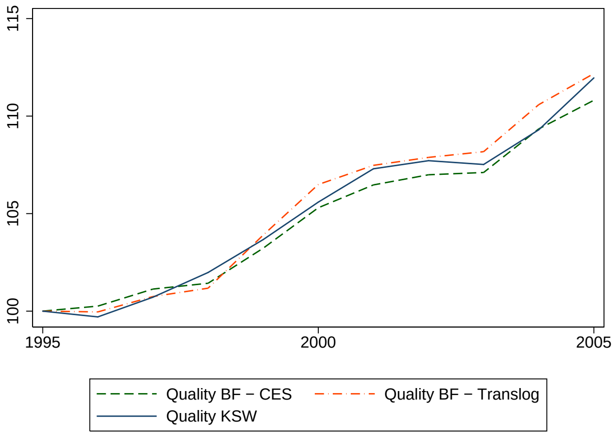
$$\text{where} \quad s_{fpct}(I_{kc}) \equiv \frac{v_{fpct}}{\sum_{(p,f)\in I_{kc}} v_{fpct}}$$

$$\text{and} \quad s_{fpct}(I_{kct}) \equiv \frac{v_{fpct}}{\sum_{(p,f)\in I_{kct}} v_{fpct}}$$

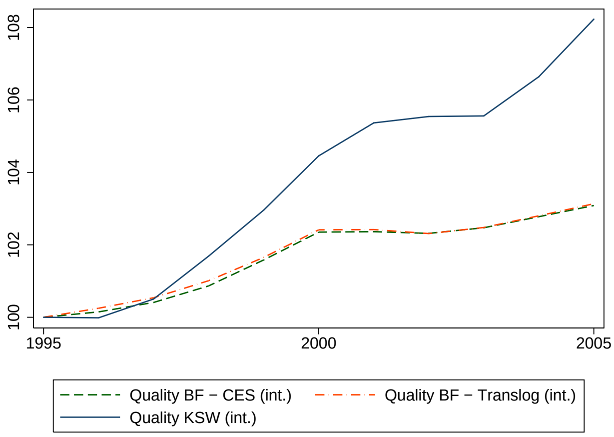
δ_{kc} scales the magnitude of the own price and cross-price elasticities. As in the CES case, the index can be broken down into an intensive and an extensive term. The first term in (A.2) captures intensive adjustments and is once again a weighted average of individual price changes. The next two terms quantify the price impact of extensive adjustments.

