

Offshoring and Job Polarisation between Firms*

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Abstract

Using linked employer-employee data for Germany, we provide evidence for job polarisation between firms and identify offshoring as an important determinant of these employment changes. To accommodate these findings, we set up a general equilibrium model in which offshoring to a low-wage country can lead to job polarisation in the high-wage country due to a reallocation of labour across firms that differ in productivity and pay wages that are positively linked to their profits by a rent-sharing mechanism. Offshoring involves fixed and task-specific variable costs, and as a consequence it is chosen only by the most productive firms, and only for those tasks with the lowest variable offshoring costs. A reduction in those variable costs increases offshoring at the intensive and at the extensive margin. Well in line with our evidence, this causes domestic employment shifts from the newly offshoring firms in the middle of the productivity distribution to firms at the tails of this distribution, paying either very low or very high wages. We also study how the reallocation of labour across firms affects economy-wide unemployment. Offshoring reduces unemployment when it is confined to high-productivity firms, while this outcome is not guaranteed when offshoring is also chosen by low-productivity firms.

JEL-Classification: F12, F16, F23

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1 Introduction

It is a well-documented phenomenon for many industrialised economies that the share of workers employed in medium-wage jobs has fallen, while the share of workers employed in either high-wage jobs or low-wage jobs has increased.¹ To rationalise this empirical pattern of job polarisation, economists usually refer to the *routinisation hypothesis* (cf. Autor et al., 2003). According to this hypothesis, job polarisation can be understood as a movement away from routine tasks, and towards tasks that are non-routine: the jobs that are lost in the middle of the wage distribution involve mainly routine tasks, whereas the jobs at the extremes of the wage distribution that experience an increase in employment are intensive in abstract or service tasks, respectively, both of which are non-routine. Readily available data on tasks and occupations has made this hypothesis a particularly attractive avenue for empirical research.

In this paper, we provide evidence that is supportive of an alternative view of job polarisation: Rather than being the consequence of a movement away from medium-wage tasks, our data suggests strongly that it can as well be the consequence of a movement by workers away from medium-wage firms. Using information from German linked employer-employee data covering the time period after the millennium, we find an increase in the employment of establishments with initially high and low average wage rates relative to the employment of establishments paying intermediate wage rates. Our data also point to firm-level differences in the use of offshoring as an important determinant of the observed employment changes.²

In the theoretical part of our paper we then show that that there is a straightforward mechanism linking offshoring to job polarisation between firms in a model that captures two well-established facts: (i) more productive firms pay higher wages than their less productive competitors; and (ii) there is selection of the most productive firms into international markets.³ The story we have in mind is simple: Suppose offshoring has fixed and variable costs, where the latter are task-specific as in Grossman and Rossi-Hansberg (2008). Furthermore, firms differ in their productivity, and – crucially – there is some mechanism linking firm productivity to firm-level average wages. In equilibrium, high-wage firms offshore some of their tasks, while low-wage firms do not offshore at

¹For instance, Autor et al. (2006, 2008) and Autor and Dorn (2013) provide evidence for the US, whereas Dustmann et al. (2009) and Goos et al. (2009, 2014) document job polarisation for various European economies.

²The units of observation in our benchmark regressions are establishments, not firms. However, we show in a robustness check that this distinction is not essential for our results. Recent empirical findings by Harrigan et al. (2016), Heyman (2016), and Kerr et al. (2016) are in line with the movement of workers between firms being an important determinant of job polarisation.

³Supportive evidence for the first fact can be found in empirical labour market research (see Blanchflower et al., 1996; Abowd et al., 1999, for two early contributions and Card et al., 2013, for a more recent one). Regarding the second fact, Bernard and Jensen (1995) provide first systematic evidence that exporters are larger and more profitable than non-exporters, and the subsequent literature has pointed out that these differences are due to a selection of better firms into exporting (see Bernard and Jensen, 1999). Recent work by Hummels et al. (2014) and Moser et al. (2015) shows that the patterns of international market participation are similar if one considers offshoring instead of exporting.

all. It is now natural for an across-the-board decrease in variable offshoring costs to lead to job polarisation: Newly offshoring firms, which pay intermediate wages, since they are less productive than incumbent offshoring firms, but more productive than non-offshoring firms, reduce the number of their domestic jobs. This reduction in labour demand causes a downward pressure on wages, and therefore incumbent offshoring firms as well as purely domestic non-offshoring firms – i.e. the firms paying either very high or very low wages – increase their domestic employment.

To formalise the story outlined above and to shed light on its possible limitations, we set up a general equilibrium model with monopolistic competition among heterogeneous firms. As in [Lucas \(1978\)](#) each firm is run by an entrepreneur, who hires workers for production. Agents are equally productive as workers, but differ in terms of their entrepreneurial ability, which is instrumental for the productivity of firms and thus for the profit income that accrues to the entrepreneur as residual claimant. The entry of firms and the economy-wide supply of labour are then jointly determined by the decentralised occupational choice of agents, with entrepreneurial ability being pivotal for the decision of who becomes an entrepreneur and who becomes a worker. To analyse offshoring decisions, we place our analysis in an asymmetric two-country model, in which firms from an industrialised North have an incentive to offshore the production of tasks to a developing South, with lower wages. Trade in tasks is associated with fixed and variable offshoring costs. Assuming that offshoring costs are the same for all producers, there is selection of firms into offshoring by productivity, establishing an (endogenous) *extensive firm margin* that separates highly productive offshoring firms from less productive non-offshoring firms. As in [Grossman and Rossi-Hansberg \(2008\)](#), there is, in addition, an (endogenous) *extensive task margin* that separates tasks kept onshore from tasks put offshore.

A framework for the analysis of job polarisation requires, of course, that not all workers are paid the same wage. We therefore augment our model of offshoring by a labour market model that makes firms heterogeneous in their wage payments. To achieve this result, we consider a rent sharing mechanism that covers two models featuring prominently in the recent trade literature. The first one is a *search and matching* model, in which firms can invest into screening in order to increase the imprecisely observed abilities of the workforce actually hired and in which workers must be compensated by firms for the additional risk of failing in the screening process (cf. [Helpman et al., 2010, 2017](#)). The second one is a *gift exchange* model, which builds on the idea that firms have to pay a fair wage in order to elicit the full level of non-contractible effort from their workforce (cf. [Akerlof and Yellen, 1990](#); [Egger and Kreickemeier, 2012](#); [Amiti and Davis, 2012](#)). Although the two frameworks differ considerably in their specific micro-foundations, both of them accord with the well established fact that larger, more productive firms pay higher wages, and, in the specific implementations commonly used, they are in fact isomorphic regarding the

impact of globalisation on firm-level wages and employment. We associate offshoring with vertical multinational firms and, in line with evidence from [Budd and Slaughter \(2004\)](#) and [Budd et al. \(2005\)](#), assume that intra-firm rent sharing exists within and across borders so that wages of both domestic and foreign workers are positively correlated with firm-level profits. The equilibrium then features two continuous wage distributions, one in each country, with some workers in each country being unemployed due to the labour market imperfection.

Since, as a byproduct of rent sharing, our model features economy-wide unemployment, we can use it to address the politically charged question of whether offshoring to low-wage countries destroys jobs in high-wage countries in the aggregate.⁴ We show that our model gives a nuanced answer to this question, the main reason being that in general equilibrium it is of course possible for workers who have lost their jobs due to offshoring to find employment elsewhere. Specifically, for these workers our model points to three possible alternatives to unemployment: they may be hired as production workers in a different firm, they may work in the offshoring service sector, or they may become entrepreneurs themselves.⁵ Economy-wide unemployment in our model increases in the extent of wage dispersion between firms, *ceteris paribus*, since the latter is a measure for the severeness of the labour market distortion. We show that offshoring reduces wage dispersion in the North relative to autarky if the offshoring cost is very high, and therefore only the most productive firms use this option. With the labour market distortion less severe, offshoring leads to lower aggregate unemployment in this case. We also show that this positive labour market effect can be overturned at low levels of offshoring cost, since in this case wage dispersion between firms increases.

