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Offshoring: What Consequences for Workers? Evidence from Global Value Chains

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Abstract

This paper investigates the question which aspects of offshoring harm low skilled workers using data from the WIOD for 14 manufacturing industries in 16 countries between 1995 and 2008. By considering the use of foreign production factors in domestic production, the paper shows that low skilled workers are *directly* and negatively affected by offshoring of low skilled tasks. Importantly, the paper determines a further *indirect* channel highlighting the role of growing foreign competition in domestic markets for intermediate goods.Accordingly, wage shares of low skilled workers decline when competition in domestic downstream value chains increases. Interpreting this channel in the light of the literature on defensive skill-biased innovation, the shift in wage shares away from low skilled workers might be provoked by skill intensive investments in response to tougher foreign competition in domestic markets for intermediate goods.

JEL classification: F23, L23, L24, M11.

Keywords: Global value chains, Input–Output Tables and Analysis, Organization of Production, Empirical Studies of Trade.

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1 Introduction

Over the past decades, value chains underwent a fundamental transition. Especially in high wage economies, declining transportation and coordination costs motivated entrepreneurs to "slice up" their value chains by breaking the production process into many geographically separated steps (Feenstra and Hanson, 2001; Krugman et al., 1995). At the same time, these countries experienced a profound decline in the employment and wages of low skilled manufacturing workers. With regard to the simultaneous occurrence of these two phenomena, the apparent causation of declining manufacturing employment and wages lies in the emergence of global value chains.

However, the identification of mechanisms, how global value chains affect labor markets, is not trivial and is subject to a controversial debate ever since. In a theoretical context, consequences of offshoring on workers have most prominently been debated by Feenstra and Hanson (1995, 1997) as well as Grossman and Rossi-Hansberg (2008). On the one hand, Feenstra and Hanson (1995, 1997) develop a model showing that offshoring leads to a decline in relative employment and wages for unskilled workers in the offshoring country. On the other hand, Grossman and Rossi-Hansberg (2008) highlight productivity gains for factors whose tasks have been moved offshore in the long run, thus showing that offshoring can be even beneficial for low skilled workers.

The related empirical literature identified rather detrimental effects for low skilled workers. Accordingly, various studies showed that offshoring not only affects relative employment and wages of low skilled workers but also raises the probability of displacement and job changes to lower paid non-manufacturing sectors (see e.g. Egger and Egger (2005) and Geishecker (2006) for empirical evidence of the former; Geishecker (2008) and Ebenstein et al. (2015, 2014) for employment and wage dynamics).

Yet, there exist two core shortcomings of the cited empirical literature. First, the use of traditional trade data as proxy for offshoring risks to misjudge consequences for domestic workers. Given the high degree of international fragmentation of value chains, export flows are no longer fully attributable to the country of origin as exports contain foreign value added as well as purely double counted flows. Second, existing empirical studies focus on analyzing effects from offshoring occurring in the upstream value chain of the considered sector itself. Still, this approach neglects that workers are not only affected *directly* by the reorganization of the sector's own upstream value chain. Workers might also be affected *indirectly* when domestic downstream clients get increasingly involved in offshoring. As this development alters the degree of foreign competition in domestic downstream value chains, it potentially forces sectors to reorganize their production and may not be ignored when impacts on low skilled workers are assessed.

Therefore, the present chapter ties up with the research question of Feenstra and Hanson (2001) by using an offshoring proxy expressed in terms of value added and by taking into account that offshoring not only occurs in a sector's own upstream value chain but also in value chains of domestic downstream clients.[1] In view of the fact that especially manufacturing industries in high wage countries relocated parts of their production to destinations with more favorable conditions, this question is evaluated for fourteen manufacturing sectors in sixteen high wage countries between 1995 and 2008.[2]

Within this framework, the present chapter uses the decomposition approach presented in Miller and Blair (2009) and data from the World Input-Output Database (WIOD) to define both offshoring of the regarded sector itself and the degree of foreign competition in domestic downstream industries in terms of foreign value added. In this context, it is crucial to highlight that the use of data from the WIOD's socio economic accounts allows to trace how much foreign capital and labor entered domestic production. This strategy allows to examine precisely if and to what extent the use of foreign production factors led to a shift in the demand for domestic low skilled workers.

Regression results show that low skilled workers are *indirectly* and negatively affected by growing competition in domestic downstream value chains. Accordingly, the wage share of low skilled workers decreases in response to stronger competition in domestic downstream sectors. This result can be interpreted in the light of theoretical and empirical evidence on defensive skill biased innovation (Anderton and Oscarson, 2002; Dutt and Traca, 2010; Thoenig and Verdier, 2003; Wood, 1995). Although this chapter does not provide a formal evidence of the theoretical model, regression results suggest that declining wage shares of low skilled workers might have been driven by defensive skill biased innovation. Following this approach, tighter competition in domestic downstream value chains urges firms to

[1] In this context, offshoring has to be distinguished from *outsourcing*. While the latter describes the decision of a firm to produce intermediates within the boundaries of a firm or sourcing intermediates from external suppliers, the former describes the reallocation of production steps abroad. As *outsourcing* is only observable at the detailed firm level, this chapter considers offshoring in its broadest definition, where intermediates are sourced from abroad either from a subcontractor or from an affiliate.

[2] Throughout this chapter, high wage countries are defined based on thresholds of the World Bank to classify countries as high income countries based on their GNI. As Greece, Korea, Portugal and Taiwan are only marginally above the threshold of the high income class, these countries are left out of the sample.

undertake investments in more skill intensive technology so that demand shifts towards more skilled labor thereby negatively affecting low skilled workers. Regarding the *direct* impact of offshoring, the relocation of low skill tasks was identified as main driver behind the declining wage bill share of low skilled workers hence supporting the theoretical implications highlighted by Feenstra and Hanson (1995, 1997).

The remainder of the chapter is structured as follows. Section 2 briefly presents the current state of literature. In order to outline the procedure and findings of this chapter in a conclusive way, section 3 provides an overview about the empirical strategy pursued in this study. Subsequently, section 4 presents the underlying data. In section 5, regression results of wage share changes on offshoring are analyzed while the final section 6 concludes.

2 Literature Review

The present chapter builds on mainly two streams of empirical literature. First, there are numerous studies aiming at assessing to what extent technical change and offshoring contributed to the decline of employment and wages of low skilled workers, while, second, there are recent contributions on the methodical fundamentals to map and analyze global value chains.

Regarding the former, the question of how technical change affects the demand for differently skilled labor regained importance when developed countries started to invest heavily in skill demanding information and communication technologies as well as in RnD. In the wake of this development, skill biased technological change was identified as driving force behind the increasing demand for skilled labor and the declining need for low skilled workers (Berman et al., 1994; Michaels et al., 2014).

To determine further drivers of growing wage and employment inequalities between differently skilled workers, many papers devoted attention to the role of offshoring. Focusing on different country settings and levels of data aggregation material offshoring was determined as a main driving force for the worsening wage and employment inequality between high and low skilled workers (Crinò, 2009). In this context, it has been shown that offshoring of especially low skill intensive activities to destinations with lower wages significantly accounted for rising wage and employment differences over the past decades in countries like the US, Austria or Germany (Crinò, 2009; Egger and Egger, 2005; Feenstra and Hanson, 1996, 1999; Geishecker, 2006; Lorentowicz et al., 2008). Yet, different from these implications, there also exist studies detecting no significant effect from neither material nor service offshoring on employment when focusing on the US from 1992 up to the millenium (Amiti and Wei, 2009). Turning the focus to short-run employment dynamics based on individual worker level data, related studies confirm negative effects from offshoring on particularly low skilled workers. Accordingly, it has been shown that offshoring raises the probability of displacement, lowers low skilled wages within firms and especially forces workers performing routine tasks in manufacturing industries to switch to lower paid jobs outside of manufacturing (Ebenstein et al., 2015, 2014; Geishecker, 2008; Hummels et al., 2014; Munch, 2010).

Regarding technical approaches to map global value chains, the fundamentals were defined by Wassily Leontief in the 1930's. Based on the input-output structure across industries, Leontief (1936) conceptualized the so called Leontief inverse matrix allowing to determine the output of an industry, which is necessary to sustain the production of a unit of a final good (worth one dollar) of another industry. In the wake of growing trade volumes within global value chains, the Leontief inverse was rediscovered to serve as a useful tool to disentangle domestic and foreign value contributions in both the overall production and the production of exports (Koopman et al., 2014; Miller and Blair, 2009; Wang et al., 2013). Importantly, these frameworks allowed to integrate already existing measures of global value chain participation. These measures were in particular the vertical specialization (VS) measure and several variations thereof like the VS1 or VS1*. More precisely, they measure global value chain participation as the foreign value added in the production of exports (VS), the value of intermediates entering the production of third countries (VS1) and the domestic value added used as intermediate input by other countries before finally returning to the home country(VS1*) (Daudin et al., 2011; Hummels et al., 2001). Used in conjunction with input-output databases like the Global Trade Analysis Project (GTAP) database, OECD Inter Country Input-Output (ICIO) data or the WIOD, the concepts to trace value added provide valuable insights into the altering production structure. In this context, it could be shown that the international fragmentation of value chains increased substantially from the 1990-ies onwards with a growing share of value added by capital and high skilled labor (Los et al., 2015; Timmer et al., 2014). Regarding consequences of these findings for low skilled workers, both offshoring and the increased use of capital in production were identified to have equally contributed to the low skilled workers' decrease in employment (Reijnders et al., 2016).

