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Value Added Trade, Quality Upgrading, and Skill Demand in Middle-Income Countries

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Abstract
This paper relates trade in value added to wage bill shares of high-skilled workers in ten middle-income countries. We apply a recently developed measure to a novel database, the World Input-Output Database, to estimate the value added that each industry contributes to final consumption of goods and services consumed abroad. We fix domestic production technologies and the sourcing of foreign intermediate inputs at initial levels, and identify the effect of value added exports from variation in foreign final consumption. Value added exports to rich countries are found to increase industries' wage bill share of high-skilled labor, in support of the quality upgrading hypothesis of Verhoogen (2008).

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1. Introduction

Globalization and technological change have coincided with rising inequality *within* many developing countries since the 1990s (Pavcnik, 2011). As yet, it is unclear how much one of the mechanisms of globalization, the quality upgrading mechanism, contributes to this observed aggregate wage inequality. The quality upgrading hypothesis states that exporters in developing countries produce higher quality goods for the export market to appeal to consumers in rich countries (Verhoogen, 2008). For example, the Volkswagen plant in Puebla, Mexico produces New Beetles and Original Beetles. The New Beetles are destined for the North American market, whereas Original Beetles are sold in the Mexican market. If product quality is more sensitive to the quality or use of high-skilled labor, exports to richer destinations should increase the ratio of high-skilled to low-skilled wages or employment within the firm. So far, the quality upgrading hypothesis has found empirical support by researchers that use firm-level data for selected industries and periods. Exporting to rich countries is associated with higher relative wages for high-skilled workers in Mexican manufacturing (Verhoogen, 2008; Frias *et al*., 2012), and with more skill-intensive production in Argentina's manufacturing firms during the period 1998-2000 (Brambilla *et al*., 2012).

This paper analyzes the link between exports to rich countries and skill demand at a detailed 35 industry level of the total economy in 10 large middle-income countries for the period 1995 to 2009. A consistent industry level data set on wage bill shares for developing countries and related data to trace the final destination of industries' value added are now for the first time available in the World Input-Output Database (WIOD). Hence our first contribution is an empirical analysis of the quality upgrading hypothesis in a global setting.

The new and consistent industry-level dataset on labor compensation across countries indicates that the wage bill share of highly-educated workers in total labor compensation has been increasing within most middle-income countries for the period from 1995 to 2009. We observe that high-skilled wage bill shares increased in all countries, except Mexico (declining after 1998-1999). The increase in high-skilled wage bill shares, except for Brazil and Mexico, was on par or exceeded that in the United States. Supply of high-skilled workers increased in most countries during the period analyzed, but so did wages of high-skilled workers relative to low-skilled workers, implying a shift in demand towards more high-skilled workers.

Our second contribution relates to the measurement of trade. We apply a recently developed method by Johnson and Noguera (2012) to the new World Input Output Database (WIOD) to measure value added exports rather than gross exports. Instead of the value of gross output exported by a given industry (gross exports), value added exports measure the value added that the industry contributes to final consumption abroad. For example, only 10 percent of the factory price of iPods that are exported to the US and the European market is value added that accrues to Chinese assembly plants (Dedrick et al., 2010). Most value added comes from Japan and South Korea that produce sophisticated intermediate inputs. Hence value added exports differ from gross exports.

Furthermore, if quality upgrading is driven by the greater willingness from rich-country consumers to pay for quality, the final destination of goods matters. In the quality upgrading literature, the export destination is the country purchasing a firm's output, whether the output is consumed in that country or used as input in the production of another good, which may be exported to a third country. As Johnson and Noguera (2012) describe, output from a particular country and industry travels through the global production chain and may be embodied in any final good consumed in any other country. In our analysis, the destination of value added exports of each country and industry is the country in which the final good - to which value added was contributed - is ultimately consumed.

A third contribution comes from our identification strategy. One way to identify the effect of exports on wages and employment has been to exploit shocks to foreign demand for the focal country's output, such as exchange rate changes (Verhoogen, 2008; Brambilla et al, 2011). Instead, we note that in this new metric of trade, value added exports are a product of domestic production technologies, the global sourcing of intermediate inputs, and foreign final consumption. In our empirical setup, we fix the former two at the base year 1995 in order to isolate changes in value added exports due to changing foreign final consumption. We assume that initial domestic production technologies and global sourcing of intermediate inputs are independent of subsequent changes in high-skilled wage bill shares. With global foreign final consumption exogenous to the industry level high-skilled wage bill share in middle-income countries, we are able to estimate the causal effect of foreign final demand on high-skilled wage bill shares.

Our results show that rich-country demand for value added increases the high-skilled wage bill share at the industry level in our set of middle-income countries. Non-rich-country value added demand has the opposite effect. These results are robust to iteratively dropping countries, which suggests that no country in particular is driving the observed relationship. However, we also find that the particular mechanism that we focus on in this paper – within-industry quality upgrading in response to changes in foreign value added demand – cannot explain the overall trend in wage inequality in our sample of countries.

The remainder of this paper is structured as follows. In section 2, we describe the socio-economic accounts data and the method for measuring value added exports. Section 3 describes the trends in skilled labor use in middle-income countries and shows that most changes between 1995 and 2009 were due to within-industry increasing skill-intensity. Section 4 presents the economic theory and econometric method. Results are presented in section 5, and section 6 concludes.

2. High-skilled wage bill shares and value added exports

This section consists of three parts. First, we discuss our main data source for high-skilled wage bill shares in section 2.1. Thereafter, in section 2.2 we introduce a method for measuring value added exports that closely follows Johnson and Noguera (2012). Descriptive statistics are presented in section 2.3.

2.1 High-skilled wage bill shares

WIOD provides information on output and inputs for a large set of developed and developing countries.[1] We focus here on the wage bill shares in ten middle-income countries included in the database, namely Bulgaria, Brazil, China, Hungary, India, Indonesia, Mexico, Romania, Russia, and Turkey. The main variable of interest is the wage bill share of high-skilled workers in total labor compensation, but we will use information on other variables such as the capital stock and value added from WIOD as well. All variables are available at a 35 industry level of the total economy from 1995 to 2009 (see appendix table 2 for the industries distinguished).