Despite the voluminous empirical literature finding evidence for job polarisation (see for example [Autor et al., 2006](#); [Goos et al., 2009, 2014](#)), there are only very few papers providing a theoretical basis for [Autor et al.'s \(2003\) *routinisation hypothesis*](#). As a notable exception, [Acemoglu and Autor \(2011\)](#) set up a model featuring an endogenous assignment of skills to tasks. Distinguishing three different worker types, they show that the replacement of routine tasks through technological change or offshoring can explain job polarisation, with displaced medium-skilled workers being reallocated to tasks previously performed by better-paid high-skilled workers or worse-paid low-skilled workers, respectively. [Costinot and Vogel \(2010\)](#) formulate a model, in which a continuum of workers sorts across a continuum of tasks depending on their comparative advantage. As pointed out by the authors, this model is also equipped to explain job polarisation, for reasons

⁴As pointed out by [The Economist \(2009\)](#), “Americans became almost hysterical” about the job destruction due to offshoring, when [Forrester Research](#) predicted a decade ago that 3.3 million American jobs will be offshored until 2015.

⁵Evidence from matched worker-firm-owner data shows that individuals who are unemployed (cf. [Berglann et al., 2011](#)) or displaced from their job (cf. [von Greiff, 2009](#)) are more likely to become entrepreneurs. Furthermore, [Autor et al. \(2014\)](#), [Artuç and McLaren \(2015\)](#), and [Keller and Utar \(2015\)](#) provide evidence that the movement of workers to other sectors is an important channel for the adjustment of labour markets to globalisation shocks.

not too different from those outlined by [Acemoglu and Autor \(2011\)](#). However, focussing on a model with atomistic firms, neither [Costinot and Vogel \(2010\)](#) nor [Acemoglu and Autor \(2011\)](#) can explain job polarisation between firms. Hence, our model complements existing theoretical work by highlighting a new channel through which job polarisation can materialise: the creation and destruction of jobs by firms that differ in their wage payments.

Our model also builds on a large literature that studies the consequences of offshoring to low-wage countries (cf. [Jones and Kierzkowski, 1990](#); [Feenstra and Hanson, 1996](#); [Grossman and Rossi-Hansberg, 2008](#); [Rodriguez-Clare, 2010](#); [Acemoglu et al., 2015](#)), including several recent contributions that place their analysis in a framework with heterogeneous firms (cf. [Antràs and Helpman, 2004](#); [Antràs et al., 2006](#); [Davidson et al., 2008](#); [Groizard et al., 2014](#); [Egger et al., 2015](#)). Furthermore, accounting for labour market distortions, our paper is related to an old and well established literature dealing with the effects of globalisation on unemployment and wage inequality (cf. [Brecher, 1974](#); [Davidson et al., 1988](#); [Hosios, 1990](#)), and more directly to the recent papers by [Egger and Kreickemeier \(2009\)](#), [Helpman et al. \(2010\)](#), [Amiti and Davis \(2012\)](#), and [Egger and Kreickemeier \(2012\)](#), who analyse the link between international goods trade, residual wage inequality and unemployment in models with firm heterogeneity. Although the rationale for a wage premium in high-productivity firms in those papers extends one to one to our model, there is an important difference between international trade and offshoring regarding the induced reallocation of labour in the home country. Whereas international trade in these models unambiguously leads to a shift of labour away from low-wage firms towards high-wage firms, offshoring in our model has the potential to reallocate labour away from medium-wage firms towards high- *and* low-wage firms. Hence, explaining job polarisation along the firm dimension by international market integration requires that the market integration is associated with more offshoring.

The paper is structured as follows. In [Section 2](#) we discuss evidence on job polarisation and its determinants, using linked employer-employee data for Germany. In [Section 3](#), we illustrate by means of a simple elasticity decomposition the key mechanism leading to job polarisation in our model. [Section 4](#) presents the main building blocks of our model and [Section 5](#) introduces the firm's problem. In [Section 6](#), we solve for the general equilibrium. In [Section 7](#), we analyse the effects of falling (variable) offshoring costs on the domestic employment of offshoring and non-offshoring firms and characterise the conditions under which job polarisation materialises. In [Section 8](#), we determine the effects of offshoring on economy-wide unemployment. [Section 9](#) concludes with a summary of the most important results.

2 Evidence on job polarisation and its determinants

In this section, we present evidence on job polarisation in Germany. The analysis uses the linked-employer-employee dataset (LIAB) from the Institute for Employment Research in Nuremberg, which combines rich data from an annual survey on German establishments with detailed administrative data on workers from social security files. In particular, it contains the information necessary for distinguishing changes in employment at the establishment level from changes in employment at the occupation level. The evidence in this section is presented in two steps. First, we show that between the years 1999 and 2005, which is the time span covered by our data set, job polarisation in Germany has occurred between establishments, while no job polarisation can be observed between occupations. Second, we add measures of firm-level offshoring and technological change as control variables in order to shed light on the economic variables responsible for the job polarisation that we find.

In order to analyze the question of job polarisation between establishments, we compute average monthly wages at the establishment level, group establishments into 20 wage categories of equal size, and determine the log employment change of the average establishment in a wage category between 1999 and 2005.⁶ We focus on this specific time span because it covers the years for which information on offshoring is available, and in our first specification we consider a balanced sample covering only those 2,878 establishments that we observe in both 1999 and 2005. The results are summarised in Panel A of Figure 1. The first (last) observation on the horizontal axis refers to the employment changes of establishments paying on average the lowest (highest) wages in the initial period. The results provide clear evidence for job polarisation between establishments, with establishments from the middle of the wage distribution experiencing lower employment growth than establishments paying on average very low or very high wages. In this graph, we also report the regression line capturing the outcome of local polynomial smoothing in order to facilitate the assessment of the employment changes.⁷

We now use an analogous approach and presentation in order to check whether there is also job polarisation between occupations in our dataset, similar to what has been found, for instance, by [Goos et al. \(2009\)](#) and [Autor and Dorn \(2013\)](#). We build on the analysis of these authors, distinguish more than 330 (3-digit) occupations according to the German nomenclature from 1988 (KldB88), and construct 20 groups of occupations, which are ranked according to the average

⁶We de-trend employment changes to isolate changes specific to establishments from certain wage groups from changes common to all producers due to macroeconomic shocks and labour market reforms around the millennium. The way we present the descriptive evidence on job polarisation is akin to [Goos and Manning \(2007\)](#).

⁷A clear advantage of local polynomial smoothing is that it performs better than other smoothing methods near the bounds of the data interval. We rely on a smoothing algorithm that is based on Epanechnikov kernel-weighting with degree 1 and determine the optimal bandwidth by using the rule-of thumb method of bandwidth selection that minimises the conditional weighted mean integrated squared error (see [Fan and Gijbels, 1996](#)).

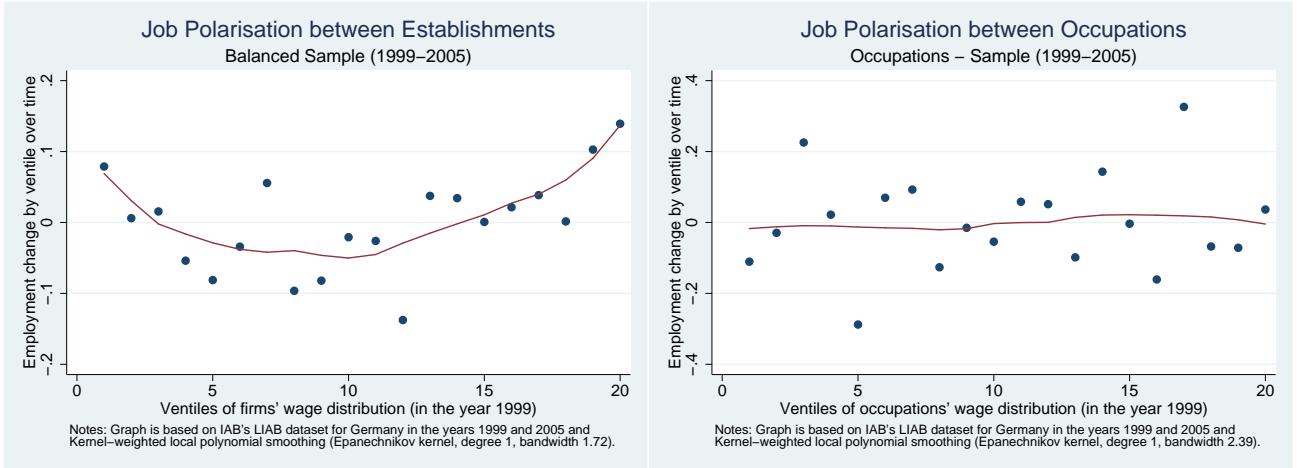


Figure 1: *Job Polarisation between Establishments and Occupations 1999-2005*

wage received by workers in 1999. We report the log employment changes for these 20 occupation groups in Panel B of Figure 1. Based on this simple graphical approach, we find no evidence for job polarisation between occupations in our dataset.