The subsequent section will outline how the cited technical approaches are used in this chapter to identify how low skilled workers were affected by the reorganization of value chains.

3 Theoretical Background and Empirical Strategy

A crucial step to empirically evaluate effects of offshoring on workers, is to find a functional form allowing to theoretically link labor market outcomes with a proxy for offshoring. In this context, the usage of a translog cost function offers some helpful properties as it permits to derive the link between wage shares of differently skilled workers and structural variables. First used by Berman et al. (1994) and later by Feenstra and Hanson (2001), the translog cost function established itself as standard approach in the literature to assess relative labor demand and wage effects *within* industries. Before turning to the empirical specification of the translog function used in this paper, the following section highlights the main features of the theoretical mechanism of Feenstra and Hanson (2001) and demonstrates their approach to treat offshoring as an exogenous variable.

3.1 Theoretical Background

The derivation of the translog function used in this chapter closely follows the model of Feenstra and Hanson (2001). Accordingly, it is assumed that two inputs y_i, $i = 1, 2$, are used to produce a final manufacturing good m. The production of y_i requires high skilled labour H, low skilled labor L as well as capital K and takes the form of a concave and linearly homogenous production function: $y_i = f_i(L_i, H_i; K_i), \quad i = 1, 2.$[3] With the production of y_1 being low skill labor intensive and the production of y_2 being high skill labour intensive, it is assumed that some low skill labor intensive inputs can be imported from abroad, $x_1 < 0$, while high skill intensive inputs can be exported, $x_2 > 0$. To produce good m, y_1 and y_2 are bundled together so that the production of the final manufacturing

[3]As outlined in subsection 4.2, high and medium skilled labour are grouped together as high skilled labour H. This aggregation might be challenged regarding the empirical finding on polarization of skill demand to the detriment of medium skilled workers (Michaels et al., 2014). As the present chapter aims at identifying drivers of declining wage shares of *low* skilled workers, it is important to isolate the wage share of *low* skilled workers from wage shares of *medium* skilled workers. Given that the aggregation of high and medium skilled workers as high skilled labor H represents the counterpart of changes in wage shares of low skilled workers, each decline in wage shares of medium skilled workers is mitigating the decrease of low skilled workers' wage share. Consequently, grouping high and medium skilled labor in one category is working against any mechanism related to the decline in wage shares of low skilled and is thus preferable over an aggregation of low and medium skilled labour.

product corresponds to: $y_m = f_m(y_1 - x_1, y_2 - x_2)$.

The optimal output of the industry is obtained by maximizing the revenue function of final good m taking into account the production of inputs as well as the following factor constraints: $L_1 + L_2 = L_m,\ H_1 + H_2 = H_m,\ K_1 + K_2 = K_m$. The revenue function including the price of the final good p_m and p as the price of the imported intermediate input hence reads:

$$F_m(L_m, H_m, K_m, p_m, p) = p_m f_m(y_1 - x_1, y_2 - x_2) + px_1 + x_2 \tag{1}$$

Defining $V_m = F_m(L_m, H_m, K_m, p_m, p)$ as the optimized value of equation 1 measuring the value added of sector m and defining F_m as the aggregate production function of m, it is possible to specify the corresponding *short-run cost function* with low skilled wages w and high skilled wages q in the following form:

$$C_m(w, q, V_m, p, p_m) = wL_m + qH_m \tag{2}$$

Importantly, this equation assumes capital to be quasi fixed so that low and high skilled labor represent the variably chosen production factors. As the cost minimization at the aggregated level for sector m also requires a cost minimization for the production of inputs y_1 and y_2, it is also possible to define the following cost functions: $C_i(w, q, Y_i) = wL_i + qH_i, \quad i = 1, 2$. To demonstrate how offshoring impacts the use of high and low skilled labour in production of m, it is important to consider the unit-cost function $c_i(w, q)$ implied by the cost function of inputs i: $C_i(w, q, Y_i) = Y_i c_i(w, q)$. In this context, the zero profit conditions for inputs y_1 and y_2 correspond to $p = c_1(w, q)$ as well as $1 = c_2(w, q)$ ensuring that domestically produced inputs are competitive with foreign inputs at world market prices p and unity.

The reasoning how offshoring impacts workers starts with the assumption that there is an exogenous price decrease of the low skilled labor intensive input from p to p'. As this price decrease favors the use of imported intermediates, x_1 increases. Given the zero profit condition for $p' < p$, unit costs of the low skilled intensive input c_1 decline thus triggering a decrease in the relative wage of low skilled workers w.

3.2 The Translog Cost Function

In order to capture these theoretical dynamics empirically, the cost function of equation 2 is proxied by a translog cost function.

$$\begin{aligned}\ln C = \; & \ln \frac{1}{1-\mu} + \alpha_h \ln w_h + \alpha_l \ln w_l + \alpha_v \ln V + \alpha_k \ln K \\ & + \frac{1}{2}[\beta_{hh} \ln w_h^2 + \beta_{hl} \ln w_h \ln w_l + \beta_{lh} \ln w_l \ln w_h \\ & + \beta_{ll} \ln w_{ll}^2 + \beta_{kk} \ln K^2 + \beta_{vv} \ln V^2] \\ & + \gamma_{hk} \ln w_h \ln K + \gamma_{hv} \ln w_h \ln V \\ & + \gamma_{lk} \ln w_l \ln K + \gamma_{lv} \ln w_l \ln V \\ & + \gamma_{kv} \ln K \ln V\end{aligned} \tag{3}$$

Given equation 3, the use of Shephard's lemma allows to determine the demand for a certain factor by deriving the total costs function with respect to the price of this particular factor. In the present case, Shephard's lemma can be expressed as: $\frac{\partial C}{\partial w_l} = S_l$. Thus, the cost share of e.g. *low* skilled labour can be obtained by deriving the translog cost function with respect to $\ln w_l$.

$$\frac{\partial \ln C}{\partial \ln w_l} = S_l = \alpha_l + \beta_{ll} \ln w_l + \beta_{lh} \ln w_h + \gamma_{lk} \ln K + \gamma_{lv} \ln V \tag{4}$$

It holds that $\beta_{ll} + \beta_{lh} = 0$ due to the homogeneity of cost shares of degree zero as well as $\gamma_{lk} + \gamma_{lv} = 0$ due to the linear homogeneity of the production function.[4] While equation 4 can be estimated over time for a given industry, this chapter follows the approach of Berman et al. (1994) and Feenstra and Hanson (2001) who obtain estimation coefficients by pooling data across industries. To ensure that data for the regression can be pooled across different industries, the chapter relies on the assumption that the above stated cost function holds true for all (manufacturing) sectors (Feenstra and Hanson, 2001). In line with Berman et al. (1994) and Feenstra and Hanson (2001), it is further assumed that variations of wages are only driven by quality-variation of workers and are therefore containing little information across industries. Consequently, wage terms are dropped from the right-hand side of equation 4. Importantly, it is then possible to add all cost shifting parameters such as the stock of capital, value added, technological change (Berman et al., 1994) or offshoring (Feenstra and Hanson, 2001).

[4] Symmetry implies $\beta_{lh} = \beta_{hl}$.

As outline in the previous subsection, offshoring is considered as a direct consequence from an exogenous decrease of imported input prices triggered by e.g. declining transport or coordination costs. Consequently, offshoring itself can be perceived as exogenous demand shifter affecting relative cost shares of variable input factors H and L.[5] The choice to distinguish two skill types of workers in this chapter is mainly driven by practical reasons related to the distinction of skills in the data. As outlined in greater detail in section 4, it might be problematic that skill categories differ across countries due to discrepancies in the national education system. In this context, grouping high and medium skilled workers together allows to distinguish if a worker holds any high school or college diploma or no diploma at all (low skilled). Therefore, the present chapter distinguishes high skilled workers H, grouping together high- and medium skilled workers and low skilled workers L. Thus, the wage share of labour with skill level $j \in \{h, l\}$ is regressed on the domestic real capital stock, K, real value added, V, and offshoring, O (as cost shifting parameter).Taking the difference between two subsequent years, the estimation equation for workers of skill level j in industry i and country c at time t becomes:

$$\Delta S^{j}_{cit} = \alpha_{ct} + \beta \Delta \ln K_{cit} + \delta \Delta \ln V_{cit} + \theta \Delta \ln O_{cit} \tag{5}$$

Thus, changes in cost shares of low or high skilled workers are explained by the real capital stock and real value added of an industry as well as by the change of the degree of offshoring triggered by exogenous price decreases of foreign intermediates. Subsequently, it will be outlined how the more detailed proxy for offshoring used in this chapter is derived.

