



# Export quality and wage premium

Francesco Guerra<sup>1</sup> 

Accepted: 12 October 2023  
© The Author(s) 2023

## Abstract

A growing body of research suggests a positive association between the quality of export products and income per capita, arguing that quality upgrades affect income through changes in the relative demand for skilled labor. This article falls within this literature and intends to shed light on the effect of quality upgrades of export products on average wages at the industry level. The study is conducted on the manufacturing sector over a set of 23 countries for which industry-level wage data are available. Contrary to previous studies which use unit values as an indirect measure of product quality, we rely on the methodology proposed in Khandelwal (Rev Econ Stud 77(4):1450–1476. <https://doi.org/10.1111/j.1467-937X.2010.00602.x>, 2010) and estimate quality as a residual of a demand equation. To establish a direct causal link between export quality upgrades and changes in wages, we use an instrumental variable strategy. Our results show that ahead of upgrades to export quality within a specific industry, average wages offered within the industry increase. In addition, we observe that the effect is larger for developing countries. Our findings imply that export product quality upgrades require more intensive use of qualified workers, who require higher wages.

**Keywords** International trade · Product quality · Wage premium · Economic development

**JEL Classification** F1 · F14 · F16

---

✉ Francesco Guerra  
francesco.guerra@imtlucca.it

<sup>1</sup> Scuola IMT Alti Studi Lucca, Piazza S. Ponziano, 6, 55100 Lucca, Italy

## 1 Introduction

The quality of goods produced and exported by a country affects its economic environment in different ways. The literature often highlights the role played by demand for product quality in foreign markets as a decisive incentive for firms to improve product quality to be competitive in the export market.<sup>1</sup> Firms that choose to upgrade the quality of their export products need to become more intensive in skilled labor. The studies of Verhoogen (2008) and Brambilla et al. (2012) examine and verify the positive association between exporting to the US and the wages offered by firms in the cases of Mexico and Argentina. Their results imply that firms exporting to high-income markets need to upgrade the quality of export products and, for this reason, to increase the number of skilled workers employed. This circumstance generates a demand for skilled employees, which translates into an increase in average wages paid by firms.

This paper is oriented within this context and intends to provide insights into the quality provision mechanism according to which production of high-quality products requires the employment of skilled labor, which, in turn, demands higher wages. With this view, our analysis aims at examining the importance of quality in explaining the wage premium. The study is conducted on the manufacturing sector over a set of 23 countries and 118 different industries and makes use of data on the average level of wages paid at the industry level for each country. The use of data at such a large scale does not allow us to distinguish the documented effect across firms within the same industry. However, thanks to the broad coverage of our dataset, we are able to provide worldwide evidence of the quality provision mechanism.

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

---

<sup>1</sup> Empirical studies on this issue include (Kugler & Verhoogen, 2012; Verhoogen, 2008; Bustos, 2011).

increase in imports from rich countries corresponds to an increase in demand for quality.

We find a positive and significant causal relationship between quality upgrades of export products and wage premia at the industry level. Our results indicate that an industry that upgrades the quality of its export products by moving from the first quartile to the second quartile of the quality distribution shows an increase in its wage premia of 3.5%.<sup>2</sup> Moreover, we find the effect of product quality upgrades on wage premia to be stronger for low-income countries. This is likely to be explained by the fact that in low-income countries, the wage differential between low-skilled and high-skilled workers is larger. This finding suggests that a rise in demand for skilled labor due to export product quality upgrades could have beneficial effects on economic development, especially in low-income countries where there is low incentive to invest in education.

This paper is closely related to the work of Brambilla and Porto (2016), which studies the importance of exporting to countries where quality is valued more and establishes a link between destination-country income and average wages paid at the industry level on a large panel of countries. In their study, they use exported product prices as an indicator of quality. However, relying on prices alone poses limitations, as the price disparity between two varieties could stem from factors other than quality differences, such as lower production costs, undervalued exchange rates, or pricing-to-market strategies. With respect to Brambilla and Porto (2016) we provide evidence of the quality provision mechanism using a measure of quality of exported products based on a structural estimation derived from our theoretical model. This approach offers the advantage of providing a more robust and accurate assessment of quality, as it takes into account various factors that influence quality other than prices, such as market conditions, production capabilities, and trade dynamics.

This paper contributes to the literature on the relationship between export product quality and labor force composition. The seminal paper of Verhoogen (2008) examines wages offered by Mexican firms that increased their exports after the peso devaluation in 1995 and finds that firms exporting to the US are more skill-intensive and pay, on average, higher wages to both skilled and unskilled workers. Using Argentinian data, Brambilla et al. (2012) show that Argentinian firms that increase exports to richer countries are characterized by higher skill composition of their workforce and, therefore, pay on average higher wages. Similarly, the study of Brambilla et al. (2019) explores the link between firm export status and demand for skilled tasks and finds that exporters use more skilled labor than non-exporters.

Our study is also related to the literature on export specialization and country development. The seminal paper of Hausmann et al. (2007) points out that certain products are growth-promoting and that countries that produce and export these kinds of products are likely to grow faster. The ability of developing countries to specialize in the production and export of products that permit knowledge and technological spillovers is seen as a determinant of long-run economic growth

---

<sup>2</sup> A major issue with the quality measure obtained as a demand residual is that it cannot be interpreted according to its absolute value but only in terms of position on the quality ladder in a market.

(Hausmann et al., 2014). While several studies analyze the dynamics of industry specialization (Schott, 2003; Chiappini, 2014), inter-industry mobility (Ban, 2017) and the role of growth-promoting products in relation to country income trends, our analysis focuses on the upgrading of product quality as a potential determinant of wage increases.<sup>3</sup>

The remainder of this paper is organized as follows. In Sect. 2, we present the theoretical model describing the relationship between export quality and wages. In Sect. 3, we present the data used in the analysis and the methodology used to obtain the measure of quality of exported products at the industry level. In Sect. 4, we present the identification strategy and the main results. In Sect. 5, we present some robustness analysis, and Sect. 6 concludes.

## 2 Theory

In this section, we introduce a multi-sector multi-country partial equilibrium model. The purpose of the model is to describe the quality provision mechanism which establishes a link between the quality of exported products and the average level of wages offered by a firm. The underlying mechanism implies that product quality depends on employee skills and that the capability of a firm to attract better-qualified employees is determined by the wages that it offers. The model is based on a representative mono-product firm for a given exporting country. In the model, we assume competitive labor markets with no labor market frictions such that employees with the same level of skills and ability working in different industries are paid the same wage. The structure of the model presented is based on the theoretical framework proposed by Verhoogen (2008) and reminiscent of its extended version in Brambilla and Porto (2016). With respect to Brambilla and Porto (2016), we use a demand function à la Berry (1994) which allows us to define a structural measure of export quality at the industry level and to propose a testable empirical model of the link between wages and the measure of export quality obtained.

