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**How Offshoring Can Affect the
Industries' Skill Composition**

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How Offshoring Can Affect the Industries' Skill Composition

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Abstract

While most offshoring literature focus on the effects on relative wages, other implications do not receive the necessary attention. This paper investigates effects on the industries' skill ratio. It summarizes the empirical literature, discusses theoretical findings, and provides first empirical evidence for Germany. As results show, effects are mainly driven by the industry where offshoring takes place. In high skill intensive industries, the high skill labor ratio increases (vice versa for low skill intensive industries). Since this result is in line with other empirical findings but seems to contradict with theory, the paper additionally discusses possible explanations.

Keywords: offshoring; labor market implications; skill ratio; skill composition

JEL classification: F16, J21

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1 Introduction

Within the last decades offshoring became an important issue in economic research and moved into the focus of political and public discussion as well. The process of slicing up the value chain, relocating the production of specific fragments abroad and importing the respective intermediates instead is assumed to significantly affect the domestic labor market.¹ In this respect, a huge amount of theoretical and empirical literature emerged, especially focusing on the implications on relative wages.

Feenstra and Hanson (1996a,b, 1999) e.g. contributed very early by examining offshoring effects on relative high skill wages. Assuming a relative high skill abundant economy that relocates its relative low skill intensive parts of production abroad, theoretical as well as empirical results for the US-Mexican case show that, following the decreasing pressure on relative low skill labor demand, a significant effect on relative high skill wages occurs: Since the relocated fragment is assumed to be relative low skill intensive for the offshoring, but relative high skill intensive for the inshoring economy, relative high skill wages significantly increase in both of them. This result is meanwhile known as the “factor bias” of offshoring. Since Feenstra and Hanson assume only one industry, Arndt (1997, 1998b,a) extended the Feenstra and Hanson model, distinguishing between a relative low and a relative high skill intensive industry. Thus, Arndt moved the focus towards more disaggregated industry levels. With the so called “sector bias” of offshoring, Arndt showed that the effects on relative wages depend crucially on the skill intensity of the industry where offshoring takes place. If the relative low skill intensive industry relocates parts of the production process abroad, relative low skill wages increase, whereas relative high skill wages increase if offshoring takes place in the relative high skill intensive industry. Similar as the process of skill biased technological change, the effects are initiated by a reduction of unit costs and an enabled wage markup that, depending on the respective industry, either flows to low or high skilled labor. The discussion of the factor and the sector bias of offshoring, as well as the respective wage effects, can be followed in a huge amount of theoretical and empirical contributions, as e.g. Berman et al. (1994), Egger and Egger (2002), Egger and Falkinger (2003), Geishecker and Görg (2005), Hijzen (2007), Horgos (2009b), or Kohler (2009).

Inspired by these well known implications of offshoring, most of the following literature kept the focus on the effects on relative wages. However, these effects are by no means the whole story. In general equilibrium - and even within the labor market - there exist several other important implications. One of these issues is the effect of offshoring

¹In this contribution, offshoring is used as in most recent publications, combining the imports of intermediates produced in foreign affiliates (FDI) and the imports of intermediates produced at arms' length (international outsourcing).

on the industries' skill composition. How does the industries' production structure (the high to low skill labor ratio) change when offshoring activities take place?² In this respect, however, only few contributions emerged recently providing a far less clear picture compared to that provided for the wage effects. One reason for several ambiguities in the results is the existence of different ways how offshoring can affect the industries' skill composition: On the one hand, there exists a direct "offshoring-effect". When parts of the production process are relocated abroad, relative demand of the factor mainly used in the relocated intermediates decreases. This, however, gets accompanied by an indirect "wage-effect" resulting from the effects of offshoring on relative wages. If e.g. offshoring increases relative high skill wages (what, according to Arndt (1997) could be assumed when taking place in the relative high skill intensive industry), a substitutional process occurs towards more low skill intensive production. While the direct offshoring-effect depends on the skill intensity of the relocated fragment, the indirect wage-effect differs with the industry where offshoring takes place. Since causalities are more complex compared to the effects of offshoring on relative wages, and only rarely examined by theoretical as well as empirical investigations so far, there is a need for further examinations. With this contribution, we try to shed some more light into the discussion.

Therefore, Section 2 provides an empirical literature review of the contributions investigating the effects of offshoring on the industries' skill composition. Section 3 discusses theoretical frameworks. Section 4 conducts the empirical analysis using data for the German economy. As results show, there is no significant effect visible when examining more aggregated industry levels. When examining more disaggregated industry levels, significant results occur showing that the implications differ strongly between the different industries where offshoring takes place. Contrary to the theoretical models (but in line with other recent empirical findings), the high skilled labor ratio increases if offshoring takes place in relative high skill intensive industries and decreases if the relative low skill intensive industries relocate production. Since there seems to be a puzzle between theoretical predictions and empirical findings, Section 5 discusses the results in greater detail in order to provide suggestions on how to reconcile theory with empirics. Section 6 concludes by summarizing the major results.