3.3 Expressing Offshoring in terms of Foreign Value Added

In their seminal paper on the impact of offshoring on labor market outcomes, Feenstra and Hanson (2001) refer to the share of imported intermediates in total intermediate inputs as a proxy for offshoring. Yet, as stated introductory, in the presence of global value chains, traditional trade statistics lose their reliability to accurately depict value and factor flows among countries as imports are no longer fully attributable to the country of origin. Hence, relying on imported intermediates as offshoring proxy neglects the fact that imports also

[5] It should be noted that the use of a translog cost function also allows to abstain from investigating the question whether the increase in offshoring has been induced by a supply or a demand shock (like e.g. Autor et al. (2013)). As both supply and demand shocks can be considered as scaling parameters, they would not structurally shift cost among high and low skilled workers. Thus, in a translog framework, the dependent variable would be untouched.

contain value added from the importing country itself due to the involvement of domestic upstream industries in global value chains.[6] Given these closely intertwined production chains, the present chapter relies on the concept of tracing value added in production.[7] As this approach allows to disentangle foreign and domestic value added in production, it is a suitable concept to distinguish among the value of intermediates sourced from abroad and those sourced from domestic suppliers.[8]

Technically, the computation of value added by production factors located abroad and domestically is based on the usage of detailed input-output statistics. As it will be shown in section 4, these statistics provide data on the input and output structure among industries and countries. Starting with these data, it is possible to express the input-output identity. This identity can be written as $X = A \cdot X + Y$, where X is an output vector of dimension CS x 1, for c countries and s sectors, A is a CS x CS matrix containing input-output coefficients and Y is a final good vector of dimension CS x 1.[9] The equation basically states that output is either used to produce intermediate or final goods. On that basis, a so-called Leontief inverse or total requirement coefficient, $(I - A)^{-1} = B$, can be derived which provides information on the amount of a country or industry's gross output needed to produce an extra unit of a final good.[10] In order to trace the value contribution of industries, a vector describing the direct value added per unit of output, V, can be added. The resulting equation in more detailed matrix notation for two countries (c and p) and two industries (1 and 2) hence reads: [11]

[6] To provide an example, one might consider the German automotive industry. Let a German supplier of car components deliver intermediates to Poland for further processing. If these further processed components are re-imported to Germany, these imports contain not only value added by Polish firms but also value added by the German supplier of car components who was involved in the upstream production process and initially exported these intermediates.

[7] An alternative proxy would have been the vertical specialization (VS) indicator as proposed by Hummels et al. (2001) and conceptualized by Koopman et al. (2014) and Wang et al. (2013). Yet, by measuring the foreign value added in the production of *exports*, the VS indicator represents only a subset of foreign value added as it neglects foreign value added in the production of goods destined for the domestic market. Given that the wage shares are determined by the use of labor in total production, foreign value added is most suited to explain changes in workers' wage shares.

[8] At this point it should be noted that the chapter relies on an offshoring proxy in a *broad* rather than a *narrow* sense. While the *narrow* concept of offshoring only regards foreign value added from the same sector, the *broad* concept regards foreign value added stemming from all industries. As value chains are increasingly fragmented across both borders and sectors, the *broad* concept is more prone to capture the magnitude of offshoring accurately. See Crinò (2009) for an overview about the use of the *broad* and *narrow* concept in the empirical literature.

[9] More precisely, matrix A contains input-output coefficient, a_{12}^{pc} describing units of intermediate goods produced by sector 1 of country p used in the production of one unit gross output produced by sector 2 in country c (Koopman et al., 2014).

[10] Originally conceptualized by Wassily Leontief (1936), this basic relationship can be expressed mathematically as $X = (I - A)^{-1}Y$ or, more simplified, as $X = B \cdot Y$, where $B = (I - A)^{-1}$.

[11] In this setting, $\hat{V}$ and $\hat{Y}$ refer to the value added and the final goods consumption vector written as

$$\hat{V}B\hat{Y} = \begin{pmatrix} v_1^c & 0 & 0 & 0 \\ 0 & v_2^c & 0 & 0 \\ 0 & 0 & v_1^p & 0 \\ 0 & 0 & 0 & v_2^p \end{pmatrix} \begin{pmatrix} b_{11}^{cc} & b_{12}^{cc} & b_{11}^{cp} & b_{12}^{cp} \\ b_{21}^{cc} & b_{22}^{cc} & b_{21}^{cp} & b_{22}^{cp} \\ b_{11}^{pc} & b_{12}^{pc} & b_{11}^{pp} & b_{12}^{pp} \\ b_{21}^{pc} & b_{22}^{pc} & b_{21}^{pp} & b_{22}^{pp} \end{pmatrix} \begin{pmatrix} y_1^c & 0 & 0 & 0 \\ 0 & y_2^c & 0 & 0 \\ 0 & 0 & y_1^p & 0 \\ 0 & 0 & 0 & y_2^p \end{pmatrix}$$
$$= \begin{pmatrix} v_1^c b_{11}^{cc} y_1^c & v_1^c b_{12}^{cc} y_2^c & v_1^c b_{11}^{cp} y_1^p & v_1^c b_{12}^{cp} y_2^p \\ v_2^c b_{21}^{cc} y_1^c & v_2^c b_{22}^{cc} y_2^c & v_2^c b_{21}^{cp} y_1^p & v_2^c b_{22}^{cp} y_2^p \\ v_1^p b_{11}^{pc} y_1^c & v_1^p b_{12}^{pc} y_2^c & v_1^p b_{11}^{pp} y_1^p & v_1^p b_{12}^{pp} y_2^p \\ v_2^p b_{21}^{pc} y_1^c & v_2^p b_{22}^{pc} y_2^c & v_2^p b_{21}^{pp} y_1^p & v_2^p b_{22}^{pp} y_2^p \end{pmatrix} \quad (6)$$

In order to trace the value added by both domestic and foreign upstream suppliers, it is necessary to consider different entries within a column.[12] This perspective reveals the value contribution of country-sectors (given by the row) to the production of another country-sector (given by the column). For example, $v_1^p b_{11}^{pc} y_2^c$ indicates the foreign value added of sector 1 in country p included in the production process of sector 2 in country c. Consequently, by summing across all rows within the column, one obtains the absolute total value of final goods production in country c's industry 2, y_2^c.

In general notation the calculation of foreign value added (FVA) can be written as depicted in equation 7. As the set of partner countries varies by the respective country for which the formula is given, the set of partner countries should have an index for the country to which the equation is referring p_c. However, in order to simplify the notation throughout the paper, subscripts are omitted so that formulas are given for a manufacturing industry i in a specific country c for its respective set of partner countries P. Consequently, equation 7 depicts the calculation of FVA from all manufacturing and non-manufacturing industries j in partner country $p \neq c$ used in production of a final good produced by any arbitrary manufacturing industry i in country c:

$$FVA_i^c = \sum_{p \in P} \sum_{j \in J} v_j^p b_{ji}^{pc} y_i^c \quad (7)$$

diagonal matrix.

[12] See Wang et al. (2013) for a discussion on the different interpretation of elements along a column as well as along a row.

In this context, it is crucial to highlight the role of foreign production factors entering domestic production. By using imported intermediates, producers (in)directly employ foreign capital and labor. Thus, the total value of a final product can not only be decomposed into domestic and foreign value added but also according to domestic and foreign capital and labor. As the value added is the sum of capital and labor reimbursement, it is possible to rewrite equation 7 as follows below where single elements are obtained by merely post-multiplying the matrix presented in equation 6 by vectors of capital and labor shares (high, h, and low skilled, l) in value added:[13]

$$FVA_i^c = \sum_{p\in P}\sum_{j\in J} cap_j^p b_{ji}^{pc} y_i^c + \sum_{p\in P}\sum_{j\in J} h_j^p b_{ji}^{pc} y_i^c + \sum_{p\in P}\sum_{j\in J} l_j^p b_{ji}^{pc} y_i^c \quad (8)$$

Turning back to regression equation 5, these three variables are added as refined offshoring proxies. Still, to ensure that estimates for offshoring proxies are not obscured by skill biased technical change causing a shift between the use of different production factors, individual variables are normalized by the respective total factor use. Regarding for example capital, the total amount of foreign capital in the production of a manufacturing industry i located in country c is calculated as the sum of capital stemming from all manufacturing and non-manufacturing industries j of a partner country $p \neq c$ and is divided by the overall use of capital from country c as well as all partner countries p (captured as country set Z).

$$foreignCAP_i^c = \frac{\sum_{p\in P}\sum_{j\in J} cap_j^p b_{ji}^{pc} y_i^c}{\sum_{z\in Z}\sum_{j\in J} cap_j^z b_{ji}^{zc} y_i^c}$$

This approach is hence capturing the amount of a production factor which is sourced from abroad (sum across all manufacturing and non-manufacturing industries j from partner countries P) in relation to the total respective factor use (from all manufacturing and non-manufacturing industries j in the set of countries Z including both country c itself and all partner countries P). In line with the reasoning of Feenstra and Hanson (2001) outlined in subsection 3.1, offshoring is considered as optimal response to exogenous changes in the price of imported intermediates and may hence be perceived as exogenous cost shifter for high and low skilled labor in production. While Feenstra and Hanson (1996, 1999) use the share of imported intermediates in production as proxy for offshoring, the present chapter relies on a refined calculation of offshoring based on the amount of foreign production

[13] This relation can be expressed as: $\frac{V}{X} = \frac{CAP}{X} + \frac{H}{X} + \frac{L}{X}$ or $v = cap + h + l$, where capital letters refer to values as given in the data and small letters refer to the values per unit of output. These vectors can be used like the direct value added vector in equation 6. (see Online Appendix of Timmer et al. (2014))

factors in total factor use thus allowing to disentangle whether changes in the wage share of low skilled workers are driven by an implicit relocation of low skill tasks abroad.[14] The first refined regression equation hence reads:[15]

$$\begin{aligned}\Delta S^{j}_{cit} &= \alpha_{ct} + \beta\Delta\ln K_{cit} + \delta\Delta\ln V_{cit} \\ &+ \theta\Delta\ln foreignCAP_{cit} + \gamma\Delta\ln foreignH_{cit} + \mu\Delta\ln foreignL_{cit}\end{aligned} \tag{9}$$

Based on this equation, the following subsection outlines how a measure of downstream competition can be added.