The graphical analysis can be transferred into a parsimonious regression framework that allows for analysing further the two contrasting patterns of job polarisation illustrated in Figure 1. We begin with an analysis of job polarisation between establishments and specify the following empirical model:

$$\Delta empl_i = \beta_0 + \beta_1 wage_g + \beta_2 wage_g^2 + \varepsilon_i, \quad (1)$$

which explains log changes of employment in establishment i between the first and the last year of observation, $\Delta empl_i$, by a constant and the average wage paid by the establishments of a given wage group $g \in \{1, \dots, 20\}$ in the base year 1999, $wage_g$. This variable also enters as a squared term, $wage_g^2$, to account for the non-monotonicity in employment changes displayed in Panel A of Figure 1.⁸ We denote the error term by ε_i , and cluster standard errors at the wage group level since our wage groups are defined at a more aggregate level than our dependent variable (cf. Moulton, 1986; Angrist and Pischke, 2009).⁹ We present the results of this analysis in Panel A of Table 1. In Panel B, we report employment changes for occupation groups, building on an empirical model similar to Eq. (1). In this specification, i refers to a specific 3-digit occupation and g gives one of the 20 occupation groups outlined above. This allows us to compare directly the two forms of job polarisation. The emerging picture is clear. Table 1 provides strong evidence for job polarisation

⁸Following Goos et al. (2009) and in contrast to the graphical representation in Figure 1, we use wage levels instead of the categorical wage groups as explanatory variables in the regression analysis.

⁹The clustered estimator is consistent as the number of clusters grows. Cameron and Miller (2015) stress that there is no clear lower bound for the admissible number of clusters. Since our main results are very similar for 20 and 100 clusters, this issue seems negligible.

Table 1: Job Polarisation between Establishments and Occupations in Germany

	1999-2005		1999-2003	1999-2007	
	20 groups	100 groups	10 groups	20 groups	
Panel A (Establishments)					
Initial wage	-0.252** (0.074)	-0.204** (0.072)	-0.276** (0.076)	-0.216* (0.083)	-0.193** (0.052)
Initial wage squared	0.062** (0.015)	0.051** (0.015)	0.068** (0.015)	0.048** (0.016)	0.047** (0.010)
No. of observations	2,878	2,878	2,878	3,788	2,218
Panel B (Occupations)					
Initial wage	0.128 (0.218)	0.044 (0.262)	0.180 (0.188)	0.003 (0.194)	0.034 (0.209)
Initial wage squared	-0.018 (0.031)	-0.003 (0.038)	-0.026 (0.027)	-0.010 (0.028)	-0.006 (0.030)
No. of observations	334	334	334	335	334

Notes: The dependent variable is the log employment change by establishment (Panel A) or occupation (Panel B) between the base year 1999 and the last year of the sample period. The variable *Initial wage* is the average wage across establishments (Panel A) or occupations (Panel B) of a given wage group in the base year 1999. A constant is estimated but not reported. Standard errors are clustered at the wage-group level and reported in parentheses. Significance levels are indicated by $^{\circ}$ $p < 0.1$, $*$ $p < 0.05$, and $**$ $p < 0.01$, respectively.

between establishments but no evidence for job polarisation between occupations. This outcome is robust to changes in the sample period or the number of distinct establishment and occupation groups.¹⁰

Based on these first insights from Figure 1 and Table 1, we now shed further light on possible determinants of the observed job polarisation between establishments. In order to have a sufficiently high number of observations, we use in our main regression an unbalanced sample that covers all establishments from 1999 for which we have the relevant information. We compute the log employment change between the first and the last year of observation, covering 7,434 establishments for the years 1999 to 2005. We estimate a model of the following form:

$$\Delta empl_i = \beta_0 + \beta_1 wage_g + \beta_2 wage_g^2 + \beta_3 incumbent_i + \beta_4 new_i + \beta_5 overlap_g + \beta_6 overlap_g^2 + \beta_7 routine_i + \beta_8 ict_i + \varepsilon_i, \quad (2)$$

¹⁰The results in Panel B do not contradict the more supportive evidence for Germany documented by other studies (cf. Dustmann et al., 2009; Goos et al., 2014). As put forward by Senfleben-Koenig and Wielandt (2014) job polarisation between occupations can be found in the German data prior to the millennium, whereas evidence for it after 2000 is far less conclusive. In the Appendix, we provide further robustness checks for this result. In this respect, the experience of Germany seems different from the experience of other industrialised countries. For instance, based on UK establishment data Cortes and Salvatori (2018) document a strong increase in the share of workplaces conducting non-routine tasks between 1998 and 2011.

where we extend our baseline specification in Eq. (1) by adding six control variables. Thereby, $incumbent_i$ and new_i are dummy variables related to the offshoring status of an establishment. Our dataset provides for the years 1999, 2001 and 2003 qualitative information on the use of foreign intermediate inputs. The variable $incumbent_i$ takes a value of one if the establishment reports offshoring, i.e. a positive share of foreign intermediate input goods, in 1999 and zero otherwise. The variable new_i takes a value of one if a non-offshoring establishment in 1999 starts buying foreign intermediate goods between 2000 and 2003 and in addition shuts down, sells off, or spins off part of its establishment in the same time period. Hence, we only classify new imports of intermediates as offshoring if an establishment reports restructuring around the years in which it starts to import those intermediates. This is done to acknowledge that offshoring typically involves long-lasting organisational decisions.

Beyond these establishment-level measures of offshoring, we consider the variable $overlap_g$, which is computed as the proportion of (incumbent and new) offshoring establishments out of all producers in each wage group, entering the regressions linearly as the offshoring share and as a squared term. Adding these group-level variables is motivated by recent empirical work showing that the productivity thresholds separating offshoring from non-offshoring firms are not sharp and that the ranges of productivity supporting offshoring and non-offshoring, respectively, overlap in the data (see, e.g., Tomiura, 2007; Antràs and Yeaple, 2014). Including these controls allows us to isolate the specific effects on incumbent and new offshoring firms common to all wage groups from effects materializing due to distinct patterns of offshoring in the respective wage groups.

Finally, we consider two variables associated with technological change. On the one hand, we follow Spitz-Oener (2006) and Becker et al. (2013) and construct a measure of routinisation at the occupation level for 1999, using data from the BiBB/BAuA Employment Survey.¹¹ The thus computed initial share of routine tasks, $routine_i$, is added as a further control to make sure that our findings regarding the impact of offshoring do not pick up the effects of routine-biased technological change. We also add a variable for the change in ICT capital divided by value added, ict_i , in an establishment's industry during the sample period. Even though it is not a priori clear why advancements in ICT should lead to job polarisation, Michaels et al. (2014) show such a pattern for 11 industrialised countries. Following them, we merge data from EU KLEMS to the LIAB at the industry level, control for changes in ICT capital in a given industry and account for the adoption of ICT as an important form of technological change during the sample period.¹² The Appendix provides further details on the data input.

The estimation results are reported in Table 2. In the first column we replicate the evidence

¹¹This survey is conducted in Germany every five to six years, and it is run jointly by the Federal Institute for Vocational Education and Training (BiBB) and the Federal Institute for Occupational Safety and Health (BAuA).

¹²See O'Mahony and Timmer (2009) for a description of the EU KLEMS database.