For series of employment and wages of various types of labor, material is collected from employment and labor force statistics. Employment is cross-classified by educational attainment according to the 1997 International Standard Classification of Education (ISCED). High-skilled labor corresponds to workers at the first stage of tertiary education or above (ISICED 5 and 6).

Data on the number of workers by educational attainment are available for a large set of countries (e.g. Barro and Lee, 2010), but WIOD provides an extension in two directions. First, it provides industry level data, which better reflects the large heterogeneity in the skill levels used in various industries (compare e.g. agriculture and financial and business services). Moreover, it provides relative wages by skill type that reflect the differences in remuneration of workers with different levels of education. The wage data is made consistent with the quantity data.

For each country, a choice was made of the best statistical source for consistent wage and employment data at the industry level. In most cases this was the labor force survey (LFS), which in some cases was combined with household surveys when wages were not included in the LFS. Care has been taken to arrive at series which are time consistent, as most employment surveys are not designed to track developments over time, and breaks in methodology or coverage frequently occur.

[1] The database is available at www.wiod.org. See Timmer (2012) for a detailed discussion of the database.

Data has been collected for both the number of workers, and their wages. If available the data refers to all workers including self-employed and family workers, but mostly they refer to employees only.[2] Numbers of workers is reported, unadjusted for differences in hours worked. The latter is preferable, but based on the available evidence there is no clear relationship between hours worked and skill-level. In principle, data is constructed for the period from 1995 to 2009. Annual availability of data differs across countries. Also, data on wages is scarcer than for number of workers and more imputations have to be made.

For each country there is at least one observation of wages in this period, to ensure that country-specific skill-premiums are reflected in the data, and match with the definition for quantities. For most countries there are at least three observations across the period to reflect the changes in skill premiums that take place over time. The level of industry detail also varies across countries and depends crucially on the sample sizes of the surveys on which the estimates are based. Quantity data by skill type is available for at least 14 industries in all countries, up to 35 in some (e.g. India and Mexico). In order to derive shares for all 35 WIOD industries it is assumed that the skill distribution of workers in sub-industries is similar as the shares for more aggregate industries.

Relative wage data is scarcer. Sometimes it is available at a more aggregate level than data for quantities, e.g. for China only for 3 broad sectors. In these cases it is assumed that relative wages of both high-skilled and medium-skilled workers relative to low-skilled in sub-industries is the same as in the more aggregate industry. As relative wages will differ much less across industries than quantities this assumption can more easily be made at higher levels of aggregation. For example, while in China the relative number of high- to low-skilled workers is much higher in chemicals than in textile manufacturing, the relative wages of high- to low-skilled workers in both industries will be closer together. Also, relative wage data is not always available on an annual basis. In those cases relative wages are interpolated for years in-between. As relative wages develop only slowly, this assumption is relatively harmless. A more detailed description of the data is provided in Erumban et al. (2012).

[2] Labor compensation of self-employed is not registered in the National Accounts, which, as emphasized by Krueger (1999), leads to an understatement of labor's share. WIOD makes an imputation by using information on relative wages and employment shares of informal workers (e.g. workers 'sem carteira' in Brazil and workers in the 'unorganized sector' of India). If such information is not available (e.g. for China), it is assumed that the compensation per hour of self-employed is equal to the compensation per hour of employees. The adjustment for informal workers is especially important for industries which have a large share of self-employed workers, such as agriculture, trade, business and personal services. Also, it is assumed that labor characteristics for self-employed are the same as for employees when information on the former is missing. These assumptions are made at the industry level.

2.2 Measuring value added exports

To measure value added exports we follow Johnson and Noguera (2012). Define the vector **f** as the ratio of value added to *gross output* with dimension CG x 1, where C is the number of countries (C=1,..,41), and G is the number of industries (G=1,…,35). An element in this vector indicates the value added share in gross output contributed directly by the producing country-industry, for example the value added contributed in the Chinese electronics industry to produce one dollar of output. Value added consists of payments to domestic factors, i.e., labor and capital services.

The elements in **f** only measure direct value added contributed in the producing industry, because they do not account for value added embodied in intermediate inputs used. To measure both direct and indirect value added contribution, we need to define a matrix **B** (of dimension CG x CG) by applying the Leontief inverse as follows:

$$\boldsymbol{B} = \hat{\boldsymbol{f}}(\boldsymbol{I} - \boldsymbol{A})^{-1} \tag{1}$$

where $\hat{\boldsymbol{f}}$ indicates that the vector **f** is diagonalized. **A** is a world input-output matrix with intermediate input coefficients of dimension CG x CG. We use the World Input-Output Table for 1995, available in WIOD.[3] The matrix **A** describes how a given product in a country is produced with different combinations of intermediate products from any country and industry. The diagonal G x G sub-matrices track the requirement for domestic intermediate inputs, while the off-diagonal elements track the requirements for foreign intermediate inputs.

To aid interpretation of the Leontief inverse, note that it can be expressed as a geometric series: $(\boldsymbol{I}-\boldsymbol{A})^{-1} = \sum_{k=0}^{\infty} A^k$. The k-th order term measures the intermediate inputs used in the k-th step of the production process. Multiplying by the value added share vector **f**, the first (zero-order) term gives the direct value added share in final output of a given good. Next, the first-order term adds the value added contributed through intermediates used to produce the final output. The second-order term adds the value added contributed through intermediates used to produce the first round of intermediates, etc.

