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Abstract

This study empirically investigates how backward linkages impact the skill structure of domestic labor demand by estimating a system of factor equations and measuring elasticities of factor demand. This was made possible by constructing a dataset using data on labor compensation from the Socio-Economic Accounts (SEA) along with industry-level international trade data for the period 1995 to 2009, covering 40 countries from the World Input-Output Database (WIOD). Based on an input-output model, an indicator that measures the pervasiveness of global value chains (GVCs), "foreign value-added in exports (FVAiX)," is calculated. Including this index in a translog cost function, this study estimates a system of variable factor demand equations, using the iterative seemingly unrelated regressions (ISUR) method. Results reveal that participating in GVCs has both positive and negative effects on demand for different skill types of labor. On the one hand, there is a positive trend for high-skilled workers, regardless of the region or GDP per capita of the country. On the other hand, results indicate a widening gap between high- and low-skilled labor, suggesting an increase in inequality, especially in low-income countries. Consequently, it is becoming increasingly important to have policies that support flexible and frictionless labor markets in order to emolliate the change in demand, while sustaining the positives firms can benefit from access to variety of production options. Thus, these policies should facilitate the groups suffering from losses to move along sectors, countries and transfer their skills to a new task.

Keywords: International trade, Labor demand, Labor skills, International linkage, Global value chains
JEL codes: F14, F15, F16

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1. Introduction

In recent years we have witnessed the world economy rapidly integrating through international trade. Behind this phenomenon is the international fragmentation of production in global value chains (GVCs). A value chain can be simply defined as the full range of activities that firms and workers carry out in order to bring a product from its conception to its end use and beyond (Gereffi and Fernandez-Stark, 2011). The term global comes from the fact that these activities are more and more spread over multiple countries. Innovations such as the internet and container shipping have revolutionized trade and value chains.

This global integration of goods and services markets, however, has had diverse effects on individuals, households and firms. Theoretically and empirically, it is now common knowledge that trade liberalization is associated with both job destruction and job creation. However, the debate continues regarding to what extent trade liberalization has impact on the labor market, and what complementary policies may be effective to implement along with trade liberalization in order to maximize (minimize) the benefits (costs).

Among other drivers such as education, migration, environment and the government, labor issues remain an important factor when deciding international trade policies. One of the reasons why it is becoming increasingly important to examine the causal relationship between trade and labor is that the global integration of goods and services markets inevitably have direct or indirect effects or both on the labor market. Decisions made by governments and firms around the world that lead to tariff elimination or offshoring for instance will affect the labor situation of the citizens, such as unemployment and inequality. Naturally, people worry that if their country's imports from their partner country increase due to a newly-signed free trade agreement (FTA), the unemployment rate might rise and/or their wages may decrease. Thus, with the world economy rapidly integrating through the fragmentation of production processes, it is becoming increasingly important to measure the effects of trade liberalization on the labor market.

This brings us to this paper's research question: is there a link between firms' increasing reliance on foreign production processes and the change in skill structure of the domestic labor market? In other words, do GVCs have any connection with the labor market, and if so, what kind? So as to investigate this, I examine the role of backward linkages in the skill structure of labor demand. This study uses data on labor compensation from the Socio-

Economic Accounts (SEA) along with industry-level international trade data for the period 1995 to 2009, covering 40 countries, from the World Input-Output Database (WIOD) [1].

WIOD's SEAs used in this study cover low-, medium- and high-skilled labor compensation as well as hours worked. Figure 1 depicts the change in the shares of hours worked and compensation among skill types by sector. It clearly shows that during the period 1995-2009, hours worked by high-skilled workers have increased relative to hours worked by medium- and low-skilled workers. Although hours worked by medium-skilled workers do not show that much fluctuation, the decline in hours worked by low-skilled workers is striking. This set of graphs signifies a possible replacement of low-skilled labor by either high-skilled labor (skill-biased technical change) or the traditional foreign offshoring of less-skilled activities.

The remainder of this paper is organized as follows. Section 2 provides theoretical and empirical literature and recent findings. Section 3 introduces the foreign value-added in exports (FVAiX) indicator, followed by description of the model and estimation techniques in Section 4. Results are presented in Section 5. Section 6 concludes.

2. Literature and Recent Findings

This section sets out by examining the available theoretical arguments and empirical evidence on the possible employment effects of international trade. I will first give a brief overview of recent developments in the theoretical trade literature.

As mentioned, despite the fact that there is considerable agreement among economists that fragmentation of production stages does affect wages and employment across countries and industries, to date there has been little agreement on the expected direction of these potential effects. On the one hand, if globalization of value chains mainly involves tasks carried out by low-skilled labor, as we have long seen, then theoretically, the relative demand

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[1] This World Input-Output Database is available at http://www.wiod.org/database/index.htm.

The core of the database is a set of harmonized national supply and use tables, linked together with bilateral trade data in goods and services. These two sets of data are then integrated into a world input-output table. See Timmer *et al.* (2015) for the detailed framework and calculations.

for high skills would cause relative wages to shift towards more-skilled workers, increasing and contributing to a widening wage gap between skilled and unskilled labor (Feenstra and Hanson, 1996a). On the other hand, however, if the associated cost reductions are particularly strong in low-skilled labor intensive industries, international fragmentation may reduce the wage gap between skilled and unskilled labor as resources are reallocated towards low-skilled labor intensive industries (Jones and Kierzkowski, 1990).

There has been some development in international trade theory towards linking liberalization and production fragmentation with unemployment. The new movement was made possible when trade theory evolved into incorporating models with increasing returns to scale and imperfect competition (Krugman, 1980); and more recently, inter-firm differences in productivity (Melitz, 2003) and propensity to export within industries (Roberts and Tybout, 1997; Bernard and Jensen, 2004). Among the theorists exploring the connection between trade and employment is Matusz (1996), who embed theories of efficiency wages and job search into trade models. In addition, Kasahara and Lapham (2013) extends Melitz (2003)'s model to incorporate imported intermediate goods.