Table 2: *Offshoring and Job Polarisation between Establishments, Unbalanced Sample (1999-2005)*

	Model I 20 groups	Model II 20 groups	Model III 20 groups	Model IV 20 groups	Model V 20 groups
Initial wage	-0.123* (0.058)	-0.254 (0.155)	-0.255 (0.153)	-0.254 (0.157)	-0.230 (0.163)
Initial wage squared	0.032* (0.012)	0.060 (0.039)	0.061 (0.038)	0.061 (0.039)	0.055 (0.040)
Incumbent offshorer		0.059** (0.018)	0.055** (0.018)	0.049* (0.018)	0.046* (0.016)
New offshorer			-0.206** (0.052)	-0.208** (0.054)	-0.204** (0.054)
Overlap	No	Yes	Yes	Yes	Yes
Share of routine tasks	No	No	No	Yes	Yes
ICT	No	No	No	No	Yes
No. of observations	7,434	7,434	7,434	7,384	7,384

Notes: The dependent variable is the log employment change by the establishment between the base year 1999 and the last year the establishment is observed during the sample period. The variable *Initial wage* measures the average wage of establishments within a given wage-group in the base year 1999. The variable *Incumbent offshorer* is a dummy variable that takes a value of one if the establishment reports a positive share of foreign intermediate inputs in base year 1999. The variable *New offshorer* is a dummy variable that takes a value of one if the establishment does not offshore in the base year but starts to offshore and restructures afterwards. The variable *Overlap*, measuring the share of incumbent and new offshorers in a given wage-group, enters linearly and as a squared term. The variable *Share of routine tasks* captures the establishment's share of workers performing tasks vulnerable to offshoring in 1999. The variable *ICT* stands for the change in ICT capital divided by value added in a given industry from the base year to the end year. A constant is estimated but not reported. Standard errors are clustered at the wage-group level and reported in parentheses. Significance levels are indicated by ° $p < 0.1$, * $p < 0.05$, and ** $p < 0.01$, respectively.

for job polarisation between establishments reported in Panel A of Figure 1 for the unbalanced sample, using the parsimonious regression model outlined in Eq. (1). Our estimation results confirm a u-shaped pattern of employment growth, with establishments at the bottom and the top of the wage distribution enjoying relatively larger employment growth. In Columns 2 and 3, we add the two offshoring variables as additional controls. Both parameter estimates are significant at the 1 percent level and the two offshoring variables exert opposing effects on establishment-level employment changes. Whereas incumbent offshorers experience a less pronounced employment loss (or more pronounced employment gain), establishments that start to offshore experience an additional domestic employment loss. Starting from Column 2, we additionally control for the share of incumbent and new offshorers in a given wage group to account for the overlap of offshoring and non-offshoring producers in our data. The observation that initial wage differences lose their statistical significance when adding the offshoring controls indicates that offshoring status and changes thereof are indeed important determinants of the observed job polarisation between Ger-

man establishments. Finally, the results in Columns 4 and 5 show that our empirical findings on offshoring activity are robust to the inclusion of two widely used variables on technological change. Neither the share of the routine tasks at the establishment level nor changes in ICT capital at the industry level materially affect size and significance of the coefficients of the two offshoring variables. Our preferred specification, based on the unbalanced sample and with all the control variables just discussed, is reported in Column 5 of Table 2.

In the Appendix, we present the results from a number of robustness analyses, in which we vary, for instance, the sample period and the number of distinct wage groups. We also consider a balanced instead of an unbalanced sample of establishments and address the issue of selection bias due to attrition by weighting observations with the inverse predicted probability of remaining in the sample due to non-closure (cf. Wooldridge, 2010, ch. 19). In a further extension, we combine these attrition weights with the sampling weights provided by the IAB to ensure that our empirical results are representative for the German economy. Moreover, we consider average residual instead of actual wages to make sure that workforce composition does not drive our findings on job polarisation between establishments. Finally, we employ an alternative ICT measure, allow for different employment trends in manufacturing and other industries, add a control for the establishments' export status, and restrict the sample to single-plant establishments, which are classified as firms, to show that the distinction between firms and establishments is not material for our analysis. The main results from Table 2 are robust to all these changes.

3 Offshoring and firm-level employment

The empirical analysis above provides evidence supportive of job polarisation between establishments and points to offshoring as an important determinant of the establishment-level employment changes observed in the data. Furthermore, the results from Table 2 show that the employment changes are different for incumbent and new offshorers, suggesting that a theory that aims at explaining firm-level changes in domestic employment by changes in offshoring activity should allow to distinguish the channels relevant for incumbent and new offshoring producers. Before introducing our model in the next section, we conduct a simple elasticity decomposition for the employment effects at the firm level of a change in variable offshoring costs to illustrate why the distinction between incumbent and new offshorers is crucial for generating the empirically observed employment changes. The decomposition analysis differs from the one in Grossman and Rossi-Hansberg (2008), who conduct a similar exercise for economy-wide wages in their seminal work on trade in tasks. For our purpose, it is convenient to split the domestic firm-level employment effect of offshoring into a *direct effect* (indexed by λ), which only exists for producers choosing to offshore,

and an *indirect effect* (indexed by μ), which exists for all offshoring and non-offshoring firms.

As pointed out by Egger et al. (2015), the direct domestic employment effect is itself a composite of two parts: a negative *relocation effect*, resulting from moving tasks offshore, which leads to less domestic employment per unit of output, and a positive *productivity effect* due to the offshoring-induced cost reduction, which allows firms to expand their employment in non-offshored tasks and to sell more units of their now less expensive products.¹³

Using v as firm index, we can denote the percentage change in domestic firm-level employment in response to a change in the variable offshoring cost (in semi-elasticity terms) as follows:

$$\varepsilon_l(v) = \varepsilon_\lambda(v) + \varepsilon_\mu, \quad (3)$$

where $\varepsilon_l(v)$ is the change in domestic employment of firm v , $\varepsilon_\lambda(v)$ is the direct domestic employment effect, and ε_μ is the indirect employment change common to all firms that is required to restore labour market equilibrium at endogenously adjusting wages.

By definition, we have $\varepsilon_\lambda(v) = 0$ for all non-offshoring firms. For offshoring firms, $\varepsilon_\lambda(v)$ differs between those firms that start offshoring due to the reduction in offshoring costs (*new offshorers*, with the elasticity denoted by ε_λ^N) and those firms that already engage in offshoring prior to the reduction in offshoring costs (*incumbent offshorers*, with the elasticity denoted by ε_λ^I). The elasticities differ since, in reaction to a reduction in offshoring costs, incumbent offshorers move their marginal tasks abroad, while new offshorers move abroad all tasks up to the marginal one. Intuitively, as a consequence the relocation effect is stronger for new offshorers, which leads to $\varepsilon_\lambda^N < \varepsilon_\lambda^I$.

In general equilibrium, the firm-specific direct effect of offshoring and the indirect effect are linked via the accounting identity

$$\tilde{\varepsilon}_l = \text{share}^I \varepsilon_\lambda^I + \text{share}^N \varepsilon_\lambda^N + \varepsilon_\mu, \quad (4)$$

where $\tilde{\varepsilon}_l$ is the average employment change across firms due to a change in offshoring costs, and share^I , share^N denote the shares of production workers employed by incumbent and new offshoring firms, respectively.¹⁴ The left-hand side of Eq. (4) is determined by features of the labour market.

¹³The distinction between two counteracting effects of offshoring on domestic employment is akin to the employment effects of two facets of technological change put forward by Acemoglu and Restrepo (2018). However, the evidence reported in Section 2 indicates that offshoring does not simply capture a specific form of technological change but provides an explanation that goes beyond the routinisation or automatization of production processes. Furthermore, the existence of two countervailing forces in the determination of the direct firm-level employment effect and changes in their relative importance provide a rationale for the inconclusive empirical evidence on the consequences of offshoring for firm-level employment (cf. Sethupathy, 2013; Hummels et al., 2014; and Moser et al., 2015).

¹⁴Notably, $\text{share}^I + \text{share}^N < 1$ if some firms do not offshore.