### 2.1 Demand

The demand system is derived from a discrete choice model of consumer behavior. We base the model on a simple utility specification that is still flexible enough to illustrate our main objectives. We assume that each representative firm from exporting country  $i$  exports only one type of product  $h$ , so that different varieties are indexed with  $ih$ . The discrete choice structure of the model implies that consumer  $n$  living in country  $j$  chooses the variety  $ih$  that provides her with the highest utility

---

<sup>3</sup> A number of studies point out the importance of country specialization in different quality segments. Schott (2004) observes that within-product specialization is at least as important as specialization across products. The papers of Schott (2008) and Rodrik (2006) analyze the export similarity between China and the US and find that both countries export the same products despite China being endowed with unskilled labor.

among all varieties available for a given industry  $k$ . We assume a nested logit framework that allows consumer tastes to be correlated across varieties of the same product and implies a more logical correlation structure of consumer preferences. Products  $h$ , therefore, represent the nests, while each variety  $ih$  corresponds to the alternatives within the nests. Following Berry (1994), the indirect utility provided by the consumption of variety  $ih$  is:

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

where  $p_{ijh}$  corresponds to the price of the variety in country  $j$  and  $\lambda_{ijh}$  represents the quality of the variety.<sup>4</sup> The quality of the variety corresponds to the quality perceived by consumers and can differ in each destination  $j$ . Indeed, consumer perceptions of product quality are influenced by a common national taste for specific product features. For example, in the market for bakery products, Mediterranean countries are used to lower quantities of butter than northern European countries, and it is likely that biscuits made with significantly high quantities of butter are perceived to be of higher quality in northern Europe than in the Mediterranean area. For these reasons, quality is indexed with  $ijh$ .

$\epsilon_{nijh}$  corresponds to the idiosyncratic preference of each consumer for a variety and captures heterogeneity in consumer tastes for horizontal attributes.<sup>5</sup> The term  $\sum_{h=1}^H d_{ih} \mu_{nh}$  is proper to the nested logit structure, where  $\mu_{nh}$  is the common valuation of product  $h$  from consumer  $n$  and  $d_{ih}$  is a dummy variable equal to one when variety  $ih$  belongs to product  $h$  and has a distribution that depends on  $\sigma$ .<sup>6</sup> The probability that variety  $ih$  has the highest valuation across all import varieties depends on its price and quality relative to the other varieties and is:

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

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

<sup>4</sup> The direct utility function is equal to  $u_{nijh} = \ln(\lambda_{ijk} v_{nijh}^{(\sigma-1)} e^{\mu_{njh}})$ , where  $v_{nijh}$  is assumed to be Fréchet distributed or extreme value type II with a cumulative distribution function equal to  $\exp\{-(v/s)^{-\alpha}\}$ , where  $\alpha$  reflects the heterogeneity of consumer preferences and  $s$  corresponds to the scale parameter. We set  $s = 1$  and  $\alpha = 1$  by default. In the indirect utility function,  $\epsilon_{nijh} = \ln v_{nijh}$ ; therefore,  $\epsilon_{nijh}$  is distributed according to a type I extreme value distribution, also known as a Gumbel distribution, with a mean equal to zero and a scale parameter equal to 1.

<sup>5</sup>  $\lambda_{ijh}$  can also be interpreted as the average appreciation of variety  $ih$ , while  $\epsilon_{nijh}$  is consumer deviation from the average appreciation.

<sup>6</sup> Cardell (1997) shows that if  $\epsilon_{nijh}$  is distributed according to a type I extreme value distribution, there exists a unique distribution for  $\mu_{nh}$  that depends on the parameter  $0 < \sigma < 1$  such that  $\mu_{nh} + (1 - \sigma)\epsilon_{nijh}$  is also type I extreme value distributed. The parameter  $\sigma$  is an approximated measure of correlation among the alternatives in each nest and is assumed to be the same for all nests (see Train (2009)). When  $\sigma = 1$ ,  $\mu_{nh} = 0$ , and the choice probability comes down to a standard logit.

## 2.2 Technology

Firms are heterogeneous along two attributes: their capability of producing quality for a given destination  $\xi_{ijh}$ , which reflects the technologies available for the production of product quality, and their productivity  $\varphi_{ih}$ , which corresponds to firms' efficiency in the physical production of output, conditional on quality. This twofold firm heterogeneity recalls the framework of Hallak and Sivadasan (2013), who distinguish between process productivity and product productivity, with the difference that in our model, the capability to produce quality varies across firms producing different products and is specific to each destination.<sup>7</sup> Labor is the only factor of production, and the production function of physical units is  $x_{ijh} = \varphi_{ih} \ell_{ijh}$ , where  $\ell_{ijh}$  is the number of workers used for production of variety  $ih$  exported to country  $j$ . The cost of producing one unit of physical output is equal to  $\frac{w_{ih}}{\varphi_{ih}}$ , where  $w_{ih}$  is the average salary paid to employees in charge of producing product  $h$ . Workers capability and firm capability are complements in determining output quality, as in Kugler and Verhoogen (2012). The quality production function of variety  $ih$  serving country  $j$  is:

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

where  $\theta_{ih}$  refers to the capability to produce the quality of workers employed in the production of product  $h$ . The parameter  $\zeta$  represents the degree of complementarity between firm technologies used to produce quality and employee capabilities. We assume  $\zeta > 0$  such that the function of quality  $\lambda_{ijh}$  is log-supermodular in  $\xi_{ijh}$  and  $\theta_{ih}$ . A higher  $\zeta$  implies a higher level of complementarity between worker ability and firm capability. As in Verhoogen (2008), employees' capability to produce quality,  $\theta_{ih}$ , depends on the wages offered by the firm. The higher the wages offered, the better are the capabilities of employees:<sup>8</sup>

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

where  $\bar{w}_i$  is average wages in country  $i$ . The ratio  $w_{ih} / \bar{w}_i$  corresponds to the wage premium,  $\eta$  corresponds to the elasticity of worker capabilities to the wages offered and  $\kappa_{ik}$  represents labor supply shocks.<sup>9</sup> The resulting firm profit function for a variety in each destination corresponds to:

<sup>7</sup> The parameter  $\xi_{ijh}$  is interpreted as the entrepreneurial capacity to produce quality and is destination specific because it depends on knowledge of the market and consumer preferences in the destination country. Considering the previous example of bakery products, a firm may be capable of producing biscuits of superior quality with high quantities of butter but be unable to produce good-quality biscuits using low quantities of butter. This attitude corresponds to an entrepreneurial capability to produce high-quality products for northern European countries but not for Mediterranean countries.

<sup>8</sup> A rise in wages can be interpreted as an increase in the share of skilled with respect to unskilled workers, as in Brambilla and Porto (2016), or, in the spirit of the O-ring model of Kremer (1993), as employment of more capable workers within the two categories, as in Verhoogen (2008).

<sup>9</sup> Here, we consider labor supply shocks as exogenous shifts in the disutility of supplying labor.

