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 exporters, within industries. Two alternative indicators are used on firm-level data to measure quality changes. Both lead to similar conclusions. Namely, we show that the mean quality of French exports increased by 10-15% between 1995 and 2005. Quality improvement is significantly more pronounced in markets in which competition from low-wage countries has increased the most. This holds true for various specifications including two different identification strategies. The results are consistent with competition from low-wage countries leading developed countries to 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) has triggered 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 measured 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 quantitatively. First, the trade literature has emphasized the importance of the between-firm reallocation of activities as a determinant of aggregate trade patterns (see Melitz and Trefler, 2012, for a review). 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.[2] 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.[3] 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.[4] When low-wage countries open up to international trade, countries specialize in the segment of the quality ladder that corresponds to their comparative advantage. The exports from LWCs concentrate on the lower segments

[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 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.

[3]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.

[4]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 distribution level, etc.

while rich countries have become increasingly specialized in high-quality goods: market shares are reallocated to firms producing the highest qualities that are somewhat insulated from low-quality LWC competition.[5] In such a framework, one can expect the competition from low-wage countries to drive the quality content of northern countries' 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 between-firm reallocation) by industry and destination market. In the aggregate, we find that the quality of French exports increased by 10-15% 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 where the competition from low-wage producers intensified the most. This feature of the data is consistent with intra-industry specialization induced by 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 accommodate reallocations of market shares across incumbent firms as well as through net entries.[6] Importantly, they both display similar patterns. Second, we need to propose an identification strategy to isolate the causal impact that competition from low-wage countries has on the quality content of exports. Again, our analysis relies on several strategies which lead to the same conclusions.

Our first quality index builds upon the macroeconomic literature studying the microeconomic underpinnings of aggregate TFP changes (e.g. Foster et al., 2008). The idea is to estimate quality at the most disaggregated (variety) level and aggregate across microeconomic units to measure changes in the mean quality of consumption. The heterogeneity in the quality of the products exported by French firms in a given market, defined by a product category and a destination country, is estimated using a strategy built upon Khandelwal,

[5]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. The latter 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. This "within-firm" channel is not investigated in this paper but is supported by evidence in Bloom, Draca and Van Reenen (2011), Mion and Zhu (2011) and Utar (2012).

[6]The "new good problem" is a classical issue in the index number literature, see for instance Diewert (1993). The problem is especially prevalent when it comes to building quality indices since new varieties often have innovative characteristics that increase consumers' willingness to pay for the product. See Pakes (2003) for a discussion of this issue. As detailed in Section 2, we pay attention to defining quality in a way that is consistent with adjustments at both the intensive and extensive margins. In our data, extensive adjustments (the net entry of better quality producers) account for about one half of aggregate quality growth.

Schott and Wei (2011).[7] Using these estimates, it is possible to observe reallocations of the import demand along the quality ladder and quantify their impact on the quality content of exports. Our second quality indicator relies on the methodology proposed by Aw and Roberts (1986) and Boorstein and Feenstra (1987) and recently used by Harrigan and Barrows (2009) on sectoral data. The quality of a consumption basket is defined as the mean utility its consumption induces, per unit of consumption. Using insights from the price index theory, the definition implies a simple measure of changes in the quality content of aggregate exports that involves comparing the unit value and price index, both calculated at the level of the export basket. We show that this comparison amounts to measuring reallocations of market shares favoring firms which sell goods at different price levels, interpreted as heterogeneous qualities. An increase in the index is explained by a reallocation of market shares, in favor of more expensive, better-quality goods.

Once the quality measures are computed, the second challenge consists in finding a convincing identification strategy for a causal impact of low-wage country competition on the quality content of French exports. This step is all the more challenging since the explained variable likely captures various factors affecting the quality content of exports, beyond the competition from low-wage countries. In order to circumvent the issue, we identify the effect using the heterogeneity within sectors, across destination markets. Using sector and country fixed effects in our regression framework allows us to control for a wide set of unobserved determinants of quality changes, which may be correlated with the penetration of LWC exports. We alternatively rely on two proxies for the strength of competitive pressures coming from low-wage countries.

The first proxy uses observed changes in the market share of low-wage countries, by product and destination, as a measure of changes in the intensity of competitive pressures coming from LWCs.[8] Both the OLS and IV estimations show that, within sectors, quality has increased the most in those destinations where low-wage countries have increased their penetration the most. This holds true in cross-sections, when the estimation uses observed changes in quality over the whole 1995-2005 period, as well as in panel regressions. The second proxy for LWC competition uses the natural experiment of the quota removal on Chinese exports, under the Agreement on Textile and Clothing (ATC). After China entered the WTO in 2001, a number of quotas imposed on its exports to the European Union and the United States were removed. A nice feature of this natural experiment is that the removal of quotas was decided on a bilateral basis, product-by-product. This implies that the set of products for which quotas were removed for Chinese exports to the European Union was not the same as for exports to the United States. We take advantage of this heterogeneity in our difference-in-difference regressions. Our results suggest that, in those markets that were somewhat insulated from Chinese competition through quotas, the aggregate quality of French exports has increased relatively less, in comparison with other destinations in the same product category. After the quotas were removed, quality growth accelerated in these

[7] Hummels and Klenow (2005) also use this strategy to estimate quality with product-level data.

[8] These market shares are computed with respect to world exports minus French exports, to avoid a mechanic endogeneity between the explained and the explanatory variables.

markets.

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 to 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.[9] Holmes and Stevens (2010) also emphasize the role of between-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.

In this paper, the analysis is focused on the role of reallocations across firms, within a sector, as a driver of aggregate quality growth. 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., 2011; Mion and Zhu, 2011; Utar, 2012). 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; Utar, 2012) and rely more on innovation (Bloom et al., 2011; Utar, 2012). The between-firm quality upgrading that we identify in our data is consistent with the evidence in those papers, even though we focus on a different transmission mechanism. Both lines of research suggest that LWC competition affects the quality content of aggregate exports in a way that is consistent with within-industry specialization along the quality dimension.

The rest of the paper is organized as follows. Section 2 presents our strategy to measure (between-firm) quality changes in our firm-level data. Section 3 discusses the relationship between market-level quality changes and the strength of the competition from low-wage countries. We first propose OLS and IV estimates using changes in LWC market shares to proxy changes in the intensity of the competition faced by French firms in each destination market (Section 3.1). Section 3.2 then presents an alternative difference-in-difference framework using the removal of ATC quotas on Chinese exports as a natural experiment of changes in the intensity of competition. Finally, Section 4 concludes.

2 Measuring Quality Changes

This section presents our measurement strategy to quantify patterns in the mean quality of exports, by sector and destination country. Our empirical analysis focuses on aggregate quality changes driven by a reallocation of market shares along the quality ladder (the

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

"between-firm" channel). We discuss the assumptions and intuitions upon which two alternative quality indices are constructed. While within-firm quality adjustments are not formally treated in the empirical analysis, we discuss how such adjustments affect aggregate quality. We show that they do not bias our measures of between-firm quality improvements, even though we mechanically underestimate aggregate quality changes by focusing solely on this channel.

2.1 Notations

For each sector and destination pair, we consider the universe of French exporters, called I_{pct} where the p, c and t indices respectively stand for a product, a destination country and a year. The mean quality of the export basket is called $Qlty_{pct}$. Our objective is to quantify changes in the mean quality of exports ($\Delta \ln Qlty_{pct}$ where Δ is the time difference operator between periods $t-1$ and t) and test for a causal impact of competition from LWCs on these changes.

The mean quality of aggregate exports evolves over time through two distinct channels. The first one is a "within-firm" channel that our analysis neglects. Aggregate quality increases whenever individual firms in I_{pct} upgrade the quality of their product, on average. Calling Λ_{fpct} the quality level of the variety produced by firm f, this happens if a large enough share of exports is realized by firms with $\Delta \ln \Lambda_{fpct} > 0$. In a world of within-industry specialization, competition from low-wage countries may induce such within-firm quality upgrading if individual firms in France specialize in the upper segment of the quality ladder when facing competitive pressures from firms with a comparative advantage in the production of low-quality varieties. Such an effect is consistent with evidence provided by Bloom, Draca and Van Reenen (2011), Mion and Zhu (2011) and Utar (2012).