²The effects on the industries production structure also have far reaching implications for migration and education policies and thus, are of great importance for the political authority and the public discussion as well.

2 Offshoring and the Industries' Skill Composition: A Look at some Empirical Results

As mentioned, most empirical contributions on the implications of offshoring focus on relative wages, whereas the literature on how offshoring affects the industries' skill composition is relatively rare. Furthermore, the few empirical works on the effects of offshoring on skill composition do not distinguish among different industries where offshoring takes place, and run cross-industry estimates. It is acknowledged that cross-industry regressions make the implicit assumption that the estimated cost or production function is the same across industries, and this assumption can indeed be far-stretched. Even if we assume a similar production function across manufacturing industries, there will be very different factor intensities used across industries. This heterogeneity in factor intensities should be very relevant for offshoring choices. The results of the regressions run across all industries do not allow to see a different impact of offshoring according to the different factor intensities, as the theory suggests, and do not consider the differences in factor intensity of the inputs which are imported.

A partial exception to this last problem are the studies that differentiate imports of intermediate inputs according to the country of origin, assuming that imports from less developed and emerging countries with low (unskilled) labor costs will be intensive in unskilled labor. Examples of these studies are given by Egger and Egger (2005) and Geishecker (2006), who consider imports of intermediate inputs in Western European countries from Central and Eastern Europe, and find that these imports have a positive and significant effect on the relative employment or relative wage of skilled workers. But imports from countries with relatively low labor cost do not need to be relatively unskilled-labor intensive. Especially in the CEECs, the endowment of skilled workers is abundant relative to other areas of the world. Therefore, even if controlling for the geographical origin of the intermediate inputs is an attempt to take into account the factor intensity of these inputs, it can only partially do so.³

A couple of studies instead explicitly address the issue of differences across manufacturing industries that can affect the impact of offshoring. The first is the work by Geishecker and Görg (2005), who assess the effect of international fragmentation of production on wage levels in Germany. The data used show that the extent and the dynamic of fragmentation of production is quite differentiated between industries. In the estimates obtained including all industries, they don't find a significant effect of international fragmentation, but splitting the sample between skill-intensive industries

³A very recent work by Becker et al. (2009) addresses the issue of which types of tasks are kept at home by German multinationals when offshoring occurs, but data limitations again do not allow to model explicitly which types of tasks are offshored. For this sample of MNEs, the location where offshoring takes place does not seem to matter for the effect on domestic employment.

and low-skill intensive industries, they find a differentiated effect of fragmentation. Furthermore, in their sample they can distinguish between types of workers in each industry, and their estimates show a positive and significant effect of fragmentation on the wages of the high-skilled workers in the skill-intensive industries and a negative and significant effect on the wages of low-skilled workers in the low-skill intensive industries. This sharp difference in results highlights the importance of assessing carefully the effect of offshoring in each specific context. However, their analysis is restricted to the effects on relative wages only.

The work by Falzoni and Tajoli (2010) instead looks at the effect of offshoring on the employment of skilled and unskilled workers in Italy. In Italy too, offshoring is more extensive in relatively skill-intensive industries (as in Germany), in spite of differences in the overall manufacturing specialization between the two countries. Even if considering employment rather than wages, the results by Falzoni and Tajoli (2010) are consistent with the ones by Geishecker and Görg (2005), as the impact of offshoring appears only weakly significant and not robust when regressions are run across all manufacturing industries. But when splitting the sample between skill-intensive and unskill-intensive industries, the picture changes, as the impact on skill composition differs across industries. Offshoring has a significant and negative effect on the relative employment of skilled workers in the unskilled-intensive sectors, while it has positive and significant effect on the relative employment of skilled workers in the skill-intensive industries. Here too, therefore, the context in which offshoring takes place is crucial.

3 Short Sketch of the Theoretical Background

As in the empirical literature, contributions investigating the effects of offshoring on the industries' skill composition are relatively rare. This section summarizes some of the theoretical predictions in order to provide testable hypothesis for the empirical analysis below.

Even if the broadly known framework of Feenstra and Hanson (1996a,b, 1999) does not explicitly investigate the implications on the skill ratio, some results can be drawn from this model. Assuming a high skill abundant economy (without distinguishing between different industries) where offshoring takes place by relocating low skill intensive production parts abroad, demand of low skilled labor decreases. Straight forward, relative wages of high skilled labor increases in both, the offshoring as well as the inshoring economy. With respect to the offshoring economy, the relocated production block is assumed to be relatively low skill intensive whereas with respect to the inshoring one, the relocated production block is relative high skill intensive instead. The follow up effects on the skill ratio are twofold: In the high skill abundant home

economy, e.g., the skill ratio should on the one hand increase as it is the relative low skill intensive production part that gets relocated. On the other hand, due to the increasing effect on relative wages of the high skilled, there should be a substitution effect towards more low skill intensive production. In the aggregate (that is in the focus of the Feenstra and Hanson model), these effects are likely to sum up to zero. Proposition 1 summarizes this pattern.