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

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

### 2.3 Relationship between wages and average export quality

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

$$\max_{w_{ih}, p_{ijh}} \pi_{ih} = \max_{w_{ih}, p_{ijh}} \sum_j \pi_{ijh} = \max_{w_{ih}, p_{ijh}} \sum_j \left( p_{ijh} - \frac{w_{ih}\tau_{ijh}}{\varphi_{ih}} \right) x_{ijh} \tag{6}$$

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

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

The resulting price equation corresponds to a markup over the constant marginal cost and the iceberg trade cost. The equation on the right represents the wage premium as a function of the qualities perceived in each destination  $\lambda_{ijh}$  weighted by the export values. Since export product quality may be perceived differently according to the export destination, the relationship between export product quality and the wage premium can be puzzling. To provide a comprehensive and straightforward understanding of the relationship of interest, we define  $\bar{\lambda}_{ih}$  as the weighted average level of quality exported from country  $i$  for product  $h$  to all destinations:

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

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

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

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

### 3 Data and quality estimation

#### 3.1 Data

Data on country-level trade flows have been taken from BACI, a detailed international trade database made available by CEPII that covers a large number of countries and 5000 products expressed in terms of Harmonized System (HS) (1996 revision) codes at the 6-digit level. The BACI dataset has been obtained by CEPII through a process of data harmonization of import and export values reported by the Comtrade database.<sup>10</sup> In addition to import values, the data also record import weights, while prices are not directly reported. Each variety's unit values, calculated as the ratio of the value and weight of the trade flows and deflated using the consumer price index (CPI), are, therefore, used as a proxy for prices.<sup>11</sup> Supplementary data on GDP, population and distance are taken from the CEPII gravity dataset. Data on industry characteristics are taken from the Industrial Statistics Database (INDSTAT 4) made available by the United Nations Industrial Development Organization (UNIDO). The INDSTAT 4 dataset reports annual data on output, total wages and salaries paid, and total number of employees in each manufacturing industry. Overall, the database covers a total of 118 different manufacturing industries defined at the 4-digit level according to the International Standard of Industrial Classification (ISIC) revision 3 nomenclature, over a time range from 1995 to 2010. Although the INDSTAT 4 dataset covers a large number of countries, for many of those countries, the number of industries covered by the database is scant, which results in a highly

<sup>10</sup> The process of harmonization done by CEPII takes into account the reliability of importer and exporter declarations and allows researchers to work with better data with wide country coverage. See Gaulier and Zignago (2010) for further details.

<sup>11</sup> CPI (2010 = 100) data are from the World Bank database.



unbalanced panel. For the current analysis, the panel is restricted to 23 exporting countries that report a balanced panel over at least 8 years between 1995 and 2008. Our sample includes the major exporting countries in the world and represents 60% of total world exports.<sup>12</sup>

### 3.2 Quality estimation

Quality is an intangible element of goods and is very difficult to measure, especially for aggregates of different types of products. Beyond a few studies conducted on the export of specific products,<sup>13</sup> the literature on international trade often relies on different types of proxies for quality. Unit values have been widely used in this context, although they also reflect other characteristics such as differences in pricing strategies and costs due to efficiency in the production process. While unit values have proved to perform poorly as quality proxies, the studies of Khandelwal (2010) and Khandelwal et al. (2013) provide different strategies to estimate quality as a demand residual. In this study, we firstly rely on the methodology proposed by Khandelwal (2010) to derive the export quality at the exporter-industry-destination level. Then, we exploit the results of the theoretical model developed in Sect. 2 to calculate the aggregate measure of quality at the exporter-industry level, which can be directly related to the industry level wages available in the data. Following Khandelwal (2010), quality is estimated as a demand residual such that, conditional on prices, the larger the market share of a product, the higher is the quality. The quality estimated corresponds, therefore, to quality as perceived by consumers. Based on Eq. (2), we derive the relative demand for variety  $ih$  compared to other varieties within industry  $k$  in country  $j$ . Here, a variety is defined at the 6-digit level (HS6 - Revision 1996), while industries are defined at the 4-digit level (ISIC - Rev 3). The demand function is estimated for each market corresponding to an importer-industry pair. Like Berry (1994) and Khandelwal (2010), we complete the demand system with an "outside" variety that has mean utility normalized to zero. The outside variety corresponds in our case to domestically produced goods and allows consumers the possibility of not purchasing any of the imported varieties. We obtain the market share of domestically consumed products by subtracting exports from total production. The total number of regression runs is equal to 1916. Despite running separate regressions for each industry-importer pair, we keep the indexation for importer  $j$  and industry  $k$  as we aggregate the measure of quality obtained across different importing countries in the subsequent step. The demand function estimated is:

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

<sup>12</sup> Tables 7 and 8 of the Appendix describe the countries and the number of industries per country included in the analysis.

<sup>13</sup> The works of Crozet et al. (2012) and Chen and Juvenal (2016), for example, use expert wine ratings as a direct measure of quality.

where  $s_{ijht}$  corresponds to the market share of variety  $ih$  in destination  $j$  and  $s_{0kt}$  to the market share of the outside variety. Market shares are calculated over total sales at the industry level by virtue of utilizing data on domestic production from INDSTAT 4. On the right-hand side of the equation,  $p_{ijht}$  corresponds to the price of variety  $ih$ , while the term  $s_{ijht,H}$  is a specification that derives from the nested logit structure of the utility and corresponds to the market share of the variety  $ih$  within product  $h$ .  $\lambda_{1,ijkt}$  corresponds to an exporter-year fixed effect,  $\lambda_{2,jh}$  is a product fixed effect, and  $\lambda_{3,ijht}$  is the error term. By employing this set of fixed effects, we effectively address the inherent heterogeneity among products within an industry. The inclusion of the product fixed effect  $\lambda_{2,jh}$  enables us to account for the specific characteristics of each product. Additionally, this approach allows us to derive an exporter-destination-industry-year component of quality  $\lambda_{1,ijkt}$ , which aligns well with our objective of measuring export quality at the industry level.<sup>14</sup>

Since  $\ln p_{ijht}$  and  $\ln(s_{ijht,H})$  are likely to be correlated with the error term, we use an IV strategy to obtain consistent estimates of the import demand model. Price is instrumented through the weighted average price of variety  $ih$  in other destination countries  $j$ . Under the hypothesis that each variety shares common production costs, the price charged for the same type of product in other destinations constitutes a valid predictor of the price of the variety and is likely to be uncorrelated with specific country demand shocks.<sup>15</sup> As in Khandelwal (2010), we instrument the variety market share within its nest  $\ln(s_{ijht,H})$  with two count variables: the number of varieties imported within product  $h$  by the importer and the number of destinations to which the exporting country exports variety  $ih$ .<sup>16</sup>

Starting from the fixed effect exporter-year  $\hat{\lambda}_{1,ijkt}$ , which is destination-industry specific, as the demand system is estimated for each destination-industry, we rely on the theoretical section of this study to obtain an aggregate measure of quality at the exporter-industry level. Following Eq. (8) in Sect. 2, we set the substitution parameter between industry technology and employee capabilities  $\zeta = 1$ , and we calculate the average export quality of each exporter-industry-year triplet as  $\ln \bar{\lambda}_{ikt} = \ln \sum_{j \in J} \frac{\tau_{ijh}^{\alpha} \lambda_{ijkt} \hat{\lambda}_{ijkt}}{\sum_{j \in J} \tau_{ijh}^{\alpha} \lambda_{ijkt}}$ . The number of countries included in  $J$  includes only large importers. This decision stems from the fact that our measure of quality, denoted as  $\hat{\lambda}_{ijkt}$ , captures the relative product quality of industry  $k$  compared to all other imported varieties. A critical factor influencing this quality measure is the quality of competing varieties imported from different countries. By focusing on large importers, who typically source products from a wide range of exporters, we aim to ensure that our measure of quality remains comparable across markets and is not biased by a restricted range of imported varieties. This approach accounts for the crucial role

<sup>14</sup> The estimated quality of variety  $ih$  in destination  $j$  is equal to  $\hat{\lambda}_{ijht} = \hat{\lambda}_{1,ijkt} + \hat{\lambda}_{2,jh} + \hat{\lambda}_{3,ijht}$ .