Figure 1: Evolution of the Aggregate Quality of French Exports

(a) Whole sample

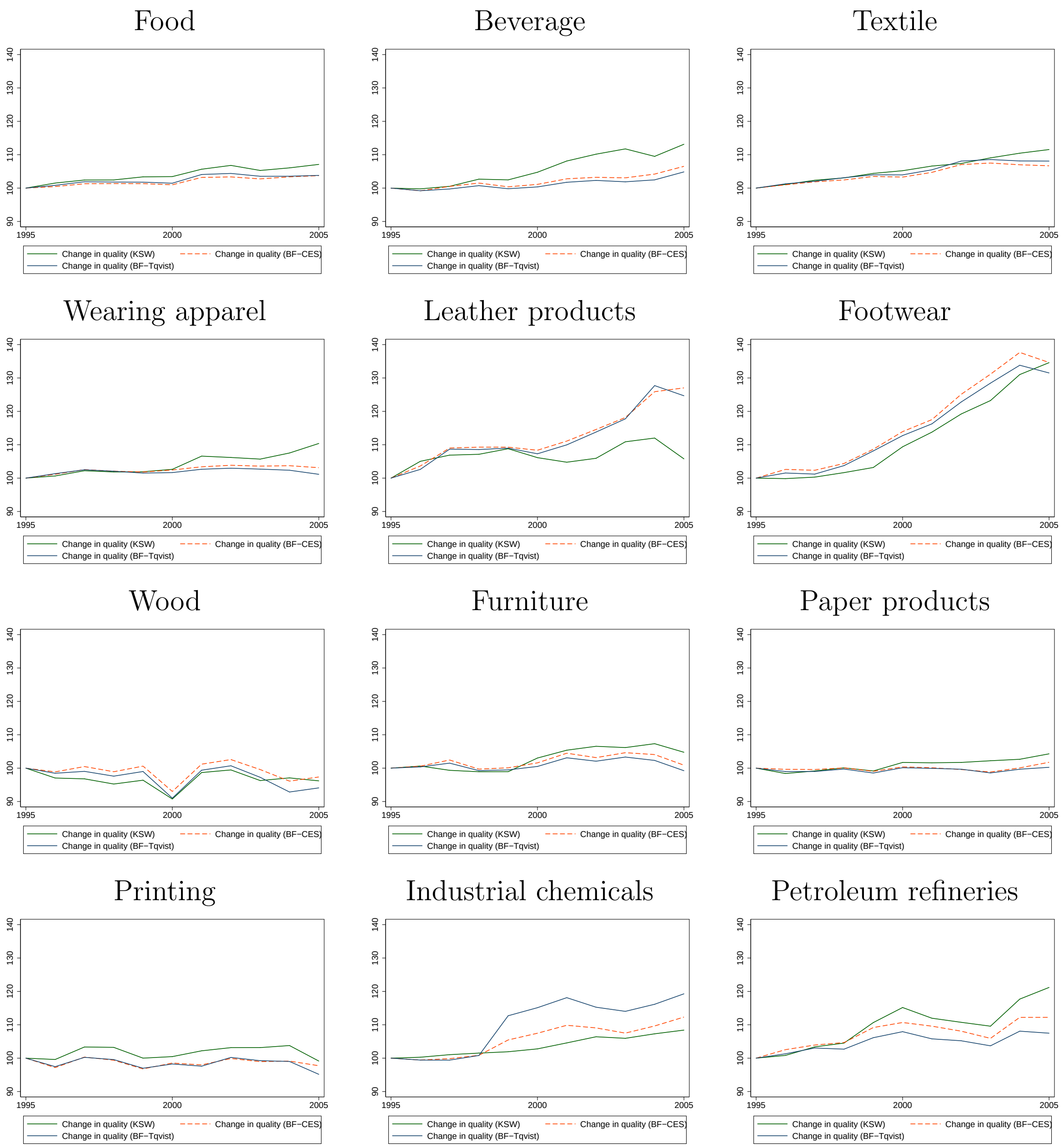


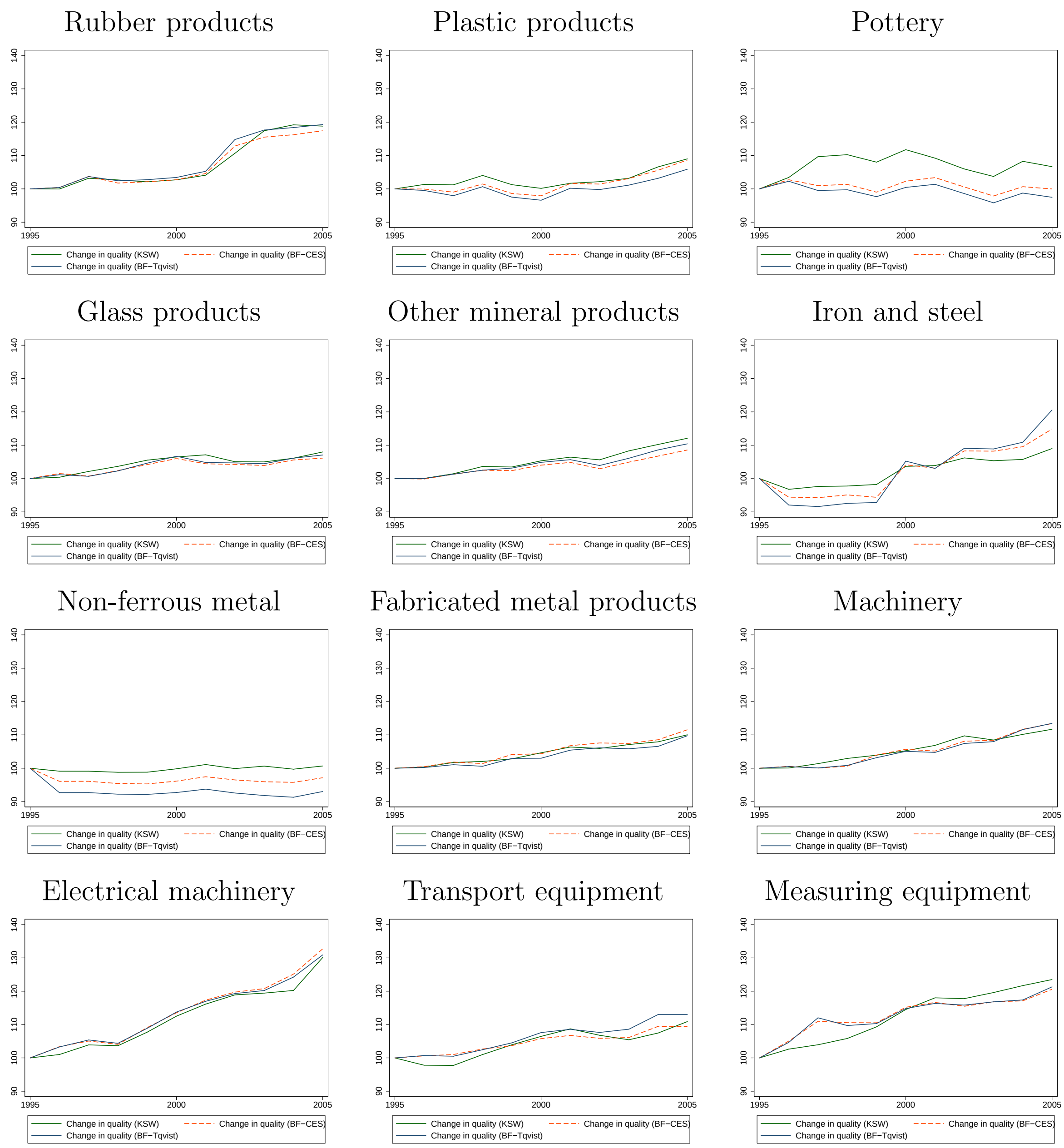
(b) Intensive margin



Notes: The multilateral quality index is obtained from an aggregation of sectoral and country-specific quality indices (Q_{kct}). The aggregation weights are either the Sato-Vartia ones for the BF-CES index or the Tornqvist ones for the BF-Translog and KSW indices. The "Intensive margin" sample is defined using the set of firms present in the considered market over two consecutive years.