Proposition 1: *Concerning the aggregated whole economy, the high skilled labor ratio is assumed to increase if low skill intensive production fragments are relocated abroad. However, since the decrease in low skilled labor demand increases relative high skilled wages, there should also be a substitution effect towards more low skilled labor. Summing up, the implication of offshoring on the skill ratio of production is assumed to be ambiguous in the aggregate.*

One theoretical model that explicitly focus on the effects on the industries' skill ratio is the already mentioned framework of Arndt (1997, 1998b,a).⁴ Assuming two industries with two kinds of labor, the model focus on more disaggregated industry levels and investigates offshoring within a traditional Heckscher-Ohlin framework. The essence of the results is that the effects on relative wages do not depend on the skill intensity of the relocated production block. By contrast, the skill intensity of the industry where offshoring takes place is the driving parameter: Due to the small country assumption, offshoring enables an additional wage premium since the industries' unit costs decrease. Depending on the relative skill intensity of the respective industry, this wage premium gets either payed to the high or the low skilled worker. In this form, offshoring induces a similar skill bias already known from technological progress. Thus, relative high skill wages increase if offshoring takes place in the relative high skill intensive industry and vice versa for the relative low skill intensive one. The effects are summarized in Figure 1.

As can be seen in this Pearce-Lerner diagram (with high skilled labor (H) on the vertical and low skilled labor (L) on the horizontal axis), there exist two industries, the relative high skill intensive industry (X) and the relative low skill intensive one (Y). The factor intensities are given by the two expansion paths X and Y . At the initial

⁴This model got extended in several contribution in order to investigate different aspects of offshoring effects. Deardorff (2001a,b) e.g. illuminates the importance of the relative factor intensity of the relocated production blocks. Egger and Falkinger (2003) consider different modes of final goods production and examine several different equilibrium situations in order to determine the dominance of the factor or the sector bias of international outsourcing. Recently, Kohler (2009) investigates differences between the sector bias models and the literature that meanwhile emerged on task trade, initiated by Grossman and Rossi-Hansberg (2008). In this paper Kohler specifically mentions the importance of offshoring heterogeneous tasks at the industry level and thus, the sector bias of offshoring and how this sector bias model of offshoring can be reconciled with the task trade framework of Grossman and Rossi-Hansberg.

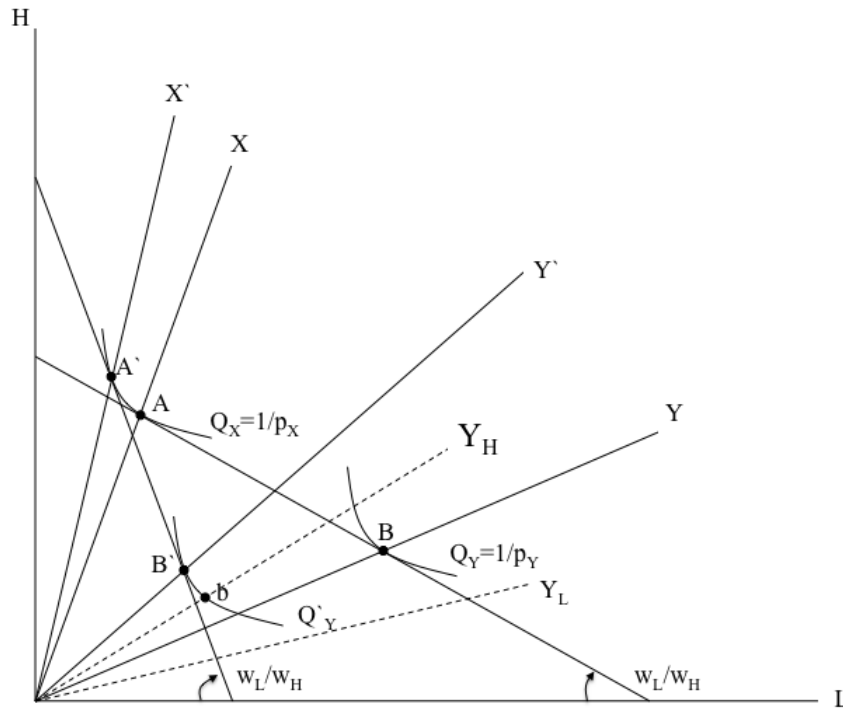


Figure 1: Labor Market Effects of Offshoring - The Sector Bias

equilibrium, production takes place at points A and B , where the unit value isoquants Q interact with the relative price line w_L/w_H . The Y industry produces at point B with the use of two intermediate products Y_H (relative high skill intensive) and Y_L (relative low skill intensive).