<sup>15</sup> The average price of competing varieties in the same market has been used as an instrument for the price by Bernini and Tomasi (2015) and Jäkel (2019)

<sup>16</sup> Details on the quality estimation results are reported in Table 9 of the Appendix.

played by the market size in destination countries, ultimately enhancing the robustness and reliability of our quality measure. Suppose that quality is estimated in a small importing country such as Slovenia; the number of importing varieties for an industry is likely to be small, and as a consequence, the estimated quality  $\hat{\lambda}_{ijkt}$  depends mainly on the characteristics of the few competing varieties. For this reason, we opt to estimate export quality in specific markets that represent the largest world importers during the period under consideration. These countries are Australia, Canada, China, Belgium, Germany, Spain, France, the United Kingdom, Indonesia, India, Italy, Japan, South Korea, Malaysia, Mexico, the Netherlands, Turkey, Ukraine, and the United States and account for 67.8% of total world imports during the period under analysis.<sup>17</sup> We obtain in this way a measure of quality for each exporter and industry in our sample; the measure corresponds to the weighted average quality perceived in the large markets to which a country exports.<sup>18</sup>

Trade in high-quality products is characterized by a number of currently acknowledged factors. The objective of the following analysis is to verify that the measure of quality obtained is coherent with well-established trade dynamics reported in several studies. Following the seminal intuitions of Linder (1961) and Alchian and Allen (1964), a considerable number of studies find that richer countries import higher-quality products (Hallak, 2006; Bastos et al., 2018) and that because per-unit transportation costs decrease with product quality, high-quality products are more likely to be exported to more distant destinations Hummels and Skiba (2004); Bastos and Bastos (2010); Emlinger and Lamani (2020).

Table 1 displays the correlation between the measure of quality obtained and unit values, export exposure to high-income destinations and average distance of export. In Column (1) of Table 1, we analyze the relationship between export quality and exposure to high-income destinations, measured as  $g_{ikt} = \ln \left( \sum_j s_{ijkt} * gdp/cap_{j,1995} \right)$ , where  $s_{ijkt}$  corresponds to the export share of destination  $j$  for industry  $k$  in source country  $i$ . The measure of exposure to high-income destinations is obtained as in Brambilla and Porto (2016). As expected, we observe a positive correlation between quality and the share of exports to high-income countries. In Column (2), we analyze the correlation between quality and the weighted average distance that products are exported, calculated as  $\ln distance_{ikt} = \sum_{h \in k} \sum_j \ln distance_{ihjt} * \omega_{ijht}$ , where  $\omega_{ijht}$  corresponds to the share of exports of variety  $ih$  to country  $j$  relative to the total exports of exporter  $i$  for industry  $k$ . The coefficient of distance is positive and significant, which indicates that industries exporting higher-quality products export to more distant countries on average. We then analyze the correlation between quality and unit values in Columns (3) and (4). In Column (3), unit values are measured as total exports in terms

<sup>17</sup> To select the countries we rely on two key criteria: the value of total imports and the availability of industry-level data on total output for each country. Due to the unavailability of data on the total output produced at the industry level, we regretfully excluded countries such as Russia and Sweden from our sample.

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

of value over total exports in terms of weight for the exporter-industry pair. In Column (4), we instead use an index that takes into account unit values at the product level. The index  $I_{ikt}^{uv}$  corresponds to the weighted average of deviations between the variety's unit value and the average unit value of competing varieties in the same market and aggregated at the industry-exporter level. It is calculated as  $I_{ikt}^{uv} = \sum_j \sum_{h \in k} [(\ln uv_{ihjt} - \ln \bar{uv}_{hjt}) * \omega_{ihjt}]$ , where  $\omega_{ihjt}$  corresponds to the share of exports of variety  $ih$  with respect to total exports within industry  $k$  for country  $i$  and  $\bar{uv}_{hjt}$  is the average unit value of imported varieties  $ih$  in country  $j$  for product  $h$ . When this price measure is positive, the average price of the varieties exported by a country is higher than the average price at which the varieties are sold in each market. We observe that in both Columns (3) and (4), the correlation between unit values and quality is positive and significant.

## 4 Empirical analysis and results

In this section, we present our empirical strategy, which aims to assess the causal relationship between export product quality upgrades and the average wage premium at the industry level. Our empirical analysis refers to the theoretical framework presented in Sect. 2 and, in particular, the findings reported in Eq. (9). First, we introduce the empirical model. Then we discuss potential endogeneity issues and propose an instrumental variable strategy to assess the causal relation between export quality and wages.

### 4.1 Empirical model

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

$$\Delta \text{premium}_{ikt} = \beta_1 + \beta_2 \widehat{\Delta \text{quality}}_{ikt} + \Delta(X'_{ikt})\beta_3 + \phi_{it} + \phi_{kt} + \epsilon_{ikt} \quad (11)$$

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

The vector  $\mathbf{X}'$  includes a set of variables controlling for the relative trade intensity and productivity of an industry. We control for trade intensity motivated by the

**Table 1** Correlations between quality of exports, income, unit values and distance

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

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

studies highlighting the impact of sector liberalization on the labor market, which has received particular attention in the case of developing countries (Goldberg & Pavcnik, 2007), while our inclusion of productivity is explained by our theoretical model, which predicts that more productive firms maximize their profits when they produce higher-quality products. In this regard, some studies provide empirical evidence on the interrelation between firm productivity and export product quality (Verhoogen, 2008; Kugler & Verhoogen, 2012). Even with the inclusion of controls for relative trade intensity and productivity, it is probable that there exist additional factors that could introduce endogeneity. To address this concern and determine a causal effect, we employ an instrumental variable (IV) approach.