The matrix **B** pins down the total value added (directly and indirectly contributed) per unit of final output. And since we know where final output is consumed, the matrix **B** will be used to derive the amount of value added that can be attributed to observed levels of final demand. To do so, we take the vector of final demand for a particular country *c*, $\mathbf{d}^c$. The vector of final demand is of dimension CG x 1 and shows imported final demand (from all C-1 foreign countries) and domestic final demand for G goods and services.[4] A particular element in this vector shows, for example, the consumption of electronics in the US imported from China. Another element in that

[3] The WIOT includes 41 countries and 35 industries, i.e. the A matrix is of dimension 1435 by 1435.
[4] Final demand is expressed in US dollars converted at exchange rates.

vector may contain consumption of New Beetles in the US imported from the Volkswagen Puebla plant in Mexico. It also shows consumption of domestically produced final goods. To find the value added contribution from each country and industry that can be attributed to observed final consumption in a particular destination country, the following expression is used:

$$p^c = Bd^c \tag{2}$$

A typical element of p^c indicates the value added produced in a given source country and industry that is embodied in final consumption in country *c*. By stacking the resulting vectors $\mathbf{p^c}$ for all countries we end up with the value added of each source country-industry that ends up in domestic final consumption and in final consumption in each of the (C-1) foreign countries in the dataset. Since value added exports are recorded for each pair of source country-industry and destination country, we can split up value added for domestic final consumption, for rich-country final consumption, and for final consumption in the rest of the world. The three components sum up to total value added (GDP) in the source country-industry.

Over time, changes in value added exports are due to changes in the domestic value added to output ratios (**f**), changes in global sourcing of intermediate inputs (**A**), and changes in final demand in destination countries ($\mathbf{d^c}$). To identify the effect of exports on skill demand, we will exploit variation in final demand, while holding the other two components constant at the 1995 level. Let us call the resulting measure of value added exports the *foreign value added demand*.

Using foreign value added demand allows us to isolate the quality upgrading hypothesis from the outsourcing hypothesis that has similar empirical implications for wage inequality.[5] Feenstra and Hanson (1996) hypothesize that outsourced production activities are relatively low-skilled for developed countries but high-skilled for developing countries, raising skill demand in both places. Hence, the sourcing of foreign intermediate inputs is an alternative explanation for the relation between North-South value added trade and inequality in South. But by holding constant the global sourcing of intermediate inputs, we focus only on changes in foreign final consumption, which should be exogenous to changes in the high-skilled wage bill share in middle-income countries. Thus we are able to estimate the causal effect of foreign final demand on skill demand.

2.3 Value added exports and foreign final demand

For understanding the economic interpretation of value added exports, it will be useful to, first of all, compare it to gross exports. As an example, figure 1 shows the ratio of value added exports to

[5] Note that the exact mechanism underlying the quality upgrading hypothesis is subject to further research. For example, a positive link between exporting to high-income countries and wages in middle-income countries may run via profit sharing in a model of fair wages (Amiti and Davis, 2011), or higher wages to reduce labor turnover (Verhoogen, 2008), or higher wages due to scale economies from exporting (Yeaple, 2005).

gross exports of textiles, electronics, and business services in China in 2009. Both numbers are total exports from these industries in China summed over all foreign destinations. The two measures differ because value added is only a part of gross output (or gross sales), but also because value added of an industry may be embodied in the exports of other industries. This is most clearly seen in services industries. In figure 1, the ratio of value added exports to gross exports for business services is much larger than one because many industries use intermediate business services for the export of goods. Hence, a lot of value added from business services ends up in the consumption of goods abroad. These exports are not captured in standard gross export statistics. For textiles and electronics, the ratio of value added exports to gross exports is less than one, because these industries produce goods that are not embodied in the exports of other goods, but are directly exported and mainly the value added portion is measured.

Figure 2 illustrates the difference between total value added exports and foreign value added demand. The latter is measured with the base-year (1995) vector of value added to output ratios (**f**) and world input-output coefficients (**A**). In 1995, both measures are the same, but the change over time is different: changes in foreign value added demand are changes in value added exports solely due to changes in foreign final consumption demand. In China's textiles industry, we see that value added exports increased from 15,000 to almost 90,000 current USD. If we only allow foreign final demand to vary, we see that foreign value added demand for Chinese textiles increased to about 75,000 USD. For the average industry in our sample (see row "All MIC" in Table 1), the share of value added exports in total value added increased from 0.23 to 0.29. Looking at foreign final demand only, we see an increase from 0.23 to 0.25. On average in middle-income countries, foreign final demand growth accounts for about half of total value added exports growth, as a share of industries' total value added.

In table 1, descriptive statistics are presented by country and for all middle-income countries combined, with information for the United States included for reference. Value added exports and foreign demand for value added are expressed as shares in total value added. On average, value added exports as a share in total value added ranges from 13% in Brazil to 46% in Hungary in 2009. The relatively low value for Brazil indicates that a large share of value added in Brazil's industries end up in goods consumed domestically. In contrast, almost half of the value added in the average Hungarian industry ends up in goods consumed abroad. On average, all countries show an increase in the VA exports share of total VA, meaning that in 2009 a larger share of industries' value added was being consumed in foreign countries than in 1995.

The next four columns of table 1 show the level and change of VA exports and foreign VA demand restricted to rich-country destinations.[6] Rich countries account for a substantial share of total VA exports and foreign demand for VA in 2009. However, the increase of VA exports and foreign VA demand to rich countries between 1995 and 2009 was lower than the total increase in VA exports and foreign VA demand (as a share of total VA) in most countries, and sometimes negative. This indicates that for the average industry in most middle-income countries, rich countries have become less important as a final destination of their value added. For foreign VA demand, the change from 1995 to 2009 is negative in all countries except Hungary and Turkey, indicating the rich-country demand for middle-income countries' VA was growing slower than total VA in most middle-income countries.

2.4 Skill demand

Table 2 shows the high-skilled wage bill share for each country, for the total economy, in 1995 and 2009. High-skilled wage bill shares differ across countries, largely as expected, being lowest in China and highest in Brazil and Hungary. Over the period from 1995 to 2009 we observe that high-skilled wage bill shares have been increasing in all countries, except Mexico, where medium-skilled labour share have increased at the cost of low- and high-skilled shares (not shown). The increase in high-skilled shares in the other countries, except for Brazil, was on par or exceeded that in the United States.