Now suppose that, e.g. due to advances in technology and communication, offshoring gets possible and that the low skill intensive industry (e.g. the import competing one in a high skill abundant economy) relocates production of its relative low skill intensive intermediate abroad and imports the respective input instead. Thus, domestic production of Y consists solely of production of the relative high skill intensive component Y_H . At the initial relative wage ratio, factor intensity in the Y industry shifts to the more high skill intensive expansion path Y_H (let's call this the "offshoring-effect"). While the relative price of Y remained unchanged, overall costs decrease due to the lower-cost procurement of the foreign country, shifting the unit isoquant inward to Q'_Y . However, due to this decrease in costs, the unchanged relative price of Y is now inconsistent with the initial relative wage ratio. Therefore, Y producers increase the relative demand for low skilled labor (since it is the relative low skill intensive industry). Relative wages of the low skilled increase as long as the new ratio is tangent to the new isoquant Q'_Y , resulting in the new equilibrium of production at A' and B' (let's call this the "wage-effect"). As can be seen with the new expansion paths X' and Y' , the combination of the "offshoring-effect" and the "wage-effect" induces skill shifts in both industries towards more high skill intensive production patterns. The framework can

easily be extended to generalize the results, that are summarized in Proposition 2.

Proposition 2: *The implications of offshoring on the industries' skill ratio are driven by a direct "offshoring-effect" as well as an indirect "wage-effect". If offshoring takes place in the relative low skill intensive industry, the industries unambiguously shift production towards more high skilled labor when relocating the relative low skill intensive production block. If the industry relocates its high skill intensive fragment, results are ambiguous since the wage and the offshoring-effect work in different directions. If offshoring takes place in the relative high skill intensive industry, the industries' unambiguously shift production towards more low skill intensive processes when relocating the relative high skill intensive fragment. Again, results are ambiguous if the industry offshores its low skill intensive production process.*

As could be shown in this section, theoretical results on the implications of offshoring on the industries' skill composition are not as clear cut as e.g. the implications on relative wages. Results depend on the level of industry aggregation as well as on more specific characteristics of the offshoring process: on which industry relocates parts of its production fragments, on the relative skill intensity of the relocated parts, and, from a more formal point of view, also on the model set-up and its assumptions (as e.g. the elasticity of substitution) predicting if the wage-effect outperforms the offshoring-effect or vice versa.⁵

4 Empirical Evidence for Germany

This section empirically investigates the effects of offshoring on the within industries' skill ratio for Germany from 1991 - 2000. Before describing the data and presenting the estimation results, we distill three testable hypothesis from the theoretical examination above:

- (i) On more aggregated industry levels (as e.g. the whole economy or the manufacturing sector), different forces are expected to occur that sum up to insignificant effects of offshoring on the industries skill ratio.
- (ii) When conducting the analysis on more disaggregated industry levels, effects should get significant and, due to industry heterogeneity, illuminate different

⁵In the above assumed scenario (when the relative low skill intensive industry relocates its relative low skill intensive part of production), the wage and the offshoring-effect work in the same direction: Shifting production towards more high skill intensive activities. However, using this graphical framework, it is easy to show, that results would not be as clear cut when offshoring would take place in the relative low (high) skill intensive industry by relocating its relative high (low) skill intensive part of production. As Horgos (2009a) shows formally, results strongly depend on the assumed elasticity of substitution between low and high skilled labor. Assuming Cobb-Douglas elasticities, the wage-effect always outperforms the offshoring-effect, yielding unambiguous results.

patterns if offshoring takes place in different industries.

- (iii) Following the framework of the sector bias of offshoring, increasing high skill ratios would be expected if offshoring takes place in relative low skill intensive industries and vice versa for relative high skill intensive ones.

Data

The empirical analysis bases on data for the German economy from 1991 - 2000. To measure offshoring activities on the two digit NACE industry level, we use input-output tables provided by the German Federal Statistical Office. Since offshoring can not be directly observed at the industry level, there is the need for adequate proxies. Therefore, literature developed several indices with some of them quite common in use.⁶ In this paper we use one of these indices called Vertical Specialization (VS). The VS-index is introduced in Campa and Goldberg (1997), Feenstra (1998), and Strauss-Kahn (2003) and can be calculated using

$$VS_t = \sum_{j=1}^n \sum_{w=1}^z \frac{f_{wt} \cdot q_{wjt}}{p_{jt}} = \sum_{j=1}^n \sum_{w=1}^z \frac{(m_{wt}/s_{wt}) \cdot q_{wjt}}{p_{jt}} \quad (1)$$

with q_{wjt} as industry j 's total inputs of good w (domestic as well as from abroad) in year t , p as the level of production and f as a ratio estimating the international fraction of the inputs. The international estimation ratio f relates imported goods m to domestically used goods s . The goodness of the VS index depends strongly on the international estimation ratio f . As shown in Horgos (2009b), the VS index has quite good properties proxying offshoring activities, especially on more disaggregated industry levels.