## 4.2 Instrumental variable approach

The endogeneity concerns in our empirical model are primarily associated with omitted variable and reverse causality biases. As pointed out by Brambilla and Porto (2016), unobserved productivity shocks not captured by labor productivity ( $\Delta productivity_{ikt}$ ) could lead to an increase in firm profits and, when shared with workers, increase wages. As a consequence, this would lead to an upward bias of the estimation of  $\beta_2$ . Another factor that can contribute to an upward bias in the estimated coefficient is significant changes in firm fixed or transportation costs, which impact the minimum productivity threshold for profitable exporting. For instance, if export duties sharply increase, the productivity threshold for exporting would rise, resulting in less productive firms being excluded from the export market. Consequently, the remaining firms in the market

would likely be the most productive ones, exporting higher-quality products and paying higher wages. On the other hand, all factors which increase the level of protection of an industry, such as an increase in union power, are likely to generate a downward bias in the estimated coefficient. A higher protection level in an industry could result in low-productivity firms entering the market and decreasing the quality of exported products. Additionally, labor unions could also exert pressure for higher average wages. Finally, our measure of quality corresponds to the quality perceived by consumers in importing markets and includes factors other than purely intrinsic product quality, such as taste or reliability, which could induce consumers to prefer one variety instead of another. If, for example, an international media scandal related to product safety were to lead to a decline in trust (or confidence) in an industry's export products abroad, this would decrease the quality of those products perceived abroad with no concrete product quality changes.

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

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

The instrument is obtained as follows:

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

where  $demand_{ijkt}$  denotes the demand for products of industry  $k$  from exporter  $i$  in country  $j$  and is proxied by the total value of imports of competing varieties. It is measured as  $demand_{ijkt} = \ln \sum_{i' \neq i} import_{i'jkt}$  and corresponds to imports of products belonging to industry  $k$  in country  $j$  from countries  $i' \neq i$ .  $demand_{ijkt}$  is weighted by

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

### 4.3 Main results

Table 2 reports the results of the instrumental variable estimates. For all specifications, standard errors  $\epsilon_{ikt}$  are clustered within the exporter-industry pair to control for serial correlation across the same group. From Columns (1) to (5), we instrument the change in export quality with the change in demand for quality. In Column (1), we report the results of the regression of changes in the wage premium on the first differences of quality, conditional only on the set of fixed effects. The coefficient is positive and significant, which indicates that an industry that upgrades the average quality of its exports across all destinations increases its average wages offered relative to both the national average and the industry average worldwide. In Column (2), we use the difference in the degree of trade openness as a proxy for the degree of protection of the industry. The degree of openness of an industry is measured as  $openness_{ikt} = \ln \frac{import_{ikt} + export_{ikt}}{production_{ikt}}$  and is intended to measure industry exposure to international competition. Greater openness has a twofold implication for domestic firms. They are subject to tougher competition from foreign varieties in the domestic market, and at the same time, they have a higher propensity to participate in export activities, which makes them more exposed to competition in international markets. We observe that there is a negative correlation between an industry's degree of openness and the wages it offers on average, which implies that the more protected an industry (or the lower the trade openness), the higher is the wage premium. This is related to the competitive effect of globalization, which leads to a decrease in wage protections (Pavcnik et al., 2004; Goldberg & Pavcnik, 2005; Feliciano, 2001)). In Column (3), we include the first difference of exports expressed in log terms. As outlined by ? and Brambilla et al. (2012), the activity of exporting includes international marketing, advertising and distribution, which require the hiring of qualified labor. In Column (4), we control for changes in industry productivity, measured as log output per worker. According to the model that we introduced, more productive firms are likely to produce higher-quality products.<sup>19</sup> In Column (5), we include all covariates simultaneously. In Column (6), we add another

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

**Table 2** Results of the instrumental variable regression

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

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

instrument that corresponds to the change in the industry average distance of exports and is measured as  $\Delta \tilde{\lambda}_{ikt} = \ln distance_{ikt} - \ln distance_{ikt-1}$ , where the average distance is calculated as  $\ln dist_{ikt} = \sum_{h \in k} \sum_j \ln distance_{ihjt} * \omega_{ijkt}$ . The idea of using changes in the distance is based on the Alchian-Allen effect, according to which better-quality products are likely to be exported greater distances. We observe that adding the change in the average distance does not considerably increase the relevance of the instruments, as the  $\chi^2$  statistic increases from 30.4 to 31.9. Adding a second instrument, however, allows us to perform the Sargan-Hansen test, also known as the Sargan J test, which is a test of overidentifying restrictions used to ensure the exogeneity of the instruments used. As expected, the p-value of the Sargan J test is well above the critical values, which indicates that we cannot reject the null hypothesis that our instruments are not correlated with the error term. For all regression reported on Table 2 the results indicate that the coefficient of quality is positive and significant for all specifications, including the case in which we control for productivity changes.<sup>20</sup> The F-statistic and Sanderson-Windmeijer (SW) first-stage  $\chi^2$  tests

<sup>20</sup> The reported value of R-squared is close to zero, and occasionally negative, which is not uncommon in IV regressions, particularly when estimating models that do not aim to predict the dependent variable. However, since our focus is solely on evaluating the causal impact of quality on the wage premium, a negative R-squared is not concerning.



of underidentification and weak identification indicate that the instrument is relevant. The coefficient reported in Column (5) suggests that for each 10% increase of the quality of exported products, the wage premium increase by approximately 1.3%. This result implies that, on average, an industry that upgrades its export product quality by moving from the first quartile to the second quartile of the quality distribution shows an increase in the wage premium of 3.5%.<sup>21</sup>

#### 4.4 Additional results

The magnitude of the quality upgrade of exports on wages may be influenced by the degree of prosperity of the exporting country. Since higher-income countries are likely to have more rigid labor markets and higher minimum wages than lower-income countries, we expect the documented effect to be stronger for the latter. Starting from our empirical model, we separate the effect of export quality upgrades on wages between higher- and lower-income countries using a dummy that splits our sample into two groups. The dummy  $G_{it} = 1$  when exporter  $i$  has a GDP per capita larger than the sample cutoff. We propose three different cutoffs which correspond to the quartiles of the sample distribution of the GDP per capita.

The results of the regressions are reported in Column (1), (2) and (3) of Table 3. The cutoff for  $G$  corresponds to the median of the GDP per capita distribution in Column (1), to the first quartile in Column (2) and to the third quartile in Column (3). We observe that the documented effect is stronger for lower-income countries, which implies that when lower-income countries increase their export product quality, the extent to which wages increase is larger than that in higher-income countries. To substantiate these findings, in Column (4), we add the log of the GDP per capita in interaction with  $\widehat{\Delta quality}_{ikt}$  instead of using a dummy variable. The result indicate that there is a negative correlation between the magnitude of the documented effect and the level of GDP per capita of the exporting country, which is in line with our findings in Columns (1), (2) and (3). The difference in the magnitude of the effect is probably because low-income countries often exhibit less regulated labor markets and that the salary differences between unskilled and skilled workers are more pronounced.

These findings suggest new insights on the effects of trade on country development. The relationship between trade openness and economic growth has been extensively investigated without yielding to a consensus. On the one hand, higher trade openness seems to increase productivity and therefore have a positive effect on wages (Goh & Javorcik, 2005; Kumar & Mishra, 2008); on the other hand, it increases competition and, in turn, leads to a drop in the wage level of previously highly protected sectors (Goldberg & Pavcnik, 2005; Pavcnik et al., 2004; Feliciano, 2001).<sup>22</sup> Our findings suggest an additional element of understanding, little

<sup>21</sup> The calculation is based on the average distribution of industry quality across all exporters in our sample.