Following these works, Helpman *et al.* (2012) develop a model with heterogeneity in fixed exporting costs and costs of screening worker abilities across firms. Estimating this extended model, they find that overall wage inequality arises within sectors and occupations across workers with similar observable characteristics. This within component is driven by wage dispersion between firms, and wage dispersion between firms is related to firm employment size and trade participation.

Costinot and Vogel (2010) implement a model that focuses on heterogeneous workers. By taking different skill intensities into account, they examine the relationship between trade liberalization and wage premium. They analyze the impact of North-South trade, which results in an increased wage gap in the North, and a decrease in relative wages in the South. They present this as an explanation for the shrinking of the middle class due to workers leaving the medium-skilled industries in the North.

With the ongoing development in international trade theories, empirical literature has also been increasing. However, empirical research to date has yet to offer any conclusive evidence on the effects of trade liberalization on employment and wages. Hoekman and Winters (2005) suggest that this is in part due to the potential endogeneity problem when dealing with trade policy. Trade policies can have a significant impact on the level and structure of employment, wages, income inequality, labor market institutions and policies, and labor and social policies can also influence the outcomes of trade policies in terms of growth of output, employment and the distribution of income. This makes it difficult to isolate the effects of trade from other policies implemented simultaneously with trade reform.

Many of the recent empirical works tend to focus on offshoring and examine its effects on the skill structure of labor demand. They analyze relative demand for labor by estimating a translog cost function, which gives the variable costs in the respective industries, and through conditional and unconditional labor demand functions, which are derived through cost minimization and profit maximization for a given output respectively.

One of the studies that investigates how production offshoring affects skill structure and wage inequalities is Hijzen, Görg and Hine (2005). They use a translog cost function to study the impact of offshoring on the different types of workers in the United Kingdom. They divide the education groups into three: high-, semi- and low-skilled workers by occupation. Using data on United Kingdom's manufacturing industries over the period 1982-1996, they estimate a system of equations, one for each type of variable cost (the three different types of labor and materials). Results indicate that increased intra-industry offshoring has a negative impact on the demand for all three occupation groups. The magnitude of the effects, however, is different; the lower the level of skills, the stronger the impact of offshoring becomes. Their paper concludes that offshoring as well as technological change through research and development are important factors in explaining the changing skill structure which the United Kingdom has experienced.

Similarly, Feenstra and Hanson (1999), Falk and Koebel (2002) and Strauss-Kahn (2003) examine the impact of offshoring on the demand for skilled labor in the United States, Germany and France, respectively. Their results also tend to indicate that offshoring has had a negative impact on the demand for unskilled labor. An exception is Falk and Koebel (2002)'s study, whose results indicate that the increase in imported materials is driven by higher output growth rather than input substitution for different types of labor.

More recently, Foster-McGregor, Stehrer and de Vries (2013) estimate the relationship between offshoring and the skill structure of labor demand using the WIOD for 40 countries over the period 1995-2009. They estimate a system of variable factor demand equations, and their results indicate that while offshoring has had a negative effect on all skill (low, medium and high) levels, the largest impact has been observed for medium-skilled workers. This is notable in a sense that it is consistent with the aforementioned recent trend towards the shrinking of the middle class (see Costinot and Vogel, 2010; Blanchard and Willmann, 2013).

As mentioned, much of the recent literature tend to consist of empirical studies that focus on offshoring. These studies use measures such as share of imported intermediate purchases in value-added to represent offshoring. When examining the effects of GVCs, however, it is necessary to use a measure that can account for the increased interconnectivity of production processes.

The value of gross exports that are reported in official trade statistics exceeds the value-added actually created in a country in the production of its exports. Therefore, there have been increasing amount of studies that attempt to capture the value-added created in foreign countries that is previously imported in the form of intermediates, and after some processing, is embodied in the country's exports. Recent developments in multi-sector input-output model of the global economy include Foster-McGregor and Stehrer (2013)'s approach for calculating factor content of trade that take both imports and exports into account simultaneously, which is based on Trefler and Zhu (2010)'s work. Johnson and Noguera (2012) introduce a measurement of value-added content of bilateral trade, called the ratio of value-added to gross exports. Hummels, Ishii and Yi (2001) empirically define vertical specialization, which measures the amount of imported inputs used to produce exports. Modifying this measurement, Amador, Cappariello and Stehrer (2015) introduce the foreign value-added in exports (FVAiX) indicator. Their concept of foreign value-added embodied in a country's exports improves on other indicators introduced above, by taking into account the country of origin of the value-added contained in the imported intermediate inputs used to produce goods and services that are subsequently exported. In this study, I will be using their indicator in order to focus on international linkages.

3. The FVAiX Index

Using trade data from the WIOD[2], this study attempts to reveal the relationship between participation in the GVC and change in domestic labor demand. In order to do so,

[2] In this current study, out of the 35 industries available (Table A.1), I dropped Private Households with Employed Persons due to its excessive amount of missing values.

this study decomposes a country's gross exports into foreign value-added that is used to produce exports, which represents backward linkage in a GVC. For the calculation of this FVAiX indicator, I follow Amador *et al.* (2015)'s input-output model.

FVAiX, again, captures backward linkages, which is foreign value-added that is used to produce exports, in contrast to forward linkages, which represents domestic value-added that is exported, and in turn, subsequently used by the partner country to produce its own exports. Naturally, this study chooses to focus on backward linkages, since the main purpose here is to estimate the impact on the domestic labor market.