Even if quality at the firm-level is constant, however, the mean quality of product- and destination-specific exports may well evolve over time, through composition effects. This is the "between-firm" channel that this paper seeks to identify. Taking the distribution of individual qualities as given, $Qlty_{pct}$ will tend to increase over time if the demand addressed to French firms reallocates in favor of high-quality producers. Again, such a trend in the mean quality of French exports can be the outcome of increased competition from low-wage countries, in a world of within-industry specialization.

If high-quality firms are more competitive than low-quality producers, increased competition from LWCs should indeed push some low-quality French exporters out of the market. Such an extensive margin effect (consistent with Baldwin and Harrigan, 2011) should drive the mean quality of French exports up. But LWC competition may also induce a reallocation of French exports in favor of the best qualities, within the set of incumbent firms. A sufficient condition for this to happen is that the elasticity of substitution between French and LWC firms is higher for low-quality than for high-quality producers located in France. Provided varieties exported by low-wage countries are low quality, on average, a model of vertical differentiation *à la* Gabszewicz and Thisse (1979) displays such heterogeneity in substitution elasticities.[10] The "between-firm" channel of quality growth that we identify in our data accounts for both the intensive and the extensive components.

The rest of this section describes how we measure the between-firm component of quality growth in our data, using two alternative strategies. Before going into detail, it is important to note that the strategy we follow is entirely based on a data set of French exporters. As will become clear in the next two sections, the way we measure quality precludes any interpretation in level terms, or in relative terms with other producing countries. This means that we may measure an increase in the quality content of French exports in a specific sector and destination, while the mean quality of this export basket has decreased with respect to other exporting countries serving the same market with the same good. This is a caveat in our strategy. Using firm-level data makes it possible to investigate the microeconomic underpinnings of within-industry specialization, but precludes any cross-country analysis. From this point of view, our results are complementary to those proposed by Amiti and Khandelwal (forthcoming) based on cross-country product data.

2.2 The KSW Approach

The first approach used to measure between-firm quality changes builds upon the macroeconomic literature studying the microeconomic underpinnings of aggregate TFP changes (Foster et al., 2008, e.g.). The idea is to estimate quality at the most disaggregated (variety) level and aggregate across microeconomic units to decompose changes in the mean quality of consumption. The decomposition follows Griliches and Regev (1995) and Foster, Haltiwanger and Syverson (2008). Assuming that aggregate quality is a consumption-weighted average of individual qualities, changes in the aggregate quality level decompose as follows:

$$\Delta \ln Qlty_{pct} \equiv \underbrace{\sum_{f\in I_{pc}} \bar{w}^N_{fpc}\Delta \ln \Lambda_{fpct}}_{Within-firm} + \underbrace{\sum_{f\in I_{pc}} \Delta w^N_{fpct}(\ln \bar{\Lambda}_{fpc} - \ln Q\bar{l}ty_{pc})}_{Between-firm\ intensive}$$
$$+ \underbrace{\sum_{f\in N_{pct}} w^N_{fpct}(\ln \Lambda_{fpct} - \ln Q\bar{l}ty_{pc}) - \sum_{f\in X_{pct-1}} w^N_{fpct-1}(\ln \Lambda_{fpct-1} - \ln Q\bar{l}ty_{pc})}_{Between-firm\ extensive} \quad (1)$$

where Δ denotes time differences and upper bars are used for averages between periods $t-1$ and t. w^N_{fpct} and Λ_{fpct} respectively stand for the market share of firm f in nominal exports and the quality of its product. $I_{pc} \equiv I_{pct} \cap I_{pct-1}$ is the set of varieties that are offered in market (p, c) in both periods $t-1$ and t. $N_{pct} \equiv I_{pct} - I_{pc}$ and $X_{pct-1} \equiv I_{pct-1} - I_{pc}$ respectively stand for the set of firms entering and exiting the market between periods $t-1$ and t.

As explained before, changes in the aggregate quality of the basket exported to market (p, c) decompose into a within and a between component. The within component in equation

[10] The working paper version of this paper develops such a model. See Martin and Mejean (2010). Auer and Sauré (2011) use a similar setting embodied in a Shumpeterian model to study endogenous growth when innovation is driven by producers wanting to differentiate their production from that of existing firms.

(1) is positive whenever a large enough share of exports is realized by individual firms upgrading the quality of their products ($\Delta \ln \Lambda_{fpct} > 0$). The "between-firm" components push aggregate quality up if i) demand is reallocated to producers of relatively high qualities, within the set of incumbent firms (i.e. $\Delta w^N_{fpct} > 0$ for $f \in I_{pc}$ such that $\ln \bar{\Lambda}_{fpc} > \ln Q\bar{l}ty_{pc}$), ii) entrants produce high quality goods ($\ln \Lambda_{fpct} > \ln Q\bar{l}ty_{pc}$ for $f \in N_{pct}$) or iii) firms exiting were producing goods of relatively poor quality ($\ln \Lambda_{fpct-1} < \ln Q\bar{l}ty_{pc}$ for $f \in X_{pct-1}$).

The decomposition is easy to perform in our data, provided we can estimate the quality of each single variety (in relative terms with respect to the average). The estimates of individual qualities are obtained using a procedure built upon Khandelwal, Schott and Wei (2011). They show how to estimate the quality of a variety, as defined by a specific good produced in a given country. We adapt their strategy to varieties defined as a specific good sold by a firm in a given destination. Two elements are key in the strategy. First, quality is assumed to play the role of a demand shifter. Second, preferences are assumed to be CES across producers of imperfectly substitutable varieties. The identification is based on the following demand equation:

$$q_{fpct} = p_{fpct}^{-\sigma_p} \Lambda_{fpct}^{\sigma_p - 1} P_{pct}^{\sigma_p - 1} Y_{pct} \tag{2}$$

where σ_p is the elasticity of substitution between varieties. Equation (2) explains the demand addressed to each single producer f (q_{fpct}) by its price p_{fpct} in relative terms with respect to the price index P_{pct}, the quality of its variety Λ_{fpct} and the real demand expressed by the market Y_{pct}/P_{pct}.[11]

In logs, equation (2) becomes:

$$\ln q_{fpct} + \sigma_p \ln p_{fpct} = \underbrace{(\sigma_p - 1)\ln P_{pct} + \ln Y_{pct}}_{Fixed\ effect\ (p,c,t)} + \underbrace{(\sigma_p - 1)\ln \Lambda_{fpct}}_{Residual} \tag{3}$$

This equation shows how the quality of each variety can be estimated as the residual of a demand equation, controlling for prices at the individual and aggregate level and the nominal demand expressed by the market. Since price indices and demands are not observed at the product- and destination-level, we follow Khandelwal, Schott and Wei (2011) and approximate market-level variables with fixed effects. Based on prices and quantities observed at the variety level, and a calibration of the elasticity of substitution σ_p, it is thus possible to measure the left-hand side of equation (3), demean in the (p, c, t) dimension and rescale to account for the heterogeneity in product-level elasticities of substitution to obtain an estimate of $\ln \Lambda_{fpct}$.[12]

[11] At this stage, French firms selling goods in market (p, c) do compete with each other, but may also compete with producers of substitutable varieties produced in other countries. The impact of the competition coming from other producing countries is reflected in the price index P_{pct}. In practice however, we will estimate a distribution of qualities that is centered around the mean quality of French exporters. A change in the competitive environment coming from other countries may well affect the relative demand addressed to French producers, thus the mean quality of their products, without affecting the distribution of estimated qualities.

[12] Note that this empirical strategy relies on the assumption that preferences are time invariant. More

This strategy leaves us with an estimate of the distribution of individual qualities, across French producers, for each product, destination and year. Importantly, the estimated qualities obtained with this method cannot be interpreted in levels. They are defined in deviation with respect to the mean quality of exports, for each year, across French firms serving the same destination market. This property of our estimation strategy makes it impossible to compute the "within-firm" component in equation (1). Fortunately, this does not bias our measure of the between component, which involves individual qualities, in deviation from the mean. In the following, we will thus use our estimates of individual relative qualities, aggregate across French producers using observed market shares w^N_{fpct}, and recover the between-firm components of equation (1). This corresponds to the "KSW index" used in the rest of the analysis.