For several countries it has been shown that the total increase in skill demand is due to changes within industries, rather than the growth of skill-intensive industries (e.g. Chamarbagwala and Sharma (2011) for India). This type of decomposition divides the total change in high-skilled wage bill share (ΔS_c^H), into within-industry and between-industry components:

$$\Delta S_c^H = \sum_i \Delta S_{i,c}^H \cdot \bar{P}_{i,c} + \sum_i \Delta P_{i,c} \cdot \bar{S}_{i.c}^H \ ,$$

where $P_{i,c}$ is industry i's share in the country c's total wage bill, changes are for the period 1995-2009, and $\bar{P}_{i,c}$ and $\bar{S}_{i.c}^H$ are period averages. Decomposing the total change in high-skilled wage bill shares per country, as shown in Figure 3, we find that the within-industry contribution dominates in most middle-income countries. The within-industry component is somewhat smaller

[6] The rich countries distinguished in our database are shown in appendix table 1. The selection is based on the World Bank income grouping and the GDP per capita in 2008 at GK 1990US$ PPPs. The ten poorest countries, based on GDP per capita and World Bank country groupings, were considered middle-income. Latvia, Lithuania, and Poland are considered neither middle-income nor rich countries, because they were poorer than some countries in 1995 but substantially richer in 2009. Also, Poland is considered high-income in the World Bank income grouping. These countries were therefore grouped with the 'rest of the world' category. Empirical results do not depend on including these countries among the rich countries or middle-income countries.

in Bulgaria, Romania, and Russia, where it accounts for about half of the total increase. This suggest that our econometric approach that relates changes in wage bill shares within industries to changes in value added exports does not provide a full explanation of changes in wage inequality.

The dominance of the within-industry component has often been presented as suggestive evidence for the importance of technological change, as this is an effect that takes place within industries, whereas the effect of trade would come from a structural change from less skill-intensive to more skill-intensive industries. However, recent trade models, including the quality upgrading models of Verhoogen (2008) and Brambilla *et al.* (2012) are perfectly in line with within-industry changes of the high-skilled wage bill share. Hence, the decomposition results are discussed here just to convey that the unit of analysis in our empirical analysis - the industry - is relevant for understanding changes in skill demand in middle-income countries.

In the next section we describe a formal approach to relate foreign demand for value added to wage bill shares of high-skilled workers.

3. Economic theory and econometric model specification

Our econometric specification is derived from the economic theory of a production function. For each industry i = 1, …, I in country c = 1, …, C we consider a production function at time *t*:

$$VA_{c,i,t} = f_{c,i,t}\,(L_{c,i,t}\,,\,M_{c,i,t},\,H_{c,i,t},\,K_{c,i,t}), \tag{1}$$

where VA is value added that is produced using the production factors L low-skilled labor, M medium-skilled labour, H high-skilled labour, and K the capital stock. We assume the production function $f_{c,i,t}$ is increasing and concave in ($L_{c,i,t}$, $M_{c,i,t}$, $H_{c,i,t}$, $K_{c,i,t}$).

The short-run cost function, obtained when the levels of capital and output are fixed but labor (by skill type) is flexible, is defined as:

$$C_{c,i,t}\,(w_{Lc,i,t},\,w_{Mc,i,t},\,w_{Hc,i,t},\,K_{c,i,t},\,VA_{c,i,t}) \equiv min_{L,M,H}\; w_{Lc,i,t}L_{c,i,t} + w_{Mc,i,t}M_{c,i,t} + w_{Hc,i,t}H_{c,i,t},$$

subject to equation (1). (2)

We assume the cost function, equation (2), can be approximated by a second order flexible functional form such as the translog.[7] Cost minimization therefore implies:

[7] We prefer a translog functional form compared to a Cobb-Douglas function, because a flexible functional form does not restrict the signs and the sizes of the elasticity of substitution.

$$\ln C_{c,i,t} = \propto_0 + \sum_{j=1}^{J} \propto_j w_{j,c,i,t} + \sum_{l=1}^{L} \beta_l \ln x_{l,c,i,t} + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{K} \gamma_{ij} \ln w_{j,c,i,t} \ln w_{k,c,i,t} + \frac{1}{2}\sum_{l=1}^{L}\sum_{m=1}^{M} \delta_{lm} \ln x_{l,c,i,t} \ln x_{m,c,i,t} + \sum_{j=1}^{J}\sum_{L=1}^{L} \theta_{jl} \ln w_{j,c,i,t} \ln x_{k,c,i,t}, \quad (3)$$

for j = L, M, and H, and where w_{ji} denote wages. The variables $x_{l,c,i,t}$ are shift parameters and denote either the quantities of the fixed input capital or value added.

If we take first order derivatives of the cost function, we get $\frac{\delta \ln C}{\delta \ln w_j} = \left(\frac{\delta C}{\delta w_j}\right)\left(\frac{w_j}{C}\right)$. Note that $\left(\frac{\delta C}{\delta w_j}\right)$ equals the demand for input j. Therefore, $\left(\frac{\delta C}{\delta w_j}\right)\left(\frac{w_j}{C}\right)$ equals the payments to factor j relative to total costs, which we denote by the cost shares s_j. Differentiating equation (3) with respect to ln w_j therefore results in:

$$s_{j,c,i,t} = \alpha_i + \sum_{j=1}^{J} \gamma_j \ln w_{j,c,i,t} + \sum_{l=1}^{L} \theta_l \ln x_{l,c,i,t}, \quad (4)$$

Here the cost share for high-skilled is $s_{i,c,t}^H = \frac{w_{H,c,i,t}H_{c,i,t}}{w_{L,c,i,t}L_{c,i,t}+w_{M,c,i,t}M_{c,i,t}+w_{H,c,i,t}H_{c,i,t}}$, and the cost shares for the other labour skill types are obtained in a similar manner.