Figure 2: Evolution of Quality, by Sector

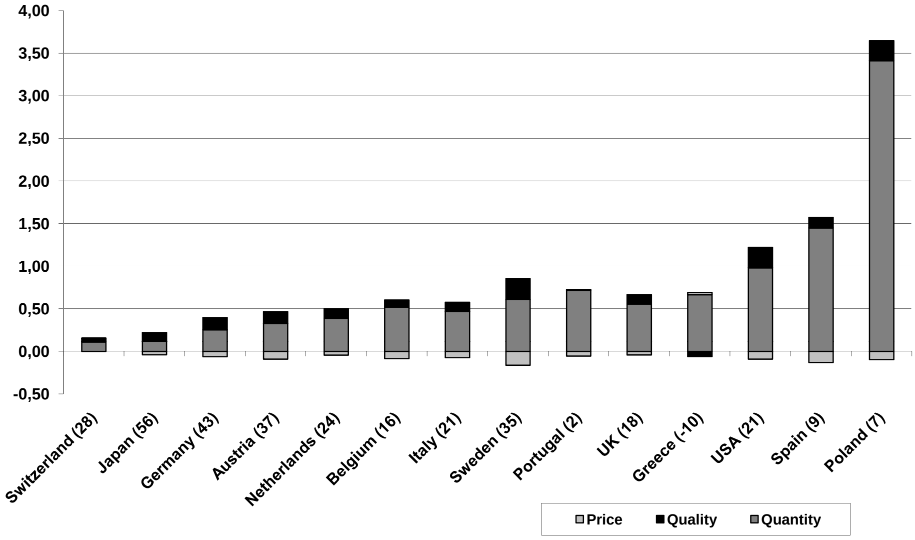




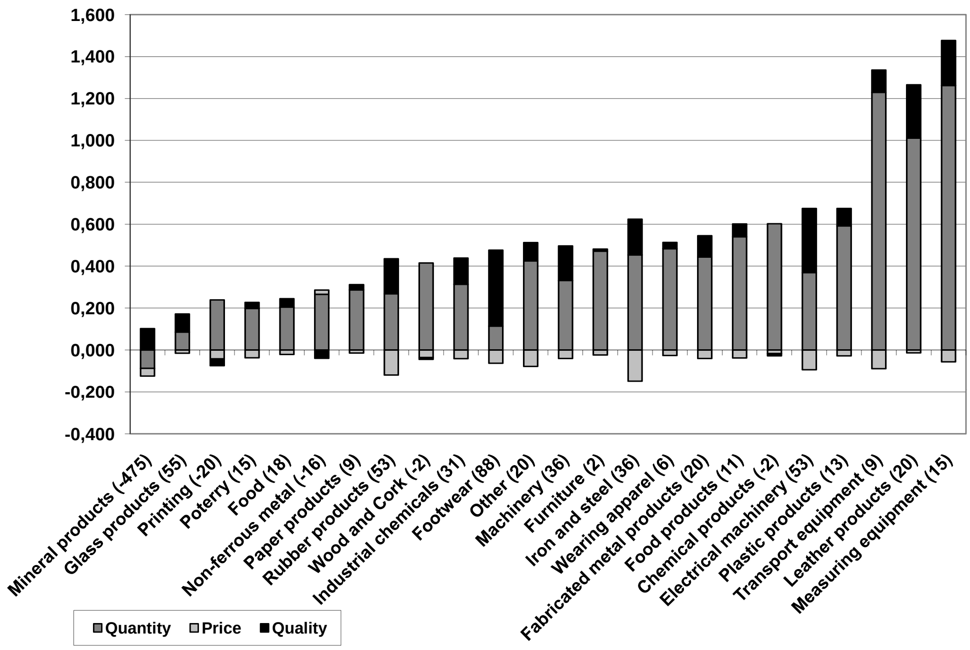
Notes: The sectoral quality index is obtained from an aggregation of country-specific quality indices (Q_{kct}). The aggregation weights are either the Sato-Vartia ones for the BF-CES index or the Tornqvist ones for the BF-Translog and KSW indices.

Figure 3: Decomposition of Changes in the Value of Exports

(a) By country



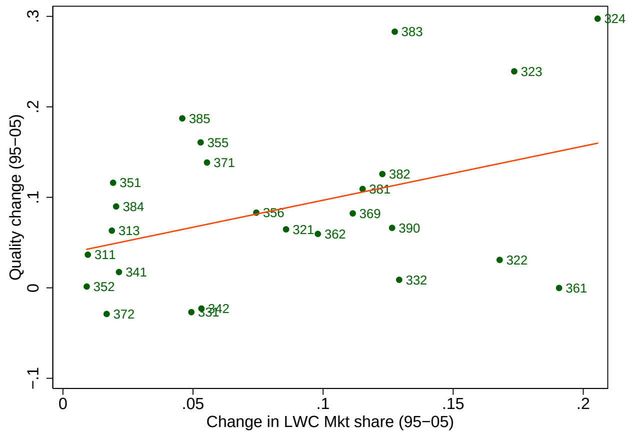
(b) By sector



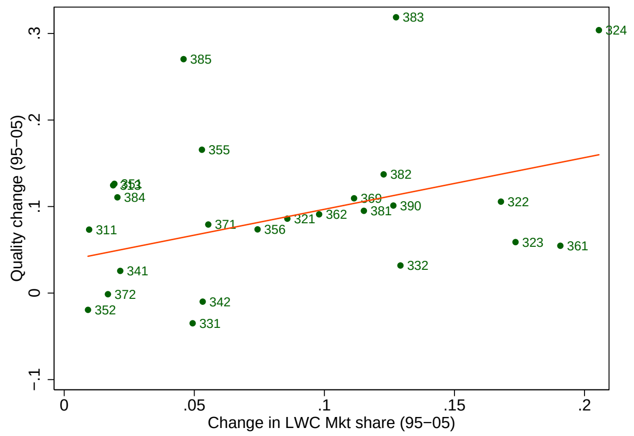
Notes: The breakdown is based on equation (7), computed at the hs6 level for each destination market. Data are then aggregated at the country level (panel (a)) and at the sectoral level (panel (b)) using Tornqvist weights. Each bar measures the growth rate of French exports (in value) between 1995 and 2005. The growth rate is broken down into a price, a quantity and a quality component. The relative size of the quality is reported between parentheses.