In a model with a fixed supply of production workers and full employment, $\tilde{\varepsilon}_l$ would be equal to zero, and Eq. (4) could be interpreted as a labour market equilibrium condition, according to which the indirect effect would in the aggregate exactly offset the direct effects of offshoring to restore labour market clearing. By contrast, our model features an endogenous supply of production workers due to an occupational choice mechanism, and there is also involuntary unemployment as a consequence of firm-level rent-sharing. Therefore the left-hand side of Eq. (4) in our model is non-zero in general. Despite this complication, the inverse relationship between the direct and the indirect employment effects remains largely intact in our model, albeit in attenuated form.

The combination of firm-specific direct employment effects and an inversely related indirect employment effect is a necessary prerequisite for job polarisation between firms to materialise. In addition, non-offshoring producers must exist along with incumbent and new offshorers, and there must be a clear ranking of these producers by their (productivities and) wage rates. We generate this ranking in our model in the usual way by assuming fixed costs of offshoring that are the same for all producers, thereby leading to self-selection of high-productivity high-wage producers into offshoring. Then, a decline in variable offshoring costs causes job polarisation if the following three conditions are fulfilled: (i.) $\varepsilon_\mu < 0$, (ii.) $\varepsilon_\lambda^I + \varepsilon_\mu < 0$, and (iii.) $\varepsilon_\lambda^N + \varepsilon_\mu > 0$. Under the first two conditions low-productivity and thus low-wage non-offshoring as well as high-productivity and thus high-wage incumbent offshoring firms expand their domestic employment, whereas under the third condition newly offshoring firms with intermediate productivities and intermediate wage levels reduce their domestic employment if the offshoring costs fall. We use our theoretical model outlined in the next section to pin down $\tilde{\varepsilon}_l$ and to determine the exact parameter domain for which the three conditions necessary for offshoring to produce job polarisation are fulfilled.

4 The model: basics

We set up a model with an endogenous mass M of monopolistically competitive firms that produce horizontally differentiated intermediate inputs facing a demand function

$$x(v) = Ap(v)^{-\sigma}, \quad (5)$$

in which $A > 0$ is a demand shifter determined in general equilibrium but exogenous to the firm, v is a firm index, and $\sigma > 1$ is the constant price elasticity of demand. Following [Acemoglu and Autor \(2011\)](#) we model production as the mapping of a continuum of tasks with measure one into an output good using a Cobb-Douglas technology. The production level of task $\hat{\eta}$ in firm v is given by $l(\hat{\eta}, v)^\delta \bar{a}(\hat{\eta}, v)$, where $l(\hat{\eta}, v)$ is the mass of workers employed and $\bar{a}(\hat{\eta}, v)$ is a measure of *effective* labour productivity. Parameter $\delta \in (0, 1)$ imposes decreasing returns to employment and implies

that labour quantity and labour quality are not perfect substitutes in task production. Workers can be employed at home or abroad, where employment abroad is associated with offshoring. Output of firm v is given by

$$y(v) = \varphi(v) \exp \left[\int_0^1 \ln l(\hat{\eta}, v)^\delta \bar{a}(\hat{\eta}, v) d\hat{\eta} \right], \quad (6)$$

where $\varphi(v) > 1$ is a firm-specific baseline productivity parameter. Effective labour productivity in the production of task $\hat{\eta}$, $\bar{a}(\hat{\eta}, v)$, is endogenous to the firm for two reasons. First, offshoring involves variable costs of the iceberg type, and hence the *effective* productivity of workers in the production of a task depends on whether it is produced at home or abroad. Second, firms may take measures to increase the productivity of their labour input by screening their applicants as in Helpman et al. (2010) and Helpman et al. (2017).

We assume that tasks differ in terms of the variable costs for moving them offshore, and without loss of generality we order the tasks in such a way that these costs are increasing in $\hat{\eta}$. Specifically, we borrow from Grossman and Rossi-Hansberg (2008, p. 1986) the functional form:

$$T(\hat{\eta}) = \left[\tau(1 - \hat{\eta})^{-t} \right]^\delta, \quad (7)$$

with $\tau > 1$ and $t > 0$. Thereby, τ represents the variable offshoring cost for the task with the lowest such cost, and with the elasticity of $T(\hat{\eta})$ given by $t\delta\hat{\eta}/(1 - \hat{\eta})$, higher values of shape parameter t are associated with a more steeply increasing offshoring cost schedule.

Facing demand (5) and technologies (6) and (7), profit maximising firms have to take a sequence of three decisions that directly and indirectly shape their offshoring behaviour. First, a firm decides upon market entry, and on whether or not to offshore. Second, if a firm has chosen to offshore it decides on how many tasks to put offshore. Third, the firm sets a wage rate and hires workers for performing the various tasks needed to produce output $y(v)$. Both decisions at stage three are linked in that hiring the desired number of workers is only possible if the wage rate is high enough to make working for the firm attractive. We model a wage setting mechanism at the firm level based on the idea of rent sharing, which leads to a positive relationship between firm productivity, firm size and firm-level wage rates. *Some* mechanism leading to firm-specific wage rates is crucial, of course, to accommodate our empirical result that reallocation of workers between firms has been instrumental for job polarisation. Furthermore, the positive relationship between those three variables is in line with a large body of empirical evidence (cf. Card et al., 2018).

When writing down our model, we frame the analysis in terms of generic variables that have a representation in different models of the labour market. In the Appendix, we show that two specific and widely used micro-foundations of firm-level rent-sharing, a search-and-matching mechanism

(augmented by a screening motive), as in [Helpman et al. \(2010\)](#), and a gift-exchange mechanism, as in [Amiti and Davis \(2012\)](#); [Egger and Kreickemeier \(2012, 2013\)](#), are compatible with our analysis, and that they are therefore isomorphic in the context of our model.¹⁵

5 The firm's problem

We solve the multi-stage decision problem of firms by backward induction, starting with hiring and wage setting, which are jointly determined at stage three. With tasks combined in a symmetric Cobb-Douglas production function as specified in Eq. (6), profit maximisation leads to equal expenditures for all tasks. In addition, with a constant-elasticity demand function in Eq. (5) it also implies that the overall wage bill and the operating profits are both constant shares of revenues. Taken together, those two results directly lead to an employment equation of the form

$$l(\hat{\eta}, v) = \begin{cases} \frac{\rho_w}{\rho_\pi} \frac{\pi(v)}{w(v)} & \text{if } \hat{\eta} \text{ is produced at home} \\ \frac{\rho_w}{\rho_\pi} \frac{\pi(v)}{w^*(v)} & \text{if } \hat{\eta} \text{ is produced abroad} \end{cases}, \quad (8)$$

where $l(\hat{\eta}, v)$ is the employment in firm v for the production of task $\hat{\eta}$, $\pi(v)$ denotes firm v 's operating profits, ρ_w and ρ_π are the constant shares of revenues accruing to production workers and operating profits, respectively, and $w(v)$ and $w^*(v)$ are the wages paid by firm v at home and abroad.

Firm-level wages at home and abroad are linked to firm-level operating profits $\pi(v)$, and to labour market conditions external to the firm via wage equations of the following form:

$$w(v) = \pi(v)^\theta b_w^{1-\theta}, \quad w^*(v) = \pi(v)^\theta (b_w^*)^{1-\theta}, \quad (9)$$

where labour market conditions are country-specific, and they are denoted by b_w at home and by b_w^* abroad, and $\theta \in (0, 1)$ is the constant elasticity of firm-level wages with respect to firm-level operating profits. Firm-level wages increase in local labour market conditions with elasticity $1 - \theta$, and while the exact definition of b_w and b_w^* depends on the specific micro-foundation, their ratio is directly linked to the ratio of expected wages for production workers abroad and at home, ω :

$$\omega \equiv \frac{(1 - u^*)\bar{w}^*}{(1 - u)\bar{w}} = \left(\frac{b_w^*}{b_w} \right)^{\frac{1-\theta}{1-\vartheta}}, \quad (10)$$

where \bar{w} and \bar{w}^* are the average wages of production workers in the two countries, and u and

¹⁵A different class of models that can also explain the positive association of firm success and firm-level wage rates build on positive assortative matching between heterogeneous workers and heterogeneous firms ([Sampson, 2014](#); [Grossman et al., 2017](#)).

u^* are the respective unemployment rates. Parameter ϑ governs the elasticity with which relative labour market conditions for workers react to a change in the ratio of expected labour incomes. Eq. (9) embodies the idea of international rent sharing, since the firm’s global (rather than national) operating profits are a determinant of firm-level wage rates in both markets.¹⁶ Together, Eqs. (9) and (10) imply that the intra-firm wage differential $w^*(v)/w(v)$ is equal to $\omega^{1-\vartheta}$, and therefore the same for all firms. In the Appendix, we provide alternative micro-foundations for Eq. (9), and also parameter constraints necessary for the equation to hold.

