Offshoring and non-linear employment effects across industries*

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7th November 2017

Abstract

We analyze the effects of offshoring across sectors with different shares of offshorable tasks. Our main result suggests that, when sectors are linked in general equilibrium, a reduction in labor demand will not only occur in offshoring-intensive sectors but also in sectors with a low share of offshorable tasks. To derive this result, we set up a GOLE model with a continuum of sectors that differ in their intensity of offshorable tasks. In this framework, offshoring leads to heterogeneous profits across sectors with firms in offshoring-intensive industries gaining relative to their counterparts in non-offshoring sectors. In the long-run, capital is mobile and will be re-invested towards high profitable industries. This leads to firm entry (exit) in sectors with a high (low) share of offshorable tasks and generates a hump-shape pattern of employment across sectors. While offshoring-intensive industries face a reduction in employment because of the relocation effect, labor demand in sectors with a high prevalence of domestic production falls because of rising domestic wages in general equilibrium and firm exits. Hence, our model predicts positive employment effects only for industries with a medium share of offshorable tasks. To take this prediction to the data, we focus on Germany and use the fall of the Iron Curtain as a natural experiment, which greatly increased the opportunities of German firms to engage in offshoring. Using high-quality administrative data, we find strong empirical support for the hump-shape in the change of employment across industries with different scopes for offshoring.

JEL Classification: F12, F16, F23, J23, L13
Keywords: General oligopolistic equilibrium; Task offshoring; Offshoring and employment

*We thank Hartmut Egger, Ingo Geishecker, Udo Kreickemeier, Jens Wrona and participants at Research Seminar in Wuerzburg, IO-Trade Seminar in Munich, European Trade Study Group in Helsinki, Workshop International Economics in Goettingen and the Junior Faculity Retreat in Munich for their helpful comments. Michael Irlacher thanks the German Science Foundation (DFG grant number EC 216/7-1) for financial support.

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1 Introduction

The allocation of resources across firms and industries is essential for countries to absorb shocks and sustain economic growth. One of the main challenges during the past decades was offshoring, i.e. the fragmentation of the production process across borders to source intermediate inputs from many different countries (Yi, 2003). From the perspective of workers, offshoring generates substantial endogenous mobility ("push effects") out of the exposed sectors in the short-run and leads to differences in employment and wages across industries.[1] From the perspective of firm owners, offshoring induces inter-sectoral reallocation of capital in the long-run, triggered by a business stealing effect towards industries which benefit above average from offshoring ("push effects").[2] While net changes in factor demand across industries following trade liberalization is the core of traditional trade models, less attention is drawn on the sectoral heterogeneity in the possibilities to offshore and its implications in a general equilibrium framework.[3] Investigating how offshoring leads to inter- and intra-industry reallocation of workers and capital in the short and long-run and the consequences for sector specific employment and competition and overall welfare is the aim of this paper.

We document a substantial heterogeneity in the potential prospects for offshoring across industries within an economy.[4] We employ German social security data from the Institute for Employment Research (IAB) for the period 1975-2014. At the individual level our sample contains a 2% sample of workers covered by social security including occupation (4-digit level) and industry (5-digit level) information. At the plant level, we use the Establishment History Panel covering 50% of establishments including industry and entry and exit information. This information can be merged with occupation specific indicators of task contents ("offshorability") and industry specific trade flow data (e.g. intermediate goods imports). We follow the definition of Blinder and Krueger (2013), to quantify the offshorability at the occupation level, which is finally used to generate a measure of offshorability at the industry level.

We build on the general oligopolistic equilibrium model (GOLE) introduced by Neary (2016), to investigate offshoring effects in a multi-sector model. In our setting the home country consists of a continuum of sectors, where each sector produces a homogenous final good under Cournot competition. Labor is the only variable factor of production and can freely move among industries. As documented in the first step, sectors differ in the intensity of routine and non-routine tasks and

[1]For instance, Dauth et al. (2016) document substantial reallocation of workers across industries for Germany after the fall of the Iron Curtain and after China entering the WTO. Artuç and McLaren (2015) point to the importance of a worker's industry and occupation when determining who is affected from shocks relying on US Data. Furthermore, recent empirical work on job switching provides quite substantial movements of workers among industries. For instance, workers in the United States change 1-digit industries at rates of between 13% (Kambourov and Manovskii, 2008) and 20% (Parrado et al., 2007) a year.

[2]Looking at the hard disk drive industry, Igami (2017) documents that due to a competitive pressure "the incentives to offshore increase as more rivals offshore: offshoring breeds offshoring" (p. 5) thereby reducing prices and market shares of competing firms.

[3]See the discussion to the related literature below.

[4]Becker and Muendler (2015) and Hummels et al. (2016) also find significant variation across industries in the level and growth of intermediate imports.

thus in the opportunities to offshore parts of the production process to a low wage country. To keep the analysis tractable, we assume that the foreign economy just serves as a big labor reservoir for routine task production and foreign labor income is solely spend on freely tradable final goods, while final goods are exclusive assembled at home.[5] In contrast to Neary (2016), firm entry is endogenous in our setting. Thereby, we follow Egger and Etzel (2014) and assume that setting up a firm requires one fixed unit of capital and capital owners receive profits made by the firm.

In the closed economy all sectors are fully symmetric with respect to their unit production costs, as all routine and non-routine tasks must be performed domestically. Since profits decline in the number of competitors within an industry, firm number is the same in all sectors to make capital owners indifferent in their investment decision and we end up in a "featureless economy" (cf. Neary 2003). When allowing for offshoring routine tasks to a low-wage country, production costs vary among industries. The magnitude in cost-differences depend beside trade costs to ship tasks among countries on the size of the foreign labor force, which affects offshore production costs in a general equilibrium setting. The impact of offshoring can be decomposed into three different channels: (i) a reallocation effect, which captures the substitution of domestic routine task employment by foreign workers, (ii) a productivity effect, as offshoring firms produce at lower marginal costs and (iii) a market size effect, arising from additional demand for domestic produced freely tradable final goods by foreign workers.

In the short-run, i.e. for given allocation of capital and thus symmetric firm number in all sectors, opening the economy leads to changes in profits among industries.[6] While profits unambiguously increase in high offshoring intensive industries, sectors with a small share of routine task production may see their profits declining in a general equilibrium framework, when the productivity effect is stronger than the reallocation effect. In the long-run, we allow capital owners to de- and reinvest which results in a reallocation of capital towards high offshoring intensive, i.e. high profit industries. As profits negatively depend on the number of competitors within an industry, the business stealing effect leads to a decline (increase) in profits in high (low) offshoring intensive industries and, in equilibrium, to symmetric profits over all sectors.

After fully characterizing the general equilibrium in the short and long-run, we investigate the labor market effects of offshoring. Sector specific employment depends on a complex interplay among the three different offshoring channels. In high offshoring intensive industries, the reallocation effect dominates the productivity and market size effect and leads to job losses. Similar affects arise in low-offshoring intensive industries, where the reallocation effect is not present by construction but are a result of falling outputs and profits due to higher domestic production cost. Contrary, in medium offshoring intensive industries, labor demand increases as the market size and productivity effect outweigh the reallocation effect. To put it differently, our model predicts a

[5] A similar parsimonious modeling of the foreign economy can be found in Egger et al. (2015) in the context of offshoring.

[6] The endogeneity of capital investment as a criterion to distinguish the long-run from the short-run is common in the literature (see, for instance, Blanchard and Giavazzi, 2003) and is also used by Egger and Etzel (2014) to introduce firm entry and exit in the long run in the GOLE framwork.

hump-shape in employment growth depending on the routine task production of industries.

By introducing endogenous firm entry and exit we can also disentangle the short and long-run effects from offshoring. Thereby offshoring leads to substantial reallocation of workers from high- and low-offshoring intensive industries, towards industries with a medium share of routine tasks in the short-run. In the long-run, aggregate labor demand within an industry is unaffected by the reallocation of capital. However, the exit and entry of firms leads to intra-industry reallocation of workers. Hence, our model predicts strong push and pull effects of workers across industries in the short-run and within industry worker movements in the long-run. Furthermore, the inter-sectoral reallocation of capital towards offshoring intensive industries mitigates the (positive) productivity effect on wages and welfare in the long-run.

Finally, we take the key predictions of our stylized two-country model of offshoring to the data and use the fall of the Iron Curtain as a natural experiment for Germany. Thereby, Germany is well suited to study the labor market effects of offshoring as the reallocation of production of Germany to Central and Eastern Europe increased rapidly in the aftermath of the fall of the Iron Curtain (e.g. Geishecker, 2006; Marin 2006; Dustmann et al., 2014). We use the pre-fall distribution of occupations across (West) German industries as a proxy for the sector-specific offshorability and investigate how differences in offshorability affect changes in total employment, worker reallocation and establishment entry and exit. Looking at employment growth, we find a statistically significant hump-shape as predicted by our theory. Thereby the differential impact of offshorability on the change in sector employment is even more pronounced when expanding the period of time before and after the fall of the Iron Curtain.

By investigating the labor market effects of offshoring our paper contributes to a large literature on offshoring in general equilibrium models. Thereby, the discussion has mostly focused on labor-market outcomes (e.g. skill premium, job destruction) by modification of traditional trade models (Feenstra and Hanson 1997, Grossman and Rossi-Hansberg 2008, Burstein and Vogel 2010) or more recently, trade models with firm heterogeneity (e.g. Antras and Helpman 2004, Antras et al. 2006, Egger et al. 2015). Thereby, positive labor and welfare effects are more likely, if the productivity effect dominates the reallocation effect, the two major effects of offshoring that have been identified in the literature. However, in spite of nearly two decades of research on offshoring, less attention is drawn on sectoral heterogeneity in the possibilities to offshore. This paper aims to fill this gap by investigating how labor and welfare effects arising from offshoring vary if one takes sectoral differences in offshoring into account. To be more specific, as capital owners shift the resources towards sectors which benefit above average from offshoring, we show that existing models exaggerate the productivity effect by ignoring inter-sectoral reallocation in the long-run. Furthermore, due to the exit of firms in non-offshoring sectors, labor markets effects arise even in sectors, where one would not expect any.