2.3 The BF Approach

Our second quality measure follows the approach developed by Aw and Roberts (1986) and Boorstein and Feenstra (1987), and recently used by Harrigan and Barrows (2009). Contrary to the measure just described, the quality index is not obtained by aggregating estimated individual qualities, taking the reallocation of market shares across individual producers into account. Instead, the definition of quality is derived at the level of a consumption basket using insights from the price index theory.

The BF methodology starts from a utility function. Let us assume that preferences over the consumption of French products in market (p, c) can be described by a function $C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$ where $\mathbf{q}_{pct}$ is the vector of quantity consumed, $\mathbf{\Lambda}_{pct}$ the vector of individual qualities and I_{pct} the set of French varieties available in market (p, c).[13] Consumers maximize utility by choosing $\mathbf{q}_{pct}$ given the vectors of prices $\mathbf{p}_{pct}$ and qualities $\mathbf{\Lambda}_{pct}$. Following Boorstein and Feenstra (1987), define the "quality" of the consumption basket as the mean utility which its consumption induces per unit of goods:

$$Qlty_{pct} = \frac{C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})}{Qty_{pct}} \tag{4}$$

where $Qty_{pct} \equiv \sum_{f \in I_{pct}} q_{fpct}$ is the number of units consumed in market (p, c).

Given the definition, changes in the mean quality of consumption can be assessed by comparing changes in the utility of consumption and in the quantity consumed. Unobserved utility changes are approximated using insights from the price index theory. As soon as $C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$ is separable from the consumption of other goods available in markets (p, c),[14] there exists an ideal price index P_{pct} satisfying: $Val_{pct} = P_{pct} C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$ with

specifically, we use the same calibrated value for elasticities of substitution, for each year-specific estimation of the distribution of qualities in a given market.

[13]Again, the definition relies on the stability of preferences, over time: the utility function that we posit is potentially heterogeneous across products and destination markets. However, for the BF methodology to apply, the form of preferences must be time invariant.

[14]The separability assumption is not innocuous in our application of Boorstein and Feenstra (1987). It implies in particular that we assume a separability of consumption between varieties produced in France and

$Val_{pct} \equiv \sum_{f \in I_{pct}} p_{fpct} q_{fpct}$ the total value of consumption. This means that changes in the utility of consumption can be assessed by comparing changes in the value of consumption and in the ideal price index. Putting this condition into (4), we obtain a simple measure of quality changes, at the level of the export basket:

$$\Delta \ln Qlty_{pct} = \underbrace{\Delta \ln Val_{pct} - \Delta \ln Qty_{pct}}_{\Delta\ Unit\ Value} - \underbrace{\Delta \ln P_{pct}}_{\Delta\ Price\ Index} \tag{5}$$

The evolution of quality as defined by Boorstein and Feenstra (1987) can be assessed by comparing the unit value of consumption and the ideal price index. The intuition surrounding the decomposition is easy to gather once one recalls that the unit value of consumption is a quantity-weighted average of individual prices, while the ideal price index is a value-weighted average. As detailed in Appendix A, Taylor approximations of the unit value and ideal price index around their value in $t-1$ help recognize the sources of changes in the aggregate quality index defined by Boorstein and Feenstra (1987) in equation (5). Namely:[15]

$$\Delta \ln Qlty_{pct} = \underbrace{\sum_{f \in I_{pc}} w^N_{fpct-1} \Delta \ln \Lambda_{fpct}}_{Within-firm} + \underbrace{\sum_{f \in I_{pc}} (w^N_{fpct-1} - w^R_{fpct-1}) \Delta \ln w^R_{fpct}}_{Between-firm} \tag{6}$$

where variables are defined as before and $w^R_{fpct} \equiv q_{fpct}/Qty_{pct}$ is the market share of firm f, in real terms.

Again, the BF quality index captures two sources of changes in the mean utility per unit of consumption, the "within" and the "between" channels. The within-firm channel is similar to what it was before: it is positive if a large enough number of firms upgrade the quality of their variety. As discussed in Appendix A, it is not possible in general to quantify the magnitude of such within-firm quality changes because measures of the ideal price index in practice assume $\ln \Lambda_{fpct} = \ln \Lambda_{fpct-1}$. The "between-firm" channel is related to the reallocation of (real) market shares between varieties bought by the representative consumer in market (p, c). This is the component that we will quantify in our data, referred to as the "BF index". It is positive if demand is reallocated in favor of firms whose market share is larger in nominal than in real terms $(w^N_{fpct-1} > w^R_{fpct-1})$. One can verify that these firms happen to sell goods at a relatively high price $(p_{fpct-1} > \sum_{f \in I_{pc}} w^R_{fpct-1} p_{fpct-1})$. Assuming that high-price firms produce better quality goods, on average, this means that consumption is reallocated to high-quality producers with a positive end effect on the mean quality of the consumption basket. Finally, note that this effect is identified on the comparison of ex-post real and nominal market shares. A corollary of this is that between-firm quality adjustments are unbiased in the presence of within-firm quality upgrading (see details in Appendix A).

A nice property of Boorstein and Feenstra (1987) is that quality is defined directly at the

those produced in other producing countries. With standard Armington preferences, this assumption would not hold.

[15] This formula holds true assuming that the set of available varieties I_{kct} is constant between periods $t-1$ and t. Appendix A discusses how the net entry of firms affects the BF quality index, under CES or translog preferences.

level of the consumption basket. As a consequence, we do not need to posit an aggregation scheme for individual varieties. The form of the aggregation is a direct consequence of the assumption on the underlying preferences. This is particularly useful when it comes to assessing the impact of extensive adjustments on the quality content of exports. Depending on the form of preferences, such extensive adjustments may have a different impact on the utility of consumption, and thus on the quality index as defined by Boorstein and Feenstra (1987) (see details in Appendix A). When measuring quality changes based on equation (5), we will posit two alternative utility functions, namely a CES aggregator and a translog function. These preferences have been studied in the price index theory. At the intensive margin (for a given set of varieties $I_{pc} = I_{pct} \cap I_{pct-1}$), the corresponding price indices are the Sato-Vartia and the Tornqvist indices, respectively in the CES and translog cases. Feenstra (1994) and Feenstra and Weinstein (2010) show how each of these price indices can be augmented to take extensive adjustments into account. By using these price indices, we are able to measure the contribution of extensive adjustments to quality changes in a way that is consistent with the underlying form of preferences.[16] In fact, this component of quality changes is the main driver of discrepancies between quality growth measured using the KSW and the BF indices. This is not surprising since the former does not take into account the possibility that the entry of a high-quality producer may have a different effect on the utility of consumption depending on the substitutability between new and incumbent firms.

In comparison with the KSW index, the BF measure of quality changes relies on an additional assumption, namely that individual qualities and prices are positively correlated. The BF quality index will thus increase if demand is reallocated to expensive products. Let us suppose that the heterogeneity in prices has nothing to do with quality differentiation, but reflects heterogeneity in the productivity of firms instead, as in Melitz (2003). This would reverse the expected sign of the empirical relationship tested in this paper. Namely, an increased competition from LWC firms would disproportionately hurt low-productive, high-price firms with a negative end effect on our measure of "quality". Given that we consistently find a positive relationship between the BF index and competition from LWCs, the interpretation of changes in the BF index in terms of quality differentiation seems reasonable.

2.4 Data

The two previous measures of (between-firm) quality changes are implemented on 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 each year between 1995 and 2005. The empirical analysis is restricted to the sub-sample of

[16] Contrary to the intensive component of price indices, the extensive components proposed by Feenstra (1994) and Feenstra and Weinstein (2010) both depend on the underlying parameters that determine the substitutability between new varieties and incumbent firms. In the case of CES preferences, the extensive component depends on the elasticity of substitution, σ_p, which we calibrate in a similar way to the estimates of individual qualities in KSW. With translog preferences, a single parameter can be used to capture both the own-price and cross-price elasticities (the parameter called γ in Feenstra and Weinstein, 2010). Again, we rely on the calibration of this parameter to compute the corresponding price indices.

destination countries that represent at least 1% of French exports, minus Taiwan, Nicaragua, Kuwait, and Kazakhstan. This restriction insures that our sample contains countries that are served by a large enough number of French firms, even at the disaggregated product level. The empirical exercise also 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 and aircraft industries, which are very concentrated in France, and the industries of "Other food 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 × product × 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×product composition effects to be small, at least on a yearly basis. But 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). 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 the sector- and market-specific quality index $Qlty_{kct}$, using either the KSW or the BF definition. Changes in quality indices are computed on a yearly basis to limit the bias that preference instability may induce. Annual growth rates are then cumulated over time to compute changes in quality over longer periods. 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.[17] 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. For some regressions, hs6-specific quality indices are aggregated at the 3-digit ISIC (Revision 2) level using either the Sato-Vartia (KSW and BF with CES preferences) or the Tornqvist formula (BF with translog preferences). This allows to smooth any remaining noise in our measure of quality while retaining a sector dimension.