3.4 Measuring the Degree of Foreign Competition in Domestic Downstream Value Chains

As stated in the introduction, the present chapter not only assesses consequences from offshoring when a sector reorganizes its proper upstream value chain but also takes into account that offshoring occurs in the value chains of domestic downstream clients. Given the latter, the degree of foreign competition faced by an industry in its domestic downstream value chain changes considerably.

In order to numerically capture the magnitude of the exposure to foreign competition in domestic downstream value chains, it is necessary to consider the upstream value chains of all domestic downstream clients of an industry. As an example, one might consider industry i in country c which provides intermediates to the domestic sector j. In that case, the exposure to foreign competition in the value chain of sector j is measured as the value added by a foreign industry i in the value chain of sector j as a share in the total value added sourced from sector i domestically and abroad. This approach is hence posing the question how much domestic downstream clients purchase from abroad instead of sourcing intermediates from the domestic industry.[16]

In more general notation for a set of j manufacturing and non-manufacturing downstream

[14] As stated in subsection 3.2., the optimization of the short run cost function underlying the regression equation assumes capital to be quasi fixed. Adding foreign capital as cost shifting variable is hence implicitly assuming that foreign capital can be adjusted more easily. In this context, it is important to stress that the procurement abroad does not require a physical investment but might also use capital invested from local suppliers.

[15] Due to linear homogeneity it holds that $\beta = -\delta$.

[16] To confirm that changes in foreign value added are reflecting tougher competition rather than changes in direct value added coefficients due to technical change captured in v, a figure of standard errors of the ratio between material input and value added is provided in the Appendix. As the standard deviation is lower than 0.1 for the vast majority of country-industries of the sample, it can be assumed that changes in foreign value added are driven by tougher competition rather than by changes in v.

industries, a set of foreign suppliers P and a set of countries Z, which comprises the set of foreign suppliers P and country c itself, this approach can be expressed as follows:[17]

$$DS_i^c = \frac{\sum_{j\in J}\sum_{p\in P} v_i^p b_{ij}^{pc} y_j^c}{\sum_{j\in J}\sum_{z\in Z} v_i^z b_{ij}^{zc} y_j^c} \tag{10}$$

Technically, the nominator of equation 10 captures payments from the production of final goods in downstream industries j located in country c to manufacturing industry i anywhere in the world except country c itself while the denominator captures total payments of the same industries j in c to industry i anywhere in the world including c.

With respect to the integration of this variable (hereinafter "DS variable") into the regression equation, it is important to stress that there is no direct mechanism explaining the effect of an increased import competition in value chains of domestic downstream clients on workers' wage shares. In the first place, increased competition in domestic downstream sectors lowers intermediate sales of manufacturers as domestic downstream clients purchase goods from foreign competitors instead of sourcing them domestically. Consequently, tougher competition in domestic downstream value chains primarily scales down sales thus equally affecting low and high skilled workers rather than shifting costs among high and low skilled. In this context, the DS variable has to be considered in conjunction with other parameters to explain how tougher competition in domestic downstream value chains of an industry shifts costs among high and low skilled workers. Recalling that the regression presented in equation 9 is estimating the direct impact of cost shifting structural variables on the wage shares of differently skilled workers, the impact of the DS variable has to be considered rather indirectly.

The link between growing import competition in value chains of domestic downstream clients and changes in workers' wage shares can be established in the light of defensive skill biased innovation as first defined by Wood (1995) and later theoretically derived and empirically confirmed by Thoenig and Verdier (2003), Anderton and Oscarson (2002) and Dutt and Traca (2010). In general, the present chapter does not aim at providing detailed empirical evidence for the theory of defensive skill biased innovation. Still, this theory offers a further approach to explain declining wage shares of low skilled workers in response to increasing competition in the broad sense. Accordingly, the theoretical

[17] Like in subsection 3.2, this equation suppresses subindices. As the set of downstream variables varies depending on the considered manufacturing industry i, all indices j should ideally have a subindex i, thus j_i. Still, for simplicity, these subindices are omitted and equations are provided for an example of a manufacturing industry i in country c with a specific set of downstream industries j.

concept of defensive skill biased innovation points to the fact that globalization might also increase the threat of product or process imitation. Thoenig and Verdier (2003) develop an innovation growth model in which firms defend their competitive position by investing in new technology to immunize their products and production processes against imitation.[18] As these investments favor the use of skilled labor, firms tend to substitute low skilled by more skilled workers.

In the context of the present paper, one might hence hypothesize that the increasing competition in domestic downstream value chains indirectly affects the wage share of low skilled workers in the regarded industry through increased skill intensive innovation. Following this line of reasoning, it is important to highlight that the emergence of China and other low wage countries with a low enforcement of intellectual property rights intensified the threat of imitation especially for low skill intensive products and processes (Dutt and Traca, 2010; Mercurio, 2012; Thoenig and Verdier, 2003; Wood, 1995). Moreover, as stated by Feenstra and Hanson (2001) most offshored activities are low skill intensive due to considerable difference in the relative wage of low skilled workers in high and low wage countries. Thus, the impact of increased competition in domestic downstream value chains should be most visible in *low skilled labor intensive industries* facing *foreign competition* from *low wage* countries.[19] Regarding regression equation 9, the channel of defensive skill biased innovation is hence captured as interaction term between the variable capturing the degree of domestic downstream competition (DSvariable) and the low skilled labor intensity of an industry in 1995. Importantly, to capture the fact that there is an increase in domestic downstream competition from *low wage* economies, the set of partner countries P in equation 10 is limited to low wage countries (lw). Consequently, the second regression equation

[18] In general, literature on defensive skill biased innovation does not distinguish between competition abroad or at the domestic market. Still, comparing sales of country-industries to domestic and foreign markets shows that around 64% of all country-industries in the sample earn the majority of their total intermediate sales at the domestic market. Stronger competition at the domestic market can thus be valued as an important determinant of firm behavior. A comparison of average intermediate sales to domestic and foreign markets is provided in the Appendix.

[19] Here, L- intensity is defined as $Lint_{ci,1995} = \frac{L_{ci,1995}}{H_{ci,1995}+CAP_{ci,1995}}$.

reads:[20]

$$\begin{aligned}\Delta_t^{t+2} S_{ci}^j &= \alpha_{ci} + \beta \Delta \ln K_{cit} + \delta \Delta \ln V_{cit} \\ &+ \theta \Delta \ln foreignCAP_{cit} + \gamma \Delta \ln foreignH_{cit} + \mu \Delta \ln foreignL_{cit} \\ &+ \eta \ln Lint_{ci,1995} + \iota \Delta \ln DScomp_{cit}^{lw} + \lambda \ln Lint_{ci,1995} * \Delta \ln DScomp_{cit}^{lw}\end{aligned} \tag{11}$$

Thus, the change in wage shares of low skilled workers is regressed on changes of the domestic capital stock and real value added, foreign capital, high and low skilled labor as well as an interaction term capturing the impact of tougher competition in domestic downstream value chains along with the initial skill intensity channel of the regarded sector.

4 The WIOD as Main Data Source

As stated in the introduction, the WIOD serves as important data source for this study. The version released in November 2013 does not only provide input-output tables (WIOTs) specifying the supply and use of intermediates and final goods at the sectoral level, but also provides socio-economic accounts (SEA). Data are available for 40 countries plus a rest of the world region (RoW) and 35 industries (whereof 14 sectors are manufacturing industries) over the time period from 1995 to 2011 (Timmer et al., 2015). More precise information on the advantages of the WIOD compared to alternative databases, like for example the GTAP, and details on the data construction can be found in Dietzenbacher et al. (2013).

4.1 Structure and Data Availability in World Input-Output Tables

Table 1 illustrates in which manner matrices and vectors presented in section 3 are available in WIOTs.[21]

The area on the left hand side with entries of A corresponds to matrix A. This matrix provides information on trade of intermediate goods. More precisely, each submatrix, as e.g. A_{BA}, indicates the value of intermediates flowing from a particular country-industry (indicated by the row, here: B) to a recipient industry of a country (indicated by the column, here: A). In the case of the WIOD, which covers 35 industries, each submatrix

[20] It should be noted that the adjustment of the factor use in the value chain abroad does not instantly affect the domestic wage shares. In order to allow these changes to materialize in a greater time span the left hand side variable is a Δ between t+2 and t.