Figure 4: Quality & Competition from Low-Wage Countries, Across Industries

(a) BF-CES index



(b) KSW index



Notes: The change in the market shares of low-wage countries is a weighted average that reflects the composition of France's trade. It is computed as $\Delta_{95-05}Mks_k^{lwc} = \sum_c w_{kc}^{fra}\Delta_{95-05}Mks_{kc}^{lwc}$ where w_{kc}^{fra} is the weight of country c in French exports of good k and $\Delta_{95-05}Mks_{kc}^{lwc}$ is the change in the market share of low-wage countries in sector k and country c. An OLS estimation with the BF-CES index as explained variable gives:

$$\Delta_{95-05}lnQlty_k = \underset{(0.20)}{0.46^b}\Delta_{95-05}Mks_k^{lwc} + \underset{(0.03)}{0.04}$$

with an adjusted R^2 of 0.14. With the KSW index:

$$\Delta_{95-05}lnQlty_k = \underset{(0.18)}{0.37^c}\Delta_{95-05}Mks_k^{lwc} + \underset{(0.03)}{0.06^b}$$

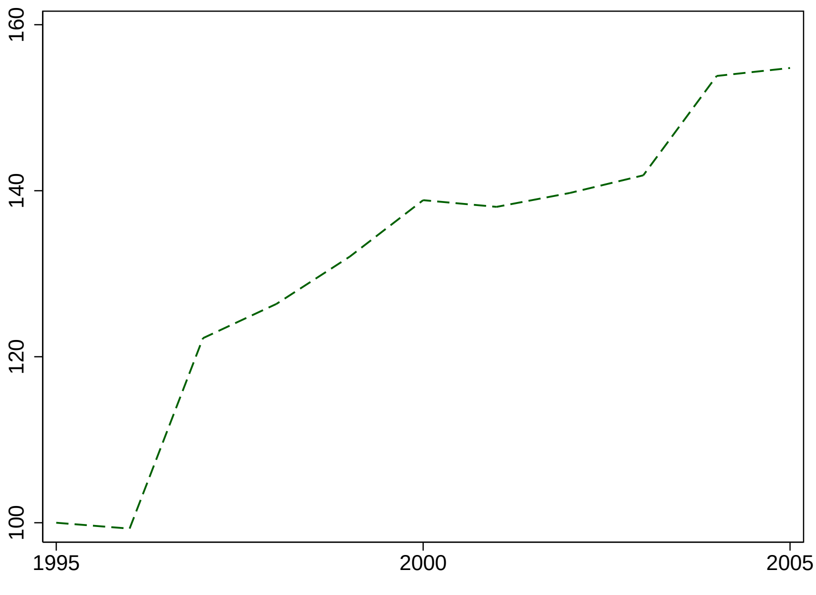
with an adjusted R^2 of 0.11. ^{a}, ^{b} and ^{c} denote significance at the 1%, 5% and 10% level, respectively.

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	pctle 5	pctle 95	N
BF-CES index					
Quality (Int + Ext)	116.3	62.5	58.5	190.7	1,170
Quality (Int)	105.6	42.6	66.3	148.6	1,170
BF-Translog index					
Quality (Int + Ext)	116.4	66.1	59.1	195.3	1,170
Quality (Int)	105.1	39.4	68.1	146.9	1,170
KSW-Between index					
Quality (Int + Ext)	113.6	35.4	75.8	166.6	1,170
Quality (Int)	105.4	17.6	81.5	135.2	1,170
KSW-Within index					
Quality	120.8	59.5	58.5	209.5	1,170

Notes: These summary statistics are computed across the distribution of sector- and destination-specific indices for 2005 ($Q_{kc,05}$ with $Q_{kc,1995} = 100$). The breakdown of the between indicators is either performed on the whole sample ("Int + Ext" rows) or on the subsample of intensive flows ("Int" rows).