As discussed before, both the KSW approach and the BF index calibrated to CES pref-

[17] 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.

erences involve a measure of the elasticity of substitution between varieties (σ_p). We use estimates available at the 3-digit ISIC (Revision 2) level from Imbs and Mejean (2009).[18] In the translog version of the BF index, the structural parameter determining the magnitude of the own-price and cross-price elasticities, which enters into the computation of the extensive component of price adjustments, is calibrated to 0.5. This is consistent with the median estimate obtained by Feenstra and Weinstein (2010) for their γ parameter.

2.5 Patterns in the Quality of French Exports

At the ISIC level, our sample contains 1,171 (destination- and sector-specific) time series. Table 1 gives summary statistics on the corresponding end-period quality indices (for 2005, with quality in 1995 normalized to 100). The first two lines correspond to quality indices computed using the BF formula, under CES or translog preferences. The next line is obtained based on the KSW definition for between-firm quality adjustments. As is straightforward from the table, our different measures of aggregate quality give similar results, at least on average. Over the 1995-2005 period, the mean quality increased by 15 to 22%. Both the mean and the dispersion are larger with the KSW index.

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 1,171 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 index). Despite different underlying assumptions, the aggregate evolutions are remarkably similar. They show a monotonous improvement in the quality of French exports over the period. The cumulative growth rate between 1995 and 2005 is measured equal to 11% with the BF index and 15% with the KSW measure.

These aggregate evolutions hide a strong degree of heterogeneity however, as shown by the large distribution of quality growth rates around their mean (Table 1). Despite the average upward trend, the quality of the French export basket thus decreases in about 35% of the 1,171 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. This heterogeneity within sectors across destinations is exploited in our empirical exercise to identify the impact of the competition from LWCs.[19]

[18] Since these elasticities are estimated, the first-step estimation error should be taken into account while measuring quality. To check the robustness of our results, we have implemented a bootstrap procedure in which we take 500 draws of the elasticities from a normal distribution parameterized with the estimated means and standard errors, compute the quality indices for each draw and run the baseline regression on the outcome. Given that the procedure is extremely time-consuming, the bootstrap has been implemented restricting the analysis to the BF-CES index and the two OLS regressions reported in Table 2, columns (1) and (2). The results are robust, see footnote 22.

[19] In a web appendix to this paper, we compute the patterns of quality at the sector level and country by country. The comparison of quality indices across sectors on the one hand and across countries on the other hand shows a strong degree of heterogeneity in quality patterns.

3 Impact of 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 competition from LWCs. If countries indeed specialize within industries, quality growth should be stronger in those markets in which France faces harsher competitive pressures from low-quality producers.

We develop two distinct strategies to assess the impact of competition from low-wage countries. The first strategy uses changes in the market share of LWCs, by sector and destination, as a proxy for competitive pressures on the lower segment of the quality ladder. The second strategy uses the removal of quotas on Chinese exports in textile and clothing industries after the entry of China in the WTO as a natural experiment.

3.1 Quality Changes and Low-Wage Country Market Shares

Our first measure of "low-quality competition" relies on the growing penetration of goods produced in low-wage countries, in world markets. 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.[20] If, on average, low-wage countries produce lower qualities, as evidence in the literature suggests, the increased penetration of their products should exert pressures on the firms located at the bottom of the quality ladder. In turn, this should push the aggregate quality of exports up, for countries with a comparative advantage in higher-quality goods, potentially including France.

As preliminary evidence, Figure 2 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.[21] It shows a positive relationship between quality growth and the percentage change in the average market share of LWCs. This holds true no matter how quality is measured, either using the BF index (panel (a)) or with the KSW method (panel (b)). We

[20] 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.

[21] Here and in the rest of the analysis, market shares are systematically computed using world exports minus French exports as the denominator:

$$MkSh^i_{kct} \equiv \frac{IMP^i_{kct}}{\sum_{l \neq France} IMP^l_{kct}} \text{ and } MkSh^{lwc}_{kct} = \sum_{i \in lwc} MkSh^i_{kct}$$

where IMP^l_{kct} is the value of good k imported by country c from country l at time t. Excluding French exports avoids introducing a mechanical source of endogeneity in the analysis. With French exports included in the denominator of market shares, a demand shock hitting, say, French high-quality producers would affect the quality of French exports *and* the country's market share, and thus mechanically the market share of LWCs.

now use a regression analysis to ask whether this positive 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.

The baseline specification relates cumulated changes in the quality of exports in sector k to country c to changes in low-wage country market shares in the same destination market. Market shares are computed using the total amount of imports in market (k, c) minus imports from France as a reference. This avoids introducing a mechanical relationship between the explained and explanatory variables. The time differentiation allows us to get rid of country- and sector-specific determinants jointly explaining the *level* of quality provided by France and the market share of LWCs. However, a number of omitted variables may still bias the regression. One way to limit the omitted variable bias is to include several dimensions of fixed effects to control for unobserved determinants of quality changes. In our regressions, we systematically include sector-year and country-year fixed effects. Sector fixed effects capture all determinants of quality changes that are not heterogeneous across countries. For instance, technology improvements in some sectors may reallocate the demand across producers, with an end effect on quality, *and* affect the market share of low-quality producers. Likewise, if French producers tend to outsource the low-quality tasks of their production process to low-wage countries, while maintaining a local production of high-quality components, we should observe an increase in the quality of sectoral exports, together with a rise in the amount exported by LWCs. To the extent that these factors affect quality in a way that is homogeneous across destinations, they should be accounted for by sector-time fixed effects. Likewise, country-time fixed effects control for all destination-specific macroeconomic evolutions that may explain both a change in LWC market shares and a change in the demand addressed to French high-quality firms. For instance, income growth in the destination country should push the demand for high-quality goods up, thus reducing the market share of low-quality producers both in France and in LWCs, without this being related to within-industry specialization.

The first set of results based on such a fixed effect model is presented in Table 2. Here, we use 10-year growth rates in quality as the left-hand side variable. This is meant to capture long-run changes in the quality composition of French exports (Trefler, 2004). With this definition of quality growth, the time dimension vanishes and the regression is cross-sectional. Each panel in Table 2 corresponds to one measure of quality, as described in Section 2. We first estimate the within-sector, between-destination effect of changes in LWC market shares (columns (1) and (2)) before adding control variables. Column (1) uses sector fixed effects defined at the 2-digit level of aggregation, while column (2) has 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 Table 2, columns (1) and (2), show a positive coefficient on the variable measuring changes in LWC market shares. The growth in quality described in Section 2.5 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.[22] Within sectors, a relative increase in LWC market shares of 10 percentage points leads to a growth in the quality content of French exports of 3 to 4%.

Columns (3) and (4) of Table 2 introduce additional control variables to see whether the effect of LWC competition is homogeneous across sectors and countries. In column (3), the change in market shares is interacted with a dummy equal to one if the destination country is relatively rich, as measured by a GDP per capita greater than the median country in our sample. This specification allows for a different impact of competition from LWCs on the quality content of exports, depending on the destination country's income level. For instance, if the domestic production is of relatively high quality in richer countries, we should expect the forces toward intra-industry specialization to be mitigated there. Estimates are consistent with this hypothesis, but the difference across country groups is not significant. In column (4), the change in market shares is interacted with a Balassa index computed for France in each destination market, with data for 1994.[23] This specification tests whether a change in LWC competition leads to more reallocations in sectors in which France initially had a comparative advantage. Again, the coefficient on the interaction is positive but not significant. Overall, the results in columns (3) and (4) suggest that increasing pressures from LWCs induce a similar growth in quality across sectors whatever the comparative advantage of France, and across countries whatever their GDP per capita.