[21] Author's presentation based on Erumban et al. (2012).

		Intermediates			Final Goods			
		Ctry A	Ctry B	Region RoW	Ctry A	Ctry B	RoW	
		Industry	Industry	Industry				
Ctry A	Ind.	A_{AA}	A_{AB}	A_{AR}	Y_{AA}	Y_{AB}	Y_{AR}	X_A
Ctry B	Ind.	A_{BA}	A_{BB}	A_{BR}	Y_{BA}	Y_{BB}	Y_{BR}	X_B
Region RoW	Ind.	A_{RA}	A_{RB}	A_{RR}	Y_{RA}	Y_{RB}	Y_{RR}	X_R
		VA_A X_A	VA_B X_B	VA_R X_R				

Table 1: Schematic Overview of a World Input Output Table

is of a 35 x 35 dimension. Similarly, the area on the right hand side with entries of Y corresponds to matrix Y. It specifies the value of final goods produced in a particular country-industry (indicated by the row) which is absorbed by a recipient country (indicated by the column). To decompose the production according to the method presented in section 3.2, matrix Y is summarized along the rows and results in a 35 x1 vector indicating the total final production of a country-industry. In accordance with the gross output identity, stating that all gross output is used either as final or intermediate good by the domestic or foreign economy, the total row sum of matrix Y and the row sum of matrix A equals the value of gross output, X.

4.2 Data Availability in the Socio Economic Accounts

Data on the real value added, the real fixed capital stock (both denoted in 1995 prices) and information on the dependent variable, shares in total labour compensation per skill level, are taken from the SEA.[22] Moreover, the SEA also contain data on the compensation of capital and labor, which are needed to further decompose foreign value added according to production factors.[23] In this context, the compensation of labor is further split into compensation of high, medium and low skilled workers. Following the International Standard Classification of Education (ISCED) low skill levels refer to *up to high school eduction*,

[22] Timmer et al. (2015) derive real fixed capital stocks based on the perpetual inventory method using information from investment series for assets related to reproducible physical capital and software which are covered by national accounts statistics.

[23] It should be noted that capital compensation is derived as residual of gross value added minus labor income. According to Timmer et al. (2015), capital is hence considered in a wide sense. Besides the traditional components like machinery and buildings, it also contains mineral resources, land, intangible and non-reproducible assets (RnD knowledge stock, software, databases, brandnames and organizational capital) and financial capital.

while medium skill levels refer to *high school eduction but no college* and high skill levels refer to *college eduction or above* (Timmer et al., 2015). To account for the fact that the cutoff between these three skill categories might be a bit blurry across countries, high and medium skilled workers are summarized into one category. It is hence distinguished if workers hold any kind of high school or college diploma or no diploma at all.

As there is no information in the SEA about the rest of the world, the share of capital and labor compensation in value added was derived from available data in the WIOD. In line with the method how data for the rest of the world were derived in general, the share of capital and labor compensation is computed as an unweighted average of six emerging economies. Besides the so called BRIC countries, this country set also comprises Indonesia and Mexico (Dietzenbacher et al., 2013). To match data from the SEA, which is only available in local currency, data were converted in US$ using exchange rates which underlie the harmonization of supply and use tables of the WIOD (WIOD, 2012). Moreover, in order to assess the competition from low wage countries in domestic downstream value chains as expressed in equation 11, it is important to classify the 40 countries of the WIOD according to their wage level. Therefore, countries were assigned to different wage groups according to the yearly gross national income per capita provided by the World Bank and the respective thresholds for income categories. Details and country classifications over time can be found in the Appendix. Finally, the data availability across countries, sectors and time allows to study the impact of global value chains on wages for 14 manufacturing industries in 16 countries over the time span from 1995 to 2008.[24]

[24]The industries regarded are: food, beverages & tobacco (C15t16); textiles(C17t18); leather & footwear(C19); wood & cork (C20); pulp, paper, printing & publishing (C21t22); coke, ref. petroleum & nuclear fuel (C23); chemicals (C24); rubber & plastics (C25); other non-metallic mineral (C26); basic metals & fabricated metal (C27t28); machinery (C29); electrical & optical equipment (C30t33); transport equipment (C34t35); manufacturing & recycling (C36t37).
Countries, considered as offshoring economies: Australia, Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, Great-Britain, Ireland, Italy, Japan, the Netherlands, Sweden and the US. Even though Cyprus and Luxembourg can also be classified as high income countries based on their GNI in 1995, they are not considered individually due to their small country size.
Middle and low income countries in the WIOD: Bulgaria, Brazil, China, Cyprus, Czech Republic, Estonia, Greece, Hungary, India, Indonesia, Korea (South), Latvia, Lithuania, Luxembourg, Malta, Mexico, Poland, Portugal, Romania, Slovakia, Slovenia, Taiwan, Turkey and Russia.

5 Results

5.1 The Impact of Foreign Production Factors

As outlined in section 3 and 4, detailed data on the factor use of sectors can be used to trace back how much foreign capital and labor entered the production of final goods in a given industry. Figure 1 provides an overview over the development of both domestic and foreign capital, high and low skilled labor in production. Each data point represents the value added by a given production factor for a specific country-sector in 1995 and 2008. Decomposition results from 2008 (on the y-axis) are plotted against decomposition results in 1995 (on the x-axis). Thus, points above the 45-degree line indicate that the value added share of the regarded production factor increased whereas points below the 45-degree line indicate that its share declined.

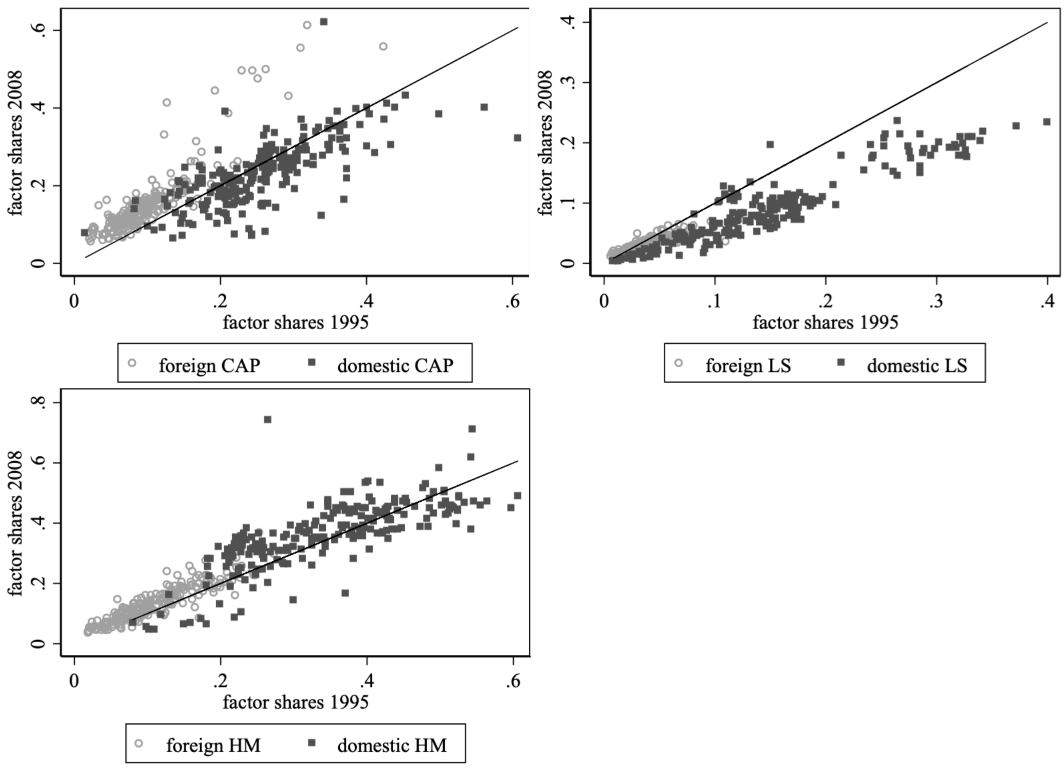

Figure 1: Domestic and Foreign Value Components in Production

Looking at capital, it can be seen that the *domestic* capital share is more or less clustered around the 45-degree line hence indicating that the share of *domestic* capital used in production remained at a relatively constant level. In contrast, the *foreign* capital share increased for almost all country-industries in the sample between 1995 and 2008. This

finding can be interpreted in the sense that domestic production increasingly uses foreign intermediates which were produced using capital abroad in the form of e.g. machinery but can also be interpreted as return to capital located abroad. The highest increase in foreign capital could be observed in the coke sector, the basic metals industry as well as in the chemical sector in several countries. A glance at the value added shares of high skilled labor confirms the well known trend towards more skilled workers involved in production. Apart from a tiny number of points located below the 45-degree line, data points indicate that this trend is valid for skilled workers from home as well as foreign. Those industries which experienced a decline in the use of domestic high skilled workers are almost exclusively located in Germany and Austria reflecting the fact that manufacturers in these two countries were highly benefitting from the vast supply of cheaper medium skilled labor especially in Central and Eastern European countries (Marin, 2006). Considering the share of low skilled workers in production, a surprising feature can be determined.
Given the well documented declining share of low skilled labor in production of (large) developed economies, it could be expected that shrinking domestic low skilled labor shares are mirrored by increasing foreign low skilled labor shares as domestic low skilled workers are substituted by low skilled workers abroad. Accordingly, one might expect that shares of *domestic* low skilled labor in production are below the 45-degree line while shares of *foreign* low skilled labor are above the 45-degree line. Yet, regarding the graph in the upper right-hand corner, it is clearly observable that *foreign* low skilled labor did not compensate the declining share of *domestic* low skilled labor as the majority of data points for foreign low skilled workers are as well clustered below the 45-degree line. Still, when comparing foreign and domestic low skilled labor in production, it can be seen that data points for the *foreign* low skilled labor share are closer to the 45-degree line than data for the domestic counterpart. This result indicates that the decline in *foreign* low skilled labor in production was not as strong as the decline in *domestic* low skilled labor. Given these findings, it is thus possible to determine two important drivers of the declining low skilled labor use in developed countries' production. First, low skilled labor in total was crowded out by more skilled workers and capital, while, second, a growing share of low skill labor is sourced from abroad instead of domestically.[25]