Building on the general oligopolistic equilibrium model introduced by Neary (2016), our model contributes to a growing literature, that investigates labor market effects in a GOLE setting (see, for instance, Bastos and Kreickemeier 2009, Egger and Etzel 2012, Egger and Koch 2012). However, in all of these papers globalization is captured by trade in final goods and less attention is drawn on trade in intermediates (or tasks).[7] Thereby, the model is especially well equipped to study the implications of offshoring. First, it provides a general equilibrium setting to study labor market and welfare effects of offshoring. Second, it allows us to incorporate sectoral heterogeneity arising from differences in non-routine and routine task requirements among industries in a tractable way. And, thirdly, it allows for strategic interaction among firms within an industry. A prerequisite to endogenize firm entry and exit to study the implications of offshoring on the competitive environment (e.g. market shares, mark-ups) within industries.[8]

2 Model setup

In this section, we introduce a simple model of offshoring and embed it into a general oligopolistic equilibrium (GOLE) framework. There are two countries Home (H) and Foreign (F), whereas H is the source and F is the host country of offshoring. Running a firm requires capital which we assume is available only in H. This implies that all firm headquarters are located in H. Foreign workers can only be employed by H firms to produce offshored tasks. They receive labor income which in turn is spent on final products of country H.

Our economy consists of a continuum of sectors, whereas each sector consists of a finite number of competing firms. To produce one unit of output, firms combine non-routine and routine tasks, whereas only the latter is offshorable. Since we are interested in sector heterogeneity with respect to the prospects for offshoring, the share of routine and non-routine tasks, respectively, varies across sectors. Within a sector, firms are identical and make use of the same technology. Further, we assume that workers are homogeneous and mobile across sectors. Finally, wages are determined at the economy-level such that firms take factor prices both in H and F as given.

In the following steps, we describe consumer preferences as well as firm technology and characterize an autarky equilibrium without offshoring. Then F enters the economy and offshoring opportunities arise. In our analysis of opening the economy, we distinguish between short-run and long-run adjustments. While the allocation of firms across sectors is fixed in the short-run, capital and, hence, firms are mobile in the long-run. Therefore, capital is reallocated in the long-run and flows towards high profitable sectors.

[7]One exception here is Eckel and Irlacher (2017). However, their focus is on product line relocations within multi-product firms and emphasize substantial differences among multi- and single-product firms.

[8]Finally, by taking the key predictions to the data our paper contributes to a large empirical literature that investigates the labor market effects of offshoring. See Hummels et al. (2016) for a survey of the literature.

2.1 Preferences

We assume an additively separable utility function defined over a continuum of sectors on the unit interval. Each sector z produces a different variety. Consumer c maximizes utility

$$U\left[x_c(z)\right] = \int\limits_0^1 \left[a x_c(z) - \frac{1}{2} b \left(x_c(z)\right)^2\right] dz \tag{1}$$

subject to a budget constraint $\int_0^1 p(z)\, x_c(z)\, di \leq I_c$ where $p(z)$ denote price of variety z and I_c is consumer c's income. Solving the utility maximization problem yields the following individual inverse demand function

$$p(z) = \frac{1}{\lambda_c}\left(a - b x_c(z)\right) \tag{2}$$

where $\lambda_c = \frac{a\sigma_1 - bI_c}{\sigma_2}$ denotes the marginal utility of income of consumer c. The latter depends on the first and second moments of prices: $\sigma_1 = \int_0^1 p(z)\, dz$ and $\sigma_2 = \int_0^1 p(z)^2\, dz$.

We derive total demand $x(z)$ by aggregating over L workers and K capital owners. The inverse demand is equal to

$$p(z) = \frac{1}{\lambda}\left(a'_{aut} - b x(z)\right), \tag{3}$$

where $a'_{aut} = (K+L)\, a,\ \lambda = \sum\limits_c \lambda_c = (a'\sigma_1 - bI)/\sigma_2$ and $I = \sum\limits_c I_c = wL + \int_0^1 n(z)\, \pi(z)\, dz = \sum\limits_c \int_0^1 p(z)\, x_c(z)\, dz = (L+K) \int_0^1 p(z)\, x_c(z)\, dz$. Throughout our analysis we assume participation and non-satiation.[9] In the following we choose $\lambda = 1$ as the numèraire.

2.2 Firms and technology

Each industry is characterized by an endogenous number of firms $n(z)$ producing a homogeneous product. In each sector, firms use an identical technology, however technologies vary across sectors. Firms use labor to produce output and invest one unit of capital to start production. While producers take into account their impact on price $p(z)$, they ignore their impact on economy-wide variables. The profit of firm i in sector z is equal to:

$$\pi_i(z) = \left(p(z) - c(z)\right) y_i(z). \tag{4}$$

Firms maximize profits with respect to output under Cournot competition. The first order condition for scale is given by $\frac{\partial \pi_i(z)}{\partial y_i(z)} = p(z) - c(z) + \frac{\partial p(z)}{\partial y_i(z)} y_i(z) = 0$. By symmetry $y_i(z) = y_j(z) = y(z)$ and per firm output is given by

$$y(z) = \frac{a'_{aut} - c(z)}{b\left(n(z)+1\right)}. \tag{5}$$

[9] In the Appendix we specify a parameter constraint that guarantees participation and non-satiation of all consumers.

Substituting into inverse demand in equation (3) gives optimal prizes in sector z

$$p(z) = \frac{a'_{aut} + n(z)\,c(z)}{n(z)+1}. \tag{6}$$

Finally, we derive markups and profits as

$$\mu = \frac{a'_{aut} - c(z)}{n(z)+1} \tag{7}$$

$$\pi(z) = by(z)^2 \tag{8}$$

2.3 Equilibrium in autarky

Starting a firm, requires one unit of capital whereas K capital owners receive firm profits in return to their investment. Since capital owners maximize returns to investment, capital is allocated to sectors where profits are the largest. This implies that profits are equalized across sectors, i.e. $\pi(z) = \pi$. Capital market clearing requires

$$K = \int_0^1 n(z)\,dz = N. \tag{9}$$

Without opportunities for offshoring and cost symmetries across firms and sectors, we drop sector indices for the autarky equilibrium, i.e. $n(z) = n$ and $y(z) = y$. Given the unit mass of industries, we get $n = K$. In autarky, there is only domestic production whereas costs to produce one unit of output are simply given by $c(z) = c = w_{aut}$. To compute domestic wages in autarky w_{aut}, we substitute (5) into the labor market clearing condition $L = ny$ and derive

$$w_{aut} = a'_{aut} - \frac{b(n+1)L}{n} \tag{10}$$

Having computed the equilibrium wages, it is straightforward to compute the autarky equilibria for equations (5) - (8). We present results in table 1.

Table 1: Equilibrium outputs, prices, markups, and profits in autarky

Equilibrium values	Autarky
Outputs	$y_{aut} = \frac{L}{n}$
Price	$p_{aut} = a'_{aut} - bL$
Markup	$\mu_{aut} = \frac{bL}{n}$
Profits	$\pi_{aut} = b\left(\frac{L}{n}\right)^2$

2.4 Open economy

In the open economy, there is a potential offshoring destination F with L^* workers. Since there is no foreign capital, and capital can not cross borders, there are no foreign located firms. Therefore, workers in F can only be employed in offshored task activities of domestic firms. In the absence of offshoring, there is no employment in the foreign country and foreign wage income falls to zero. In the open economy final goods are consumed by domestic $(K+L)$ and foreign (L^*) consumers. We abstract from any international shipment costs. Inverse demand is similar to equation (3) in the closed economy, however now $a' = (K+L+L^*)\,a$, $\lambda = \sum_c \lambda_c = (a'\mu - bI)/\sigma$ and $I = \sum_c I_c = wL + \int_0^1 n(z)\,\pi(z)\,dz + w^*L^*$.

To derive our results we proceed as follows. In a first step, we compare the extreme cases of autarky with the open economy. In a second step, we analyze a gradual decrease in offshoring costs. Within both cases, we distinguish between the short and long-run. In the short-run, we assume that capital is not mobile, i.e. there is no exit and entry of firms and the number of firms per sector is given by the allocation in the autarky scenario. In the long-run, we allow for an endogenous entry and exit decision of firms such that capital moves into sectors where profits are the highest.

Domestic firms in sector z can relocate z percent of tasks to the low wage destination. Therefore, marginal production costs in sector z can be written as follows:

$$c(z) = z(w^*\tau) + (1-z)\,w, \tag{11}$$

where τ denotes iceberg-type transport costs to ship foreign produced tasks to the domestic country. The cost structure in equation (11) captures the idea, that sectors differ in the share of routine tasks and thus in the prospective cost savings from offshoring. In contrast to the closed economy, outputs, prices, markups and profits are now sector specific.

Since foreign workers earn a labor income that is spent on domestic products, opening the economy leads to a positive demand effect (larger $a' > a'_{aut}$). This effect is the same across all sectors. However cost saving effects are sector-specific and depend on share of offshorable tasks z. In the following, we derive the short and long-run equilibrium of our framework, whereas the subscripts s and l indicate equilibrium expression in the short and long-run respectively.