Equation (4) is estimated by pooling data across countries and industries, thereby assuming that the same cost function applies to all, which is a common approach in the literature (Feenstra and Hanson, 1999; Michaels et al., 2010). Following Michaels et al. (2010), we assume that labor markets are national and abstract from cross-industry variation in wages. These are captured instead by country-time effects. We control for further time-invariant unobserved heterogeneity by including country-industry fixed effects, resulting in the following equation:

$$s_{i,c,t}^H = \alpha + \beta_K \ln(K_{i,c,t} / VA_{i,c,t}) + \beta_{VA} \ln VA_{i,c,t} + \varphi_{c,t} + \mu_{i,c} + \varepsilon_{i,c,t}. \quad (5)$$

Equation (5) is extended to capture the effect of foreign demand for value added. We add the variable $VA\_FOR/VA_{c,i,t}$, which is the *foreign value added demand* (value added exports driven by final demand abroad) as a share in total value added. This variable is a measure of the composition of total value added and captures the impact of foreign demand for value added once total value added has been accounted for. As explained in section 2.2, we derive this measure by fixed domestic production technology and global sourcing of intermediate inputs at the 1995 base year. The augmented econometric specification becomes:

$$s_{i,c,t}^H = \alpha + \beta_K \ln(K_{i,c,t} / VA_{i,c,t}) + \beta_{VA} \ln VA_{i,c,t} + \theta\, VA\_for/VA_{c,i,t} + \varphi_{c,t} + \mu_{i,c} + \varepsilon_{i,c,t} \quad (6)$$

Finally, we are interested in the different final destinations of value added, since we know whether value added ends up in final consumption in richer nations or in countries at a similar or lower levels of income per capita. This allows us to distinguish whether final demand from high-income countries is positively related to skill demand, as would be in line with the quality upgrading hypothesis. Therefore, besides estimating equation (6), we will also consider:

$$s_{i,c,t}^{H} = \alpha + \beta_K \ln(K_{i,c,t} / VA_{i,c,t}) + \beta_{VA} \ln VA_{i,c,t} + \theta_{hi} \frac{VA\_for_{hi}}{VA}_{c,i,t} + \theta_{oth} \frac{VA\_for_{oth}}{VA}_{c,i,t} + \varphi_{c,t} + \mu_{i,c} + \varepsilon_{i,c,t}, \quad (7)$$

If rich-country consumers demand higher quality goods, and this induces producers of these goods and their intermediate inputs to upgrade the quality of their products, the coefficient θ_{hi} should be positive.

4. Empirical results

In short, we find support for the quality upgrading hypothesis. Increased final demand from rich countries is related to increased demand for high-skilled workers in middle-income countries, whereas demand from middle-income countries has the opposite effect (section 4.1). The results are robust to alternative model specifications and dropping countries iteratively, which suggests that the results are not driven by one particular country (section 4.2). However, due to relative shifts in global consumption away from rich countries and towards emerging markets, we argue that the quality upgrading mechanism has not been a main determinant of rising wage inequality in middle-income countries during the past decades.

4.1 Main Findings

The first two columns in table 3 show the estimation results of equation (6) and (7). We find no effect of the total foreign demand share of value added on high-skilled wage bill shares in middle-income countries (column 1). This finding is in line with related recent research that has argued that trade is not an important factor in explaining changes in skill demand (Michaels. et al., 2010).

However, once we split up foreign value added demand according to destination countries, there is a significant positive effect of rich-country demand on the high-skilled wage bill share in middle-income countries. Since we only look at changes in foreign consumption, we consider this finding as evidence in support of the quality upgrading hypothesis.

At the same time, value added demand from ‘other’ countries has a strong negative effect, which explains the overall insignificant effect. In column 3, the ‘other’ countries are further divided into two groups: middle-income countries, which are the 10 countries for which the regression is estimated (but excluding domestic demand), and the rest of the world, which includes Poland, Lithuania, Latvia, and all countries that are not separately included in the world input output database. The latter group includes all of the world's low-income countries, but also middle-income and high-income countries such as Argentina, Norway, and Singapore, which we cannot distinguish as separate final destinations. We see that the negative effect is very large for middle-income countries, and much smaller, though still significantly negative, for the rest of the world.[8] Also in this more detailed specification, demand from rich countries is positively related to skill demand in middle-income countries.

As we argue that variation in foreign value added demand is exogenous, we interpret the estimates in columns 1, 2, and 3 as the causal effect of exports on skill demand. A one standard deviation increase in final demand from high-income countries (0.17 in the sample), corresponds roughly to a 1 percentage point increase in the wage bill share of high-skilled labor. With a sample average of 22 percent, the overall effect has moderate economic significance. Moreover, the effect of middle-income countries' value added demand is opposite. The share in value added accounted for by rich-country demand declined, on average, between 1995 and 2009, while total foreign value added demand increased. This means that value added demand from middle-income countries and other destinations grew faster than rich-country value added demand, and our results thus indicate that foreign value added demand has not been the main contributor to rising high-skilled wage bill shares in middle-income countries. In a future version we will explore this issue further by looking at country-specific experiences.

Columns 4 to 6 in table 3 show estimation results with total value added exports instead of foreign value added demand. Variation in total value added exports comes from changes in foreign final demand, but also from changes in the industry's value added to output ratio (vector **f**) and changes in global production fragmentation (the world input-output matrix **A**). The estimates are somewhat smaller in magnitude, but also show that value added exports to rich destinations are associated with greater high-skilled wage bill shares, while exports to middle-income countries and the rest of the world have the opposite effect. These estimates are potentially biased, however, due to unobserved factors driving both changes in skill demand and changes in industries' position in global value chains. Our results suggest there is a negative bias in the estimates for value added exports to rich countries, and a positive bias for value added exports to middle-income countries, which is something we have yet to investigate further.