FVAiX is calculated using matrices of value-added, intermediate inputs, gross output and gross exports statistics. The ratio of value-added to gross output in country *s* is denoted by v^s, a $1 \times NC$ vector, where N is the number of sectors and C the number of countries. This accounts for the value-added shares of the partner country s. The Leontief inverse of the global input-output matrix is expressed as $L = (I - A)^{-1}$, with dimension $NC \times NC$, where A denotes the global intermediate input coefficients matrix. It represents total requirements in gross output from country s for a one unit increase in country *r*'s demand. Country r's gross exports is denoted by a vector e^r with dimension $NC \times 1$. Pre-multiplying the Leontief inverse by the vector of value-added coefficients and post-multiplying with exports vector gives us foreign value-added content in gross exports:

$$FVAiX^{sr} = v^s L^{sr} e^r \tag{1}$$

Summing up over all partner countries:

$$FVAiX^r = \Sigma_{s,s \neq r} v^s L^{sr} e^r \tag{2}$$

Hence, this indicator captures the value-added content in country r's exports in which imported intermediate inputs are used. Taking the share of this value over gross exports will then give us the share of foreign value-added in gross exports. Using this as a measurement for GVC prevalence, this study assesses the effect GVCs, or international linkages, have on the skill structure of labor demand. The summary statistics for FVAiX is shown in Table 1.[3]

4. Model and Estimations Techniques

The next step is to create a cost function, and the transcendental logarithmic, or translog function, is the most frequently used flexible function in empirical work. This is because by fitting the system of equations, the translog cost function can fit itself to the cost and input price data. By doing so, it enables us to directly estimate the parameters for the cost shares. This setup of the model closely follows Foster-McGregor *et al.* (2013) and their predecessors. I assume that the cost functions can be approximated by a translog function and is twice differentiable, linearly homogenous, increasing and concave in factor prices. Another assumption here is that labor inputs and intermediate inputs are flexible whereas other inputs are quasi-fixed. Time subscripts are omitted for simplicity.

$$lnC_i(w,x,z) = \alpha_0 + \sum_{j=1}^{J} \alpha_j lnw_{ij} + \sum_{l=1}^{L} \beta_l lnx_{il} + \sum_{r=1}^{R} \gamma_r z_{ir} + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J} \alpha_{jk} lnw_{ij} lnw_{ik} + \frac{1}{2}\sum_{l=1}^{L}\sum_{m=1}^{L} \beta_{lm} lnx_{il} lnx_{im} + \frac{1}{2}\sum_{r=1}^{R}\sum_{s=1}^{R} \gamma_{rs} z_{ir} z_{is} + \frac{1}{2}\sum_{j=1}^{J}\sum_{l=1}^{L} \delta_{jl}\, ln\, w_{ij} lnx_{il} + \frac{1}{2}\sum_{j=1}^{J}\sum_{r=1}^{R} \delta_{jr} lnw_{ij} z_{ir} + \frac{1}{2}\sum_{l=1}^{L}\sum_{r=1}^{R} \delta_{lr} lnx_{il} z_{ir} \quad (3)$$

Where C_i depicts the total variable cost in sector $i = 1, \ldots, N$; w_{ij} denotes factor prices for factor $j = 1, \ldots, k, \ldots, J$; x_{il} denotes quasi-fixed inputs and outputs for $l = 1, \ldots, m, \ldots L$; and z_{ir} is the technological change or the demand shifter for $r = 1, \ldots, s, \ldots R$. The variable factors are low-skilled, medium-skilled and high-skilled labor,[4] and intermediate inputs. The five necessary constraints for the aforementioned assumptions to hold are:

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[3] The majority of countries with FVAiX of over 0.9 are low and lower-middle income EU countries. Europe has a high value of FVAiX compared to other regions. This shows the high degree of integration especially in the EU, and that the lower income countries export goods and services that have already been mostly finished when they imported them.

[4] Based on educational attainment. For details see Table 2.

$$\sum_{j=1}^{J} \alpha_j = 1 \qquad \text{and} \qquad \sum_{j=1}^{J} \alpha_{jk} = \sum_{k=1}^{J} \alpha_{jk} = \sum_{j=1}^{J} \delta_{jl} = \sum_{j=1}^{J} \delta_{jr} = 0$$

(4)

These restrictions ensure that changes in one variable cannot lead to changes in the sum of the cost shares, and that an identical change in the input prices does not change the usage of resources and yield for all cost shares. In addition, there needs to be symmetry restrictions. The cross-price effects need to be symmetric among the different skill groups, which implies that $\alpha_{jk} = \alpha_{kj}$.

First derivatives of the cost function with respect to the log of each factor price (w_{ij}: P_L, P_M, P_H, P_I) will yield the cost share S_i of factor j in total variable costs.

$$\frac{\partial lnC_i}{\partial lnw_{ij}} = L_{ij}\frac{w_{ij}}{C_i} = S_{ij} = \alpha_j + \sum_{k=1}^{J}\alpha_{jk}lnw_{ik} + \sum_{l=1}^{L}\delta_{jl}lnx_{il} + \sum_{r=1}^{R}\delta_{jr}z_{ir}$$

(5)

where $L_{ij} = \frac{\partial C_i}{\partial w_{ij}}$, which equals the demand for input j. Following this, $L_{ij}\frac{w_{ij}}{C_i}$ is the payments to factor j relative to total costs.

Rather than estimating a single cost share equation, this study estimates a system of demand equations by adopting the Iterative Seemingly Unrelated Regressions (ISUR) method, and controlling for time-invariant sector-specific fixed effects. A set of equations that has contemporaneous cross-equation error correlation is called an SUR system. At first look, the equations seem unrelated, but the equations are related through the correlation in the errors. (see Baum and Linz, 2009) As discussed in Greene (2008, p.277), consistent estimates can be derived by estimating any three of the four factor share equations in the system, since they sum up to unity. Dropping the fourth share equation for intermediate inputs, we can normalize the factor prices by P_I (factor price of intermediate inputs).