We now turn to the stage-two problem of determining the share of tasks put offshore by firms that have chosen to start offshoring at stage one. We denote the share of tasks put offshore by $\eta(v)$. Using Eqs. (8) and (9), we can write operating profits of firm v as:

$$\pi(v) = \rho_\pi \left(b_r A^{\frac{1}{\sigma-1}} \right)^\xi \left\{ \varphi(v) \kappa[\eta(v)]^{I(v)} \right\}^\xi, \quad (11)$$

with

$$\kappa[\eta(v)] \equiv \exp \left\{ \int_0^{\eta(v)} \ln \left[\frac{1}{\omega^{(1-\vartheta)\delta} T(\hat{\eta})} d\hat{\eta} \right] \right\}. \quad (12)$$

In Eq. (11), the term in curly brackets is effective firm productivity, and it is the product of baseline productivity $\varphi(v)$ and the productivity gain from offshoring $\kappa(v)$ (cf. [Grossman and Rossi-Hansberg, 2008](#)), which is defined in Eq. (12). $I(v)$ is an indicator function taking value one for offshoring and value zero for non-offshoring firms, and the constant $\xi > 0$ is the elasticity of firm-level operating profits with respect to effective firm productivity. All terms in front of the curly brackets in Eq. (11), including the newly introduced constant b_r , are treated parametrically by each firm, and they are the same for all producers.

Maximising their profits, firms offshore only those tasks that can be produced at lower costs abroad and these are all tasks up to a threshold $\eta(v)$, which, from Eq. (12), is implicitly given by $\omega^{(1-\vartheta)\delta} T[\eta(v)] = 1$. With the assumed functional form for $T(\hat{\eta})$, we get:

$$\eta = 1 - \left(\tau \omega^{1-\vartheta} \right)^{\frac{1}{t}}, \quad (13)$$

$$\kappa(\eta) = [(1 - \eta) \exp(\eta)]^{-\delta t}. \quad (14)$$

Notably, since the intra-firm wage differential $\omega^{1-\vartheta}$ is not firm-specific, neither are η or κ . In the following, we replace the generic firm index v by firm productivity φ and an index for the offshoring status of the firm (o and d for “offshoring” and “domestic”, respectively). The relative

¹⁶Evidence supportive of international rent sharing within firms is provided by [Budd and Slaughter \(2004\)](#), [Dobblaere \(2004\)](#), [Budd et al. \(2005\)](#), and [Martins and Yang \(2015\)](#).

operating profits and relative domestic wages of two firms with the same productivity but different offshoring status follow directly from Eqs. (9) and (11) as

$$\frac{\pi_o(\varphi)}{\pi_d(\varphi)} = \kappa^\xi \quad \text{and} \quad \frac{w_o(\varphi)}{w_d(\varphi)} = \kappa^{\theta\xi}, \quad (15)$$

where ξ can now be interpreted as the *cross-regime* elasticity of firm-level operating profits with respect to the productivity gain from offshoring, κ . In direct analogy to Eq. (15), ξ and $\theta\xi$ also denote the *within-regime* elasticities of firm-level operating profits and firm-level wages, respectively, with respect to firm-level productivity, φ . Hence, our model not only predicts, in line with a large empirical literature (cf. Blanchflower et al., 1996; Albaek et al., 1998; Idson and Oi, 1999; Lallemand et al., 2007), that more productive firms make higher profits and pay higher wages, but it also explains the existence of an offshoring wage premium for domestic workers, which is akin to the exporter wage premium and the multinational wage premium well documented by existing empirical work (cf. Frias et al., 2012; Egger et al., 2013; Aitken et al., 1996; Girma and Görg, 2007).

We now turn to stage one of the firm's profit maximisation problem, which involves its decision upon market entry and its decision to start offshoring or to produce purely domestically. Both of these decisions characterise a marginal producer who is indifferent between the available choices. Following Lucas (1978), we assume that each monopolistically competitive firm is run by a single entrepreneur who acts as an owner-manager and is the residual claimant of the firm, receiving as remuneration the firm's operating profits net of fixed offshoring costs. Operating profits depend on the entrepreneurial ability of the owner-manager, which determines (and is equal to) the productivity of the firm, φ . Being an entrepreneur is one of three possible occupations. Individuals could alternatively seek employment as production workers with uncertain wage and employment prospects and an expected income that equals the ex ante probability to be employed, $1 - u$, times the the average wage of employed workers, \bar{w} , or they could work in a service sector, which provides all inputs different from production labour and pays a guaranteed wage s . Differences in ability φ only matter for the income of entrepreneurs and agents choose the occupation yielding the highest expected income, acknowledging their realisation of φ .

Focussing on an outcome in which only a subset of firms chooses to offshore (the parameter constraint required for this outcome is introduced below), the marginal entrepreneur runs a non-offshoring (domestic) firm, whose productivity we denote by φ_d . Assuming that agents are risk-neutral and that the occupational choice is irreversible, for instance due to occupation-specific

education, the indifference condition of the marginal firm is given by

$$\pi_d(\varphi_d) = (1 - u) \bar{w} = s, \quad (16)$$

and all agents with entrepreneurial abilities at least as high as φ_d become owner-manager of their own firm because, as outlined above, operating profits are increasing in φ . The second indifference condition requires the gain in operating profits for the marginal offshoring firm, whose productivity we denote by φ_o , to be equal to the offshoring fixed cost:

$$\pi_o(\varphi_o) - \pi_d(\varphi_o) = s. \quad (17)$$

and all firms with productivity at least as high as φ_o start to offshore. The two Eqs. (16) and (17) jointly determine the share of firms that choose to offshore in our setting, χ . Accounting for Eq. (15), we can combine the two indifference conditions to obtain $\kappa(\eta)^\xi - 1 = (\varphi_o/\varphi_d)^\xi$. Under the additional assumption that the distribution of φ is Pareto and has support on interval $[1, \infty)$: $G(\varphi) = 1 - \varphi^{-k}$, with shape parameter $k > \max\{\xi, 1\}$, we can compute the share of offshoring firms as $\chi = [1 - G(\varphi_o)]/[1 - G(\varphi_d)] = (\kappa^\xi - 1)^{k/\xi}$. Accounting for the productivity effect of offshoring in Eq. (14), then establishes

$$\chi(\eta) = \left\{ [(1 - \eta) \exp(\eta)]^{-t\delta\xi} - 1 \right\}^{\frac{k}{\xi}}, \quad (18)$$

with $d\chi/d\eta > 0$. Hence, indifference of the marginal entrepreneur between career paths, indifference for the marginal offshoring firm between offshoring and domestic production, and the cost minimising choice of task production together imply that the share of firms choosing offshoring and the share of offshored tasks are positively related. Furthermore, in any interior equilibrium with $\chi < 1$ firms choose to perform some of their tasks domestically: Eq. (18) implies that the maximum share of offshored tasks compatible with an interior solution, which we denote by η_{int} , is implicitly defined by $[(1 - \eta_{int}) \exp(\eta_{int})]^{-t\xi} = 2$, and it lies strictly inside the unit interval.

The three Eqs. (13), (14), and (18) determine three important margins associated with the offshoring decision of firms. The first one is the *extensive task margin*, which is linked to the share of tasks put offshore η . The second one is the *intensive task margin*, which is the solution to the cost-minimising choice of domestic and foreign labour input, and therefore related to $\kappa(\eta)$. The third one is the *extensive firm margin* of offshoring, which is linked to the share of offshoring firms $\chi(\eta)$. The three margins are interdependent in our model, and from Eq. (13) they depend on wage differential $\omega^{1-\vartheta}$, which is determined in general equilibrium and, in view of Eq. (10), is positively related to the ratio of average labour incomes at home and abroad.