Figure A.1: Evolution in the Number of French Export Flows



Notes: The dashed line depicts the (net) flow of entries, where the number of firms in each market is normalized to 100 in 1995.

Table 2: Quality and Market Shares of Low-Wage Countries: Baseline Results

	(1)	(2)	(3)	(4)
	Dep. var: Δ_{95-05} ln Quality			
	BF-CES Index			
Δ_{95-05} LWC market shares	0.39^b		0.32^c	
	(2.394)		(1.839)	
Δ_{95-05} LWC market sh. (predicted)		0.70^b		0.95^c
		(2.155)		(1.864)
Observations	1,170	1,169	1,170	1,169
R-squared	0.089	0.088	0.119	0.120
	BF-Translog Index			
Δ_{95-05} LWC market shares	0.33^b		0.28^c	
	(2.173)		(1.697)	
Δ_{95-05} LWC market sh. (predicted)		0.78^a		1.16^b
		(2.612)		(2.525)
Observations	1,170	1,169	1,170	1,169
R-squared	0.088	0.091	0.119	0.124
	KSW-Between Index			
Δ_{95-05} LWC market shares	0.25^a		0.17^c	
	(2.639)		(1.670)	
Δ_{95-05} LWC market sh. (predicted)		0.39^b		0.17
		(2.160)		(0.566)
Observations	1,170	1,169	1,170	1,169
R-squared	0.072	0.070	0.099	0.097
Country fixed effects	Yes	Yes	Yes	Yes
2d Sector fixed effects	Yes	Yes	No	No
3d Sector fixed effects	No	No	Yes	Yes

Notes: Robust t-statistics in parentheses. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$.
The dependent variable is the log difference of the quality index between 1995 and 2005, computed at the 3-digit ISIC (revision 2) level for each destination country. "Δ_{95-05} LWC market shares" denotes the 1995-2005 change in market shares for low-wage countries. "Δ_{95-05} LWC market sh. (predicted)" is the predicted value of the previous variable obtained in the first stage of the 2SLS. The 2SLS procedure uses as instruments the country's relative distance to the destination country, the change in its world share of sectoral exports, its initial market share in the destination market, and interactions of the change in world market shares with the relative distance and the initial market share. All market shares are computed excluding France and using ComTrade data.

Table 3: Quality and Market Shares of Low-Wage Countries: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
	Dep. var: Δ_{95-05} ln Quality					
	BF-CES Index					
Δ_{95-05} LWC market sh. (predicted)	0.63^c	0.88^c	0.68^b	0.95^c	0.40^b	0.41
	(1.896)	(1.775)	(2.017)	(1.883)	(2.350)	(1.484)
Δ_{95-05} Herfindahl index	0.77^b	0.70^b				
	(2.187)	(2.001)				
Quality Ladder	-0.00		-0.01			
	(-0.676)		(-1.064)			
Ladder × Δ_{95-05} Herf	-0.08^b	-0.07^c				
	(-1.983)	(-1.770)				
Ladder × Δ_{95-05} ln GDPc			0.01	0.01		
			(0.953)	(1.031)		
Observations	1,169	1,169	1,169	1,169	1,169	1,169
R-squared	0.093	0.123	0.089	0.120	0.081	0.096
	BF-Translog Index					
Δ_{95-05} LWC market sh. (predicted)	0.75^b	1.10^b	0.79^b	1.16^b	0.45^a	0.53^b
	(2.481)	(2.453)	(2.574)	(2.538)	(2.839)	(2.077)
Δ_{95-05} Herfindahl index	0.69^b	0.62^b				
	(2.191)	(2.022)				
Quality Ladder	0.00		-0.00			
	(0.168)		(-0.152)			
Ladder × Δ_{95-05} Herf	-0.08^b	-0.07^c				
	(-2.148)	(-1.815)				
Ladder × Δ_{95-05} ln GDPc			0.01	0.01		
			(0.620)	(0.701)		
Observations	1,169	1,169	1,169	1,169	1,169	1,169
R-squared	0.095	0.127	0.091	0.124	0.080	0.095
	KSW Index					
Δ_{95-05} LWC market sh. (predicted)	0.37^c	0.16	0.37^b	0.17	0.27^b	0.20
	(1.932)	(0.525)	(1.996)	(0.566)	(2.492)	(1.111)
Δ_{95-05} Herfindahl index	0.03	0.04				
	(0.115)	(0.149)				
Quality Ladder	-0.00		-0.00			
	(-0.387)		(-0.490)			
Ladder × Δ_{95-05} Herf	0.02	0.02				
	(0.486)	(0.493)				
Ladder × Δ_{95-05} ln GDPc			0.00	0.00		
			(0.076)	(0.088)		
Observations	1,169	1,169	1,169	1,169	1,169	1,169
R-squared	0.073	0.101	0.070	0.097	0.086	0.118
Sample	All	All	All	All	Intensive	Intensive
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
2d Sector fixed effects	Yes	No	Yes	No	Yes	No
3d Sector fixed effects	No	Yes	No	Yes	No	Yes