Finally, the elasticity of factor demand with respect to factor-biased technological changes or demand shifters (z_{ir}) (all other factors kept constant) can be given by:

$$\theta_{jr} = \frac{\delta_{jr}}{S_{ij}} \tag{6}$$

Constructing a panel dataset for period 1995-2009, this study focuses on the relationship between international linkage and variable cost shares. Table 1 shows the summary statistics. [5]

5. Estimation Results

First, the Breusch Pagan test of independence is used to test the assumption that the errors across equations are contemporaneously correlated. The null hypothesis here is that the errors are not correlated, and thus the equations can be estimated separately by ordinary least squares (OLS). The test statistics are reported for all regressions in the Notes section under Tables 3-7. All of them reject the null hypothesis, indicating that the equations are not independent, providing support for using the ISUR model. This implies that the residuals from each ISUR regressions are significantly positively or negatively correlated with each other. Correlation matrices of residuals are available upon request.

The results for the pooled sample are shown in Table 3. The variable of interest, FVAiX, is statistically significant at the 1% level for all three skills' cost shares. The magnitude, however, is very minimal, and this can be said for all of the following estimation results. However, the signs of the coefficients can still give us an idea regarding the direction of impacts GVCs have on the labor demand. The pooled results do reflect Figure 1, that is, cost shares for low-skilled labor decreases while the demand for medium- and high-skilled labor groups is increasing. In order to seek the context and possible explanation behind these results, next, coefficients are estimated by goods sector and services sector.

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[5] The mean of the original raw values for compensation are intuitive and consistent with the literature that there is a very strong correlation between skill levels and wages; that higher skill levels have higher wages and lower skill levels have lower wages. However, the mean of the natural logarithm of high-skilled compensation is not, with its mean value being the lowest of the three skill types. The swap is not that surprising, nonetheless, since in the process of taking the logarithm, the individual higher values of high-skilled compensation fell below those of low-skilled compensation. Simple and clear evidence of this is shown by assuming the dataset consists of only two observations, the minimum and maximum. If you take the average of the two values for the original compensation values, the mean wage for high-skilled workers (511.92) is greater than that for low-skilled workers (377.38). Then if you compare the average compensation between the two skill groups for the respective log values, high-skilled labor compensation (4.82) has become smaller than low-skilled labor compensation (5.36).

Table 4 shows the results for the estimation of the system of cost share equations by sector. The coefficients of FVAiX are all statistically significant at the 1% level, albeit the values are almost negligible. What is interesting here is that the only cost share that is affected negatively is the medium-skilled in the goods sector. In contrast, an increase in FVAiX has a positive or at least non-negative impact on all three skill groups in the services sector, and on low- and high-skilled labor cost shares in the goods sector.

Now the sample is further grouped into three levels of technology, by sector. Here I strictly follow the categorization by Foster-McGregor *et al.* (2013), and the detailed list is provided in Table A.1. There are six types in total: low-, medium-, high-tech for each of the two sectors. The estimation results are shown in Table 5. The goods sector's results show that in all three tech-types, medium-skilled labor cost shares decrease with an increase in FVAiX. The magnitude of the effect is worse for the low-tech industries. Moreover, in these industries, all three labor cost shares are affected negatively, low-skilled labor suffering the most. We see the "shrinking" of the middle class, as been found in recent literature, in the statistics prominent in medium-tech goods industries.

As we have been seeing from the other results, services sector does not have many statistically significant or nonzero results. Nevertheless, they are all positive, which indicates that services sector is not affected that much by increasing FVAiX, and if anything, FVAiX has a positive effect for some labor cost shares.

In Table 6, we compare the effects of FVAiX among different income groups[6]. The results indicate that the only country group to experience a negative effect on the medium-skilled labor cost share is the high-income countries. FVAiX has a positive and significant effect on high-skilled labor cost shares across all four country groups, and the effect attenuates as income increases. It is also important to note that out of the four income groups, lower-middle income countries have the highest FVAiX values, followed by low-income countries. In the low-income country group, low-skilled labor cost share is affected negatively by an increase in FVAiX.

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[6] Using the values for GDP per capita (in current USD) in 2007 from the World Development Index, the 1st quantile is 11,155.83; the 2nd is 27,478.21; the 3rd is 44,654.56 (and the 4th is 107,098.7). Countries of each group are listed in Table A.2.

Lastly, results when the sample is divided into three big regions is shown in Table 7. The regions are Asian, European and American. The only statistically significant effect on the medium-skilled labor cost shares is in Europe, and it is positive. In the European region, the FVAiX coefficients are also positive and statistically significant for low- and high-skilled labor cost shares. This could reflect the success of the European Union despite the recent controversies.

Although when we look at the big picture, participation in international linkage seems to only affect cost shares for low-skilled labor negatively, the results indicate the following points. First, medium-skilled workers in high income countries tend to suffer from a negative effect from an increase in FVAiX, even though the magnitude of that effect is very small. Medium-skilled labor cost shares shrink in the goods sector, especially in the low-tech industries. These results hint that the crowding out effect of the middle class may be the medium-skilled workers in the goods sector who live in high-income countries. Second, all three cost shares decline in low-tech goods industries. Third, the overall negative effect on low-skilled labor can be seen in low-income countries. Fourth, high-skilled labor cost shares increase in all four country groups, and the effects attenuate as GDP per capita increases.

Ultimately, Table 8 reports estimates of elasticity of the cost share variables with respect to the FVAiX indices. Elasticities are calculated according to Eq.(6). Now it is possible to make inferences about how the labor demand would change in number of workers. These elasticities of factor demand reveal that in the full sample, for example, a 1% increase in FVAiX would increase medium-skilled labor by 0.08% and lower low-skilled labor demand by 0.1%. All the values here are very small, but the sign which shows the direction the labor demand will head with an increase in FVAiX may be informative.

The demand for all three labor groups increases in the services sector, whereas we witness a crowding out of the medium-skilled labor demand in the goods sector. In addition, the demand for medium-skilled labor increases in the low- and lower-middle income country groups, which have the highest FVAiX in the sample. For upper-middle and high income countries, the effect on medium-skilled labor demand is statistically insignificant. For all tech-types in the goods sector, medium-skilled labor demand decreases. Demand for all three skill groups decline in the low-tech goods sector.