6 General equilibrium

Having derived the solution to the firm's maximisation problem we now embed our offshoring model into a two-country general equilibrium framework. Since offshoring in our model is low-cost seeking, it is one-directional and (for identical technologies) requires asymmetric wages. The simplest way to capture this asymmetry is to assume that entrepreneurial abilities are only available in one country, which we associate with an industrialised North (n), so that all firms are headquartered there. Since firms only use local service input, agents in the other country, which we associate with a developing South (s), have only one career path namely the employment as production workers in Northern firms that have chosen to offshore. In this interpretation, the South serves as a labour reservoir and must have lower wages than the North in equilibrium, because firms choose to offshore only if this leads to a reduction in their production costs. Population size in the two countries is given by N_n and N_s , respectively, and each agent is endowed with one unit of labour. Furthermore, we associate firms with intermediate goods producers whose output is assembled in a competitive industry to a homogeneous consumption good, using a CES technology à la [Ethier \(1982\)](#): $Y = \left[\int_{v \in V} x(v)^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}$, where V denotes the set of available intermediates. We choose the consumption good as the *numéraire*, and therefore the market size variable A in Eq. (5) is equal to Y , the total *volume* and *value* of the consumption good produced in the North. Trade is balanced, with North importing the task output produced in the South in exchange for the consumption good.

We can now use important insights gained from solving the firm's profit maximisation problem to characterise the general equilibrium. For this purpose, we first establish a link between relative labour endowments of the two countries, N_n/N_s , and the ratio of average labour incomes, ω . Since the aggregate income of production workers is a fixed fraction ρ_w of total income, we can write

$$\omega = \frac{\gamma}{1 - \gamma} \frac{L}{N_s}, \quad (19)$$

where γ is the endogenous share of aggregate labour income accruing to the South. We show in the Appendix that γ can be written as

$$\gamma \equiv \frac{\eta\chi(1 + \chi^{-\xi/k})}{1 + \chi}, \quad (20)$$

and it is easily checked that $\partial\gamma/\partial\chi$ and $\partial\gamma/\partial\eta$ are both positive. Using Eq. (18) we can write $\gamma = \gamma[\eta, \chi(\eta)]$, with $d\gamma/d\eta > 0$. The second variable in Eq. (19) deserving further discussion is the Northern supply of production workers L , which is endogenous due to the occupational choice mechanism outlined above. We show in the Appendix that using the indifference condition in Eq.

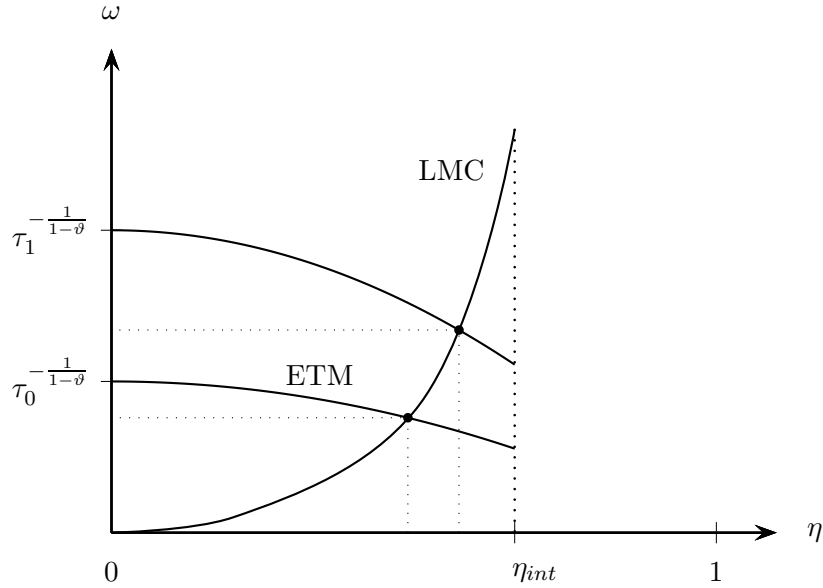


Figure 2: *General Equilibrium*

(16) and the resource constraint it is possible to write L as a function of N_n and γ . Using this expression to substitute for L in Eq. (19), we get

$$\omega = \frac{\rho_w \gamma}{1 - \rho_w \gamma - \rho_\pi \xi / k} \frac{N_n}{N_s}, \quad (21)$$

with $d\omega/d\eta > 0$. We label Eq. (21) the *labour market constraint* (LMC) since it links the two endogenous variables ω and η to the relative labour endowment N_n/N_s . Intuitively, for a constant relative labour endowment more offshoring along the extensive task margin (which is accompanied by more offshoring along the extensive firm margin) drives up the relative average wage in the destination country.

There is a second relationship between ω and η , arising from the optimally chosen extensive task margin (ETM) that we derived earlier, in Eq. (13). In the case of the ETM, the relationship between ω and η is negative: a higher relative average labour income in the destination market implies a higher relative wage an individual firm has to pay there, and therefore it is optimal for each firm to offshore fewer tasks. Together, the labour market constraint and the indifference condition for the extensive task margin can be used to solve for the two endogenous variables ω and η .

The determination of equilibrium is illustrated in Figure 2. Existence of an interior equilibrium requires that the two loci ETM and LMC intersect at $\eta \leq \eta_{int}$. According to Eqs. (13) and (21),

a unique intersection point exists under the parameter constraint

$$\frac{\rho_w \eta_{int}}{1 - \rho_w \eta_{int} - \rho_\pi \xi/k} \frac{N_n}{N_s} > (1 - \eta_{int})^{\frac{t}{1-\theta}}, \quad (22)$$

assumed in the following. Intuitively, condition (22) shows that an interior equilibrium requires the South to be sufficiently small, measured by its relative population size N_s/N_n . In this case, the wage differential between the two markets narrows quickly as more and more tasks are moved offshore, and hence the least productive firm always finds it advantageous to produce all tasks at home, thereby avoiding the fixed (and variable) costs of offshoring.

The effects of a reduction in variable offshoring costs τ can now be readily analysed using Figure 2. A decline in τ from τ_0 to τ_1 implies that the ETM locus shifts upward: a given share of offshored tasks η is compatible with a higher average labour income in the South, *ceteris paribus*, if the offshoring cost is lower. The labour market constraint is unaffected, and therefore in equilibrium a reduction in the variable cost of offshoring leads to a higher relative average income for Southern workers, and to more tasks being offshored.

Notably, our solution concept for the general equilibrium and its graphical representation in Figure 2 bear a close resemblance to a diagram developed by [Dornbusch et al. \(1977\)](#) in their seminal paper on the Ricardian model with a continuum of goods. In their model, the two endogenous variables in the general equilibrium are the relative wage rate between the countries, and the marginal good separating those goods produced in Home from those produced in Foreign. The two loci determining the equilibrium values of these variables are a labour market equilibrium condition (more goods produced in Home means a higher relative wage in Home) and a production allocation locus (for given Ricardian production technologies, a lower relative wage in Home implies that a larger number of goods is produced there), whose close relationship to the labour market constraint and the external task margin in our model are obvious from Figure 2.