Notes: Robust t-statistics in parentheses. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$. The dependent variable is the log difference of the quality index between 1995 and 2005, computed at the ISIC (revision 2) level for each destination country. "Δ_{95-05} LWC market sh. (predicted)" is the (instrumented) change in LWC market share. "Δ_{95-05} Herfindahl index" is the change in the Herfindahl index. "Quality Ladder" is Khandelwal's measure of the extent of quality differentiation, by ISIC sector. "Δ_{95-05} ln GDPc" is the (log) growth rate of the country's GDP per capita over 1995-2005.

Table 4: Quality and Competition from Low- and High-Wage Countries

	(1)	(2)
	Dep. var: Δ_{95-05} ln Quality	
	BF-CES Index	
Δ_{95-05} LWC market shares (pred.)	0.76^b	0.94^c
	(2.346)	(1.856)
Δ_{95-05} HWC market sh. (pred.)	-0.86^c	-0.69
	(-1.820)	(-1.386)
Observations	1,169	1,169
R-squared	0.093	0.122
	BF-Translog Index	
Δ_{95-05} LWC market shares (pred.)	0.83^a	1.15^b
	(2.807)	(2.518)
Δ_{95-05} HWC market sh. (pred.)	-0.73	-0.64
	(-1.597)	(-1.353)
Observations	1,169	1,169
R-squared	0.095	0.126
	KSW-Between Index	
Δ_{95-05} LWC market shares (pred.)	0.42^b	0.17
	(2.322)	(0.551)
Δ_{95-05} HWC market sh. (pred.)	-0.43	-0.47
	(-1.113)	(-1.241)
Observations	1,169	1,169
R-squared	0.072	0.100
Country fixed effects	Yes	Yes
2d Sector fixed effects	Yes	No
3d Sector fixed effects	No	Yes

Notes: Robust t-statistics in parentheses. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$. The dependent variable is the log difference of the quality index between 1995 and 2005, computed at the 3-digit ISIC (revision 2) level for each destination country. "Δ_{95-05} LWC Market shares (pred.)" denotes the (predicted) 1995-2005 change in market shares for low-wage countries while "Δ_{95-05} HWC Market sh. (pred.)" is the symmetric variable focusing on high-wage countries.

Table 5: Within- versus Between-Firm Quality and Market Shares of Low-Wage Countries

	(1)	(2)	(3)	(4)	(5)	(6)
	Dep. var: Δ_{95-05} ln Quality					
	KSW-Between Index					
Δ_{95-05} LWC market shares	0.28^a		0.23^b		0.18^c	
	(3.294)		(2.351)		(1.689)	
Δ_{95-05} LWC market sh. (predicted)		0.44^a		0.37^c		0.45
		(3.69)		(1.670)		(1.348)
Observations	1,170	1,169	1,170	1,169	1,170	1,169
R-squared	0.044	0.045	0.070	0.069	0.118	0.118
	KSW-Within Index					
Δ_{95-05} LWC market shares	-0.22^c		-0.16		-0.09	
	(-1.83)		(-0.141)		(-0.62)	
Δ_{95-05} LWC market sh. (predicted)		-0.25		-0.03		0.46
		(-1.488)		(-0.102)		(1.133)
Observations	1,170	1,169	1,170	1,169	1,170	1,169
R-squared	0.052	0.056	0.085	0.085	0.126	0.126
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
2d Sector fixed effects	No	No	Yes	Yes	No	No
3d Sector fixed effects	No	No	No	No	Yes	Yes