The elasticity of demand for low-skilled labor in the medium-tech goods sector has the highest value of 1.1%. This effect seems to be represented in upper-middle income countries.

This is surprising at first because according to the classical Stolper-Samuelson theorem, lower-skilled labor is expected to shrink in higher-skill abundant countries when opening up to trade. Given that “it is difficult to generate the same direction of movements in relative wages across countries from opening trade in the Heckscher-Ohlin model” (Feenstra, 2004, p.117), Feenstra and Hanson (1996b) provide an explanation of this phenomenon, which “acts as a type of ‘endogenous technical change’ biased in favor of the skilled factor” (p.4). Basically, production activities that are transferred from the North to the South tend to be more higher-skill intensive than those formerly produced in the South, but less skill intensive than those now produced in the North. Consequently, relative demand for high-skilled labor can increase in both the North and the South.

As for regions, Europe enjoys an increase in demand for all three types of labor. In Asia it is merely for low- and high-skilled labor, but the strength of elasticity for low-skilled labor is greater. It is even bigger in the American region, although the sign is negative: a 1% increase in FVAiX would decrease low-skilled labor demand in North and South America by approximately 0.46%.

6. Concluding Remarks

In this study I calculate an indicator that measures foreign value-added share in gross exports, following Amador *et al.* (2015)’s input-output model. Applying this to a system of variable factor demand equations, by adopting the ISUR method, this study attempts to clarify the link between international linkage and the skill structure of labor demand.

As a whole, an increase in FVAiX lowers the low-skilled labor demand, while increasing demand for medium- and high-skilled labor. Demand for low-skilled labor is negatively affcected in both the low-tech and high-tech goods sector. The negative impact on low-skilled labor can be seen in low-income countries, where high-skilled labor demand increases. This implies a widening gap between high- and low-skilled labor, suggesting an increase in inequality, in low-income countries. In addition, labor demand for all three skills decline in low-tech goods industries. These results seem to be inconsistent with the initial hypothesis based on theoretical literature, which is that they would either be higher-skill-biased or lower-skill-biased, depending on their relative factor endowments. Feenstra and

Hanson (1996b) show that due to a shift in production activities to the south, relative demand for high-skilled workers can increase both in the North and the South.

Results show a hint of the crowding out effect of the middle class. Medium-skilled labor demand shrinks in the goods sector, especially in the low-tech industries. The crowding out itself can be observed in the medium-tech goods industries. Contrarily, high-skilled labor demand increases in all four country groups, which are classified based on income level, and the effects attenuate as GDP per capita increases. Demand for high-skilled labor rises in all three regions as well, ranging from 0.11% to 0.18%. Medium-tech goods and services sectors also witness a rise in demand for high-skilled labor.

An increase in FVAiX has a greater effect in the goods sector, compared to the services sector, and in both sectors, demand goes up for all skill types, except for medium-skilled labor in the goods sector. The fact that the impact on services sector is much smaller or tend to be statistically insignificant, along with the summary statistics of FVAiX (mean of services is 0.126, as opposed to mean of goods, which is 0.144) suggest that, more detailed data on production of services as well as trade in services is needed to accurately capture the weight services sector has in GVCs.

In conclusion, in this new age of production fragmentation, participating in GVCs has both positive and negative effects on demand for different skill types of labor. On one hand, there is a positive trend for high-skilled workers, regardless of the region or GDP per capita of the country. On the other hand, there seems to be an overall negative effect on low-skilled labor demand, especially in the American region. Therefore, it is becoming increasingly important to have policies that support flexible and frictionless labor markets in order to emolliate the change in demand, while sustaining the positives firms can benefit from access to variety of production options. Thus, these policies should facilitate the groups suffering from losses to move along sectors, countries and transfer their skills to a new task.

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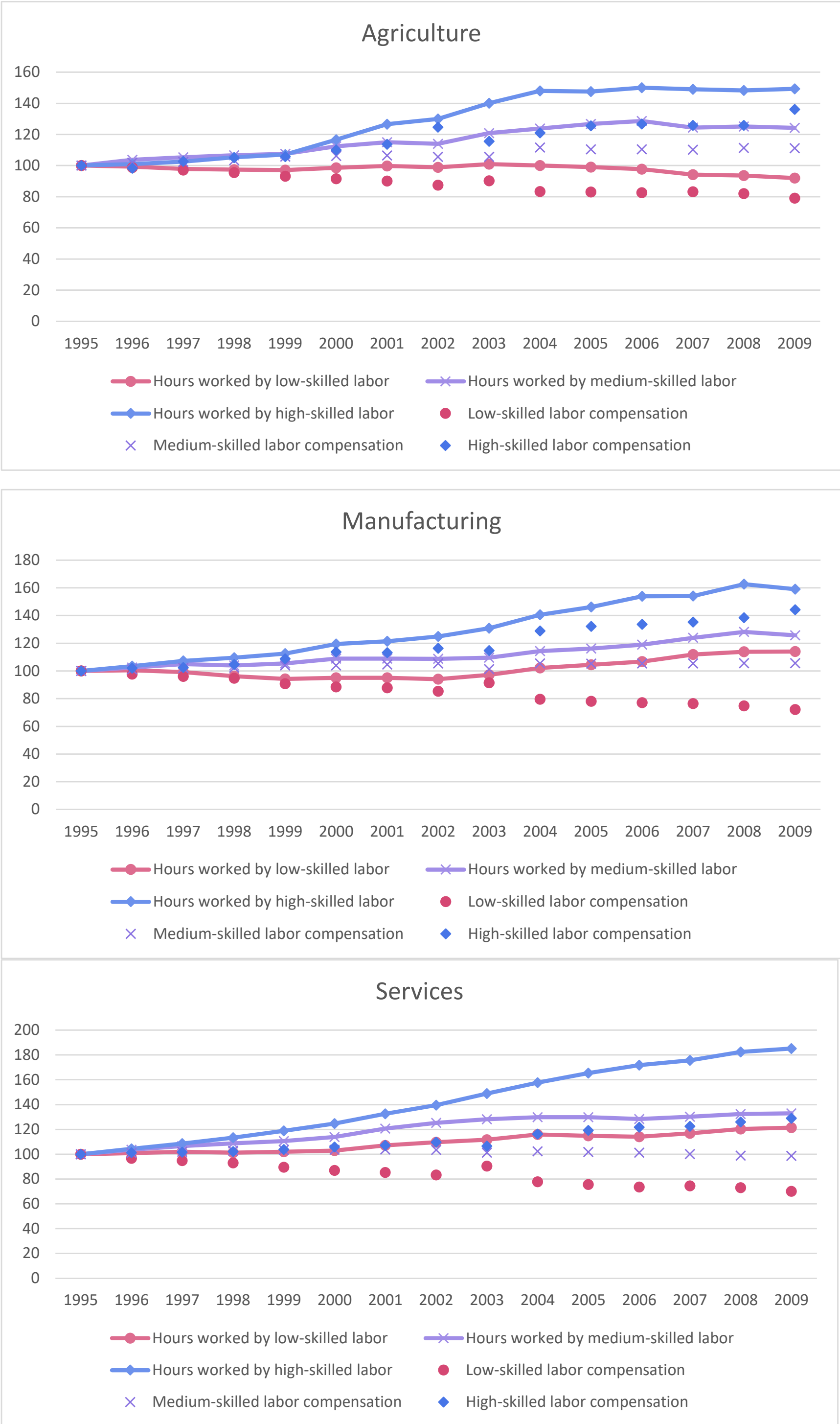
Tables and Figures