2.4.1 Short-run equilibrium

In the short-run, firm number n is given by the autarky allocation. To derive the short-run equilibrium, we determine domestic and foreign wages by making use of the domestic- and foreign labor market clearing conditions:

$$L = \int_0^1 L(z)\,dz = \int_0^1 (1-z)\,ny_s(z)\,dz, \tag{12}$$

$$L^* = \tau\int_0^1 L^*(z)\,dz = \tau\int_0^1 zny_s(z)\,dz. \tag{13}$$

By substituting optimal output (5) into the labor market clearing conditions, we compute equilibrium wages in the short-run as follows:[10]

$$w_s = a' + 2\frac{b(n+1)}{n}\left(\frac{L^*}{\tau} - 2L\right) \tag{14}$$

$$w_s^* = \frac{a' + 2\frac{b(n+1)}{n}\left(L - 2\frac{L^*}{\tau}\right)}{\tau} \tag{15}$$

Inspecting equation (14) shows that the domestic wage w_s rate decreases in domestic labor supply and increases in the size of effective foreign labor $\frac{L^*}{\tau}$. A larger pool of foreign labor implies lower foreign factor prices and higher cost savings from offshoring. Obviously, the latter increases the productivity effect of offshoring and thus increases domestic wages.

Now we are able to determine the equilibrium outcomes of equation (5) - (8) in the short-run. Since offshoring opportunities differ across sectors, outputs, prices, markups, and profits are now sector-specific. We present results in Table 2.

Table 2: Equilibrium outputs, prices, markups, and profits in the short run

Equilibrium values	Open economy in the short-run
Outputs	$y_s(z) = \frac{2\left((2-3z)L-(1-3z)\frac{L^*}{\tau}\right)}{n}$
Prices	$p_s(z) = a' + 2b(1-3z)\frac{L^*}{\tau} + 2b(3z-2)L$
Markups	$\mu_s(z) = \frac{2b\left((2-3z)L-(1-3z)\frac{L^*}{\tau}\right)}{n}$
Profits	$\pi_s(z) = b\frac{4\left((2-3z)L-(1-3z)\frac{L^*}{\tau}\right)^2}{n^2}$

Condition 1 *To ensure positive outputs in all sectors (i.e. $y_s(0) > 0$) and incentives for efficiency seeking offshoring (i.e. $w > w^*\tau$), we assume the following parameter restriction throughout our analysis: $2L \geq \frac{L^*}{\tau} \geq L$.*

Throughout our analysis, we will vary the size of foreign effective labor $\frac{L^*}{\tau}$ within the upper and lower bound. This corresponds to changes in the potential cost savings from offshoring. With $\frac{L^*}{\tau} = L$, savings from offshoring vanish since $w = w^*\tau$ which implies that firms in all sectors generate identical profits. However, as we will show, increasing $\frac{L^*}{\tau}$ leads to sector-specific cost savings effects whereas offshoring-intensive sectors will benefit most.

Proposition 1 *Since cost saving effects from offshoring increase in z, firms in offshoring-intensive sectors (higher z) face lower production costs. This implies that firms in sectors with a higher share*

[10] The proof of the existence of a unique equilibrium is provided in the Appendix.

Figure 1: Profits across sectors

of offshorable tasks set lower prices, sell at a larger scale and earn higher markups, i.e.

$$\frac{\partial p_s(z)}{\partial z} = -6b\left(\frac{L^*}{\tau} - L\right) < 0, \ \frac{\partial y_s(z)}{\partial z} = \frac{6\left(\frac{L^*}{\tau} - L\right)}{n} > 0, \ \textit{and} \ \frac{\partial \mu_s(z)}{\partial z} = \frac{6b\left(\frac{L^*}{\tau} - L\right)}{n} > 0. \quad (16)$$

In the following, we investigate firm profits at the sector-level and compare the results to autarky. While profits are identical across sector in autarky, Figure 1 shows that firm profits are increasing in the offshoring intensity of a sector.[11]

Figure 1 depicts a case where all sectors gain from opening to offshoring because of the cost savings and the market size effect. However, our framework also captures cases in which some sectors may lose from opening despite the new opportunities from offshoring production. To gain intuition for this result, we compare profits in sector 0 with profits in autarky. Furthermore, we compute the difference in profits between sector 1 and sector 0.

$$\pi_s(0) - \pi_{aut} = \frac{b\left(4\left(2L - \frac{L^*}{\tau}\right)^2 - L^2\right)}{n^2} \quad (17)$$

$$\pi_s(1) - \pi_s(0) = 3\left(\left(\frac{L^*}{\tau}\right)^2 - L^2\right) \quad (18)$$

Evaluating (17) at the upper bound for the size of the foreign labor market $\frac{L^*}{\tau} = 2L$, we derive a result where sectors with low offshoring potentials lose from opening the economy: $\pi_s(0) - \pi_{aut} = -\frac{bL^2}{n^2} < 0$. In this example, sectors $z \in [0; \frac{1}{6}]$ face lower profits whereas all other sectors gain. More

[11] To derive this figure, we compute the first and second derivative of $\pi_s(z)$ with respect to z: $\frac{\partial \pi_s(z)}{\partial z} = \frac{b}{n^2}\left[24\left((2-3z)L - (1-3z)\frac{L^*}{\tau}\right)\left(\frac{L^*}{\tau} - L\right)\right] > 0$ and $\frac{\partial^2 \pi_s(z)}{\partial z^2} = \frac{72b}{n^2}\left(\frac{L^*}{\tau} - L\right)^2 > 0$.

generally, we are able to show that the difference in profits decreases with falling offshoring costs τ:

$$\frac{\partial\left(\pi_s\left(0\right)-\pi_{aut}\right)}{\partial\tau}=\frac{8b\left(2L-\frac{L^*}{\tau}\right)\frac{L^*}{\tau^2}}{n^2}>0. \tag{19}$$

The intuition behind these results is as follows: In sectors close to 0, only few tasks are offshorable and thus benefits from falling offshoring costs are moderate. However, those sectors are hurt by general equilibrium effects on the domestic labor market. Inspecting equation (14) shows that due to the productivity effect of offshoring, domestic wages increase when offshoring costs fall. This increase in domestic factor prices especially hits sectors where the share of domestic production is relatively high. The intuition that sectors are affected differently from opening the economy to offshoring, as well as from falling offshoring costs, is important for the understanding of capital movements in the long-run equilibrium. Since firm profits are not any longer equalized across all sectors, there are incentives for capital reallocations across industries.

Finally, we analyze the event of a gradual liberalization of offshoring costs τ. Differentiating profits π_s with respect to τ yields

$$\frac{\partial\pi_s\left(z\right)}{\partial\tau}=\frac{8b\left(\left(2-3z\right)L-\left(1-3z\right)\frac{L^*}{\tau}\right)\left(1-3z\right)L^*}{n^2\tau^2}\gtrless 0. \tag{20}$$

Inspecting equation (20) shows that profits in sectors $z\in\left[0;\frac{1}{3}\right[$ are reduced following a liberalization process, i.e. $\frac{\partial\pi(z)}{\partial\tau}>0$, whereas firms in sectors $z\in\left]\frac{1}{3};1\right]$ expand profits. It is easily verified, that the same result holds true when differentiating markups $\mu_s\left(z\right)$ with respect to τ. Since we are interested in capital reallocations and thus firm movements across sectors, the latter result is of importance for our long-run analysis in the subsequent section.

Proposition 2 *Falling offshoring costs lead to lower profits (mark-ups) in low offshoring-intensive sectors and higher profits (mark-ups) in high-offshoring intensive sectors.*

2.4.2 Long-run equilibrium

In the long-run, capital is mobile across sectors within the economy and will migrate towards sectors with higher profits. In equilibrium, capital moves until owners are indifferent, i.e. profits are equalized across all sectors. Since markups and profits are largest in offshoring-intensive sectors (see proposition 1), firms will enter these sectors and will exit low offshoring-intensive sectors.

To solve the equilibrium, we consider again the domestic and foreign labor market clearing conditions in equations (12) and (13) with the difference being that now firm number $n\left(z\right)$ is sector-specific. Additionally, since we allow the firm allocation to differ from the autarky result, we make use of the capital market clearing condition (9) as well as the no arbitrage condition

$$\pi\left(z\right)=\pi=\pi\left(0\right). \tag{21}$$

Substituting profits into the latter condition, we determine the equilibrium number of firms in each sector z

$$n(z) = \frac{(a' - w)\, n(0) + z\,(n(0) + 1)\,(w - w^*\tau)}{(a' - w)}, \tag{22}$$

whereas $n(0)$ is the equilibrium number of firms in sector 0. In a next step, we substitute (22) into the capital market clearing condition (9) to derive the equilibrium number of firm in the purely domestic producing sector 0:

$$n(0) = \frac{2\,(a' - w)\, K - (w - w^*\tau)}{(2a' - w - w^*\tau)}. \tag{23}$$

From the discussion of Figure 1, we know that the firm number in sector 0 will be the lowest since profits are increasing in a sector's opportunity for offshoring z. Therefore, since short-run profits are the highest in offshoring intensive industries, $n(z)$ is increasing in z.

To derive equilibrium wages in the long-run, we substitute equations (22) and (23) into the domestic- and foreign labor market clearing conditions in equations (12) and (13).

$$w_l = \frac{a'K - (4K + 1)\, bL + \frac{(2K-1)bL^*}{\tau}}{K} \tag{24}$$

$$w_l^* = \frac{a'K + (2K - 1)\, bL - \frac{(4K+1)bL^*}{\tau}}{\tau K} \tag{25}$$

Finally, we substitute equilibrium wages (24) and (25) back into equations (23) and (22), to derive the sector-specific equilibrium number of firms in terms of exogenous variables:

$$n(0) = \frac{2K\left(2L - \frac{L^*}{\tau}\right)}{\left(L + \frac{L^*}{\tau}\right)}, \tag{26}$$

$$n(z) = \frac{2K\left((2 - 3z)\, L - (1 - 3z)\, \frac{L^*}{\tau}\right)}{\left(L + \frac{L^*}{\tau}\right)}. \tag{27}$$

Lemma 1 *In the long-run, the equilibrium number of firms per sector is an increasing function of z i.e.*

$$\frac{\partial n(z)}{\partial z} = \frac{6K\left(\frac{L^*}{\tau} - L\right)}{\left(L + \frac{L^*}{\tau}\right)} > 0. \tag{28}$$

Since capital is mobile in the long-run, new firms are founded in the most expanding sectors while less expanding (or shrinking) sectors face firm exit. Considering the thought experiment of opening the economy from autarky to the long-run trade equilibrium, it is easily shown that the firm number in sector $z = \frac{1}{2}$ is unchanged. Sectors with $z < \frac{1}{2}$ lose firms, while sectors with $z > \frac{1}{2}$ gain firms. This movement of firms ensures that the no arbitrage condition is fulfilled in the long-run equilibrium, leading to identical firm profits across all sectors:

$$\pi_l = \frac{b\left(L + \frac{L^*}{\tau}\right)^2}{K^2}. \tag{29}$$

In a next step, we analyze the effect of a gradual trade liberalization on the long-run equilibrium number of firms per sector. From the discussion of proposition 2 we know that falling offshoring cost increase profits in offshoring intensive sectors and decrease profits in sectors with predominantly domestic production. Hence, we can show that in sectors $z > \frac{1}{2}$ the firm number increases whereas in sectors $z < \frac{1}{2}$ the equilibrium number of firms falls.