The information of the input-output tables are also used to obtain the industries' output (Q_{jt}). We enrich the information of the Federal Statistical Office with the German Socio Economic Panel (GSOEP) provided in yearly waves since 1984 by the DIW Berlin.⁷ The GSOEP observes gross wages from around 40,000 individuals, including additional payments like e.g. 13th or 14th month pay or Christmas bonuses. Individuals in the GSOEP are additionally classified with respect to the International Standard Classification of Education, provided by UNESCO (1997). Thus, using the information on the level of education, we calculate the industries' mean wages of high skilled labor (w_{jH}) as well as their low skill intensive counterparts (w_{jL}).⁸ In order to obtain

⁶For a comparative analysis of different offshoring indices, their design, quality, and econometrical behavior when investigating labor market effects see Horgos (2009b).

⁷For detailed information on the German Socie Economic Panel see Haisken-DeNew and Frick (2005).

⁸According to the ISCED, low skilled workers are defined as workers with primary (1), lower secondary or second stage of basic education (2), whereas high skilled individuals are assumed to have some

information on the industries skill composition, we also refer to the German SOEP and calculate the fraction of high to low skilled labor per industry j (H_j/L_j).⁹ Overall, our panel data for the German economy covers the years 1991 - 2000 and consists of the NACE 2 digit industries' skill composition, their offshoring intensity, output, as well as the relative high skill wages. For a descriptive overview of the main variables, see Figure (2).

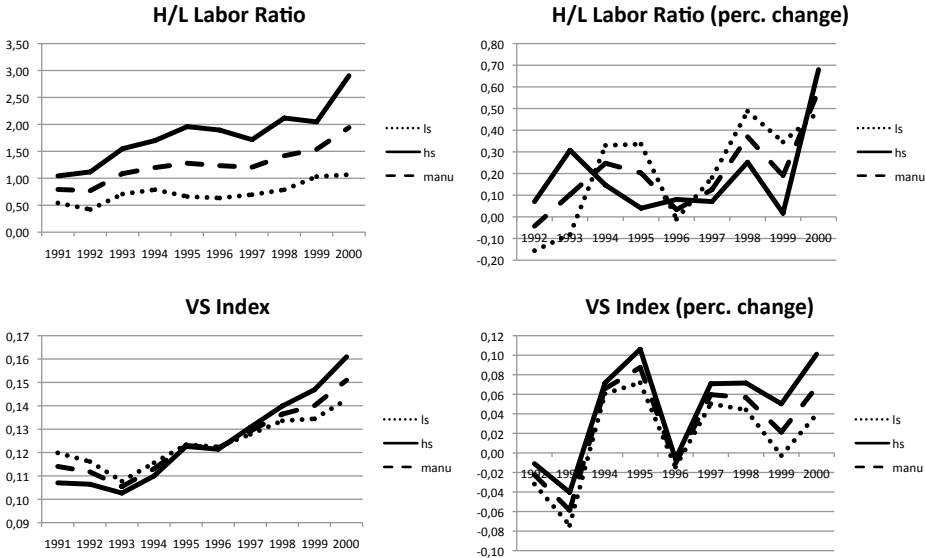


Figure 2: Descriptive Statistics: High Skill Labor Ratio and Offshoring Activity

As expected for developed economies, the figure shows a strong skill upgrading effect in the German manufacturing industry. The growth rate of the H/L ratio, however, is fluctuating over the years. Also offshoring activities (the VS-index) increase over the considered time period. While fluctuating in the first years from 1991 - 1995, a strong increase occurred after 1995. When examining the development of the VS index in greater detail, we observe that in Germany offshoring is more pronounced in the relative high skill intensive industries than in the relative low skill intensive ones.¹⁰ As shown in Falzoni and Tajoli (2010), this pattern is similar than the offshoring activities in Italy.

form of post secondary education (4, 5, or 6).

⁹As Falzoni and Tajoli (2010) mention, the consideration of educational attainments is closely related to the supply side of the labor market and highly correlated to other frequently used indices, as e.g. the white/blue collars ratio.

¹⁰In order to distinguish between relative low and relative high skill intensive industries of the German manufacturing sector, we follow the results of a cluster analysis done by Geishecker and Görg (2005).

In order to investigate the empirical importance of which industry offshores which parts of production (what is of special interest in this contribution), the magnitude and development of the VS index are also calculated on more disaggregated industry levels. The numbers are presented in Table 1.