[25] Timmer et al. (2014) also find empirical evidence for a declining low skilled labor share in production which is accompanied by growing high skilled labor and capital shares using data from the WIOD. As the authors do not limit the set of countries to developed OECD countries as in this paper, the graphical presentation of their results is not as pronounced as depicted in figure 1 but qualitatively the same.

To evaluate how the above stated features impact low skilled workers, regression equation 9 was estimated. Results are depicted in table 2. Besides the domestic capital stock and real value added, the regression shown in column 1 relies on further independent variables like the share of foreign capital in the total capital use of production as well as the share of foreign high and low skilled labor in the respective total factor use. All regressions are implemented taking country-year fixed effects. To account for the circumstance that standard errors are correlated at the country-industry level or alternatively at the country and year level, standard errors are clustered at both the country-industry level and at the individual country and year level. To account for the different sizes of sectors, regressions are weighted using the respective share of an industry in the total manufacturing wage bill.

	(1)	(2)
		β coefficients
	$\Delta_t^{t+2} LSws$	std. $\Delta_t^{t+2} LSws$
Δ ln Kstock$_{dom}$	-0.0458	-0.3451
	(0.015)***	(0.113)***
	{0.025}*	{0.187}*
Δ ln realVA$_{dom}$	-0.0136	-0.1053
	(0.009)	(0.067)
	{0.012}	{0.094}
Δ ln CAP$_{for}$	-0.0263	-0.0871
	(0.007)***	(0.024)***
	{0.011}**	{0.036}**
Δ ln H$_{for}$	0.1883	0.5917
	(0.016)***	(0.051)***
	{0.056}***	{0.178}***
Δ ln L$_{for}$	-0.1983	-0.8508
	(0.014)***	(0.062)***
	{0.054}***	{0.234}***
Observations	2,688	2,688
R-squared	0.666	0.666
Country-year FE	Yes	Yes

Robust standard errors in parentheses. Standard errors clustered by country-industry in round brackets. Standard errors clustered individually by country and year in curly brackets.
*** p<0.1, ** p<0.05, * p<0.01.

Table 2: Regression Results - Part I

A first glance at regression results depicted in column 1 shows that a key finding of the existing literature can be confirmed for the sample considered in this paper. In line with the complementarity of capital and skills proposed by Griliches (1969), the negative sign of the capital stock variable indicates that the stock of domestic capital negatively influences the wage shares of low skilled workers in the sample. In addition to this finding, the negative sign of the coefficient of the foreign capital variable, CAP_{for}, indicates that the increasing use of capital located abroad is harming the wage share of low skilled workers. This fact can be explained with regard to the role of multinationals and the nature of capital data in the WIOD. According to the WIOD data description, capital is attributed to countries according to its spatial location rather than its ownership. Thus, in the presence of multinationals, capital might be located abroad yet belonging to the parent company residing in the considered country. Consequently, the increase in foreign capital reflects a growing return to capital which is (partially) flowing back to the domestic parent company. This characteristic becomes important with respect to labor reimbursement patterns of firms. As documented by Garrett (2005), the compensation of high skilled employees becomes more and more based on the performance of the employing company while such compensation systems are rather unusual for low skilled workers. As a result, an increase in foreign capital and hence increasing profits generated abroad benefit the wage share of high skilled workers while it tends to harm the wage share of low skilled. However, compared to estimation results for the other explanatory variables, the mechanism between the increased use of foreign capital in production and a declining wage bill share of low skilled workers is not robust against the alternative clustering of standard errors at the country and year level.

Regarding the variable capturing the use of high skilled labor abroad, H_{for}, the sign of the coefficient can be seen as a result determined by statistical correlations. As the high skilled labor variable captures the share of high skilled labor which stems from abroad, it is negatively influencing the wage share of their peers employed in the domestic industry - basically due to the substitution between foreign and domestic high skilled workers. Given that the wage share of high skilled workers represents the counterpart of the wage share of low skilled workers (the dependent variable), it becomes apparent how the use of high skilled labor from abroad (indirectly) benefits low skilled workers domestically.

On the contrary, as indicated by the negative coefficient of the L_{for} variable, the increasing use of low skilled labor located abroad negatively affects wage shares of domestic low skilled workers. In line with the reasoning above, this finding can be explained in the light of Feenstra and Hanson (1995, 1997) arguing that offshoring leads to a detrimental shift in the demand curve of domestic low skilled workers. Moreover, a glance at standardized beta coefficients in column 2 reveals that the relocation of low skilled labor jobs and tasks to foreign destinations has the greatest negative effect on wage shares of domestic low skilled workers. With a coefficient of -0.8508, the L_{for} variable is even exceeding the negative effect from the domestic capital stock (-0.3451). Offshoring of jobs and tasks performed by low skilled workers can hence be seen as the most important driver of negative developments for low skilled workers' wage shares.

Still, as highlighted introductory, the present chapter aims at detecting both a *direct* and an *indirect* effect from offshoring on the demand for low skilled workers. While the analysis above showed that the re-organization of an individual industry's own value chain *directly* shifts the demand away from low skilled workers, the *indirect* impact of offshoring is shown in the following subsection.

5.2 The Impact of Increased Foreign Competition in Domestic Downstream Value Chains

The development of the variable measuring the degree of foreign low wage competition in domestic downstream value chains is depicted in figure 2. Similar to figure 1, values of 2008 are plotted against values of 1995. Points above the 45 degree line hence indicate that domestic downstream clients sourced an increasing share of their purchases from a particular industry from foreign competitors.

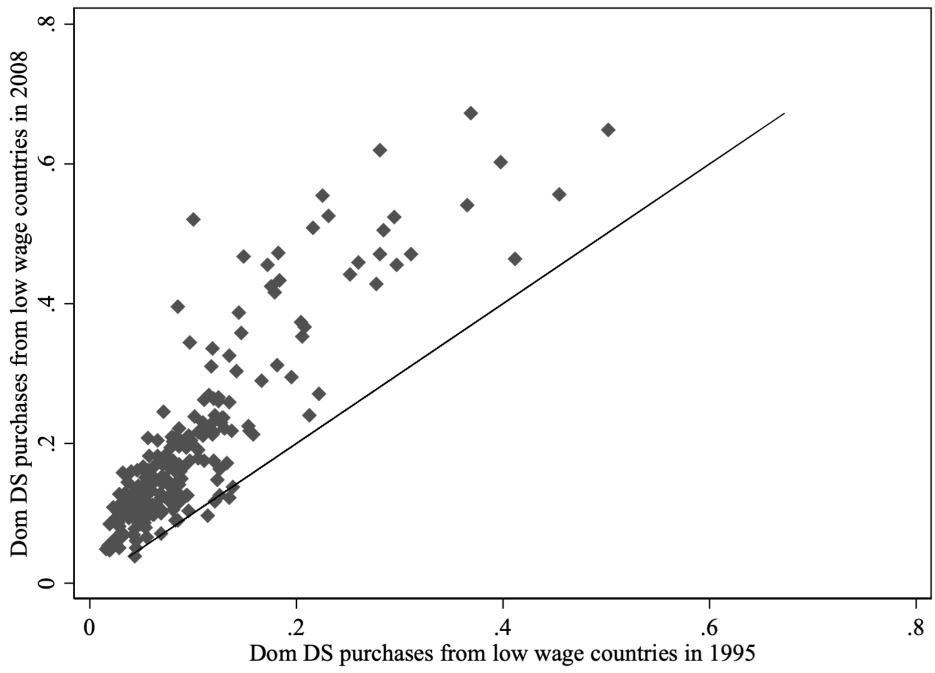

Figure 2: Competition from Low Wage Countries in Value Chains of Domestic Downstream Clients (2008 vs. 1995)