Proposition 3 *Falling offshoring costs increase profits in offshoring-intensive industries which attracts capital (firms) from sectors that produce predominantly with domestic labor, i.e.*

$$\frac{\partial n(z)}{\partial \tau} = 6K \frac{L^*}{\tau^2} \frac{L(1-2z)}{\left(L + \frac{L^*}{\tau}\right)^2} \lesseqgtr 0. \tag{30}$$

So far, our analysis has shown that - in the short-run - offshoring leads to higher markups and profits in offshoring-intensive sectors. However, since capital in mobile in the long-run, new entrants increase competition in these sectors and compete away profits from incumbent firms. To shed more light on the effects of competition, we compute the average profits in the short-run

$$\widetilde{\pi}_s = \frac{4b\left(L^2 + \left(\frac{L^*}{\tau}\right)^2 - L\frac{L^*}{\tau}\right)}{n^2} \tag{31}$$

and compare them to the average profits in the long-run (29):[12]

$$\widetilde{\pi}_s - \pi_l = \frac{3b}{K^2}\left(\frac{L^*}{\tau} - L\right)^2 > 0. \tag{32}$$

Equation (32) shows that average firm profits decrease in the long-run. The latter can be explained by competition that is intensified especially in formerly high profitable sectors.

Lemma 2 *Average profits decrease in a comparison between the short- and long-run since competition between firms is intensified in sectors that are highly profitable in the short-run.*

2.5 Labor market effects of offshoring

In this section, we focus on labor market effects in the presence of sector-specific opportunities for offshoring. In the short-run, opening the economy impacts domestic labor demand through three different channels: i) a relocation effect, ii) a productivity effect, and iii) a market size effect from additional foreign consumers. In the first part of this section, we start by comparing labor demand per sector in autarky versus the open economy. In the second part, we distinguish between the outcomes in the short and long-run equilibrium whereas we especially focus on the equilibrium wages in the two scenarios.

[12]To compute the average profits in equation (31), we simply integrate the short run profits from Table 2 over the unit interval.

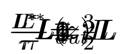

Figure 2: Labor demand across sectors

2.5.1 Labor demand in autarky versus the open economy

To investigate the impacts of offshoring in more detail, we compute the sector-specific labor demand

$$L(z) = 2(1-z)\left((2-3z)L - (1-3z)\frac{L^*}{\tau}\right). \tag{33}$$

In Figure 2, we plot labor demand per sector in autarky L_{aut} as well as in the open economy $L(z)$. The latter is drawn for three different effective sizes of the foreign labor market $\frac{L^*}{\tau}$ within the range of possible values that is predefined by Condition 1.

The dotted line represents a scenario without any cost saving effects of offshoring, since $\frac{L^*}{\tau} = L$ implies $w = w^*\tau$ such that production costs are identical in all sectors. In this case, per sector output is identical across all sectors and domestic labor demand decreases monotonically in z, whereas foreign labor demand is simply the mirror image of the domestic one. In comparison to autarky, $L(z)$ increases (decreases) in sectors $z < \frac{1}{2}$ $(z > \frac{1}{2})$. Starting from this edge case, where firms would be just indifferent whether to offshore production or not, we now increase step by step the effective supply of foreign labor (increase L^* or decrease τ). By doing so, we widen the gap between domestic and foreign wages which generates differential effects across sectors. The dashed line is drawn for intermediate cost savings from offshoring whereas the solid line represents a scenario where possible cost savings from offshoring are largest.

Given differences in factor prices and sector-specific cost savings, industries with enough routine tasks expand production whereas sectors which produce predominantly in the home country shrink compared to the case where $\frac{L^*}{\tau} = L$. The shrinkage of sectors which produce overwhelmingly with domestic labor is driven by general equilibrium effects on the domestic factor market. Since production becomes more efficient when foreign factor prices decrease, economy wide demand for labor increases because of the productivity effect. To ensure labor market equilibrium in H, domestic factor prices increase thereby hitting especially those sectors with a large share of domestic production. In the case of intermediate cost savings and thus intermediate factor price differences between H and F (dashed line), sector specific labor demand in mostly domestic sectors is still higher compared to autarky. The reason behind this result is the additional demand from foreign workers which outweighs the general equilibrium effects. However, if factor price differences are large between the two countries (solid line), the model predicts a hump-shaped pattern for the labor demand across sectors. In comparison to autarky, in sectors $z \in [\underline{z}; \overline{z}]$ labor demand increases whereas sectors $z \in [0; \underline{z}[$ and $z \in]\overline{z}; 1]$ decrease domestic labor. In industries with a high share of offshorable tasks, the reason for the reduced demand for domestic labor is straightforward: the relocation effect of offshoring. Predominantly domestic sectors i.e. $z \in [0; \underline{z}[$ shrink since they are hit most by increasing domestic wages. The increase in the latter is especially large since the productivity effect of offshoring becomes stronger the larger is the foreign pool of labor. We summarize our findings in the following proposition.

Proposition 4 *In a model with sector-specific offshoring costs, offshoring leads to a reallocation of workers across sectors. If cost saving effects of offshoring are high, the model predicts worker flows from the low and high offshoring-industries towards industries with an intermediate share of offshorable tasks. Given a larger pool of foreign workers, the productivity effect of offshoring effect becomes strong such that labor demand in predominantly domestic sectors is reduced due to rising domestic wages in general equilibrium. Sectors with a high share of offshorable tasks expand in outputs when cost saving effects are large, however due to the relocation effect, labor demand decreases compared to autarky.*

So far, we have analyzed the transition from autarky to the open economy, without elaborating differences between the short and long-run equilibrium. Equation (33) represent total employment in sector z and holds true for the short and long-run equilibrium. The difference between the two equilibria appears when we compute the labor demand per firm in the short and long-run:

$$l(z)_s = (1-z)\frac{2\left(2L + 3z\frac{L^*}{\tau} - 3Lz - \frac{L^*}{\tau}\right)}{K}, \tag{34}$$

$$l(z)_l = (1-z)\frac{\left(L + \frac{L^*}{\tau}\right)}{K}. \tag{35}$$

It is easily verified, that the labor demand per firm between the short and long-run equilibrium is unchanged in sector $z = \frac{1}{2}$. Reconsidering the discussion following Lemma 1, we already know that sectors $z < \frac{1}{2}$ face firm exit since capital is moving towards sectors with $z > \frac{1}{2}$. The latter implies that competition is dampened in sectors $z < \frac{1}{2}$ whereas it is intensified in sectors with $z > \frac{1}{2}$. Therefore, labor demand per firm is reduced in offshoring intensive sectors because of the business stealing effect and increased in predominantly domestic sectors because of a less competitive environment. These insights allow us to draw additional conclusions about the worker flows in the short and long-run equilibrium which we summarize in the following Lemma.

Lemma 3 *Opening the economy for offshoring leads to reallocations of workers between sectors in the short-run. In the long-run, workers move between firms within sectors.*

2.5.2 Wages in the short and long-run analysis

In this section, we analyze the development of domestic wages in the short and long-run equilibrium. It is important to note, that wages should be interpreted as "real at the margin" (cf. Neary, 2002, 2016) and therefore, we cannot derive any welfare implications by simply interpreting changes in wages in the short and long-run separately. However, we can compare changes in wages between the short and long-run equilibrium. Comparing wages in equations (14) and (24), we observe higher wages in the short-run

$$w_s - w_l = \frac{3b\left(\frac{L^*}{\tau} - L\right)}{K} > 0, \tag{36}$$

whereas the gap widens, the larger are the cost savings from offshoring:

$$\frac{\partial\left(w_s - w_l\right)}{\partial \tau} = -\frac{3bL^*}{K\tau^2} < 0. \tag{37}$$

The intuition behind this result is as follows: The driving force behind rising wages in the short-run equilibrium is the productivity effect of offshoring. When offshoring opportunities improve, production becomes more efficient and demand for domestic labor increases because of rising sales. In the long-run, there is an opposing force since capital moves from predominantly domestic sectors towards offshoring-intensive industries. The latter reduces domestic labor demand since firms leave sectors with a large share of domestic production and enter industries with many offshore activities. To ensure a labor market equilibrium, domestic wages are reduced compared to the short-run scenario.