<sup>22</sup> Interestingly in this context, the paper of Huchet-Bourdon et al. (2018) finds a minimum level of export quality under which trade can be detrimental to growth.

**Table 3** Additional results

	Explained variable: $\Delta premium_{ikt}$			
	(1)	(2)	(3)	(4)
$\Delta quality_{ikt} (G)$	0.097** (0.044)	0.099** (0.043)	0.091** (0.044)	
$\Delta quality_{ikt} (1-G)$	0.146*** (0.056)	0.133** (0.054)	0.208*** (0.079)	
$\Delta quality_{ikt}$				0.456** (0.225)
$\Delta quality_{ikt} * \ln gdp/cap_{it}$				-0.035* (0.021)
$\Delta export_{ikt}$	-0.008 (0.008)	-0.009 (0.008)	-0.008 (0.008)	-0.008 (0.008)
$\Delta openness_{ikt}$	0.001 (0.009)	0.000 (0.009)	0.002 (0.009)	0.002 (0.009)
$\Delta productivity_{ikt}$	0.221*** (0.024)	0.220*** (0.024)	0.222*** (0.024)	0.221*** (0.024)
FE exporter-year	Yes	Yes	Yes	Yes
FE industry-year	Yes	Yes	Yes	Yes
R-squared	0.013	0.011	-0.011	-0.016
Observations	21,586	21,586	21,586	21,586
First Stage results				
F-test $\Delta quality_{ikt} * G$	39.466	30.274	21.797	
F-test $\Delta quality_{ikt} * (1-G)$	41.231	39.709	18.554	
F-test $\Delta quality_{ikt}$				14.316
F-test $\Delta quality_{ikt} * \ln gdp/cap_{it}$				14.677

Significance levels: \*\*\*0.01 \*\*0.05 \*0.10. Two steps least squares regression where change in the quality of exports is instrumented with the change in the demand for quality in importing countries. In column (1), the cutoff for G corresponds to the median of the GDP per capita distribution, in column (2) it corresponds to the first quartile and in column (3) it corresponds to the third quartile. The instrument is interacted with the dummies in columns (1) (2) and (3) and with the interaction variable in column (4). Standard errors are clustered at the exporter-industry level and are reported in parenthesis

accounted for in literature, which is the effect of trade on the labor force composition according to the quality of products exported. A major trade openness which triggers an increase of exports of high quality products can lead to a higher demand for high-skilled and better payed employees which entails positive spillovers on the countries' economic development.

## 5 Robustness

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

**Table 4** Results with alternative instruments

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

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

## 5.1 Alternative instruments

In this part, we perform the same IV regression but instrument the variable  $\widehat{\Delta quality}_{ikt}$  with a different set of variables to verify the robustness of our results to alternative instruments. We refer to the instrument used in the main section as the preferred instrument. Table 4 reports the results of the regressions using the alternative instruments. In Column (1), we use our preferred instrument, with the difference that the changes in imports for country  $j$  are weighted by the GDP per capita of the exporter for 1995. In other words, the weights  $g_{ijkt}$  are obtained using  $g_{ijkt} = \ln(\sum_i S_{ijkt} * gdp/cap_{i,1995})$ . In this way, the instrument is built such that it is not affected by changes in exporters' GDP per capita but only by changes in the share of imports. Our results are not affected by this alternative definition of  $g_{ijkt}$ . In the previous section, we assume that the change in demand for quality in the importing countries and the change in export quality occur during the same year. We can imagine that firms need time to adapt to changes in demand from abroad and that the upgrading of product quality could be a process that requires more than one year. In

line with this intuition, in Column (2), we instrument the change in export quality with the change in demand for quality from the previous year, which corresponds to the preferred instrument lagged by one year. We observe that the SW first-stage  $\chi^2$  and F-statistics are significantly lower than those for the instrument presented before, while the results of the coefficients seem to be larger. This indicates that the lagged instrument is less relevant but is still capable of capturing part of the changes in export quality. In Columns (3) and (4) of Table 4, we instead use a variant of the proposed instrument that is also inspired by the Linder hypothesis and successive studies pointing out that high-income countries tend to import high-quality products because their population values quality more (Hallak, 2006; Bastos et al., 2018). In this case, we measure the change in demand for export product quality with the change in demand in destination countries weighted by their income. This variant of the instrument basically assumes that high-income countries import high-quality products and that when demand for exports increases more in high-income countries than in low-income countries, firms are incentivized to upgrade their export quality. The instrument is obtained as follows:

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

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

## 5.2 Alternative measures of quality

In the results section, the measure of export product quality used to analyze the documented effect corresponds to the weighted average quality estimated through the methodology proposed by Khandelwal (2010), where the weights are the share of

total exporter-industry exports. This calculation is likely to suffer from an endogeneity issue, as the market shares used as weights are likely to be positively correlated with the quality estimated in the destination country.<sup>23</sup> We propose different weights for average quality at the exporter-industry level, where the weights correspond to the share of exporter-industry exports in the first year that they record positive exports toward a specific destination. This measure has the flaw of not being precise, as the set of destinations to which a country exports varies over time. Thus, while we acknowledge the potential endogeneity problem, our preferred measure remains the average weighted with the corresponding shares of exports. In Column (1) of Table 5, we report the results of the empirical model using the alternative measure of quality. We observe that the result is very close to our main result. Column (2) reports the results of the regression where quality is estimated following the methodology proposed by Khandelwal et al. (2013). The estimation procedure for quality is conceptually similar, as quality is estimated as the residual of a constant elasticity of supply (CES) demand system.<sup>24</sup> Our results indicate that the effect is robust to the alternative measure of quality. In Column (3), we use the difference in the average unit value measured as total export value over total export quantity. In this case, the F-test indicates that the change in demand for quality in the importing countries is not a good instrument for the changes in unit values. This is because there are many other factors not related to quality that are likely to influence the change in unit values, such as pricing-to-market strategies and changes in costs. Another major problem with the use of unit values in dealing with industries is that at this scale, unit values are mainly influenced by the product composition of exports within the industry instead of export product quality. An increase in unit values may reflect an increase in the unit values of each product exported or a change in the composition of exports toward products characterized by higher unit values. For these reasons, we are not perturbed by the results in Column (3). Finally, in Column (4), we perform the standard IV regression using the difference in wages per capita instead of the wage premium as the dependent variable. There are no significant differences in the results when we use the difference in wages instead of the wage premium.

### 5.3 Excluded countries

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

1. Countries must have a balanced panel of data on wages per capita over at least 8 years available.

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

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

<sup>25</sup> See Table 8 of the Appendix for more details.

**Table 6** Robustness tests

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

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

2. Countries must have a population of at least 6 million in 1995. This is because many small countries record exports for only a few industries, and their export volumes are characterized by large fluctuations.