Figure 1: Hours worked and compensation shares by sector (year 1995=100)



Source: Author's calculation based on WIOD.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
FVAiX (z)	18,013	0.134	0.198	0.000	0.999
TC	18.013	6310.842	6207.789	150.966	25034.260
w_{LS}	18.013	242.270	157.705	65.593	689.162
w_{MS}	18.013	305.448	171.947	20.045	643.544
w_{HS}	18.013	308.388	286.975	15.185	1008.656
lnTC	18,013	8.290	0.997	5.017	10.128
lnw_{LS}	18,013	5.302	0.608	4.183	6.535
lnw_{MS}	18,013	5.515	0.710	2.998	6.467
lnw_{HS}	18,013	5.214	1.098	2.720	6.916
lnw_{II}	18,013	8.037	1.148	3.915	10.030
lnK	18,013	6.508	1.409	2.989	9.339
lnY	18,013	8.709	1.063	5.379	10.673

Table 2: Definition of skills in WIOD SEA

Skill-type	1997 ISCED level	Description
Low	1	Primary education or first stage of basic education
Low	2	Lower secondary or second stage of basic education
Medium	3	(Upper) secondary education
Medium	4	Post-secondary non-tertiary education
High	5	First stage of tertiary education
High	6	Second stage of tertiary education

Table 3: ISUR estimation results (whole sample)

	(1)	(2)	(3)
	S_{LS}	S_{MS}	S_{HS}
w_{LS}	0.002***	-0.005***	-0.004***
	(0.00)	(0.00)	(0.00)
w_{MS}	-0.000	0.004***	0.004***
	(0.00)	(0.00)	(0.00)
w_{HS}	-0.002***	0.002***	0.002***
	(0.00)	(0.00)	(0.00)
K	0.102***	-0.173***	-0.117***
	(0.00)	(0.00)	(0.00)
Y	-0.181***	0.026***	-0.003*
	(0.00)	(0.00)	(0.00)
$FVAiX$	-0.006***	0.006***	0.005***
	(0.00)	(0.00)	(0.00)
_cons	1.087***	0.546***	0.480***
	(0.01)	(0.01)	(0.01)
Observations	17,993	17,993	17,993
R-squared	0.955	0.924	0.935

Notes: The set of equations are estimated by ISUR. Breusch-Pagan test of independence: χ^2 (6)= 17581.999, p=0.0000. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Full set of year, country and sector FE dummies are included in the estimation.

Table 4: ISUR estimation results (by sector)

	Goods Sector			Services Sector		
	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}
w_{LS}	0.011***	0.001***	0.001***	0.000**	0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{MS}	0.007***	0.000**	0.000***	-0.000	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{HS}	-0.009***	-0.000***	-0.001***	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
K	0.041***	0.023***	0.022***	0.029***	0.079***	0.041***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Y	-0.087***	-0.047***	-0.036***	-0.055***	-0.140***	-0.081***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$FVAiX$	0.013***	-0.002***	0.002***	0.000**	0.002***	0.001**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
_cons	0.595***	0.321***	0.202***	0.349***	0.770***	0.526***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	8,156	8,156	8,156	9,837	9,837	9,837
R-squared	0.803	0.951	0.806	0.990	0.988	0.981

Notes: The set of equations are estimated by ISUR. Breusch-Pagan test of independence: [goods] $\chi^2(6)$= 6942.175, p=0.0000; [services] $\chi^2(6)$= 6795.555, p=0.0000. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Full set of year, country and sector FE dummies are included in the estimation.