Proposition 5 *In the long-run, domestic wages are reduced because of capital movements towards offshoring-intensive industries.*

3 Empirical analysis

3.1 Empirical setting

To take some of the key predictions of the theoretical model to the data, we consider the (West) German experience in the wake of the fall of the Iron Curtain. This setting seems to be particularly fitting and empirically attractive for a number of reasons. First, the opening-up and economic transformation of these formerly socialist countries into market economies, most of which are just at Germany's doorstep, greatly increased the opportunities of German firms to engage in cross-border production sharing. In the context of the theoretical model, this process can be interpreted as

Figure 3: The development of offshoring over time

Notes: Offshoring=share of imported intermediates in industry total output. Wide offshoring includes all imported intermediates from abroad. Narrow offshoring restricts attention to imported intermediates from the same 2-digit industry. Material offshoring only includes imported intermediates from manufacturing industries (NACE Rev. 1 codes 15–37). Services offshoring only includes imported intermediates from commercial service industries (NACE Rev. 1 codes 64–67 and 71–74). Panel A displays level values of the offshoring measures. Panel B displays index values, where all measures have been normalized to 100 for the year 1991. Output-weighted average over 2-digit industries.
Source: German input-output tables, own calculations.

having led to a significant increase in the size of the foreign (low-wage) labor pool, L^*. Moreover, since these countries are close by, trade costs with them are considerably lower than trade costs with countries that can offer a similarly skilled and yet comparatively low-paid workforce such as, say, in "Factory Asia". Also, trade costs further declined over time. Trade integration with the Central and Eastern European countries started with the Europe Agreements in the early and mid 1990s and culminated in the EU accession of several of these countries in the years 2004, 2007, and 2013.[13] Thus in the context of the model, this shock led to a decline in offshoring costs, τ. Note that, from the perspective of the West German economy, German reunification had a very similar effect.

Previous research has indeed shown that offshoring of Germany to Central and Eastern Europe increased rapidly in the aftermath of the fall of the Iron Curtain and analysed some of its (labor market) consequences (e.g. Geishecker 2006; Marin 2006; Dustmann et al., 2014). Also in an international comparison, Johnson and Noguera (forthcoming) highlight Germany as one example of an advanced economy with a particular large decrease in the value added to export (VAX) ratio, a measure of international production fragmentation, over the period 1970 to 2009 (without breaking this up by destination region, however). This decline was considerably larger than the ones experienced by, say, the US, Japan, the UK, or France over the same period of analysis.

Figure 3 further illustrates the increase in Germany's offshoring intensity over time, where the offshoring indicators are constructed from German input-output tables as the share of imported intermediates in (2-digit) industry total output.[14] Four different measures are constructed: Wide offshoring includes all imported intermediates from abroad; narrow offshoring restricts attention to imported intermediates from the same 2-digit industry; material offshoring only includes imported intermediates from manufacturing industries (NACE Rev. 1 codes 15–37) and services offshoring only imported intermediates from commercial service industries (NACE Rev. 1 codes 64–67 and 71–74) abroad. Panel A displays the development of the nominal values of these indices, while Panel B shows the growth of index values, where all measures have been normalized to 100 for the year 1991.[15] Offshoring stayed fairly flat or even slightly decreased up to the mid 90s, but increased

[13]Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Slovenia, and Hungary joined in 2004; Bulgaria and Romania joined in 2007; and Croatia joined in 2013.

[14]The figures display the output-weighted average over all 2-digit industries.

[15]Due to the limited availability of comparable input-output tables, these indices can only be constructed for the years 1991 to 2007. Moreover, they refer to the whole of (unified) Germany, while the subsequent empirical analysis will restrict attention to West Germany only.

substantially thereafter. There was another dip in the wake of the burst of the dotcom bubble in 2001, but the rise of offshoring continued from 2003 onwards. Overall, wide offshoring increased from 7.8% to 11.3% (by 46%) and narrow offshoring from 2.4% to 4.4% (by 80%). One can also see that services offshoring, while still of limited quantitative importance compared to material offshoring in level terms, had the largest growth rates between 1991 and 2007.

3.2 Empirical approach and specification

While the fall of the Iron Curtain constitutes and unforeseen shock to the West German economy as a whole, we exploit the fact that different industries were prepared to varying degrees to take advantage of the new offshoring opportunities due to their differences in the share of offshorable tasks.

Specifically, we relate industry-level labor market outcomes (several years) after the fall of the Iron Curtain to the pre-fall share of offshorable tasks. In line with the model's prediction, we allow this effect to be non-linear. We estimate different versions of the following regression model

$$\Delta Y_{jh} = \alpha + \beta_1 Offshorability_{j,1988} + \beta_2 Offshorability^2_{j,1988} + X'_{j,1988}\gamma + u_{jh}, \tag{38}$$

where j denotes the 3-digit industry and h the time horizon. As our main outcome variable, ΔY_{jh}, we consider the change in log employment between 1988 and year $1988 + h$, where we let h vary up to a maximum of 26 (given that the final year of our sample is 2014). In addition to the quadratic term of $Offshorability$, whose exact construction we explain in the data section below, we include a rich set of start-of-period control variables, $X_{j,1988}$: a dummy that equals one if the industry is part of the manufacturing sector (such that we only exploit variation within the manufacturing and the non-manufacturing sectors, respectively); employment shares by age[16]; employment shares by education[17]; female employment share; foreign employment share; and a quadratic term of log total employment.[18] To allow for a potential serial correlation of the error term within broader industry groups, we cluster standard errors at the 2-digit industry level.

3.3 Data and measurement

3.3.1 German social security data

The main data set used in the empirical analysis is the Sample of Integrated Employment Biographies (SIAB).[19] It is a 2-percent random sample of administrative social security records, which is assembled from different sources and provided by the Institute for Employment Research (IAB) at the German Federal Employment Agency.[20] The population is the universe of individuals who

[16]We distinguish 5 age groups: 18–25; 26–35; 36–45; 46–55; and 56–65.

[17]We distinguish 5 education groups: Missing; Lower secondary school or less without vocational training; Lower secondary school or less with vocational training; Abitur (with or without vocational training); University or more.

[18]Summary statistics of the dependent and the explanatory variables are given in Table A.4 in the appendix.

[19]See Antoni, Ganzer and vom Berge (2016) for a detailed description of the data.

[20]The data set was first accessed during a stay at the Research Data Centre (FDZ) of the German Federal Employment Agency at the IAB and subsequently via controlled remote data processing.

had one of the following statuses at least once during the observation period: employed in a job covered by social security; marginally employed (recorded from 1999 onwards); participation in an employment or training measure (recorded from 2000 onwards); receipt of benefits; registered as as job seeker with the Federal Employment Agency (recorded from 2000 onwards). This includes roughly 80 percent of all German employees. Notable exceptions are the self-employed and civil servants. For the sampled individuals, the data set covers the entire employment biography with respect to the covered statuses and is exact to the day.

The information provided for the employment spells includes – apart from other characteristics – the occupation of the individual following the KldB1988 classification of the German Federal Employment Agency (Bundesantalt für Arbeit, 1988). Furthermore, although the original industry classification changes a few times during the period of observation, the Research Data Centre of the German Federal Employment Agency provides a consistent series of (imputed) three-digit NACE Rev. 1 codes, which is used in the present analysis (cf. Eberle et al., 2011).

We restrict attention to regular workers between 18 and 65 years of age. That is, we discard apprentices, trainees, marginal employed in so-called "mini jobs", home workers, individuals in partial retirement, as well as individuals who are currently on leave. The data set does not contain information on the hours of work, but only whether the job is part-time or full-time. We generate a measure of full-time equivalent workers by weighting observations in part-time jobs by 18/39 (and observations in full-time jobs by 1).

For our empirical analysis, we keep observations for the 30th of June of every year and aggregate the individual-level data at the 3-digit industry level.

3.3.2 Measuring offshorability

The literature pioneered by authors such as Levy and Murnane (2004), Leamer and Storper (2001), and Blinder (2006) has converged towards the notion that a job's offshorability, i.e. its susceptibility to being relocated to a foreign country, does not primarily depend on the worker's skill level, but rather on the type of tasks performed on the job. Since tasks are most closely related to the occupation of a worker, offshorability is typically treated as an occupation-level characteristic. Conforming to this literature, we approximate industry-level offshorability in a two-step procedure. First, we assign offshorability indicators to individual workers based on their disaggregate occupations. Second, we aggregate the individual-level data to the 3-digit industry level, thereby essentially exploiting the unequal distribution of occupations across industries. For our most parsimonious and preferred occupation-level offshorability measure, which is a 0/1 dummy distinguishing non-offshorable and offshorable occupations (as we explain below), the industry-level offshorability measure boils down to the share of offshorable jobs in an industry, measured prior to the fall of the Iron Curtain in 1988.

There are various different operationalizations of occupation-level offshorability indicators. Firpo, Fortin and Lemieux (2013) and Acemoglu and Autor (2011), among others, make use of the O*NET database, which contains job content descriptions for detailed US SOC occupations. In the German setting, Spitz-Oener (2006) was the first to use the IAB/BIBB survey data to construct the five task content measures proposed by Autor, Levy and Murnane (2003), using information about the respondents' job activities. These, however, were not directly designed to capture offshorability. Relying on the same data set, but using detailed information about the respondents' workplace tools, Becker, Ekholm and Muendler (2013) have constructed measures of non-routine and personally interactive task content, respectively, and they have shown that offshoring activities of German multinationals are indeed associated with wage-bill shifts towards more non-routine and personally interactive tasks. Baumgarten, Geishecker and Görg (2013) have used the same measures to analyse heterogeneous wage effects of offshoring in the German manufacturing sector. Finally, Blinder and Krueger (2013) develop various measures of offshorability for US occupations, making use of survey data and relying both on self-reporting and professional coders' assessment.

We use Blinder and Krueger's (2013) indicator based on professional coders' assessment as our preferred measure of offshorability because it offers a number of advantages. First, it was specifically designed to capture whether the nature of the job "allows the work to be moved overseas *in principle*". Thereby, secondly, this measure avoids a potentially too large overlap with other task indicators (such as routineness), which might also capture susceptibility to automation (cf. Autor, 2013). Third, Goos, Mannings and Salomons (2014) have used this measure before in a European context and have found that it correlates well (and better than alternative measures) with actual offshoring activities.