The clustering of most data points above the 45 degree line shows clearly that the foreign competition from low wage countries increased for almost all country-sectors of the sample. The most extreme cases in which domestic downstream industries source (slightly) more than 60% from low wage countries are for example the coke industry in Denmark, Finland and Australia as well as the leather industry in Canada. In contrast to this, there are a few industries whose domestic downstream clients only purchase 3 to 5 % from low wage competitors abroad. These sectors are for example, the Spanish manufacturing and other non-metallic mineral industry, the pulp and paper industry in Japan and Canada as well as the Canadian wood industry. Despite the increase in low wage competition for most country-sectors in the sample, there are also a few sectors for which competition from foreign low wage countries even decreased, like for example the manufacturing industry in Austria, Spain and Germany as well as the Danish wood industry. Yet, the majority of considered country-sectors experienced an increase in competition from low wage countries in domestic downstream value chains and are hence prone to defend their products and production processes through innovation. Table 3 shows to what extent the consideration of increased competition from low wage countries in domestic downstream value chains is statistically relevant for wage shares of low skilled workers.[26]

Regarding regression results presented in table 3 compared to table 2, it can be seen that the additional consideration of the downstream competition variable and the initial skill intensity does not alter the absolute size of coefficients tremendously. In general, most coefficients slightly decline in size when switching from the specification in table 2 to the one estimated in table 3. Still, while results in table 2 are robust to clustering standard errors at different levels, results for the domestic real capital stock as well as results for foreign capital are no longer significant or lose significance when standard errors are clustered at the country and year level. A glance at the newly added interaction term between the downstream competition variable, $DScomp$, and the variable capturing the initial low skill intensity of sectors, $Lint_{1995}$, shows that tougher competition in domestic downstream value chains leads to a shift in the wage share of manufacturers away from low skilled workers. The fact that the negative impact of domestic downstream competition increases with the initial low skill intensity of an industry highlights that especially low skill intensive manufacturing sectors experienced a declining wage share of low skilled workers. This finding is consistent with the mechanism highlighted by the literature on defensive

[26] Similar regressions were run based on offshoring proxies CAP_{for}, H_{for} and L_{for} computed as foreign factor contributions in the production of *exports*. Computations are based on the decomposition formula of Wang et al. (2013). Regression results are available in the Appendix.

	(1)	(2)
		β coefficients
	$\Delta_t^{t+2} LSws$	std. $\Delta_t^{t+2} LSws$
Δ ln Kstock$_{dom}$	-0.0370	-0.2789
	(0.014)***	(0.102)***
	{0.023}	{0.172}
Δ ln realVA$_{dom}$	-0.0041	-0.0320
	(0.009)	(0.067)
	{0.013}	{0.102}
Δ ln CAP$_{for}$	-0.0175	-0.0579
	(0.007)**	(0.025)**
	{0.013}	{0.044}
Δ ln H$_{for}$	0.1797	0.5647
	(0.018)***	(0.056)***
	{0.057}***	{0.178}***
Δ ln L$_{for}$	-0.1869	-0.8022
	(0.015)***	(0.063)***
	{0.056}***	{0.240}***
Δ ln DScomp	-0.0171	-0.0448
	(0.009)**	(0.035)*
	{0.010}	{0.053}
ln Lint$_{1995}$	0.0042	0.1037
	(0.001)***	(0.026)***
	{0.002}*	{0.053}*
IA: Δ ln DScomp & ln Lint$_{1995}$	-0.1291	-0.0875
	(0.049)***	(0.033)***
	{0.037}***	{0.025}***
Observations	2,676	2,676
R-squared	0.683	0.683
Country-year FE	Yes	Yes

Robust standard errors in parentheses. Standard errors clustered by country-industry in round brackets. Standard errors clustered individually by country and year in curly brackets.
*** p<0.1, ** p<0.05, * p<0.01.

Table 3: Regression Results - Part II

skill biased innovation (Anderton and Oscarson, 2002; Dutt and Traca, 2010; Thoenig and Verdier, 2003; Wood, 1995). Accordingly, the shift of the wage share away from low skilled workers might be driven by higher investments in skill demanding innovation in response to increased competition from low wage countries. Moreover, the comparison of standardized beta coefficients in column 2 shows that the impact of increased domestic downstream competition is lower than the magnitude of direct offshoring of low skill intensive tasks as captured in the L_{for} variable. Yet, compared to the impact of foreign capital on low skilled workers' wage share, the interaction term between downstream competition and the sectoral skill intensity has a more negative beta coefficient and is robust to both alternatives to cluster standard errors. Consequently, the degree of competition from low wage countries in value chains of domestic downstream clients plays an important role for the development of low skilled workers' wage shares in manufacturing industries of the sixteen countries considered in this setting.

6 Conclusion

The present chapter aimed at investigating the relationship between offshoring and labor market outcomes for low skilled workers in the presence of global value chains. Following the empirical strategy of Feenstra and Hanson (2001), changes in the wage bill shares of low skilled workers were regressed on proxies for offshoring and further explanatory variables. Importantly, instead of relying on the common approach to proxy offshoring by imports, the present chapter used data from the WIOD and its socio economic accounts for 14 manufacturing industries in 16 high income countries between 1995 and 2008 to trace back to what extent foreign production factors were involved in the production of final goods. In this context, mainly two channels were explored to identify mechanisms between the increased internationalization of value chains and labor market outcomes of low skilled workers.

First, the analysis showed that there is a *direct* impact from the use of foreign production factors on wage shares of domestic low skilled workers. Accordingly, the growing use of foreign low skilled labor in domestic production was identified as key driver for declining wage shares of low skilled workers. Second, by capturing the degree of competition from low wage countries in domestic downstream value chains in terms of value added, the chapter presented a further important *indirect* mechanism of how low skilled workers are affected by global production sharing. In this context, regression results showed that low skilled workers in initially low skill intensive industries experienced a particularly pronounced decline in their wage share when the extent of competition in domestic downstream industries increased. This finding might be interpreted in the light of the literature on defensive skill biased innovation investigated by Dutt and Traca (2010); Thoenig and Verdier (2003); Wood (1995) as well as Anderton and Oscarson (2002) In this context, the increasing competition of low wage countries in domestic downstream industries of manufacturers can be seen as a driver for higher investments in skill intensive innovation. As this circumstance is in turn leading to a demand shift away from low skilled workers, the rise in foreign low wage competition in domestic value chains was detected as additional influencing factor for low skilled workers' declining wage share.

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Appendix

A1. Gross National Income of High Income/ High Wage Countries

Country	GNI in 1995
PRT	11,220
KOR	11,600
GRC	12,410
TWN	13,326
ESP	14,840
IRL	16,920
AUS	19,250
ITA	20,610
CAN	20,850
GBR	20,960
FIN	22,030
FRA	25,740
BEL	27,200
NLD	27,690
SWE	28,070
AUT	28,190
USA	29,040
DEU	29,560
DNK	32,560
JPN	42,110

Table 4: Gross National Income of Countries in 1995

Note: Data taken from World Bank (NY.GNP.PCAP.CD). For Taiwan, data is taken from National Statistics Republic of China (Taiwan) *https://eng.stat.gov.tw/point. asp?index=1*. Threshold for GNI of countries to be considered as high income country: 9,385 USD in 1995.