Table 5: ISUR estimation results (by sector tech-level)

	GOODS SECTOR								
	Low-tech			Medium-tech			High-tech		
	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}
w_{LS}	0.024***	0.001***	0.002***	-0.001	0.000**	-0.000	0.000***	0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{MS}	0.019***	0.001***	0.001***	-0.008***	-0.000	-0.001***	0.000*	0.000	-0.000*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{HS}	-0.024***	-0.001***	-0.002***	0.016***	0.000	0.001***	-0.000**	-0.000	0.000**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
K	0.034***	0.022***	0.023***	0.046***	0.021***	0.025***	0.021***	0.034***	0.012***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Y	-0.078***	-0.046***	-0.036***	-0.106***	-0.045***	-0.040***	-0.039***	-0.059***	-0.021***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$FVAiX$	-0.024***	-0.003***	-0.001**	0.071***	-0.001*	0.006***	-0.002***	-0.001*	0.000
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
_cons	0.573***	0.314***	0.202***	0.735***	0.316***	0.224***	0.250***	0.361***	0.136***
	(0.02)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Obs.	3,682	3,682	3,682	2,403	2,403	2,403	2,071	2,071	2,071
R-squared	0.482	0.948	0.817	0.474	0.953	0.825	0.963	0.961	0.953

Notes: The set of equations are estimated by ISUR. Breusch-Pagan test of independence: [low] $\chi^2(6)$= 2876.742, p=0.0000; [medium] $\chi^2(6)$= 2294.008, p=0.0000; [high] $\chi^2(6)$= 2617.565, p=0.0000. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Full set of year, country and sector FE dummies are included in the estimation.

Table 5: ISUR estimation results (by sector tech-level) – continued

	SERVICES SECTOR								
	Low-tech			Medium-tech			High-tech		
	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}
w_{LS}	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{MS}	0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{HS}	-0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
K	0.029***	0.079***	0.040***	0.029***	0.079***	0.041***	0.029***	0.079***	0.041***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Y	-0.056***	-0.139***	-0.081***	-0.055***	-0.140***	-0.081***	-0.056***	-0.140***	-0.081***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$FVAiX$	0.000	0.001	0.000	0.000	0.002***	0.001**	0.000**	0.002***	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
_cons	0.349***	0.770***	0.526***	0.349***	0.770***	0.526***	0.349***	0.770***	0.526***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Obs.	1,651	1,651	1,651	4,304	4,304	4,304	3,882	3,882	3,882
R-squared	0.990	0.988	0.981	0.990	0.988	0.981	0.990	0.988	0.981

Notes: The set of equations are estimated by ISUR. Breusch-Pagan test of independence: [low] $\chi^2(6)$= 1138.048, p=0.0000; [medium] $\chi^2(6)$= 2981.426, p=0.0000; [high] $\chi^2(6)$= 2676.014, p=0.0000. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Full set of year, country and sector FE dummies are included in the estimation.

Table 6: ISUR estimation results (by income group)

	Low Income			Lower-middle Income		
	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}
$\boldsymbol{w_{LS}}$	0.006***	-0.000	-0.000	0.004***	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{w_{MS}}$	-0.002**	0.001***	0.001***	0.009***	0.001*	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{w_{HS}}$	-0.003***	-0.000	-0.000	-0.004***	0.001**	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{K}$	0.016***	0.056***	0.065***	0.015***	0.055***	0.064***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{Y}$	-0.053***	-0.098***	-0.092***	-0.049***	-0.099***	-0.093***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{FVAiX}$	-0.012***	0.006***	0.012***	0.002	0.003***	0.008***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
_cons	0.427***	0.571***	0.451***	0.413***	0.584***	0.460***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Obs.	4,286	4,286	4,286	5,167	5,167	5,167
R-squared	0.403	0.876	0.892	0.430	0.880	0.894

	Upper-middle Income			High Income		
	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}
$\boldsymbol{w_{LS}}$	0.003***	-0.000	0.000	0.005***	-0.000	-0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{w_{MS}}$	0.004***	0.001	0.001***	-0.001	0.001	0.002***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{w_{HS}}$	-0.001*	0.000	0.000	-0.001	0.001*	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{K}$	0.012***	0.056***	0.064***	0.015***	0.056***	0.065***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{Y}$	-0.049***	-0.099***	-0.093***	-0.051***	-0.099***	-0.094***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\boldsymbol{FVAiX}$	0.029***	0.002	0.008***	-0.003	-0.001***	0.007***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
_cons	0.422***	0.581***	0.459***	0.419***	0.583***	0.461***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Obs.	4,283	4,283	4,283	4,257	4,257	4,257
R-squared	0.396	0.878	0.893	0.397	0.879	0.894

Notes: The set of equations are estimated by ISUR. Breusch-Pagan test of independence: [low] $\chi^2(6)$= 3635.721, p =0.0000; [lower-middle] χ^2 (6)=4467.928, p =0.0000; [upper-middle] χ^2 (6)=3665.356, p =0.0000; [high] χ^2(6)=3602.589, p=0.0000. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Full set of year, country and sector FE dummies are included in the estimation.

Table 7: ISUR estimation results (by region)

	Asia			Europe			Americas		
	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}	S_{LS}	S_{MS}	S_{HS}
w_{LS}	0.006***	-0.000	-0.000	0.004***	-0.000	0.000	0.003***	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{MS}	0.001	0.002***	0.002***	0.001**	0.000	0.000	0.002	0.001	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
w_{HS}	-0.000	-0.001**	-0.000	-0.003***	0.001***	0.001***	-0.005***	0.000	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
K	0.013***	0.056***	0.064***	0.016***	0.056***	0.065***	0.016***	0.055***	0.064***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Y	-0.048***	-0.098***	-0.092***	-0.052***	-0.099***	-0.094***	-0.055***	-0.098***	-0.093***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$FVAiX$	0.017***	-0.001	0.012***	0.004**	0.003***	0.007***	-0.029**	0.003	0.011**
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
_cons	0.420***	0.573***	0.452***	0.417***	0.584***	0.461***	0.437***	0.575***	0.455***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Obs.	3,969	3,969	3,969	11,990	11,990	11,990	2,034	2,034	2,034
R-squared	0.403	0.877	0.893	0.407	0.879	0.893	0.386	0.876	0.892

Notes: The set of equations are estimated by ISUR. Breusch-Pagan test of independence: [Asia] $\chi^2(6)$= 3397.848, p=0.0000; [Europe] $\chi^2(6)$= 10241.881, p=0.0000; [Americas] $\chi^2(6)$= 1717.434, p=0.0000. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Full set of year, country and sector FE dummies are included in the estimation.