In practical terms, we have mapped the US SOC based indicator into the German 3-digit KldB1988 classification applying a series of cross-walks (similar to Goos et al., 2014). Originally, the variable is measured on a 5-point scale, where 1 denotes occupations that are "not offshorable" and 5 denotes occupations that are "easily offshorable". After applying the various cross-walks which sometimes involve a many-to-many mapping and therefore give rise to a weighted average, this clean 5-point scale is slightly blurred in the German occupational data. We therefore use the following operationalization of this measure. We convert the offshorability measure in a 0/1 dummy variable such that the top 25% (1988 employment-weighted) of occupations are coded as offshorable. While arguably arbitrary, this way of coding is both convenient and closely related to the existing literature. It is consistent with Blinder and Krueger (2013) who find that their various offshorability measures all lead to the conclusion that roughly 25% of US jobs are offshorable. Firpo et al. (2013), using their O*NET based offshorability measures, also use a top quartile binary indicator in their empirical analysis.[21] As stated above, in terms of interpretation, the advantage of this approach is that, at the aggregate industry level, the offshorability corresponds to the share of offshorable jobs. We provide a detailed description of how we have constructed the offshorability measure in the data appendix.

We also performed a few plausibility checks to make sure that this measure indeed captures what we aim to measure: the offshoring potential of different industries prior to the fall of the Iron

[21] In a similar way, Autor and Dorn (2013) classify those occupations as routine-intensive that are in the top employment-weighted third of thier continuous routine task-intensity measure in the start-of-sample period.

Table 3: Pre-fall offshorability and changes in offshoring as well as displacement of offshorable jobs in 2-digit industries

	ΔOff. wide 1991–2007	ΔOff. narrow 1991–2007	ΔOff. material 1991–2007	ΔOff. services 1991–2007	ΔShare off. jobs 1988–2014
Offshorability	0.100***	0.062***	0.071**	0.020	−0.243***
	(0.030)	(0.023)	(0.030)	(0.012)	(0.066)
Observations	57	57	57	57	59
R squared	0.17	0.12	0.09	0.04	0.19

Notes: * p<0.10, ** p<0.05, *** p<0.01
Standard errors given in parentheses. Offshorability is measured by the share of offshorable occupations in the industry, where offshorable occupations are defined as being in the (employment-weighted) top 25% of the Blinder-Krueger offshorability score in 1988.

Curtain. Results are presented in Table 3. Indeed, we find that it is positively and highly significantly related to the growth in actual offshoring intensity, as measured based on the input-output indicators described above, in the aftermath of the fall of the Iron Curtain.[22] The correlation is weaker and not significant for the change in service offshoring, but a seen above, service offshoring only accounts for a small share in total offshoring activities. For the most comprehensive offshoring indicator, wide offshoring, variation in the offshorability measure explains reasonably high 17% of the variation in posterior offshoring growth. We also find that a larger share of offshorable jobs in 1988 is strongly negatively related to the change in the share of offshorable jobs between 1988 and 2014, providing suggestive evidence that these types of occupations have increasingly been displaced after the fall of the Iron Curtain.

3.4 Results

Table 4 displays the estimation results pertaining to various variants of Equation 38. In these regression, we consider the longest possible horizon and focus on long-run changes in log total employment between 1988 and 2014. The first column contains the quadratic offshorability term as only regressors, the second adds a manufacturing dummy, and the third adds the full set of control variables. While all these regressions make use of the entire set of 3-digit industries in the West German economy, the last column restricts attention to industries in the manufacturing sector.

Consistent with the predictions of the theoretical model, we find, throughout these specifications, clear evidence for a hump-shaped relationship between the initial share of offshorable occupations in an industry and subsequent (long-run) employment growth, as the negative coefficient of the squared offshorability term reveals. The significance of this relationship rises as we add control variables, and it also holds if we restrict attention to the manufacturing sector.[23]

[22] As these input-output based offshoring indicators can only be constructed at the 2-digit industry level, these

Table 4: Offshorability and long-run employment growth at the 3-digit industry level

	(1) All	(2) All	(3) All	(4) Manufacturing
	Dependent variable: Δ ln total employment 1988–2014			
Offshorability	1.171	3.993**	3.210***	2.588**
	(1.359)	(1.737)	(1.132)	(1.075)
Offshorability squared	−2.854*	−4.961***	−4.255***	−2.972**
	(1.607)	(1.711)	(1.292)	(1.264)
Manufacturing (0/1)		−0.920***	−0.435**	
		(0.300)	(0.215)	
Controls	No	No	Yes	Yes
Observations	219	219	219	103
R squared	0.05	0.20	0.50	0.52

Notes: * p<0.10, ** p<0.05, *** p<0.01
Standard errors (given in parentheses) are clustered at the 2-digit industry level. Offshorability is measured by the share of offshorable occupations in the industry, where offshorable occupations are defined as being in the (employment-weighted) top 25% of the Blinder-Krueger offshorability score in 1988. Further controls (all measured in 1988): employment shares by age (5 groups); employment shares by education (5 groups); female employment share; foreign employment share; quadratic term of log total employment.

Figure 4: Offshorability and long-run employment growth at the 3-digit industry level

Notes: The figure depicts the relationship between the start-of-period offshorability measure and the change in log total employment between 1988 and 2014 according to the regression specification (3).

To aid the (quantitative) interpretation, we also graphically illustrate the quadratic relationship by plotting the predicted values resulting from the offshorability-related coefficients in specification (3) against the offshorability values in the sample (cf. Figure 4). The maximum employment

Figure 5: Offshorability and employment growth at the 3-digit industry level: different horizons

Notes: The figure depicts the relationship between the start-of-period offshorability measure and the change in log total employment between 1988 and different end years according to the regression specification (3).

correlations are also at the 2-digit industry level, while the subsequent empirical analysis is done at the 3-digit level.

[23] We also test more formally for the existence of a hump-shaped relationship applying the appropriate test of Lind and Mehlum (2010), which tests the null hypothesis of a monotone or U shape relationship against the (one-sided) alternative of an inverse U shape relationship. For our richest (and preferred) specification (3), the p-value of the test is 0.003, implying statistical significance at all conventional levels. The null hypothesis of a monotone or U shape relationship has also to be rejected for specification (4), where we restrict attention to the manufacturing sector (p-value of 0.018).

growth is reached at an offshorability value of 0.38 and amounts to 61 log percentage points. It turns negative at an offshorability value of 0.77, which is still within the range of observable values in the sample. Thus, there are indeed sizable differences in terms of long-run employment growth after the fall of the Iron Curtain across industries depending on their initial share of offshorable jobs.

How does the relationship between ex-ante offshorability and posterior employment growth look like for different horizons? Instead of presenting the detailed regression tables, we directly jump to the graphical illustration, again making use of the regression results of the richest specification with all control variables (cf. Figure 5). In addition to the already shown results for $h = 26$ (i.e 1988–2014), we show results for $h = 5$ (1988–1993) and $h = 15$ (1988–2003). It can be seen that the hump shape becomes more pronounced over longer horizons, consistent with the model's predictions. In the short run, the hump shape is even hardly visible, reflecting the small and insignificant coefficients on both the linear and the squared offshorability term (not shown here).

In sum, these initial empirical results provide strong support for the theoretical prediction that the relationship between the prospects for offshoring and employment growth at the industry level is not linear. Industries in the medium range of offshorable tasks gain employment relative to industries both at the top and the bottom of offshorability.

3.5 Robustness checks

In this section, we subject our key finding of a non-monotone, hump-shaped relationship between ex-ante offshorability and subsequent industry-level employment growth to a series of robustness checks. We focus on our main specification (3) and the longest possible horizon of 26 years (1988–2014) for the dependent variable.

3.5.1 Different functional forms

As a first robustness check, we consider different and more flexible functional forms of the offshorability term. So far, we have relied on the parsimonious, but somewhat restrictive quadratic offshorability term. We now also consider a cubic and a semi-parametric (piecewise-constant) function, respectively. For the latter, we insert separate dummy variables for the following offshorability values: [0.1; 0.2), [0.2; 0.3) [0.3; 0.4) [0.4; 0.5) [0.5; 0.6) [0.6; 0.7), [0.7; ∞); the base category is [0; 0.1).[24] Note that, while having the advantage of being the most flexible, the drawback of this approach is that some of these coefficients are identified from a fairly low number of observations.

Since the estimated coefficients are difficult to interpret and compare across specifications, we again illustrate the relationship between the predicted employment growth (according to the estimated offshorability-related coefficients only) and offshorability graphically (cf. Figure 6).

While the predictions of the quadratic and the cubic specification almost perfectly overlay each other, the non-parametric specification, admittedly, looks somewhat off and definitely less smooth.

[24] Recall that our offshorability measure varies between 0 and 0.8 across 3-digit industries in our sample.

Figure 6: Robustness: Different functional forms

Notes: The figure depicts the relationship between the start-of-period offshorability measure and the change in log total employment between 1988 and 2014 according to various specifications. "Quadratic" represents the baseline specification (3) with the quadratic offshorability term, "Cubic" the one with the cubic offshorability term, and "Piecewise constant" the one with 8 interval dummy variables capturing offshorability.

However, it shares the key characteristics with the other specifications. That is, the lowest predicted employment growth rates are reached at the bottom and the top of the offshorability spectrum, while the highest predicted employment growth rate is reached right at the centre of the offshorabilty distribution. Taken together, this evidence lends further support to the notion of a hump-shaped relationship between employment growth and offshorability.

3.5.2 Alternative offshorability measures

We have chosen the Blinder and Krueger (2013) offshorability measure on the grounds that it was specifically designed to capture the susceptibility of a job to being relocated abroad and we have also seen that it indeed correlates quite well with actual changes in offshoring. Recall that we coded it in such a way that the top 25% (1988 employment-weighted) of occupations in terms of their offshorability score are classified as offshorable. While both convenient and in line with the existing literature, this way of coding is of course also arbitrary.