We interpret the positive relationship between quality and changes in the market share of LWCs as evidence of intra-industry specialization. An alternative interpretation, however, could be that quality increases when competition becomes harsher, whatever the quality level of competing firms. In order to discriminate between these explanations, column (5) in Table 2 includes an additional control variable that measures changes in the market share of high-wage countries. If it is overall competition that drives quality up, competitive pressures coming from high-wage countries should have the exact same effect as those exerted by LWC firms. Instead, if intra-industry specialization is at work, we should expect competition from HWCs to have the exact opposite effect on the quality content of French exports. To the extent that firms in high-wage countries produce high-quality goods, on average, an increase in these countries' market share should drive the quality content of French exports down. In this regression, the variable measuring changes in the market share of high-wage countries is

[22] The results in Table 2 for the KSW index and the BF-CES index are built from sector-specific elasticities of substitution that are *estimated* by Imbs and Mejean (2009). To account for the estimation error in the first stage, we have implemented a bootstrap procedure described in footnote 18. The results obtained with the bootstrapped BF-CES index are as follows. With 2-digit sector fixed effects, the mean elasticity is equal to 0.4 with a standard error of 0.04. With 3-digit fixed effects, the elasticity is 0.39 with a standard error of 0.05. The coefficients are significant and of the same order of magnitude as the one estimated without bootstrapping the quality indices. Moreover, the bootstrapped standard errors are twice as low as the robust standard errors estimated in the baseline results.

[23] We use Comtrade data at the 3-digit ISIC (revision 2) level to compute the Balassa index. The formula for the Balassa index of France in sector k is $Bal_{FRA,k} = \frac{EXP_k^{FRA} / \sum_{s \in N^{FRA}} EXP_s^{FRA}}{(\sum_{c \in N} EXP_k^c)/(\sum_{c \in N, s \in N^s} EXP_s^c)}$, with EXP_s^c the value of country c's exports of good s, N^c the set of sectors in which exporters from country c are active and N the set of reference countries (the rest of the world).

constructed in a symmetric way as the LWC competition measure - on the subset of countries whose GDP per capita is above 90% of the US one. Whatever the way quality is measured, the coefficient on high-wage country competition is negative and not significant. The effect of LWC competition remains positive and is significant in two out of three regressions. The negative coefficient on HWC market shares is consistent with intra-industry specialization. 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.

A potential caveat in the regression framework tested in Table 2 is that the determinants of sector-country trends in quality are poorly controlled for, while eventually correlating with the demand addressed to low-wage countries. To see whether this biases our results, we propose a set of panel estimates that further exploits the time-dimension in our data. We cumulate annual quality growth over shorter periods (namely 1995-1998, 1998-2001, and 2001-2005) and introduce a wider set of fixed effects. This allows controlling for sector-country fixed effects, on top of the sector-year and country-year trends. Moreover, working on shorter time periods alleviates concerns about the impact of preference instability. With this structure of fixed effects, the coefficient on LWC market shares will be positive if quality growth is faster in periods when competitive pressures increase more intensively.

The results are presented in Table 3, for each quality index and with different structures of fixed effects. Columns (1), (3) and (5) show estimates obtained with 3-digit sector-time and country-time fixed effects. This specification is close to the one introduced in column (2) of Table 2, with an additional time dimension. Columns (2), (4) and (6) add sector-country fixed effects.[24] Whatever the specification and the quality index, the results show a positive coefficient on the change in LWC market shares. The effect is always significant at the 10% level, despite the fact that the degrees of freedom for identification have reduced with respect to the specification in Table 2.

An alternative way of treating the potential omitted variable bias which the fixed effect regressions in Table 2 may display is to instrument the measure of LWC competition with instruments that are orthogonal to quality changes. Given the identification strategy, the only source of endogeneity that we should fear has the country *and* sector dimension. We thus use the following country- and sector-specific instruments. First, a bilateral Balassa index, computed for each sector using 1994 data and aggregated across LWCs. This instrument is meant to proxy the initial comparative advantage of low-wage countries in a given sector. We expect future changes in market shares to be greater in sectors where low-wage countries initially had a comparative advantage (Auer and Fischer, 2010). The second instrument measures changes in the nominal exchange rate of low-wage countries with respect to each destination country. It is computed in two steps. We first compute bilateral nom-

[24] Since the specification in columns (2), (4) and (6) is extremely demanding, we recover degrees of freedom by defining the sector-year fixed effects at the 2-digit level. Sector-country fixed effects are defined at the most disaggregated level (3 digits).

inal exchange rates, for each low-wage country and destination market. Then, we compute a weighted average of exchange rate changes, using a measure of the supply potential of each country as weights (total world exports in that sector divided by the distance to the destination market).[25] Finally, the third instrument interacts the two previous variables to reproduce the heterogeneity of LWC market shares, across destinations within sectors. The exclusion restriction underlying this IV strategy is that neither the initial patterns of low-wage countries' comparative advantages nor movements in these countries' nominal exchange rates are correlated with changes in the quality content of French exports.

The results are presented in Table 4. The instruments have reasonable explanatory power when it comes to explaining changes in market shares (see the R-squared of the first stage estimation reported in the bottom panel of Table 4). The Hansen test indicates that the overidentifying restriction is not rejected, hence supporting the validity of the instruments. The Kleibergen-Paap Wald test rejects the null of weak identification. The coefficient on the interaction between the Balassa index and exchange rate changes is highly significant and positive: LWC market shares increase more in sectors where they initially had a comparative advantage and toward countries with which they gained competitiveness through exchange rate depreciation. In the most demanding regressions with 3-digit sector fixed effects, the two other instruments are highly significant as well.

The top panel of Table 4 reports the results of the second step. With 2SLS, the impact of LWCs increasing their market share on the quality content of French exports is positive, significant in all cases and sizable. This confirms our previous findings and validates the causal interpretation. In quantitative terms, in regressions with 3-digit sector fixed effects, the coefficients on the instrumented change in market shares lies between 1.6 and 3.6 which is markedly higher than in the OLS specification. It has to be noted however that the precision of the estimations is also poorer. Actually, the OLS coefficients lie in the 95%-5% confidence interval of the 2SLS coefficients. The last line of Table 4 reports the p-value of the Wu-Hausman endogeneity test. In 5 of the 6 regressions, exogeneity cannot be rejected. The only specification that does reject the null of exogeneity (column 1) has 2-digit fixed effects as controls. This suggests that, if any, the endogeneity is driven by omitted variables which are captured by the 3-digit sector fixed effects.

Overall, the different robustness checks which we have proposed for the results in Table 2 suggest that our regressions do not suffer from an important endogeneity issue. The results confirm the causal interpretation. Within sectors, changes in the quality content of French exports are positively impacted by the strength of competitive pressures from LWCs, as measured by the growth in their market shares. In the next section, we use a natural experiment to provide additional support for the causal interpretation of our results.

[25] 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*).

3.2 MFA and China's Entry in the WTO

In this section, we propose an alternative method to assess the impact of LWC competition on the quality content of French exports. We follow Bloom et al. (2011); Khandelwal et al. (2011); Utar (2012), among others, and use the entry of China in the WTO as an exogenous measure of changes in competition from low-wage countries. More specifically, we focus on the textile and clothing industries and use the removal of quotas under the Agreement on Textile and Clothing (ATC) as an exogenous competitiveness shock.

After China entered the WTO in 2001, a number of quotas imposed on its textile and clothing exports to the European Union and the United States were removed.[26] A nice feature of this natural experiment is that the removal of quotas was decided on a bilateral basis, product by product. This means that, in 2002, the set of products for which quotas were removed for Chinese exports to the European Union was not the same as for exports to the United States. Furthermore, other destination countries of French exports did not impose quotas on Chinese products and can thus serve as a control group. In countries imposing quotas before 2002, French exporters were somewhat protected from Chinese competition, which we expect reflects different quality patterns.