[8] This is something we will analyze further, for example by isolating value added demand from China, or by allowing a more flexible specification using the per capita GDP of destination countries.

4.2 Robustness

Table 4 reports tests of robustness to alternative classifications of countries. Of the 40 countries in the World Input Output Database, we have focused on 10 middle-income countries. We test whether the results are driven by any singly country by excluding them one at the time. The finding suggests that that no country in particular is driving the observed relationship. Results are also robust to excluding the crisis period, by dropping the years 2008-09 in which consumption in the US and Europe collapsed. Finally, we considered a regression where we included the capital stock (in natural logarithm). In the main results, capital was measured as the log capital share in total value added, but using the log of capital as such does has no effect on our estimates (not shown).

5. Conclusions

This paper examined the relationship between exports and high-skilled wage bill shares in middle-income countries, to test the quality upgrading hypothesis introduced by Verhoogen (2008) in a cross-country panel setting. So far, studies of the quality upgrading mechanism were confined to manufacturing plants in Mexico and Argentina (in Verhoogen, 2008 and Brambilla *et al.*, 2012). We exploit a rich new database that includes world input-output tables and industry level data on wage bill shares in 40 countries for the years 1995-2009, the World Input-Output Database (WIOD).

The high-skilled share in total labor compensation has been increasing in most middle-income countries for the period from 1995 to 2009. This increase in high-skilled wage bill shares, except for Brazil and Mexico, was on par or exceeded that in the United States. Most of the increase came from changes within industries, which many researchers have seen as evidence in favor of technological change as the driver of inequality. However, through quality upgrading, exports to rich countries could well account for rising skill demand within industries.

We test the effect of exports using an improved measure of trade, value added exports, which is defined as the value added that an industry contributes to final consumption abroad. The metric, proposed by Johnson and Noguera (2012) allows us to derive value added in a particular country and industry that is ultimately consumed in a foreign destination country. Identification of the effect of value added exports comes from variation in final consumption in destination countries, holding global intermediate production linkages at their 1995 level. We measure this *foreign demand for value added* separately for rich destinations and other destinations.

Our results support the quality upgrading hypothesis, as increased value added demand from rich countries is related to increased high-skilled wage bill shares in middle-income countries, while value added demand from non-rich foreign countries has the opposite effect. The estimates, which are robust to alternative classifications of countries, measurement of capital intensity, and excluding the crisis years 2008-9, suggest that a one standard deviation increase in the share of total value added that is finally consumed in rich countries, raises an industry's high-skilled wage bill share by about 1 percentage point. This is a moderate effect, given the sample average wage bill share of 22 percent.

However, the negative effect of non-rich foreign value added demand, combined with the relative shifts in global consumption away from rich countries towards emerging markets, means that overall value added exports cannot account for the rising high-skilled wage bill shares in our sample. Other determinants of skill demand, such as skill-biased technological change and other factors related to globalization, such as outsourcing, immigration, and financial integration might be more relevant. These issues should be further explored in future work.

Nevertheless, this paper contributes important empirical evidence to the literature on trade and inequality, and in particular the quality upgrading literature. Whether an industry exports directly to a rich destination, or supplies inputs to an exporter, we find that the *final* destination of value added matters for an industry's wage bill distribution. This is in line with the quality upgrading hypothesis, and also with previous evidence that firms vary the quality of their products across destinations by using inputs of different quality levels (Manova and Zhang, 2012): it is not only the exporter who upgrades quality for rich consumers, but also the exporter's input suppliers.

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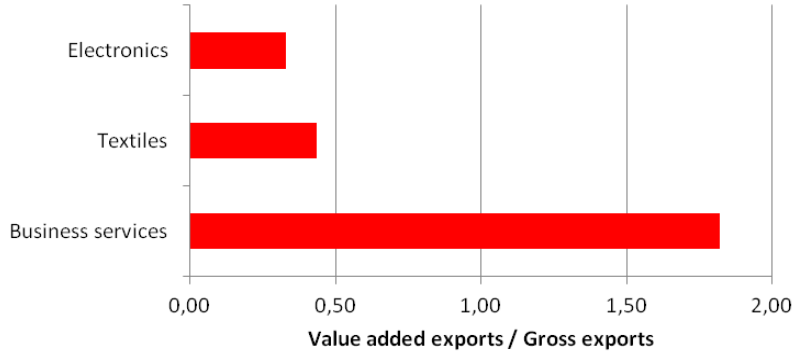
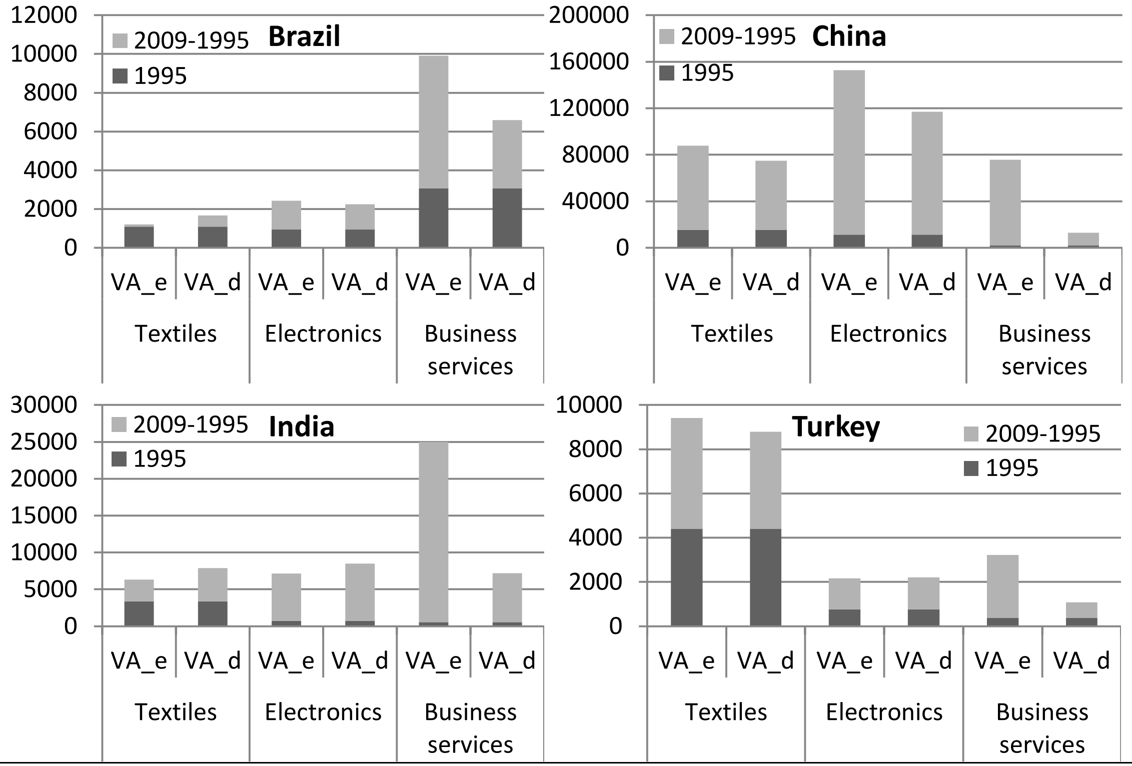
Figure 1. Value added to gross exports ratios for selected industries. China, 2009.