In this subsection, we analyse to what extent our results hinge on the exact offshorability measure chosen. On the one hand, we check different alternative implementations of the Blinder and Krueger (2013) offshorability measure, i.e. we make the cut at the top 33% and the top 20% of occupations, respectively, and we consider a continuous, standardized measure with mean 0 and a standard deviation of 1.[25] On the other hand, we also consider the offshorability measure proposed by Acemoglu and Autor (2011), which is based on various items of the O*NET database, and also has a similar predictive power for the actual subsequent change in offshoring observed at the two-digit industry level.[26] For the the Acemoglu and Autor (2011) measure, we consider three operationalizations: (i) the top 33% (1988 employment-weighted) of occupations are classified as offshorable; (ii) the top 25% (1988 employment-weighted) of occupations are classified as offshorable; (iii) a continuous, standardized measure with mean 0 and a standard deviation of 1 (across individuals in 1988).

Results are given in Table 5, where our baseline results based on the Blinder and Krueger (2013) top quartile measure are redisplayed in the second column for convenience. All specifications give rise to a hump shape according to the point estimates, even though two of the specifications – the ones based on the standardized Blinder and Krueger (2013) and the one based on the Acemoglu and

[25]The standardization has been carried out at the individual level.

[26]The measure can be constructed for US SOC occupations. Similar to the Blinder and Krueger (2013) measure, we have mapped it into the German 3-digit KldB1988 classification applying a series of cross-walks.

Table 5: Robustness: Alternative offshorability measures

	(1) BK top 25%	(2) BK top 33%	(3) BK top 20%	(4) BK std	(5) AA top 33%	(6) AA top 25%	(7) AA std
	Dependent variable: Δ ln total employment 1988–2014						
Offsh.	3.210***	2.248*	2.833***	0.109	2.035*	0.676	0.535**
	(1.132)	(1.308)	(1.058)	(0.209)	(1.099)	(1.183)	(0.219)
Offsh. sq.	−4.255***	−3.185**	−4.239***	−0.286	−2.205**	−1.586	−0.646***
	(1.292)	(1.485)	(1.291)	(0.228)	(1.071)	(1.452)	(0.228)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	219	219	219	219	219	219	219
R sq.	0.50	0.50	0.50	0.48	0.49	0.49	0.52

Notes: * p<0.10, ** p<0.05, *** p<0.01
Standard errors (given in parentheses) are clustered at the 2-digit industry level. Each column makes use of an alternative offshorability measure. BK top 25% (the baseline): the (1988 employment-weighted) top 25% of the occupations in terms of their Blinder-Krueger offshorability score are classified as offshorable; BK top 33%: like BK top 25%, but with the top 33% of the occupations classified as offshorable; BK top 20%: like BK top 25%, but with the top 20% of the occupations classified as offshorable; BK std: standardized Blinder-Krueger offshorability score with mean 0 and standard deeviation of 1 across individuals in 1988; AA top 33%: the (1988 employment-weighted) top 33% of the occupations in terms of their Acemoglu-Autor offshorability score are classified as offshorable; AA top 25%: like AA top 33%, but with the top 25% of the occupations classified as offshorable; AA std: standardized Acemoglu-Autor offshorability score with mean 0 and standard deeviation of 1 across individuals in 1988. Further controls included as described in Table 4.

and Autor (2011) top quartile measure, respectively, do not yield statistically significant estimates.[27] Still, the picture that consistently emerges from these exercises is that industries at the centre of the offshorability distribution experience faster employment growth than industries at the bottom and the top of the offshorability distribution.

3.5.3 Additional control variables

Now we address the potential concern that the relationship between employment growth and offshorability might in fact pick up other underlying factors, and hence, suffer from omitted variable bias. We address two specific concerns.

First, the relationship might be driven by long-term (and pre-existing) trends which potentially could drive both offshorability in 1988 and subsequent employment growth. To tackle this concern, we include lagged employment growth as an additional regressor. Our data allow us to go back 10 years such that we control for log employment growth between 1978 and 1988. We estimate one

[27] The sometimes lacking precision of the estimates is not all that surprising given that we have a fairly low number of observations and furthermore use clustered standard errors.

specification with a linear and another one with a quadratic lagged employment growth term.

Second, one might be worried that our offshorability term might capture technological change rather than offshoring. Despite the advantages of the Blinder and Krueger (2013) offshorability measure discussed above, there is of course no guarantee that it does not (also) pick up technological change. To address this concern, we augment the specification with a routineness indicator which aims to capture the susceptibility to automation and computerization, the two key elements of technological change over the period of analysis. It is based on the measures proposed by Spitz-Oener (2006) and calculated as the average share of routine tasks in total tasks across two-digit KldB1988 occupations.[28] We again estimate one specification with a simple linear and another one with a quadratic routineness indicator.

Results are given in Table 6. The most important insight is that the hump-shaped relationship between employment growth and offshorability remains robust. While coefficient magnitudes vary slightly, and in both directions – they are slightly dampened when controlling for lagged employment growth but become somewhat larger when accounting for routine task intensity – they remain highly significant and have the same sign as in the baseline specification.

As far as the additional control variables are concerned, employment growth between 1988 and 2014 is positively related to employment growth in the decade before and negatively to the ex-ante routine task intensity. The former indeed indicates that industry growth is also driven by long-term trends and the latter that forces related to automation and computerization are indeed labour-saving. Both of these factors, however, are (sufficiently) distinct from our offshorability measures. Interestingly, and in contrast to what we establish for offshorability, we cannot reject the null hypothesis of a monotone relationship between routineness and subsequent employment growth, as the small and insignificant coefficient of the squared routineness term indicates.

[28] The Spitz-Oener (2006) measures are based on the German IAB/BIBB survey, which consists of various waves. We take a simple average of the measures resulting from the 1986 and the 1992 waves, as our reference year is 1988. Furthermore, we have standardized this measure to have a mean of 0 and a standard deviation of 1 across individuals in 1988.

Table 6: Robustness: Additional control variables

	(1) Base	(2) Lagged	(3) Lagged squared	(4) Routine	(5) Routine squared
	Dependent variable: Δ ln total employment 1988–2014				
Offshorability	3.210***	2.610**	2.526**	3.633***	3.698***
	(1.132)	(1.012)	(1.073)	(1.138)	(1.161)
Offshorability squared	−4.255***	−3.114***	−2.966**	−4.450***	−4.526***
	(1.292)	(1.128)	(1.222)	(1.272)	(1.299)
Lagged Δ ln empl.		1.354***	1.428***		
		(0.221)	(0.198)		
Lagged Δ ln empl.			−0.175		
			(0.259)		
Routine share				−0.667***	−0.655***
				(0.164)	(0.181)
Routine share squared					0.0333
					(0.154)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	219	218	218	219	219
R squared	0.50	0.59	0.59	0.55	0.56

Notes: * p<0.10, ** p<0.05, *** p<0.01
Standard errors (given in parentheses) are clustered at the 2-digit industry level. Each column gives the results of a different specification. Base: redisplays the baseline results show in Table 4, specification (3). Lagged: includes lagged log employment growth between 1978 and 1988 (linear) as additional regressor; Lagged squared: includes lagged log employment growth between 1978 and 1988 (linear and squared) as additional regressors; Routine: includes the 1988 routine share (linear) as additional regressor; Routine squared: includes the 1988 routine share (linear and squared) as additional regressors. The routine share has been calculated based on the measures proposed by Spitz-Oener (2006) and has been standardized to have a mean of 0 and a standard deviation of 1 across individuals in 1988. Further controls included as described in Table 4.

4 Conclusion

This paper sets up a general oligopolistic equilibrium model where sectors differ in the intensity of routine and non-routine task production and thus in the opportunities to offshore parts of the production process to a low wage country. We use the model to shed light on how offshoring affects labor markets and welfare and how these effects differ in the short and long-run. In line with existing work, domestic wages increase if the productivity effect of offshoring dominates the reallocation effect. However, we show that additional results can be obtained by introducing sectoral heterogeneity in offshoring. First, labor market effects arise even in sectors where no tasks can be produced offshore. In the short-run this arises from higher domestic production costs, while in the long-run, this arises from exit of firms and the movement of capital towards sectors which benefit above average from offshoring. This so far unexplored inter-sector reallocation furthermore mitigates the productivity effect, as sectors with a high share of foreign task production expand in the long-run. Hence, by ignoring inter-sectoral reallocations, existing models exaggerate the productivity effect. In the empirical section, we test and quantify the predictions of our theory and emphasize the importance of inter-sectoral reallocations when quantifying the labor market and welfare effects of offshoring.

Whereas we think that this paper provides a useful tool to study the effects of offshoring when sectors differ in their ability to shift tasks to a foreign low wage country, it is clear that the parsimonious structure lowers the ability of our model to capture other important features of the data. For instance, in our setting we exclude intra-sectoral heterogeneity among firms or frictions in the ability of factors to migrate between sectors. Going in this direction would therefore be a worthwhile task for future research.