Table 1: Level and Development of Offshoring in Germany

	low skill int. industries		high skill int. industries	
	low skill parts	high skill parts	low skill parts	high skill parts
1991	6%	3%	2%	8%
1995	6%	3%	2%	9%
2000	6%	4%	2%	12%
1991 – 2000	7%	38%	0%	59%

As the table shows, in relative low skill intensive industries, the average level of offshoring high skill intensive parts reaches about one half (1991 and 1995) or two third (2000) of the level of relocating low skill intensive production blocks. Considering the offshoring dynamic, there is a much stronger increase in relocating high skill intensive production parts (38 percent) compared to relocating low skill intensive parts (7 percent). In relative high skill intensive industries, by contrast, the average level of offshoring high skill intensive production parts is much higher than its low skill intensive counterparts. Despite the relative high level, the increase of offshoring relative high skill intensive production parts is much more pronounced as well.

Empirical Methodology and Results

In order to assess the implications of offshoring on the industries skill ratio, we estimate

$$(H/L)_{jt} = \beta_0 + \beta_1 \omega_{jt}(l) + \beta_2 Q_{jt}(l) + \beta_3 VS_{jt}(l) + t + \epsilon_{jt} \quad (2)$$

for different levels of industry aggregation. The high skill labor ratio H/L of industry j is regressed on a constant, relative high skill wages $\omega_{jt} \equiv \frac{w_{Hjt}}{w_{Ljt}}$, the industry's output Q , offshoring measured with the VS index, and the variable t capturing the time trend. ϵ is a typical error term. Since there could be a possible endogeneity problem (not only with respect to relative wages), we ran several Durbin - Wu - Hausman tests (as suggested in Davidson and McKinnon, 1993) to proof if possible endogeneity could significantly bias the results. In order to secure pure exogenous variables on the right hand side, we decided to perform an instrumental variable regression and instrument all the exogenous variables with its lagged components (l).

To estimate (2) for the different levels of industry aggregation we use the random-effects estimator (RE) since we do not assume that the exogenous variables are strategically correlated at the industry level. The Breusch and Pagan test for unobserved heterogeneity as well as the Hausman test statistically confirm the use of a random effects model. Additional tests for consistency of the estimated error matrix, the modified Wald test for groupwise heteroscedasticity as well as the Wooldridge test for autocorrelation show that the traditional error terms are indeed driven by a heteroscedastic error structure as well as autocorrelation. Thus, we use the robust Huber / White / Sandwich estimator for all regressions. With this procedure, also taking possible outliers into account, we are able to assure the consistency and the comparability of the estimation results. The results are presented in Table 2.

Table 2: Effects on the Industries' High Skill Labor Ratio

	Whole Economy	Manufacturing Sector	Disaggregated Industry Levels	
ω	-0.0263 (-0.34)	-0.0424 (-0.54)	-0.0623 (-0.78)	-0.0498 (-0.89)
Q	1.26e-06 (0.51)	1.43e-06 (0.57)	-2.87e-06 (-1.02)	-1.62e-06 (-0.81)
VS	1.8137 (0.69)	2.1545 (0.78)	-	-
i VS (Y)	-	-	-1.1867 (-0.44)	-
i VS (X)	-	-	9.1045*** (2.62)	-
i VS (Y → L)	-	-	-	-2.9060 (-1.16)
i VS (Y → H)	-	-	-	-9.3228** (-2.05)
i VS (X → L)	-	-	-	28.6351** (2.21)
i VS (X → H)	-	-	-	7.1781** (2.54)
t	0.0988*** (7.00)	0.1093*** (7.05)	0.1072*** (7.03)	0.1183*** (11.49)
cons.	0.4782 (1.39)	0.3406 (0.74)	0.4760 (1.13)	0.5988** (2.23)
Obs.	190	165	165	330
Groups	25	20	20	40
Prob > chi2	0.0000	0.0000	0.0000	0.0000

Endogenous variable: within industries' high skill labor ratio (H/L); (t-Statistics in parantheses);

* / ** / *** indicates significance at 10 / 5 / 1 percent

As the results show for the more aggregated levels of the whole economy and the manufacturing sector (Columns 1 and 2),¹¹ effects are overall quite insignificant. As expected, if relative wages of the high skilled increase, industries exhibit a tendency to decrease the high skill labor ratio, as low skilled are substituted for the more expensive high skilled (what is part of the “wage effect”, mentioned in the theoretical section above). The effects, however, are not at a statistical significant level. The industries’ output show an increasing effect on the skill ratio, but also not at a common level of statistical significance. Concerning the offshoring index VS, the insignificant results confirm hypothesis (i). There is an increasing tendency of the high skilled labor ratio, however, the effect is not statistically significant in the aggregate, neither in the whole economy, nor in the manufacturing sector as a whole.