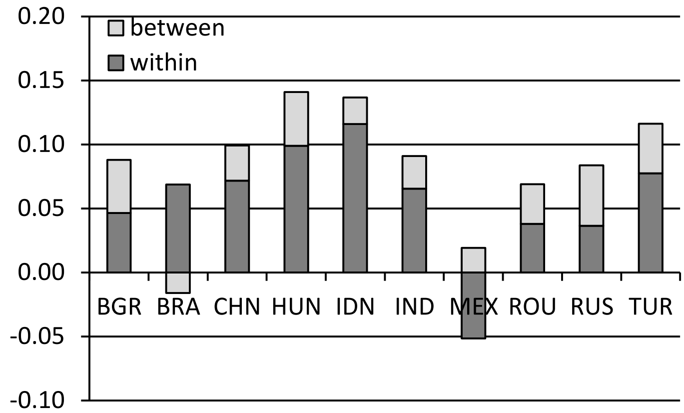
Source: Authors' calculations based on the World Input-Output Database

Figure 2. Total value added exports and foreign value added demand, 1995-2009.



Note: Values in current US Dollars. *Source:* Authors' calculations based on the World Input-Output Database.

Figure 3. Decomposition of 1995-2009 change in high-skilled wage bill share into within-industry and between-industry contributions



Source: Authors' calculations based on the World Input-Output Database

Table 1. Descriptive statistics value added trade

Country	VA exports		Foreign VA demand		VA exports to rich countries		Foreign VA demand from rich countries		
	2009	1995-2009	2009	1995-2009	2009	1995-2009	2009	1995-2009	N
Bulgaria	0.46	0.06	0.41	0.01	0.24	0.05	0.19	0.00	
	0.26	*0.09*	*0.37*	*0.22*	*0.16*	*0.12*	*0.16*	*0.12*	34
Brazil	0.13	0.03	0.11	0.01	0.06	-0.01	0.06	-0.01	
	0.09	*0.04*	*0.08*	*0.05*	*0.04*	*0.03*	*0.05*	*0.03*	34
China	0.34	0.10	0.21	-0.02	0.20	0.02	0.13	-0.05	
	0.21	*0.11*	*0.18*	*0.09*	*0.14*	*0.07*	*0.12*	*0.06*	33
Hungary	0.52	0.16	0.53	0.17	0.31	0.07	0.33	0.09	
	0.28	*0.15*	*0.66*	*0.53*	*0.19*	*0.09*	*0.47*	*0.37*	34
Indonesia	0.25	0.02	0.25	0.01	0.13	-0.06	0.14	-0.05	
	0.21	*0.13*	*0.22*	*0.14*	*0.11*	*0.09*	*0.14*	*0.09*	33
India	0.18	0.04	0.16	0.02	0.11	0.00	0.10	-0.01	
	0.14	*0.13*	*0.14*	*0.10*	*0.11*	*0.10*	*0.10*	*0.07*	35
Mexico	0.25	0.02	0.22	-0.01	0.20	0.00	0.19	-0.01	
	0.23	*0.07*	*0.21*	*0.06*	*0.20*	*0.06*	*0.19*	*0.05*	35
Romania	0.35	0.09	0.25	-0.01	0.20	0.05	0.13	-0.02	
	0.24	*0.15*	*0.24*	*0.14*	*0.16*	*0.12*	*0.12*	*0.09*	34
Russia	0.21	0.01	0.18	-0.03	0.10	-0.03	0.09	-0.05	
	0.18	*0.04*	*0.16*	*0.10*	*0.09*	*0.04*	*0.08*	*0.06*	34
Turkey	0.23	0.12	0.22	0.12	0.12	0.04	0.13	0.05	
	0.23	*0.18*	*0.30*	*0.27*	*0.13*	*0.11*	*0.18*	*0.17*	35
All MIC	0.29	0.06	0.25	0.03	0.17	0.01	0.15	-0.01	
	0.24	*0.13*	*0.32*	*0.22*	*0.16*	*0.09*	*0.21*	*0.15*	341
USA	0.16	0.03	0.18	0.05	0.07	0.00	0.08	0.01	
	0.13	*0.06*	*0.14*	*0.08*	*0.06*	*0.03*	*0.07*	*0.04*	35

Note: Value added exports and foreign demand for value added are expressed as a share in total value added at the industry level. Numbers are country averages across industries (unweighted). Columns 1995-2009 show the total change between 1995 and 2009; standard deviations are in italics below the means.