For completeness and robustness, we perform the regressions including the excluded countries. Table 6 reports the results of the IV regressions. In Column (1), we include the countries for which a balanced panel of data on wages is available only for a short period, namely, China, Romania and Poland. In Column (2), we include the countries with a population of less than 6 million in 1995, namely, Lithuania, Latvia, Finland, Norway, Slovakia and Slovenia. Finally, in Column (3), we include all countries included in the two previous regressions. While the instruments seem to perform slightly worse when we add small countries to the sample, the results remain robust. Moreover, we observe that the coefficient of quality increases, especially when we add small countries. This can be explained by the fact that over the six small countries added, four are low- to medium-income countries and that as reported in Table 3, the documented effect is stronger for low-income countries.

**Table 5** Results with alternative measures for quality

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

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

## 6 Conclusion

The literature on international trade has long investigated the impact of commerce on labor markets. Several studies find evidence of the quality provision mechanism according to which wage increases due to increases in the quality of export products (Brambilla et al., 2012; Brambilla & Porto, 2016; Fieler et al., 2018). The objective of this paper is to provide evidence of the quality provision mechanism on a global scale using a novel measure of export quality at the industry level and to establish a causal link between upgrades to export quality and variations in average wages. The analysis is conducted at the country-industry level on the manufacturing sector over a set of 23 countries and 118 industries. Export quality is estimated as the residual of a demand function following the methodology proposed by Khandelwal (2010), while we establish a causal relation through an IV strategy. Our results show that ahead of

an upgrade in export quality in a specific industry, the average wages offered within the industry also increase. Our results indicate that an industry that upgrades its export product quality by moving from the first quartile to the second quartile of the quality distribution shows an increase in its wage premium of 3.5%. Our findings imply that industries that improve their export quality adjust their workforce composition toward better-paid work categories.

The results of our analysis show us that the effect of the quality provision mechanism is larger for less developed countries. This result could have important implications for the economic growth of low-income countries which are characterized by lower export product quality and a scarcity of skilled labor due to the lack of efficient education systems and migration of the most qualified workers. A rise in demand for skilled labor among industries aiming to upgrade their export product quality could have beneficial effects for the economic development of such countries. While several studies have focused on specialization across products as a determinant of long-term economic growth (Hausmann et al., 2007, 2014), our findings suggest that within-product specialization along quality segments can have positive spillovers for economic growth too. We hope that this study inspires further research efforts which could advance the current understanding of the effect of within-product specialization on economic development.

## Appendix A: Extended Data

Since trade data are known to be noisy, we employ two trimming procedures to eliminate aberrant values: First, for each exporter-product pair, observations with unit values 10 times larger or smaller than the median unit value are dropped. Likewise, for each importer-product pair, observations with unit values 10 times larger or smaller than the median unit value are dropped. As in Sutton and Trebler (2016) and Benkovskis and Wörz (2018), countries with fewer than 2 million people in 2008 are excluded from the analysis. Table 7 reports the list of countries and the number of industries for which we conduct the analysis. The whole sample includes 118 industries, and the period under analysis is 1995–2008, consisting of 14 years. The selection of countries is constrained by data availability in UNIDO's INDSTAT 4 database, which reports the annual number of employees and wages by industry. Although INDSTAT 4 covers a larger number of countries, there are large numbers of missing observations for many countries. We choose, therefore, to include in the analysis only countries for which data on wages and employees are reported for at least 8 consecutive years and at least 70 industries. Moreover, we do not include small countries with a population of less than 6 million in 1995, as these countries record positive export values for a small number of industries only. Table 8 reports the countries excluded from the analysis for being too small or reporting too many missing years. These countries are included in the robustness analysis.



**Table 7** Period and number of industries available by country

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

**Table 8** Countries included in the robustness analysis

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

## Appendix B: Quality estimation

Table 9 reports the summary of the results of the quality estimation. Equation (10) is regressed separately on groups of observations belonging to different industry-importer pairs using an IV strategy for a total of 1996 regressions. We compare the OLS estimation with the two-stage least squares (2SLS) estimation. The OLS estimation is likely to underestimate the coefficient of price, as price and quality are positively correlated, and to overestimate the coefficient of the nest share. As reported in Table 9, the distribution of the coefficients of price for the IV regression is lower than that of the coefficients for the OLS regression, and the distribution of the coefficients of the nest share variable is lower in the case of the IV regression. These results indicate that the instruments move the coefficients in the expected direction. Lines 5 to 8 report the p-value of the first-stage F-test and  $\chi^2$  statistic; both tests indicate that the instruments are relevant for both price and nest share.

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

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

$$\ln q_{ihjt} + \sigma \ln p_{ihjt} = FE_{jt} + FE_h + \epsilon_{ihjt}, \quad (12)$$

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

**Table 9** Quality estimation results

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

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

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

**Acknowledgements** For this work I have benefited from discussions with Stéphane Turolla, Carl Gaigné, Chantal Le Mouel, Zhihong Yu, Banu Demir, Thilo R. Huning and the participants at ADRES conference 2021 in Strasbourg, France.

**Funding** Open access funding provided by Scuola IMT Alti Studi Lucca within the CRUI-CARE Agreement. The data that support the findings of this study are available from UNIDO.

**Data availability** Restrictions apply to the availability of these data, which were used under license for this study. Stata code will be provided upon readers' requests. .

## Declarations

**Conflict of interest** I have no conflict of interest to disclose.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

- Alchian, A. A., & Allen, W. R. (1964). *Exchange and production; theory in use*. Wadsworth Publishing Company.
- Ban, I. M. (2017). Measuring trade specialization dynamics: The case of Romania and Bulgaria. *Empirica*, 44, 229–248. <https://doi.org/10.1007/s10663-016-9317-7>
- Bastos, P., & Silva, J. (2010). The quality of a firm's exports: Where you export to matters. *Journal of International Economics*, 82(2), 99–111. <https://doi.org/10.1016/j.jinteco.2010.07.001>
- Bastos, P., Silva, J., & Verhoogen, E. (2018). Export destinations and input prices. *American Economic Review*, 108(2), 353–392. <https://doi.org/10.1257/aer.20140647>
- Benkovskis, K., & Wörz, J. (2018). What drives the market share changes? Price versus non-price factors. *Structural Change and Economic Dynamics*. <https://doi.org/10.1016/j.strueco.2017.12.001>
- Bernini, M., & Tomasi, C. (2015). Exchange rate pass-through and product heterogeneity: Does quality matter on the import side? *European Economic Review*, 77, 117–138. <https://doi.org/10.1016/j.eurocorev.2015.04.005>