Table 8: Elasticities of FVAiX

	S_L	S_M	S_H
All	-0.096***	0.081***	0.070***
	(0.01)	(0.01)	(0.01)
Sector			
Goods	0.197***	-0.023***	0.025***
	(0.06)	(0.00)	(0.01)
Services	0.005**	0.020***	0.011**
	(0.00)	(0.00)	(0.00)
Income group			
Low	-0.182***	0.081***	0.183***
	(0.07)	(0.02)	(0.02)
Lower-middle	0.036	0.038***	0.115***
	(0.04)	(0.01)	(0.01)
Upper-middle	0.450***	0.020	0.116***
	(0.09)	(0.03)	(0.03)
High	-0.053	0.007	0.104***
	(0.07)	(0.02)	(0.02)
Tech-type			
Low-tech goods	-0.373***	-0.037***	-0.018**
	(0.09)	(0.01)	(0.01)
Medium-tech goods	1.110***	-0.012*	0.096***
	(0.11)	(0.01)	(0.01)
High-tech goods	-0.031***	-0.013*	0.004
	(0.01)	(0.01)	(0.00)
Low-tech services	0.006	0.015	0.005
	(0.01)	(0.01)	(0.01)
Medium-tech services	0.002	0.019***	0.014**
	(0.00)	(0.01)	(0.01)
High-tech services	0.008**	0.022***	0.009
	(0.00)	(0.01)	(0.01)
Region			
Asia	0.264***	-0.008	0.184***
	(0.09)	(0.03)	(0.03)
Europe	0.065**	0.037***	0.106***
	(0.03)	(0.01)	(0.01)
Americas	-0.456**	0.042	0.174**
	(0.21)	(0.07)	(0.07)

Notes: The elasticities are based on the estimates from the baseline regression results reported in Tables 3-7. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix

Table A.1: List of industries and their corresponding sector and tech-type classifications

(35 industries)

Abbrev.	**Industry**	**Sector**	**Tech**
AHFF	Agriculture, Hunting, Forestry and Fishing	Agriculture	Low
MNQR	Mining and Quarrying	Agriculture	Med
FBAT	Food, Beverages and Tobacco	Manufacturing	Low
TATP	Textiles and Textile Products	Manufacturing	Low
LLAF	Leather, Leather and Footwear	Manufacturing	Low
WPWC	Wood and Products of Wood and Cork	Manufacturing	Low
PPPP	Pulp, Paper, Paper , Printing and Publishing	Manufacturing	Med
CPNF	Coke, Refined Petroleum and Nuclear Fuel	Manufacturing	Med
CACP	Chemicals and Chemical Products	Manufacturing	High
RUPL	Rubber and Plastics	Manufacturing	Med
ONMM	Other Non-Metallic Mineral	Manufacturing	Low
BMFM	Basic Metals and Fabricated Metal	Manufacturing	Low
MNEC	Machinery, Nec	Manufacturing	High
ELOE	Electrical and Optical Equipment	Manufacturing	High
TREQ	Transport Equipment	Manufacturing	High
MNRE	Manufacturing, Nec; Recycling	Manufacturing	Med
EGWS	Electricity, Gas and Water Supply	Services	Med
CNST	Construction	Services	Low
SMRM	Sale, Maintenance and Repair of Motor Vehicles Retail Sale of Fuel	Services	Low
WTCT	Wholesale Trade and Commission Trade, Except of Motor Vehicles	Services	Med
RETR	Retail Trade, Except of Motor Vehicles ; Repair of Household Goods	Services	Med
HORE	Hotels and Restaurants	Services	Low
INTR	Inland Transport	Services	Med
WATR	Water Transport	Services	Med
ARTR	Air Transport	Services	High
OSAT	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	Services	Med
PTEL	Post and Telecommunications	Services	Med
FINI	Financial Intermediation	Services	High
REEA	Real Estate Activities	Services	Med
RENT	Renting of M&Eq and Other Business Activities	Services	High
PASS	Public Admin and Defense; Compulsory Social Security	Services	High
EDUC	Education	Services	High
HESS	Health and Social Work	Services	High
OCSP	Other Community, Social and Personal Services	Services	High
PHEP	Private Households with Employed Persons	Services	High

Table A.2: Alphabetical country codes and list of countries by income group

Code	Country	Group	Code	Country	Group	Code	Country	Group	Code	Country	Group
AUS	Australia	**3**	**EST**	Estonia	**2**	**JPN**	Japan	**3**	**RUS**	Russia	**1**
AUT	Austria	**4**	**FIN**	Finland	**4**	**LVA**	Latvia	**2**	**SVK**	Slovak Republic	**2**
BEL	Belgium	**3**	**FRA**	France	**3**	**LTU**	Lithuania	**2**	**SVN**	Slovenia	**2**
BRA	Brazil	**1**	**DEU**	Germany	**3**	**LUX**	Luxemboburg	**4**	**KOR**	South Korea	**2**
BGR	Bulgaria	**1**	**GRC**	Greece	**2**	**MLT**	Malta	**2**	**ESP**	Spain	**3**
CAN	Canada	**3**	**HUN**	Hungary	**2**	**MEX**	Mexico	**1**	**SWE**	Sweden	**4**
CHN	China	**1**	**IND**	India	**1**	**NLD**	Netherlands	**4**	**TWN**	Taiwan	**2**
CYP	Cyprus	**3**	**IDN**	Indonesia	**1**	**POL**	Poland	**2**	**TUR**	Turkey	**1**
CZE	Czech Republic	**2**	**IRL**	Ireland	**4**	**PRT**	Portugal	**2**	**GBR**	United Kingdom	**4**
DNK	Denmark	**4**	**ITA**	Italy	**3**	**ROU**	Romania	**1**	**USA**	United States	**4**

Notes: The categorization is based on the values for GDP per capita (in current USD) in 2007 from the World Development Index. The 1st quantile is 11,155.83, the 2nd is 27,478.21, the 3rd is 44,654.56, and the 4th is 107,098.7.