Interesting results occur when moving the analysis towards more disaggregated levels of industry aggregation (Column 3 and 4). First, consider Column 3. We replace the aggregated VS index by two variables interacting the VS index with dummy variables set one for either the relative low or the relative high skill intensive industries (both as subsamples of the manufacturing sector only). Therefore, i VS (Y) proxies offshoring taking place in the relative low skill intensive Y industry and i VS (X) offshoring in the relative high skill intensive X industry. The results support hypothesis (ii): The implications of offshoring on the industries skill ratio strongly depend on the industries where offshoring takes place. If it takes place in relative low skill intensive industries, the high skill labor ratio shows a decreasing tendency, even when not reaching a common level of statistical significance. By contrast, if offshoring takes place in the relative high skill intensive industries the industries’ high skill labor ratio increases, statistically significant at the 1 percent level. This result goes in hand with the pattern shown in other empirical investigations (see e.g. Falzoni and Tajoli (2010) for results on the Italian economy), however, contradicts with the pattern expected from the theoretical literature. As we discussed above and summarized in hypothesis (iii) the high skill labor ratio should increase if offshoring takes place in the relative low skill intensive industries and decrease in the relative high skill intensive ones. The empirical results here support exactly the opposite (what will be discussed in detail in the next section).

In order to move to a higher level of disaggregation, Column 4 extends the analysis by further distinguishing the offshoring activities of the two industry samples. i VS (Y \rightarrow L) proxies offshoring of the low skill intensive production parts (L) in the low skill intensive industry (Y), whereas i VS (Y \rightarrow H) proxies offshoring activities of the high skill intensive fragments. For the high skill intensive X industries we continue this notation and get i VS (X \rightarrow L) as well as i VS (X \rightarrow H). Again, we achieve a significantly increasing effect in the high skill intensive industries and a partly significantly decreasing effect in the low skill intensive ones. The interesting point to mention here is that the

¹¹Since the examination here focus on material offshoring, we exclude the service sector in all regressions.

implications of offshoring on the industries skill ratio seem to be primarily driven by the industry where offshoring takes place, and only minor by the skill intensity of the relocated production fragments. Consider e.g. the high skill intensive X industry: If the industry offshores its low skill intensive production parts (i VS $X \rightarrow L$), the estimated coefficient on the industries' high skill labor ratio is positive, quite high, and at a high level of statistical significance. If the industry offshores its high skill intensive parts of production (i VS $X \rightarrow H$), the estimated coefficient is slightly smaller, but still highly significant positive. Thus, even if the industry offshores its high skill intensive parts of production, production shifts towards more high skilled labor. The same pattern holds for the low skill intensive Y industry. If the industry offshores its high skill intensive parts (i VS $Y \rightarrow H$), the effect on the industries' high skill labor ratio is strongly significant negative. However, the effects also show a negative tendency (even when being slightly outside a common level of statistical significance) if the industries relocate their low skill intensive parts of production (i VS $Y \rightarrow L$).

5 Discussing the Results

As the empirical results for Germany show, implications on the high skill labor ratio are mainly driven by the skill intensity of the industry where offshoring takes place, and only to a lesser extent by the skill intensity of the relocated production block. This supports the "sector bias" of offshoring. However, the empirical tendencies found here show opposite directions: Whereas offshoring in relative high skill intensive industries increases the high skill labor ratio (theory would predict a decrease), offshoring in relative low skill intensive industries decreases the high skill labor ratio (theory would predict an increase). Even if our results seem to conflict with theory in this respect, they are in line with other empirical findings as e.g. the ones by Falzoni and Tajoli (2010) for the Italian economy. Thus, there seems to be a puzzle concerning theoretical and empirical evidence. In order to shed some more light onto this puzzle, this section discusses the link between empirical and theoretical findings as well as the importance of the specific empirical situation in greater detail.

Theoretical implications on relative wages are mostly quite clear cut. While relative high skill wages are expected to increase if offshoring takes place in relative high skill intensive industries, they are expected to decrease if it takes place in relative low skill intensive ones. The driving force behind these results is the assumption that offshoring induces a productivity-enhancing effect, similar than skill biased technological progress. However, when turning to the effects on the high skill labor ratio, as the industries' production structure, results are not as clear cut anymore. As mentioned in the theoretical section above, a wage-effect gets accompanied by an offshoring-effect, with the possibility of both effects outperforming each other. As shown in Horgos

(2009b), the elasticity of substitution between low and high skilled labor is one key parameter to solve this pattern. If the elasticity of substitution is high enough, what is assumed in most of the theoretical models, the wage-effect outperforms the offshoring effect leading to the implications described in Hypothesis (iii) above: If offshoring takes place in the relative high skill intensive industry, industries shift production towards relative more low skilled labor. Vice versa for the relative low skill intensive industry. If, by contrast, the elasticity of substitution is below a critical level, there is the possibility that the offshoring-effect outperforms the wage-effect, with opposite results. In the specific context analyzed in this contribution, we know that the strength of the wage effect is limited by the low degree of wage flexibility in Germany. Additionally, also the extent and the composition of offshoring different production parts is of high importance for the resulting tendencies. With respect to the empirical results found in the analysis above, it seems that, overall, substitutional forces as reactions on the wage effect are not as pronounced. By contrast, there seems to be another force additionally separating the industries. If the low skill intensive industries conduct offshoring activities, their production gets more and more low skill intensive, vice versa for the high skill intensive industries.