Table 2. High-skilled wage bill shares, total economy

	High-skilled wage bill share		
	1995	2009	total change
Bulgaria	0.15	0.24	0.09
Brazil	0.38	0.43	0.05
China	0.04	0.14	0.10
Hungary	0.28	0.42	0.14
Indonesia	0.11	0.25	0.14
India	0.19	0.28	0.09
Mexico	0.28	0.25	-0.03
Romania	0.12	0.19	0.07
Russia	0.20	0.28	0.08
Turkey	0.18	0.29	0.12
USA	0.37	0.47	0.10

Source: High skilled wage bill as a share in labor compensation. Authors' calculations based on the World Input-Output Database

Table 3. Foreign value added demand and the high-skilled wage bill share in middle-income countries.

High-skilled wage bill share	Foreign value added demand			Total value added exports		
	(1)	(2)	(3)	(4)	(5)	(6)
lnK/VA	-0.007	-0.007	-0.007	-0.006	-0.005	-0.005
	0.007	0.007	0.007	0.007	0.007	0.007
lnVA	0.002	0.001	0.001	0.002	0.004	0.004
	0.007	0.007	0.007	0.007	0.006	0.006
VA_for/VA	-0.004			-0.002		
	0.009			0.009		
VA_hi/VA		0.058***	0.066***		0.041***	0.048***
		0.017	0.02		0.014	0.014
VA_oth/VA		-0.112***			-0.078***	
		0.029			0.019	
VA_mi/VA			-0.274***			-0.205***
			0.094			0.056
VA_row/VA			-0.058***			-0.060***
			0.022			0.016
constant	0.183***	0.184***	0.190***	0.177***	0.158***	0.163***
	0.062	0.062	0.062	0.061	0.059	0.059
R-squared	0.42	0.42	0.43	0.415	0.423	0.426
N	4817	4817	4817	4817	4817	4817
N groups	340	340	340	340	340	340

Note: Fixed effect estimations, all regressions include country by time effects. Robust standard errors are shown below the estimates

Table 4. Foreign value added demand and high-skilled wage bill share: robustness checks

High-skilled wage bill share	VA_hi/VA	VA_mi/VA	VA_row/VA	R-squared	N	N groups
Excl. Brazil	0.064***	-0.257***	-0.054**	0.43	4307	306
	0.020	0.095	0.022			
Excl. India	0.069***	-0.279***	-0.066***	0.43	4453	306
	0.020	0.096	0.022			
Excl. Indonesia	0.041***	-0.119**	-0.057***	0.51	4330	307
	0.013	0.049	0.018			
Excl. China	0.060***	-0.243***	-0.064***	0.41	4322	307
	0.020	0.093	0.021			
Excl. Mexico	0.069***	-0.282***	-0.060***	0.44	4303	305
	0.020	0.096	0.022			
Excl. Turkey	0.071***	-0.294***	-0.064***	0.42	4305	305
	0.022	0.106	0.022			
Excl. Russia	0.069***	-0.284***	-0.062***	0.42	4310	306
	0.021	0.099	0.023			
Excl. Romania	0.067***	-0.312***	-0.060**	0.41	4329	306
	0.023	0.114	0.028			
Excl. Hungary	0.082***	-0.310***	-0.044*	0.42	4380	306
	0.023	0.106	0.024			
Excl. Bulgaria	0.065***	-0.394***	-0.038	0.41	4314	306
	0.023	0.129	0.031			
Excl. 2008-09	0.041***	-0.199***	-0.050***	0.42	4244	340
	0.013	0.067	0.019			

Note: Fixed effect estimations, all regressions also control for the capital/VA ratio and log total VA, and include country by time effects. Robust standard errors are shown below the estimates.

Appendix table 1. Industries distinguished in the World Input Output Database

Code	NACE	Description
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	C	Mining and Quarrying
3	15t16	Food, Beverages and Tobacco
4	17t18	Textiles and Textile Products
5	19	Leather, Leather and Footwear
6	20	Wood and Products of Wood and Cork
7	21t22	Pulp, Paper, Paper , Printing and Publishing
8	23	Coke, Refined Petroleum and Nuclear Fuel
9	24	Chemicals and Chemical Products
10	25	Rubber and Plastics
11	26	Other Non-Metallic Mineral
12	27t28	Basic Metals and Fabricated Metal
13	29	Machinery, Nec
14	30t33	Electrical and Optical Equipment
15	34t35	Transport Equipment
16	36t37	Manufacturing, Nec; Recycling
17	E	Electricity, Gas and Water Supply
18	F	Construction
19	50	Sale, Maintenance and Repair of Motor Vehicles Retail Sale of Fuel
20	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles
21	52	Retail Trade, Except of Motor Vehicles ; Repair of Household Goods
22	H	Hotels and Restaurants
23	60	Inland Transport
24	61	Water Transport
25	62	Air Transport
26	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	64	Post and Telecommunications
28	J	Financial Intermediation
29	70	Real Estate Activities
30	71t74	Renting of M&Eq and Other Business Activities
31	L	Public Admin and Defence; Compulsory Social Security
32	M	Education
33	N	Health and Social Work
34	O	Other Community, Social and Personal Services
35	P	Private Households with Employed Persons

Appendix table 2. Country groupings

Middle-income		*Rich*						*Other*	
1	Bulgaria	1	Australia	11	Finland	21	Netherlands	1	Latvia
2	Brazil	2	Austria	12	France	22	Portugal	2	Lithuania
3	Mexico	3	Belgium	13	United Kingdom	23	Slovak Republic	3	Poland
4	Indonesia	4	Canada	14	Greece	24	Slovenia	4	Rest of the World
5	Turkey	5	Cyprus	15	Ireland	25	Sweden		
6	China	6	Czech Republic	16	Italy	26	Taiwan		
7	India	7	Germany	17	Japan	27	United States		
8	Russia	8	Denmark	18	South Korea				
9	Romania	9	Spain	19	Luxembourg				
10	Hungary	10	Estonia	20	Malta				