- Berry, S. (1994). Estimating discrete-choice models of product differentiation. *The RAND Journal of Economics*, 25(2), 242–262. <https://doi.org/10.2307/2555829>
- Brambilla, I., Lederman, D., & Porto, G. (2012). Exports, export destinations, and skills. *American Economic Review*, 102(7), 3406–3438. <https://doi.org/10.1257/aer.102.7.3406>
- Brambilla, I., Lederman, D., & Porto, G. (2019). Exporting firms and the demand for skilled tasks. *Canadian Journal of Economics/Revue canadienne d'économique*, 52(2), 763–783. <https://doi.org/10.1111/caje.12382>
- Brambilla, I., & Porto, G. G. (2016). High-income export destinations, quality and wages. *Journal of International Economics*, 98, 21–35. <https://doi.org/10.1016/j.jinteco.2015.09.004>
- Broda, C., & Weinstein, D. E. (2006). Globalization and the gains from variety. *The Quarterly Journal of Economics*, 121(2), 541–585. <https://doi.org/10.1162/qjec.2006.121.2.541>
- Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms. *American Economic Review*, 101(1), 304–340. <https://doi.org/10.1257/aer.101.1.304>
- Cardell, N. S. (1997). Variance components structures for the extreme-value and logistic distributions with application to models of heterogeneity. *Econometric Theory*, 13(2), 185–213. <https://doi.org/10.1017/S0266466600005727>
- Chen, N., & Juvenal, L. (2016). Quality, trade, and exchange rate pass-through. *Journal of International Economics*, 100, 61–80. <https://doi.org/10.1016/j.jinteco.2016.02.003>
- Chiappini, R. (2014). Persistence versus mobility in industrial and technological specialisations: Evidence from 11 Euro area countries. *Journal of Evolutionary Economics*, 24(1), 159–187. <https://doi.org/10.1007/s00191-013-0331-7>
- Crinò, R., & Epifani, P. (2012). Productivity, quality and export behaviour\*. *The Economic Journal*, 122(565), 1206–1243. <https://doi.org/10.1111/j.1468-0297.2012.02529.x>
- Crozet, M., Head, K., & Mayer, T. (2012). Quality sorting and trade: Firm-level evidence for French wine. *The Review of Economic Studies*, 79(2), 609–644. <https://doi.org/10.1093/restud/rdr030>
- Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *The American Economic Review*, 67(3), 297–308.
- Emlinger, C., & Lamani, V. (2020). International trade, quality sorting and trade costs: The case of Cognac. *Review of World Economics*, 156(3), 579–609. <https://doi.org/10.1007/s10290-019-00372-z>
- Feliciano, Z. M. (2001). Workers and trade liberalization: The impact of trade reforms in Mexico on wages and employment. *ILR Review*, 55(1), 95–115.
- Fielser, A. C., Eslava, M., & Xu, D. Y. (2018). Trade, quality upgrading, and input linkages: Theory and evidence from Colombia. *American Economic Review*, 108(1), 109–146. <https://doi.org/10.1257/aer.20150796>
- Gaulier, G., & Zignago, S. (2010). BACI: International trade database at the product-level (the 1994–2007 version). *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1994500>
- Goh, C. c., & Javorcik, B.S. (2005). NBER working paper series. NBER Working Paper.
- Goldberg, P. K., & Pavcnik, N. (2005). Trade, wages, and the political economy of trade protection: Evidence from the Colombian trade reforms. *Journal of International Economics*, 66(1), 75–105. <https://doi.org/10.1016/j.jinteco.2004.04.005>
- Goldberg, P. K., & Pavcnik, N. (2007). Distributional effects of globalization in developing countries. *Journal of Economic Literature*, 45(1), 39–82.
- Hallak, J. C. (2006). Product quality and the direction of trade. *Journal of International Economics*, 68(1), 238–265. <https://doi.org/10.1016/j.jinteco.2005.04.001>
- Hallak, J. C., & Sivadasan, J. (2013). Product and process productivity: Implications for quality choice and conditional exporter premia. *Journal of International Economics*, 91(1), 53–67.
- Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., & Yildirim, M. A. (2014). *The atlas of economic complexity: Mapping paths to prosperity*. Cambridge: MIT Press.
- Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, 12(1), 1–25. <https://doi.org/10.1007/s10887-006-9009-4>
- Huchet-Bourdon, M., Le Mouél, C., & Vijil, M. (2018). The relationship between trade openness and economic complexity: Some new insights on the openness measurement issue. *The World Economy*, 41(1), 59–76. <https://doi.org/10.1111/twec.12586>
- Hummels, D., & Klenow, P. J. (2005). The variety and quality of a nation's exports. *American Economic Review*, 95(3), 704–723. <https://doi.org/10.1257/0002828054201396>

- Hummels, D., & Skiba, A. (2004). Shipping the good apples out? An empirical confirmation of the Alchian–Allen conjecture. *Journal of Political Economy*, 112(6), 1384–1402. <https://doi.org/10.1086/422562>
- Jäkel, I. C. (2019). Product appeal, differences in tastes, and export performance: Evidence for Danish chocolate and confectionery. *International Journal of Industrial Organization*, 63, 417–459.
- Khandelwal, A. (2010). The long and short (of) quality ladders. *The Review of Economic Studies*, 77(4), 1450–1476. <https://doi.org/10.1111/j.1467-937X.2010.00602.x>
- Khandelwal, A., Schott, P. K., & Wei, S.-J. (2013). Trade liberalization and embedded institutional reform: Evidence from Chinese exporters. *American Economic Review*, 103(6), 2169–2195. <https://doi.org/10.1257/aer.103.6.2169>
- Kremer, M. (1993). The O-ring theory of economic development. *The Quarterly Journal of Economics*, 108(3), 551–575. <https://doi.org/10.2307/2118400>
- Kugler, M., & Verhoogen, E. (2012). Prices, plant size, and product quality. *The Review of Economic Studies*, 79(1), 307–339. <https://doi.org/10.1093/restud/rdr021>
- Kumar, U., & Mishra, P. (2008). Trade liberalization and wage inequality: evidence from India. *Review of Development Economics*, 12(2), 291–311. <https://doi.org/10.1111/j.1467-9361.2007.00388.x>
- Linder, S.B. (1961). An essay on trade and transformation. Almqvist & Wiksell Stockholm.
- Pavcnik, N., Blom, A., Goldberg, P., & Schady, N. (2004). Trade liberalization and industry wage structure: Evidence from Brazil. *The World Bank Economic Review*, 18(3), 319–344.
- Rodrik, D. (2006). What's so special about China's exports? *China & World Economy*, 14(5), 1–19. <https://doi.org/10.1111/j.1749-124X.2006.00038.x>
- Schott, P. K. (2003). One size fits all? Heckscher–Ohlin specialization in global production. *American Economic Review*, 93(3), 686–708. <https://doi.org/10.1257/000282803322157043>
- Schott, P. K. (2004). Across-product versus within-product specialization in international trade. *The Quarterly Journal of Economics*, 119(2), 647–678. <https://doi.org/10.1162/0033553041382201>
- Schott, P. K. (2008). The relative sophistication of Chinese exports. *Economic Policy*, 23(53), 6–49.
- Sutton, J., & Trefler, D. (2016). Capabilities, wealth, and trade. *Journal of Political Economy*, 124(3), 826–878. <https://doi.org/10.1086/686034>
- Train, K. E. (2009). *Discrete choice methods with simulation*. Cambridge: Cambridge University Press.
- Verhoogen, E. (2008). Trade, quality upgrading, and wage inequality in the Mexican manufacturing sector. *The Quarterly Journal of Economics*, 123(2), 489–530.