A possible interpretation of these results is that in some industries there can be more complementarity than substitution between domestic production of parts and offshoring of some production phases (giving rise to a very low elasticity of substitution). For example, if a high-skill intensive industry offshores production of high-skilled parts, the workforce employed domestically must also be skilled to use those components, and therefore the high-skill to low-skill labor ratio does not decline with offshoring, but it might even increase moderately. A complementarity effect can also occur if offshoring allows the industry to expand: when expanding, low-skill intensive industries will tend to increase the number of low-skill workers more than high-skilled workers, and vice versa in the high-skill intensive industries. This also can explain why offshoring always displays a negative effect on the H/L ratio in the low-skill intensive industries and a positive sign in the high-skill intensive industries.

Thus, whereas implications on relative wages are quite clear cut, implications on the industries skill ratio' are quite fuzzy, depending strongly on specific parameter assumptions and concrete empirical situations. Since it is not possible to capture all the theoretically assumed parameter values empirically it is of great interest to compare the findings of this contribution with those of other empirical examinations. As Falzoni and Tajoli (2010) show, results are similar for the Italian economy. Also in Italy, the high skill labor ratio increases if offshoring (measured with a narrow index) takes place in relative high skill intensive industries and it decreases if offshoring takes place in relative low skill intensive industries. Thus, it is interesting to have a closer look at the empirical offshoring situation in Italy compared to those in Germany. Despite several

differences of these two economies concerning the structure and the composition of the manufacturing sector, it is interesting to note that offshoring is in both economies more pronounced in relative high skill intensive industries compared to relative low skill intensive ones. It is also worth remembering that in both economies, labor markets and especially wage rates are fairly rigid. Therefore, in both cases we can expect the wage effect to be weak, and to observe the offshoring effect prevailing.

Another finding that is one of the core results of both empirical analyses, and even supports the theoretical findings so far (summarized in Hypothesis ii), is that it is of great importance in which industry offshoring takes place. Supporting the sector bias, implications of offshoring on the industries' skill intensity differ strongly if offshoring takes place in the relative high or the relative low skill intensive industries instead.

6 Conclusions

This contribution investigates the implications of offshoring on the industries' high skill labor ratio. By contrast to the effects on relative wages, implications on the industries' production structure are not as clear cut. A more direct offshoring-effect gets accompanied by an indirect wage-effect, with the possibility of both effects outperforming each other. From a theoretical point of view results strongly depend on detailed assumptions, as e.g. the elasticity of substitution between high and low skilled labor, and on the extent and composition of offshoring activities as well. Since there are only few contributions investigating the effects of offshoring on the industries' skill ratio, this paper tries to shed some more light into this discussion.

The value added of the paper is as follows: Since the main part of offshoring literature focus on effects on relative wages, and since most empirical investigations are not based on clearly specified theoretical hypothesis, the paper summarizes the main theoretical findings on the effects of offshoring on the skill ratio in order to distill from the theory three testable hypotheses providing the theoretical base for the empirical analysis. The empirical analysis on the effects of offshoring on the industries' high skill labor ratio presents the first results for the German economy, supporting the sector bias of offshoring. The effects on the skill ratio are mainly driven by the skill intensity of the industry where offshoring takes place and only to a minor extent by the skill intensity of the relocated production fragment. If offshoring occurs in the relative high skill intensive industries, the industries' high skill labor ratio increases, whereas it decreases if offshoring takes place in the relative low skill intensive industries. This detailed result, however, seems to contradict with theory at first sight. Therefore, the paper further discusses the link between theoretical and empirical findings and the relation to other empirical examinations as well. From a theoretical point of view, results seem to crucially depend on the elasticity of substitution as well as on the extent and

composition of the offshoring activity. In an empirical manner it is interesting to note, that in Germany and also in Italy (where a similar pattern could be achieved) offshoring is strongly pronounced in the high skill intensive industries of the manufacturing sector.

These offers several possibilities for future research. A comparative cross country analysis would be of high interest. What are the factors that seem to be stable across countries and what are the ones that seem to differ? Further on, it would be worth investigating the importance of measurement differences in this respect. Additional insights could be achieved from firm level data. In order to concretely link theoretical findings to empirical examinations, the elasticity of substitution needs also to be taken into account empirically. This would be an additional area of great interest for future empirical investigations.

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