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A Appendix

A.1 Fixed offshoring costs

In this section we introduce fixed costs of offshoring. To be more specific firms have to invest F units of foreign labor to relocate production abroad and organize international fragmentation. This introduces a cutoff sector $\widetilde{z}$ at which firms are indifferent between domestic and foreign production, i.e. $\pi_d(\widetilde{z}) = \pi_o(\widetilde{z})$, and, hence:

$$b\left(\frac{a' - w}{b[n(\widetilde{z}) + 1]}\right)^2 = b\left(\frac{a' - \widetilde{z}w^*\tau - (1 - \widetilde{z})w}{b[n(\widetilde{z}) + 1]}\right)^2 - w^*F. \tag{A.1}$$

If fixed offshoring costs are sufficiently high, sectors $0 - \widetilde{z}$ will produce purely domestic and are therefore fully identical. The long-run equilibrium is determined by Equation A.1 together with the domestic and foreign labor market clearing conditions

$$L = \widetilde{z}n(\widetilde{z})y(\widetilde{z}) + \int_{\widetilde{z}}^{1} (1 - z)n(z)y(z)dz, \tag{A.2}$$

$$L^* = \tau \int_{\widetilde{z}}^{1} zn(z)y(z)dz + F \int_{\widetilde{z}}^{1} n(z)dz, \tag{A.3}$$

the capital market clearing condition

$$K = \int_{0}^{1} n\,(z)\,dz \tag{A.4}$$

and $n(z)$ from the no arbitrage condition $\pi(z) = \pi = \pi(0)$

$$n(z) = \frac{[a' - zw^*\tau - (1 - z)w]n(\widetilde{z}) + (z - \widetilde{z})(w - w^*\tau)}{a' - \widetilde{z}w^*\tau - (1 - \widetilde{z})w} \tag{A.5}$$

As we cannot solve explicitly for sector specific firm numbers, domestic and foreign wages and the cutoff sector, we solve the system of equations numerically and use the solutions to plot labor demand across sectors, which is given by

$$L(z) = (1 - z)n(z)y(z). \tag{A.6}$$

Figure A.1: Sector specific employment for different offshoring costs

Table A.1: Equilibrium values for different variable offshoring costs

τ	w	w^*	w/w^*	$n(0)$	$\widetilde{z}$
2	390.81	192.08	2.03	4.47	0.41
1.5	391.47	253.34	1.55	3.64	0.24
1.1	395.29	337.25	1.17	1.20	0.06

Notes: We use the following parameter values $a = 20$; $L = 5$; $L^* = 10$; $K = 5$; $b = 1$; $F = 0.01$.

A.2 Cobb-Douglas technology

In this section we show that the main results do not hinge on the specific technology we impose in the main text. We introduce a Cobb-Douglas technology and show that the labor market effects of offshoring are robust. The production function is given by:

$$y(z) = \left(\frac{l_o}{z}\right)^z \left(\frac{l_n}{1-z}\right)^{1-z} \tag{A.7}$$

From cost minimization we derive unit production costs in sector z as

$$c(z) = (w^*\tau)^z (w)^{1-z} = w\kappa^z \tag{A.8}$$

where $\kappa = \frac{w^*\tau}{w}$ denotes cost-savings from offshoring. We follow the steps from the main text to determine domestic wages (w), foreign wages (w^*) and firm number in sector $z = 0$ ($n(0)$). The long-run equilibrium is determined by domestic and foreign labor market clearing conditions

$$bL = \int_0^1 (1-z)\frac{n(z)}{n(z)+1}\left(a' - w\kappa^z\right)\kappa^z dz, \tag{A.9}$$

$$bL^* = \tau \int_0^1 z\frac{n(z)}{n(z)+1}\left(a' - w\kappa^z\right)\kappa^{z-1} dz, \tag{A.10}$$

the capital market clearing condition

$$K = \int_0^1 n(z)\, dz \tag{A.11}$$

and $n(z)$ from the no arbitrage condition $\pi(z) = \pi = \pi(0)$

$$n(z) = \frac{(a' - w\kappa^z)(n(0)+1) - (a' - w)}{(a' - w)}. \tag{A.12}$$

As we cannot solve explicitly for sector specific firm numbers, domestic and foreign wages, we solve the system of equations numerically and use the solutions to plot labor demand across sectors, which is given by

$$L(z) = (1 - z)n(z)y(z)\kappa^z. \tag{A.13}$$

Table A.2: Equilibrium values for different variable offshoring costs

τ	w	w^*	w/w^*	$n(0)$
2	388.04	194.92	1.99	4.96
1.5	390.81	255.8	1.53	2.92
1.2	393.54	314.67	1.25	1.41

Notes: We use the following parameter values $a = 20$; $L = 5$; $L^* = 10$; $K = 5$; $b = 1$.

Figure A.2: Sector specific employment for different offshoring costs

Empirical appendix

Data appendix

Our preferred offshorability measures are taken from Blinder and Krueger (2013). Specifically, we use their preferred indicator based on professional coders' assessment of whether the nature of the job "allows the work to be moved overseas *in principle*". This measure was developed as part of the Princeton Data Improvement Initiative (PDII). In the original data, the measure is available at the 6-digit occupational level following the US SOC 2000 classification.[29] To map this measure into the German KldB 1988 classification, which is used in the German employment data, we apply a series of cross-walks. First, we apply the crosswalk provided by the Bureau of Labor Statistics (BLS) from the 6-digit SOC 2000 to the more recent 6-digit SOC 2010 classification. In case that the mapping is not unique, we assign a weighted average of the offshorability measure to the new classification, using 2009 US labour supply weights. We then map the data into the international 4-digit ISCO 2008 classification, using the official crosswalk provided by the BLS and 2014 US labour supply weights.[30] Next, we apply the crosswalk provided by the German Federal Employment Agency from the 4-digit ISCO 2008 to the German 5-digit KldB 2010 classification, making use of 2014 labour supply weights. Finally, we map the data from the 5-digit KldB 2010 classification to the 3-digit KldB 1988 classification, again using the crosswalk provided by the German Federal Employment Agency and 2014 German labour supply weights. With this approach, we are able to assign Blinder and Krueger (2013) offshorability values to 248 out of 335 3-digit KldB 1988 occupations in our

[29] To be precise, the data are at the individual level, but generally, the same offshorability value is shared by individuals in the same 6-digit classification. In the few cases where different values were assigned to the same occupation, we chose the modal value. Using the mean value instead reproduces the results almost exactly.

[30] We have to use labour supply weights from varying years due to the changes in the occupational classification over time, which limit the availability of the required employment data.

data. We miss the remaining 87 occupations because (i) some of them are simply not mapped into by the crosswalks (−72 occupations) and (ii) the Blinder and Krueger (2013) offshorability measure is not available for all US SCOC occupations to start with (−15 occupations). We impute the offshorability value for the remaining occupations by assigning the weighted average of the next highest level of occupational aggregation, using 1988 labour supply weights.[31] Note that, while the number of occupations with imputed Blinder and Krueger (2013) offshorability scores seems rather high, they do only account for 12% of employment in 1988 West Germany.

Admittedly, this approach of assigning offshorability measures to the German 3-digit KldB 1988 occupations is prone to several sources of measurement error. First, the professional coders that assigned the scores probably did so with some margin of error to start with. Second, these offshorability scores were originally assigned to US occupations, yet we use them for German occupations. Thus, the assumption is that the work content of German occupations is similar to the one of their US counterparts. Third, they are constructed based on job content descriptions in the 2000s, yet we use them to characterize offshorability as of 1988. Clearly, job activities have also changed within occupations in that time span. However, we will mostly rely on an ordinal ranking of occupations so that the assumption is that occupations with a relatively high offshorability in the 2000s were also the ones with a relatively high (if potentially higher in absolute terms) offshorability in 1988. Fourth, we need to impute missing offshorability scores for a fraction of the German occupations. To the extent that the offshorability variable does indeed contain classical (random) measurement error, our regression results would be affected by attenuation bias. Note, however, that, despite the potential limitations of our approach, our offshorability variable has a higher predictive power regarding the actual subsequent change in offshoring activities at the industry level than alternative measures that we have taken into consideration. Moreover, we obtain offshorability scores at a fairly disaggregate occupational level, giving us substantial variation that we can exploit in our empirical analysis.

Figure A.3 depicts the variability in offshorability across 3-digit industries in our sample, while Table A.3 lists the industries with the highest and lowest offshorability scores, respectively.

Figure A.3: Variability in offshorability across 3-digit industries

Notes: Offshorability is measured by the share of offshorable occupations in the industry in West Germany in 1988, where offshorable occupations are defined as being in the (employment-weighted) top 25% of the Blinder-Krueger offshorability score in 1988.
Source: SIAB 1975–2014, own calculations.

[31] The next-highest level of aggregation of the KldB 1988 classification comprises 86 occupational groups at the 2-digit level, followed by 33 occupational sections, and, finally, 6 broad occupational areas.

Table A.3: Top 10 3-digit industries with highest and lowest offshorability in 1988 West Germany

Top 10 industries with highest offshorability	
Manufacture of footwear	0.81
Insurance and pension funding, except compulsory social security	0.80
Dressing and dyeing of fur; manufacture of articles of fur	0.79
Tanning and dressing of leather	0.78
Manufacture of leather clothes	0.76
Manufacture of ceramic tiles and flags	0.72
Preparation and spinning of textile fibres	0.72
Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products	0.70
Manufacture of luggage, handbags and the like, saddlery and harness	0.69
Activities auxiliary to insurance and pension funding	0.69

Top 10 industries with lowest offshorability	
Retail sale of pharmaceutical and medical goods, cosmetic and tollet articles	0.04
Telecommunications	0.03
Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing	0.03
Mining of chemical and fertilizer minerals	0.02
Post and courier activities	0.02
Camping sites and other provision of short-stay accommodation	0.02
Forestry, logging and related service activities	0.02
Primary education	0.01
Bars	0.01
Mining of iron ores	0.00

Notes: Offshorability is measured by the share of offshorable occupations in the industry, where offshorable occupations are defined as being in the (employment-weighted) top 25% of the Blinder-Krueger offshorability score in 1988.
Source: SIAB 1975–2014, own calculations.

Additional tables and figures

Table A.4: Summary statistics

	Mean	Std. dev.
Δ ln total employment 1988–1993	0.08	0.29
Δ ln total employment 1988–2003	−0.02	0.73
Δ ln total employment 1988–2014	−0.04	0.92
Blinder-Krueger top 25% offshorability score	0.29	0.21
Manufacturing (0/1)	0.47	0.50
Share age: 26–35	0.27	0.06
Share age: 36–45	0.23	0.05
Share age: 46–55	0.25	0.07
Share age: 56–65	0.08	0.03
Share educ: Lower secondary or less; with vocational training	0.61	0.13
Share educ: Abitur with or without vocational training	0.03	0.03
Share educ: University or more	0.06	0.08
Share educ: missing	0.07	0.08
Share females	0.33	0.20
Share foreigners	0.09	0.06
ln total employment	6.37	1.63
Observations	219	

Notes: Summary statistics for the variables used in the regression analysis.