A2. Standard Deviation of Material/Value Added Ratio over Time

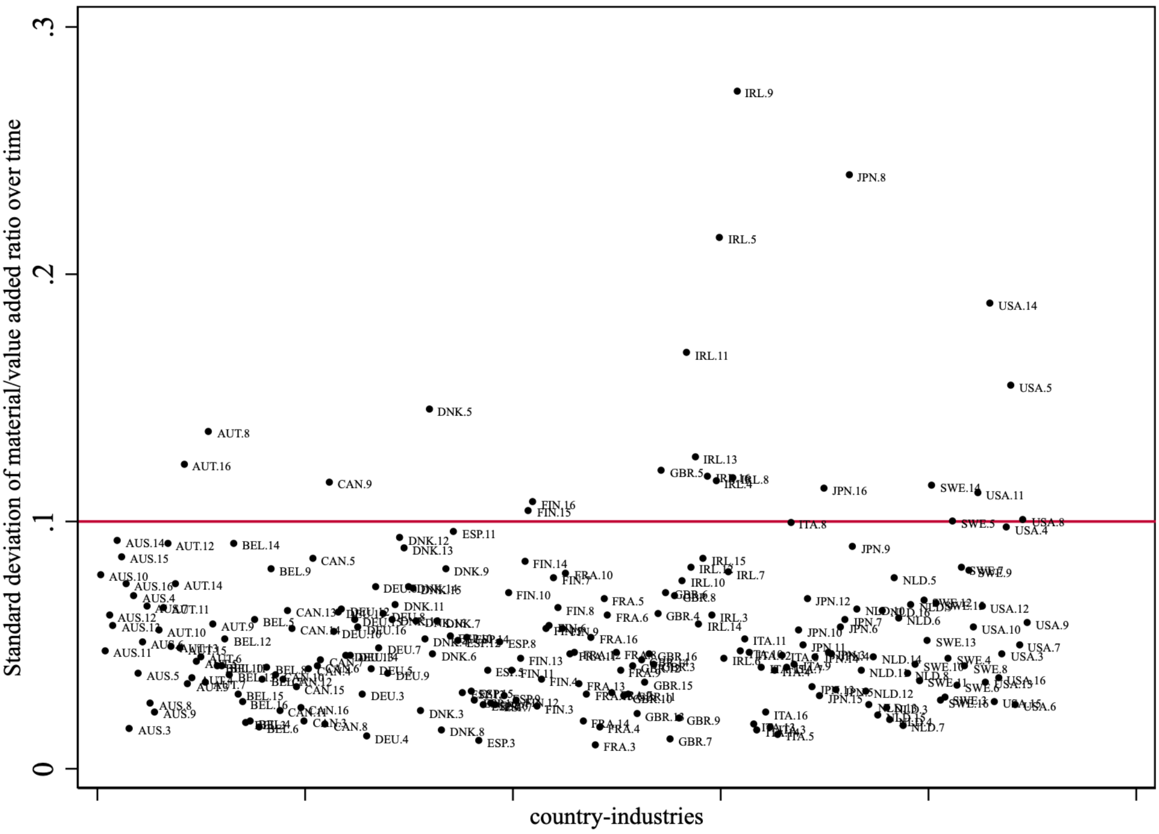

Figure 3: Standard Deviation of Material/Value Added Ratio over Time

Note: Numbers in the graph refer to: 3. food, beverages tabacco (C15t16); 4. textiles(C17t18); 5. leather footwear(C19); 6. wood cork (C20); 7. pulp, paper, printing publishing (C21t22); 8. coke, ref. petroleum nuclear fuel (C23); 9. chemicals (C24); 10. rubber plastics (C25); 11. other non-metallic mineral (C26); 12. basic metals fabricated metal (C27t28); 13. machinery (C29); 14. electrical optical equipment (C30t33); 15. transport equipment (C34t35); 16. manufacturing recycling (C36t37).

Source: Author's calculation based on WIOD data.

A3. Sales of Intermediates to Domestic vs. Foreign Markets

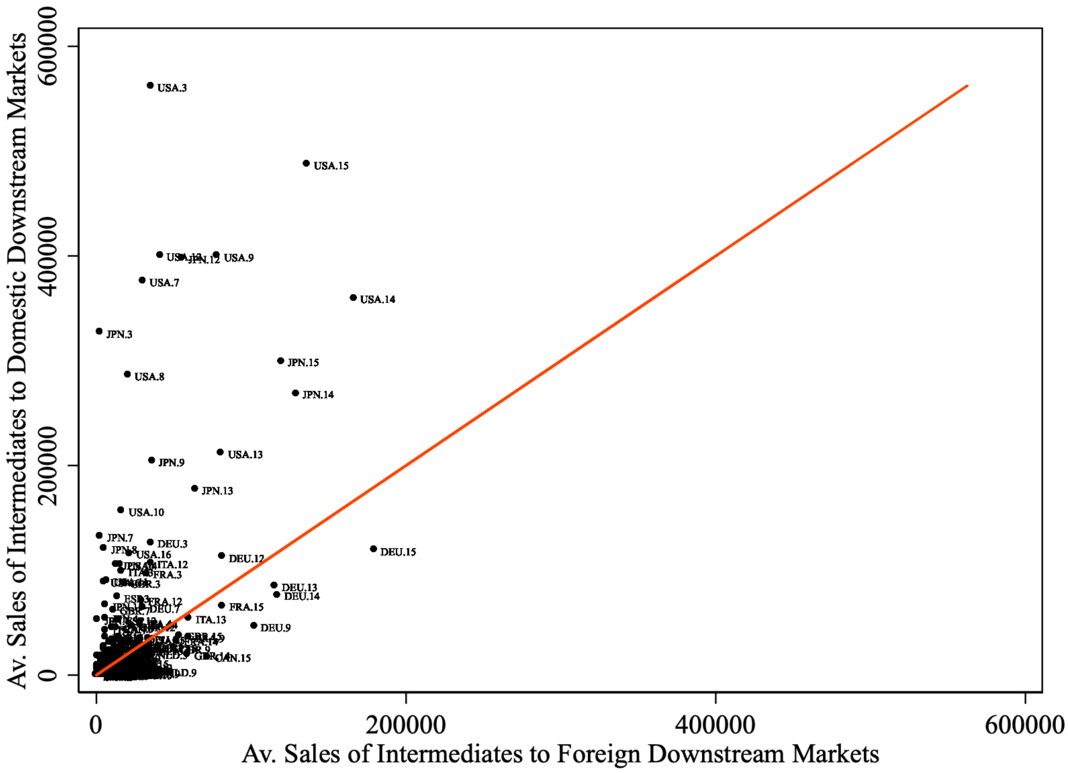

Figure 4: Sales of Intermediates to Domestic vs. Foreign Markets (Average from 1995 to 2008)

Note: For 93 of all 224 country-industries foreign markets are more important than domestic markets. Affected countries are AUT (4, 5, 9, 10, 12, 13, 14, 15), BEL (3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16), CAN (4, 5, 6, 10, 12, 13, 14, 15, 16), DEU (4, 5, 9, 13, 14, 15), DNK (3, 4, 5, 8, 9, 10, 13, 14, 15, 16), ESP 15, FIN (4, 5, 7, 9, 13, 14, 15) FRA (4, 5, 9, 13, 14, 15), GBR (5, 9, 13, 14, 15), IRL (3, 4, 5, 7, 9, 13, 14, 15, 16), ITA 13, NLD (3, 4, 5, 8, 9, 10, 12, 13, 14, 15), SWE (4, 5, 8, 9, 10, 13, 14, 15).

Numbers refer to: 3. food, beverages tabacco (C15t16); 4. textiles(C17t18); 5. leather footwear(C19); 6. wood cork (C20); 7. pulp, paper, printing publishing (C21t22); 8. coke, ref. petroleum nuclear fuel (C23); 9. chemicals (C24); 10. rubber plastics (C25); 11. other non-metallic mineral (C26); 12. basic metals fabricated metal (C27t28); 13. machinery (C29); 14. electrical optical equipment (C30t33); 15. transport equipment (C34t35); 16. manufacturing recycling (C36t37).

Source: Author's calculation based on WIOD intermediate sales data.

A4. Classification of Countries in High and Low Income Categories

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
LOW	3035	3115	3125	3030	2995	2995	2975	2935	3035	3255	3465	3595	3705	3855
HIGH	9385	9645	9655	9360	9265	9265	9205	9075	9385	10065	10725	11115	11455	11905
AUS	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
AUT	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
BEL	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
BGR	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
BRA	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
CAN	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
CHN	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
CYP	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
CZE	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw	hw	hw	hw	hw
DEU	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
DNK	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
ESP	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
EST	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw	hw	hw
FIN	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
FRA	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
GBR	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
GRC	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
HUN	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw	hw	hw
IDN	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
IND	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
IRL	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
ITA	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
JPN	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
KOR	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
LTU	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw
LUX	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
LVA	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw
MEX	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
MLT	lw	lw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
NLD	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
POL	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw
PRT	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
ROU	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
RUS	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
SVK	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	hw	hw	hw	hw
SVN	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
SWE	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
TUR	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw	lw
TWN	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw
USA	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw	hw

Figure 5: Classification of Countries According to World Bank GNI per Capita

Note: The classification of countries is based on yearly thresholds indicated in the 2nd and 3rd line of the table. Based on data code NY.GNP.PCAP.CD; low-upper middle income = low wage, high income = high wage. Following the Operational Guidelines and analytical classifications.

A5. Robustness - Offshoring Variables Calculated as FVA in Exports

	(1)	(2)
		β coefficients
	$\Delta_t^{t+2} LSws$	std. $\Delta_t^{t+2} LSws$
Δ ln Kstock$_{dom}$	-0.0385	-0.2902
	(0.013)***	(0.100)***
	{0.025}	{0.189}
Δ ln realVA$_{dom}$	-0.0029	-0.0224
	(0.009)	(0.067)
	{0.013}	{0.098}
Δ ln exCAP$_{for}$	-0.0054	-0.0245
	(0.002)**	(0.011)**
	{0.004}	{0.018}
Δ ln exH$_{for}$	0.1404	0.4626
	(0.016)***	(0.053)***
	{0.044}***	{0.147}***
Δ ln exL$_{for}$	-0.1434	-0.5996
	(0.016)***	(0.065)***
	{0.045}***	{0.189}***
Δ ln DScomp	-0.0213	-0.0783
	(0.007)***	(0.029)***
	{0.011}*	{0.062}
ln Lint$_{1995}$	0.0045	0.1092
	(0.001)***	(0.027)***
	{0.002}*	{0.054}*
IA: Δ ln DScomp	-0.1143	-0.0775
	(0.053)**	(0.036)**
	{0.040}**	{0.027}**
Observations	3,305	3,305
R-squared	0.690	0.690
Country-year FE	Yes	Yes

Table 5: Regression Results - Robustness Using Alternative Offshoring Measure Based on Wang et al. (2013)

Note: Robust standard errors in parentheses. Standard errors clustered by country-industry in round brackets. Standard errors clustered individually by country and year in curly brackets.

*** p<0.1, ** p<0.05, * p<0.01.