Importantly, the removal of quotas has actually led to an increase in competition from China. Brambilla, Khandelwal and Schott (2010) thus report that US imports from China of products on which a quota was imposed before 2002 increased by 305% after the quota was removed. However, not all quotas were binding, and the first quotas which countries decided to remove were those that were not binding. In order for the experiment to make sense, the removal of a given quota in a given country must actually increase competitive pressures faced by French exporters in that destination. In order to insure that this is the case, we focus on the subset of removed quotas that were actually binding before 2002. Following Brambilla, Khandelwal and Schott (2010), we consider as binding a quota in a sector in which China exports at least 95% of the permitted volume of exports. Data on quotas in the US, by TS10 sector, are from Brambilla, Khandelwal and Schott (2010). Data on EU quotas are from the SIGL website and are converted to the hs6 nomenclature using the correspondence table built by Utar (2012).[27]

This natural experiment is exploited in a difference-in-difference framework. We use the removal of quotas on Chinese imports in 2002 as an exogenous measure of a change in the intensity of competition from China. We focus on sectors in which either the US or the EU

[26] In 2002, China benefited from quotas previously dismantled under Phases I and II of the ATC, as well as from new quota removals, under Phase III. Under each phase of the ATC, countries imposing quotas on textile and clothing goods under the Multi-Fiber Agreement (the USA, the European Union, Norway and Canada) had to decide on a minimum number of hs6 sectors to liberalize. The choice of which hs6 sectors to liberalize first was made by the importing country and can thus be considered exogenous from changes in the quality of French exports. In this section, we focus on quotas imposed on imports by the US and the European Union. We remove Canada and Norway from the list of destination countries since these countries were also involved in the ATC, but we do not have data on which hs6 sectors they liberalized under each phase of the ATC. Of course, China is also removed from the list of destination countries.

[27] We thank Hale Utar for sharing the correspondence table with us. Data on quotas can be found here *http://trade.ec.europa.eu/sigl/*

imposed a binding quota on Chinese imports before 2002, and removed it in January 2002. When there are multiple quotas for a single hs6 industry, we consider as treated an hs6 sector in which at least one product faced a binding quota in 2001 which was relaxed in 2002. The underlying assumption is that, before 2002, French exporters faced relatively less competition in countries imposing quotas than in the control group. Furthermore, competitive pressures from Chinese goods should have increased relatively more rapidly after 2002, in countries that had removed quotas.

In the difference-in-difference framework, the explained variable is the change in the quality content of French exports, defined at the hs6 and country level. We compare the growth of quality between 1995 and 2001 and between 2001 and 2005. The estimated equation has the following form:

$$\Delta \ln Qlty_{kct} = \alpha Post2002_t + \beta Quota_{kct} + \gamma Quota_{kct} \times Post2002_t + FE_{ct} + FE_{kt} + \epsilon_{kct} \quad (7)$$

where $Post2002_t$ is a dummy equal to one after 2001 and $Quota_{kct}$ a dummy equal to one if country c imposes a quota on Chinese exports of good k, before 2002. We expect β to be negative: in sectors with binding quotas before 2002, French exporters should face relatively less pressure from Chinese exporters, and thus the forces toward within-industry specialization should be mitigated. On the contrary, γ should be estimated positive: the markets in which quotas were relaxed in 2002 experienced a surge in Chinese exports that should drive quality up.

The results are presented in Table 5. In columns (1), (2), and (3), country-time and sector-time fixed effects are used as controls. The coefficient on $Quota_{kct}$ is negative for the three quality indices, significant for two of them, and almost significant for the third one. The negative sign means that the quality of French exports increased relatively less in those markets where China faced quota restrictions before 2002. After 2002, the quality of French exports increases more strongly in the markets where quotas were relaxed, as shown by the positive coefficient on the interaction. This is consistent with the view that quality increases more in markets with more intense competition from China. In columns (4), (5), and (6), we introduce country-time fixed effects and country-sector fixed effects. This implies that the impact of quota removals is estimated within sector-countries, focusing on those destinations that imposed quotas before 2002. We find that the growth in the quality of French exports was higher after the removal of quotas on Chinese imports. Once again this is consistent with a boom in Chinese competition leading to an increase in the quality content of French exports.

Overall, the results of the difference-in-difference regressions confirm the positive impact of Chinese competition on the quality content of French exports. In the markets where France experienced a tough competition from China at the end of the ATC, the demand for French products was reallocated from low-quality to high-quality firms.

4 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 French manufacturing firms. We show that the quality of the French export basket increased by 10-15% between 1995 and 2005. The quality growth is particularly pronounced in sectors and countries where French firms faced increased competitive pressures from low-quality producers. 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 Details on the BF Quality Index

Suppose that the consumption of French varieties of good p consumed by country c can be described with a separable utility function $C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$. By definition, an ideal price index for preferences $C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$ minimizes expenditures, for each unit of utility:

$$P_{pct} = \min_{\mathbf{q}_{pct}} \left\{ Val_{pct} \equiv \sum_{f \in I_{pct}} p_{fpct} q_{fpct} \,|\, C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct}) = 1, q_{fpct} \geq 0 \quad \forall f \right\}$$

At the consumer's optimum, the product of the ideal price index and the utility of consumption must thus equal the value of consumption: $Val_{pct} = P_{pct} C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$.

Following Boorstein and Feenstra (1987), we define quality at the level of the consumption basket as the mean utility per unit of consumption. This definition implies:

$$\Delta \ln Qlty_{pct} = \Delta \ln C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct}) - \Delta \ln Qty_{pct}$$

where $Qlty_{pct}$ is the quality of the export basket in market (p, c) and $Qty_{pct} \equiv \sum_{f \in I_{pct}} q_{fpct}$ the number of units consumed. Using the definition of an ideal price index, quality changes can be decomposed as follows:

$$\Delta \ln Qlty_{pct} = \Delta \ln UV_{pct} - \Delta \ln P_{pct}$$

where UV_{pct} is the unit value of consumption:

$$UV_{pct} \equiv \frac{Val_{pct}}{Qty_{pct}} = \sum_{f \in I_{pct}} w^R_{fpct} p_{fpct}$$

with $Val_{pct} \equiv \sum_{f \in I_{pct}} p_{fpct} q_{fpct}$ the nominal consumption and $w^R_{fpct} \equiv \frac{q_{fpct}}{Qty_{pct}}$ the share of firm f in (real) consumption.

In order to gather intuitions about what the BF index captures, we will first work on the intensive component of quality changes ($I_{pc} = I_{pct} \cap I_{pct-1}$), before detailing the impact of net entries.

A.1 Intensive Quality Changes

At the intensive margin, the BF quality index is defined as:

$$\Delta \ln Qlty^{int}_{pct} = \Delta \ln UV^{int}_{pct} - \Delta \ln P^{int}_{pct}$$

where the ^{int} superscript is used to denote aggregate variables computed on the intensive set of firms ($I_{kc} = I_{kct} \cap I_{kct-1}$).

Using a Taylor approximation around the initial consumption and price patterns, one can show that the log change of the unit value and ideal price index is approximately equal to:

$$\Delta \ln UV^{int}_{pct} = \sum_{f\in I_{pc}} w^N_{fpct-1}\left(\ln \frac{p_{fpct}}{p_{fpct-1}} + \ln \frac{q_{fpct}}{q_{fpct-1}}\right) - \sum_{f\in I_{pc}} w^R_{fpct-1} \ln \frac{q_{fpct}}{q_{fpct-1}}$$

$$\Delta \ln P^{int}_{pct} = \sum_{f\in I_{pc}} w^N_{fpct-1}\left(\ln \frac{p_{fpct}}{p_{fpct-1}} - \ln \frac{\Lambda_{fpct}}{\Lambda_{fpct-1}}\right)$$

where $w^N_{fpct-1} \equiv \frac{v_{fpct-1}}{Val_{fpct-1}}$ is the share of firm f in consumption, measured in nominal terms.