Notes: Robust t-statistics in parentheses. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$.
The dependent variable is the log difference of the quality index between 1995 and 2005, computed at the 3-digit ISIC (revision 2) level for each destination country, first in the between dimension ("KSW-Between Index"), then in the within dimension ("KSW-Within Index"). "Δ_{95-05} LWC Market shares" denotes the 1995-2005 change in market shares for low-wage countries and "Δ_{95-05} LWC Market sh. (predicted) its predicted value, obtained from the first-stage of the 2SLS procedure".

Table A.1: First Stage Regressions

	(1)	(2)	(3)	(4)
	Dep. Var: Δ Bilateral Market Share			
Δ MSh in other countries	0.80^a	0.80^a	0.01	-0.03
	(22.342)	(22.372)	(0.275)	(-0.663)
Initial Bil Msh	-0.06	-0.06	-0.32^a	-0.33^a
	(-0.841)	(-0.895)	(-11.072)	(-11.356)
- $\times$ Δ Msh other countries	0.10^b	0.10^b	-0.08^a	-0.09^a
	(2.447)	(2.419)	(-5.391)	(-5.609)
Relative distance	-0.00^a	-0.00^a	0.00	0.00
	(-5.663)	(-5.642)	(1.192)	(0.774)
- $\times$ Δ Msh other countries	1.89^a	1.90^a	1.62^b	1.51^b
	(3.068)	(3.085)	(2.103)	(1.980)
Sample	LWC	LWC	HWC	HWC
Observations	33,469	33,469	10,399	10,399
R^2	0.438	0.438	0.420	0.426
Exporter fixed effects	Yes	Yes	Yes	Yes
Importer fixed effects	No	No	No	No
2d Sector fixed effects	Yes	No	Yes	No
3d Sector fixed effects	No	Yes	No	Yes

Notes: Robust t-statistics in parentheses with ^{a} $p < 0.01$, ^{b} $p < 0.05$ and ^{c} $p < 0.1$. The change in country l's market share for sector k and destination c ("Δ Bilateral Market Share") is explained by the total change in the country's market share in sector k, computed across all destination countries but c ("Δ MSh in other countries"), its initial market share in country c ("Initial Bil Msh"), the distance between l and c, in relative terms with respect to competitors ("Relative distance"), and two interaction terms.

Columns (1) and (2) are run on exporters from low-wage countries while Columns (3) and (4) restrict the sample to high-wage country exporters. The predicted variable introduced in the second stage of the 2SLS procedure is estimated using the same fixed effects (i.e. either 2- or 3-digit fixed effects).

Table A.2: Quality and the Market Shares of Low-Wage Countries: Heterogeneous σ Parameters

	(1)	(2)	(3)	(4)
	Dep. var: Δ_{95-05} ln Quality			
	BF-CES Index			
LWC market shares	0.36^b		0.30^c	
	(2.200)		(1.735)	
LWC market sh. (predicted)		0.73^b		0.90^c
		(2.152)		(1.822)
Obs.	1,170	1,169	1,170	1,169
R-squared	0.084	0.083	0.114	0.113
	KSW Index			
LWC market shares	0.35^a		0.29^b	
	(3.015)		(2.362)	
LWC market sh. (predicted)		0.51^b		0.56
		(2.437)		(1.577)
Observations	1,170	1,169	1,170	1,169
R-squared	0.080	0.076	0.101	0.099
Country fixed effects	Yes	Yes	Yes	Yes
2d Sector fixed effects	Yes	Yes	No	No
3d Sector fixed effects	No	No	Yes	Yes

Notes: Robust t-statistics in parentheses. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$. The dependent variable is the log difference of the quality index between 1995 and 2005, computed at the ISIC (revision 2) level for each destination country, with elasticities of substitution taken from Imbs and Mejean (2009). "Δ_{95-05} LWC Market shares" denotes the 1995-2005 change in market shares for low-wage countries. "LWC market sh. (predicted)" is the predicted value of this variable obtained from the first step of the 2SLS procedure.