Using those Taylor approximations, it is possible to write changes in the BF quality index as the sum of two components:

$$\Delta \ln Qlty^{int}_{pct} = \underbrace{\sum_{f\in I_{pc}} (w^N_{fpct-1} - w^R_{fpct-1}) \ln \frac{w^R_{fpct}}{w^R_{fpct-1}}}_{Between-firm} + \underbrace{\sum_{f\in I_{pc}} w^N_{fpct-1} \ln \frac{\Lambda_{fpct}}{\Lambda_{fpct-1}}}_{Within-firm}$$

The first component, the between-firm channel, is attributable to the reallocation of (real) market shares, across varieties available for consumption. The mean quality content of consumption increases through this channel whenever consumers increase their real consumption of relatively expensive goods, which represent a larger share of consumption in value than in volume: $w^N_{fpct-1} > w^R_{fpct-1} \Leftrightarrow p_{fpct-1} > \sum_{f\in I_{pc}} w^R_{fpct-1} p_{fpct-1}$. Such a reallocation of demand can be interpreted as a change in the mean quality of consumption if those relatively expensive varieties are also of better quality.

The second component, the within-firm channel, is explained by individual adjustments in the quality of the varieties offered to consumers. This component is positive if firms upgrade the quality of their products. In practice however, individual qualities are not observed in the data. The ideal price index used in the application of this method is based on the assumption that quality is constant within-firm, in which case:

$$\Delta \ln P^{int}_{pct} = \sum_{f\in I_{pc}} w^N_{fpct-1} \ln \frac{p_{fpct}}{p_{fpct-1}}$$

Under this assumption, the changes measured in the BF quality index only capture the "between-firm" component. Note that the assumption that quality is constant within-firm only affects the definition of the ideal price index, and thus the within-firm component of quality changes. The between-firm component on which our analysis focuses is left unaffected.

A.2 Extensive Quality Changes

At the extensive margin, the BF quality index is defined as:

$$\Delta \ln Qlty^{ext}_{pct} = \Delta \ln UV^{ext}_{pct} - \Delta \ln P^{ext}_{pct}$$

where the ^{ext} superscript is used to denote aggregate variables computed on the extensive set of firms (the set $N_{kct} = I_{kct} - I_{kc}$ of entrants and the set $X_{kct-1} = I_{kct-1} - I_{kc}$ of exiters).

Using the definition of the unit value index, it is straightforward to show that the extensive component of unit value changes is:

$$\begin{aligned}\Delta \ln UV_{pct}^{ext} &= \left(\ln \frac{\sum_{f \in I_{pct}} p_{fpct} q_{fpct}}{\sum_{f \in I_{pc}} p_{fpct} q_{fpct}} - \ln \frac{\sum_{f \in I_{pct-1}} p_{fpct-1} q_{fpct-1}}{\sum_{f \in I_{pc}} p_{fpct-1} q_{fpct-1}} \right) \\ &- \left(\ln \frac{\sum_{f \in I_{pct}} q_{fpct}}{\sum_{f \in I_{pc}} q_{fpct}} - \ln \frac{\sum_{f \in I_{pct-1}} q_{fpct-1}}{\sum_{f \in I_{pc}} q_{fpct-1}} \right) \\ &= \ln \frac{\tilde{\lambda}_{pct}}{\tilde{\lambda}_{pct-1}} - \ln \frac{\lambda_{pct}}{\lambda_{pct-1}}\end{aligned}$$

where λ_{pct} and $\tilde{\lambda}_{pct}$ respectively denote the share of "intensive" varieties in the value and volume of consumption, in period t. The unit value of consumption increases following the net entry of firms in the market, if new entrants represent a larger share of consumption in nominal than in real terms. Under this condition, entrants sell goods that are relatively expensive, and thus of better quality.

In the general case, it is difficult to assess the final impact that such extensive adjustments will have on the BF quality index. The effect of net entries on the ideal price index indeed depends on the underlying form of preferences. In the specific case of CES preferences, Feenstra (1994) has shown that the impact of net entries on the ideal price index can be written:

$$\Delta \ln P_{pct}^{ext} = \frac{1}{\sigma_p - 1} \ln \frac{\lambda_{pct}}{\lambda_{pct-1}}$$

where λ_{pct} is defined above and σ_p is the elasticity of substitution between the varieties composing the CES basket $C_{pc}(\mathbf{q}_{pct}, \mathbf{\Lambda}_{pct}, I_{pct})$.

With this specific form of preferences, the extensive component of quality changes thus becomes:

$$\Delta \ln Qlty_{pct}^{ext} = \ln \frac{\tilde{\lambda}_{pct}}{\tilde{\lambda}_{pct-1}} - \frac{\sigma}{\sigma - 1} \ln \frac{\lambda_{pct}}{\lambda_{pct-1}}$$

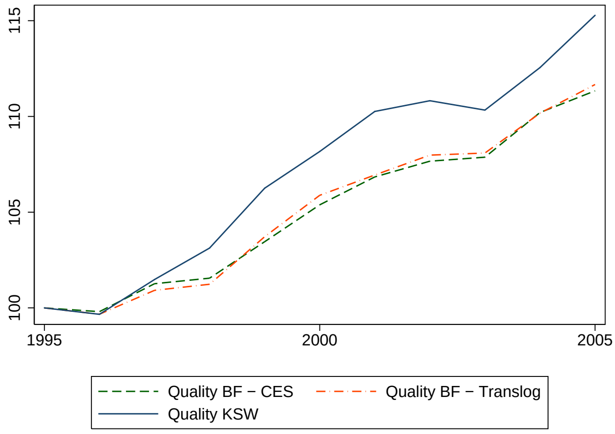
Under CES preferences, net entries increase the utility of consumption because consumers value diversity. The less substitutable those new varieties are with goods offered by incumbent firms (the lower σ_p) and the larger their share in the value of consumption, the stronger the effect is. This love for variety effect will mechanically exert upward pressures on the mean quality of consumption, as defined by Boorstein and Feenstra (1987). The effect will be reinforced if those new entrants also sell goods at a relatively high price (i.e. sell high-quality goods).

If instead, preferences are of the translog form, Feenstra and Weinstein (2010) show that the extensive component of the price index can be written:

$$\Delta \ln P^{ext}_{pct} = \frac{1}{-2\gamma} \left\{ \left[\sum_{f \notin I_{pc}} \left(H_{pct} \, {w^N_{fpct}}^2 - H_{pct-1} \, {w^N_{fpct-1}}^2 \right) \right] + \frac{1}{I_{pc}} \left[\left(\sum_{f \notin I_{pc}} w^N_{fpct} \right)^2 - \left(\sum_{f \notin I_{pc}} w^N_{fpct-1} \right)^2 \right] \right\}$$

where γ relates to the own-price and cross-price elasticities, and $H_{pct} \equiv \sum_{f \in I_{pct}} {w^N_{fpct}}^2$ is the Herfindahl index computed over French exporters in market (p, c).

Figure 1: Evolution of the Aggregate Quality of French Exports



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

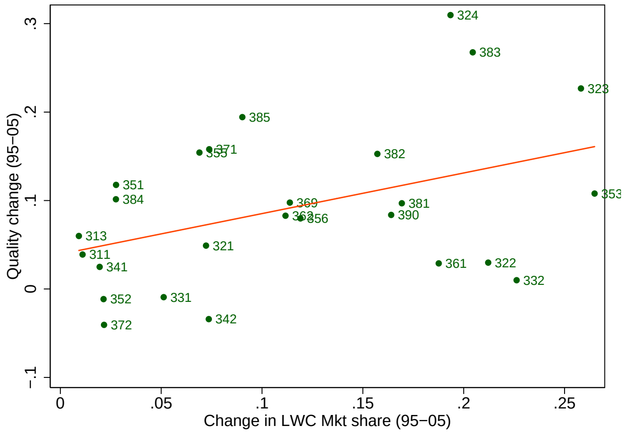
Table 1: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Pctle 5**	**Pctle 95**	**N**
BF-CES index	118.1	69.6	53.7	203.7	1,171
BF-Translog index	115.8	66.4	58.9	201.8	1,171
KSW index	122.5	81.8	65.3	209.3	1,171

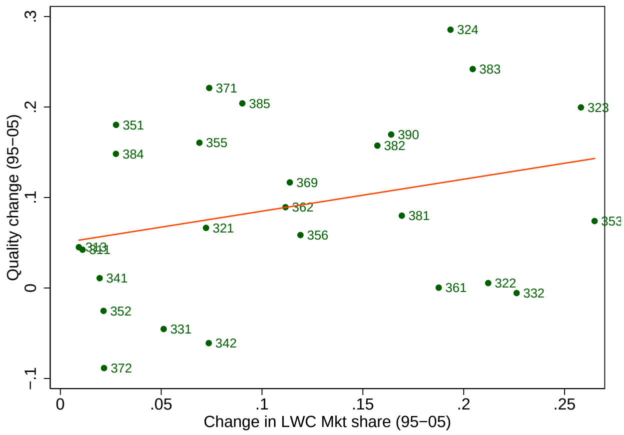
Notes: these summary statistics are computed across the distribution of sector- and destination-specific indices for 2005 ($Qlty_{kc2005}$ with $Qlty_{kc1995} = 100$). Sectors are defined at the 3-digit ISIC (Revision 2) level.

Figure 2: 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 over the period from 1995 to 2005 as $\Delta Mks_k^{lwc} = \sum_c w_{kc}^{fra} \Delta Mks_{kc}^{lwc}$ where w_{kc}^{fra} is the weight of country c in French exports of good k and ΔMks_{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 the explained variable gives:

$$\Delta \ln Qlty_k = \underset{(0.20)}{0.46^b} \Delta Mks_k^{lwc} + \underset{(0.03)}{0.04}$$

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

$$\Delta \ln Qlty_k = \underset{(0.18)}{0.37^c} \Delta Mks_k^{lwc} + \underset{(0.03)}{0.06^b}$$

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

Table 2: Quality and the Penetration of Low-Wage Countries: Cross-Sectional Results

	(1)	(2)	(3)	(4)	(5)
			Dep. var: $\Delta \ln Qlty_{kct}$		
			BF-CES Index		
Δ LWC market shares	0.35***	0.34**	0.48**	0.37*	0.34*
	(2.692)	(2.471)	(2.080)	(1.903)	(1.770)
- $\times$ Rich Cty			-0.21		
			(-0.725)		
- $\times$ Balassa Index FRA				0.04	
				(1.182)	
Δ HWC market shares					-0.17
					(-1.251)
R^2 (within)	0.093	0.130	0.121	0.121	0.122
			BF-Translog Index		
Δ LWC market shares	0.31*	0.30*	0.32	0.26	0.24
	(1.971)	(1.787)	(1.529)	(1.499)	(1.391)
- $\times$ Rich Cty			-0.05		
			(-0.185)		
- $\times$ Balassa Index FRA				0.04	
				(0.841)	
Δ HWC market shares					-0.15
					(-1.214)
R^2 (within)	0.097	0.133	0.133	0.133	0.134
			KSW Index		
Δ LWC market shares	0.43**	0.41**	0.34**	0.31**	0.29*
	(2.437)	(2.186)	(2.223)	(2.174)	(1.986)
- $\times$ Rich Cty			-0.01		
			(-0.045)		
- $\times$ Balassa Index FRA				0.03	
				(1.501)	
Δ HWC market shares					-0.12
					(-1.066)
R^2 (within)	0.097	0.121	0.130	0.131	0.131
Observations	1,171	1,171	1,171	1,171	1,171
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	2d	3d	3d	3d	3d

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 LWC market shares" denotes the 1995-2005 change in market shares for low-wage countries (countries with a GDP per capita below 5% of the US one). "Δ HWC market shares" denotes the 1995-2005 change in market shares for high-wage countries (countries with a GDP per capita above 90% of the US one). "Rich Cty" is a dummy equal to one if the destination country's GDP per capita is higher than the median GDP per capita in the sample. "Balassa Index FRA" is the sector-specific Balassa index of France, computed in 1994, a measure of comparative advantage. All market shares are computed with respect to world exports, minus France, and using ComTrade data.

Table 3: Quality and the Penetration of Low-Wage Countries: Panel Results

	(1)	(2)	(3)	(4)	(5)	(6)
	Dep. var: $\Delta \ln Qlty_{kct}$					
	BF-CES		BF-Translog		KSW	
Δ LWC MShares	0.35**	0.30*	0.29**	0.29**	0.28**	0.24*
	(2.566)	(1.802)	(2.499)	(1.971)	(2.491)	(1.715)
Observations	3,513	3,513	3,513	3,513	3,513	3,513
R^2 (within)	0.067	0.059	0.068	0.061	0.073	0.070
Country-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-year FE	3d	2d	3d	2d	3d	2d
3d Sector-country FE	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 over three-year periods (1995-1998, 1998-2001, and 2001-2005), computed at the 3-digit ISIC (revision 2) level for each destination country. "Δ LWC MShares" denotes the corresponding change in market shares of low-wage countries (countries with a GDP per capita below 5% of the US one). "2d" and "3d" respectively refer to 2-digit and 3-digit sector effects.

Table 4: Quality and the Penetration of Low-Wage Countries: 2SLS Estimation

	(1)	(2)	(3)	(4)	(5)	(6)
	Dep. var: $\Delta \ln Qlty_{kct}$					
	BF-CES		BF-Translog		KSW	
Δ LWC MShares	6.36***	3.58*	5.01***	3.10**	2.21***	1.56**
	(5.185)	(1.916)	(5.115)	(2.178)	(3.319)	(1.989)
	First Step: Δ LWC MShare					
Balassa 94	-0.00	-0.01**	-0.00	-0.01**	-0.00	-0.01**
	(-0.190)	(-2.481)	(-0.190)	(-2.481)	(-0.190)	(-2.481)
Relative ER	-0.01	-0.03***	-0.01	-0.03***	-0.01	-0.03***
	(-0.819)	(-3.094)	(-0.819)	(-3.094)	(-0.819)	(-3.094)
- $\times$ Balassa	0.02***	0.01***	0.02***	0.01***	0.02***	0.01***
	(5.660)	(2.919)	(5.660)	(2.919)	(5.660)	(2.919)
R^2	0.402	0.492	0.402	0.492	0.402	0.492
Observations	1,171	1,171	1,171	1,171	1,171	1,171
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	2d	3d	2d	3d	2d	3d
Hansen J-stat (p.val)	0.72	0.53	0.72	0.53	0.72	0.53
Kleibergen-Paap Wald F-stat	13.4	13.1	13.4	13.1	13.4	13.1
Endogeneity test (p.val)	0.04	0.49	0.14	0.82	0.12	0.29

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 over three periods 1995-1998, 1998-2001, and 2001-2005, computed at the 3-digit ISIC (revision 2) level for each destination country. "Δ LWC MShares" denotes the corresponding change in market shares for low-wage countries. It is instrumented by the Balassa index of LWCs in the sector in 1994, the average evolution of exchange rates of LWCs, and an interaction of the two previous variables.

Table 5: Quality and Competition from China: Natural Experiment

	(1)	(2)	(3)	(4)	(5)	(6)
			Dep. var: $\Delta \ln Qlty_{kct}$			
	BF-CES	BF-Translog	KSW	BF-CES	BF-Translog	KSW
Post2002	-	-	-	-0.16**	-0.14*	-0.16**
	-	-	-	(-2.169)	(-1.926)	(-2.235)
MFA Quota	-0.11*	-0.09	-0.13**	-	-	-
	(-1.685)	(-1.491)	(-2.373)	-	-	-
- × Post2002	0.21**	0.19**	0.26**	0.23***	0.19**	0.29***
	(2.128)	(2.012)	(2.568)	(2.766)	(2.217)	(3.700)
Observations	5,896	5,896	5,896	5,896	5,896	5,896
R^2	0.219	0.207	0.195	0.011	0.007	0.022
Sector FE	Yes	Yes	Yes	No	No	No
Cty - Year FE	Yes	Yes	Yes	No	No	No
Cty - Sect FE	No	No	No	Yes	Yes	Yes

Note: clustered (member × MFA product dimension) standard errors in parentheses with ^{a} $p < 0.01$, ^{b} $p < 0.05$ and ^{c} $p < 0.1$. Robust standard errors (not reported here) are smaller than clustered standard errors.

The dependent variable is the log difference of the quality index between 1995 and 2001 and 2001 to 2005, computed at the (hs6) sector level, by destination country. We focus on French exports to 44 countries in the clothing and apparel sectors in which i) the US or the EU had a quota on Chinese exports, ii) the quota was removed in the EU or in the US in January 2002 (586 hs6 sectors). "Post2002" is a dummy that takes the value 1 in the second sub-period. "MFA Quota" is a dummy equal to one for country-sector with a quota on Chinese exports until 2002.