7 Offshoring and firm-level employment

We now turn to the effect of a change in offshoring costs on the allocation of workers between firms in the North, thereby providing a theoretical foundation for the employment effects identified by a simple elasticity decomposition in Section 3. For this purpose, we have to elaborate how labour market condition b_w is linked to the expected labour income $(1 - u)\bar{w}$ in general equilibrium. We postulate a linear relationship of the form $b_w = \zeta^{\frac{1}{1-\theta}}(1 - u)\bar{w}$, where ζ is a positive constant larger than or equal to one, such that, according to Eq. (9), the wage paid by the least productive producer is at least as high as expected labour income, prompting workers to accept job offers from this producer. The linear relationship considered here accords with the outcome of the search and

matching as well as the gift exchange model outlined in the Appendix, and it allows us to write domestic firm-level employment in non-offshoring firms and offshoring firms as

$$\ln l_d(\varphi, \eta) = \ell_0 + (1 - \theta)\xi \ln \varphi + \mu(\eta), \quad (23)$$

$$\ln l_o(\varphi, \eta) = \ell_0 + (1 - \theta)\xi \ln \varphi + \mu(\eta) + \lambda(\eta), \quad (24)$$

where ℓ_0 is a constant, and $\lambda(\eta)$, $\mu(\eta)$ are defined as

$$\lambda(\eta) \equiv [1 - t(1 - \theta)\delta\xi] \ln(1 - \eta) - t(1 - \theta)\delta\xi\eta, \quad (25)$$

$$\mu(\eta) \equiv - \left[\frac{(1 - \theta)\xi}{k} \right] \ln \left\{ \left(1 - \rho_\pi \frac{\xi}{k} \right) [1 + \chi(\eta)] - \rho_w \eta \chi(\eta) \left[1 + \chi(\eta)^{-\frac{\xi}{k}} \right] \right\}. \quad (26)$$

Eqs. (23) and (24) show that domestic employment for both types of firms is increasing in firm productivity with constant elasticity $(1 - \theta)\xi$. Furthermore, domestic firm-level employment is affected by the share of offshored tasks η via two separate channels, which we have summarised in the respective terms $\lambda(\eta)$ and $\mu(\eta)$: The term $\lambda(\eta)$ appears only in Eq. (24), indicating that it represents the direct link between η and employment in those firms that conduct offshoring. The term $\mu(\eta)$ is common to both equations, showing that it represents indirect market forces that affect employment in all firms equally. While Eqs. (23) and (24) are written as functions of the endogenous variable η , we have shown above that there is a monotonic link between η and the exogenous offshoring cost parameter τ . We can therefore analyse the comparative statics in terms of η , in the understanding that an increase in η is the result of a decrease in τ .

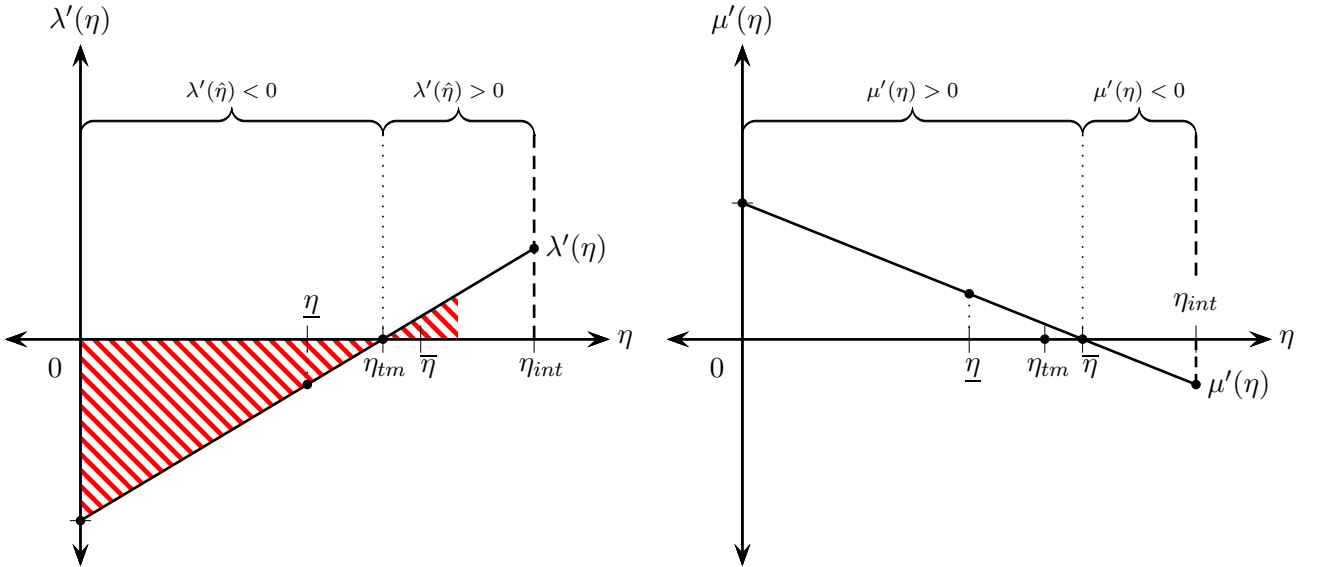


Figure 3: *Direct and indirect employment effects of offshoring*

We focus on the direct effect of offshoring on domestic firm-level employment first, since the

indirect effect common to all firms is a second-round effect that is easily understood once the sign of the first-round effect is known. As shown above, if an increase in η in our model is the result of a reduction in τ , then χ , the share of firms that choose offshoring, increases as well. In the following we will therefore carefully distinguish the effect a reduction in τ has on the domestic employment in *incumbent offshoring firms* from the effect it has on domestic employment in the *newly offshoring firms*.

Eq. (24) shows that the direct effect on the log of domestic employment in incumbent offshoring firms is equal to $\lambda'(\eta)$. It is the composite of a positive productivity effect, capturing the increase of domestic employment as a result of increased output, and a negative relocation effect, capturing the reduction in domestic employment due to the relocation of tasks to the South.¹⁷ Since the productivity effect works on infra-marginal tasks only, as pointed out by [Grossman and Rossi-Hansberg \(2008\)](#), it is increasing in η , therefore becoming more important at higher levels of offshoring. On the other hand, the absolute value of the relocation effect is decreasing in η since with a high η employment in newly offshored tasks is relatively low as firms have already shifted employment towards the cheaper tasks moved offshore before. Overall therefore, $\lambda'(\eta)$ is negative at $\eta = 0$, and it is monotonically increasing in η , as illustrated in the left panel of [Figure 3](#).

Whether or not $\lambda'(\eta)$ turns positive at some $\eta < \eta_{int}$ depends on offshoring cost parameter t . As we show in the Appendix, there exists a threshold level t_1 that is implicitly defined by

$$\ln 2 = -t_1 \delta \xi \ln \left(1 - \frac{1}{t_1(1-\theta)\delta\xi} \right) - \frac{1}{1-\theta} \quad (27)$$

and has the following interpretation: If and only if $t > t_1$, $\lambda'(\eta)$ becomes positive at some $\eta < \eta_{int}$, implying that the productivity effect dominates at high levels of η , and that, all other things equal, a reduction in variable offshoring costs increases domestic employment in incumbent offshoring firms. Intuitively, a high value of t is conducive to $\lambda'(\eta) > 0$ because the elasticity of the offshoring cost schedule is increasing in t and therefore a high value of t implies for a given η large cost savings on infra-marginal tasks, which in turn means that the productivity effect is large. In the following, we focus on the empirically relevant case $t > t_1$, which allows the domestic firm-level employment effect of offshoring to be negative (cf. [Biscourp and Kramarz, 2007](#); [Mion and Zhu, 2013](#); [Hummels et al., 2014](#); [Monarch et al., 2016](#)) or positive (cf. [Moser et al., 2015](#)), depending on the share of offshored tasks η . We denote by η_{tm} , implicitly defined by $\lambda'(\eta_{tm}) = 0$, the critical level above which $\lambda'(\eta)$ becomes positive.¹⁸

¹⁷These two counteracting effects are also present in [Grossman and Rossi-Hansberg \(2008\)](#). However, the analogy is not perfect, since firms in the model of Grossman and Rossi-Hansberg are atomistic, and hence they frame their discussion in terms of changes in aggregate labour demand rather than in terms of changes in firm-level employment.

¹⁸Focussing on the domestic employment of incumbent offshoring firms in the U.S., [Sethupathy \(2013\)](#) does not find a significant effect of a reduction in the cost of offshoring to Mexico. In view of our model, this indicates an extensive task margin for US firms in the neighbourhood of η_{tm}

We now turn to the newly offshoring firms, and to the direct effect that an increase in η has on domestic employment in those firms. Newly offshoring firms move abroad in one go all tasks $\hat{\eta} \leq \eta$, and therefore the direct firm-level employment effect for those firms is given by $\lambda(\eta) = \int_0^\eta \lambda'(\hat{\eta})d\hat{\eta}$. We depict $\lambda(\eta)$ in Figure 3 as the area between $\lambda'(\eta)$ and the horizontal axes. Figure 3 shows that for values of η larger than but sufficiently close to η_{tm} an increase in η is associated with a direct domestic employment effect that is positive for incumbent offshoring firms (λ' is positive) but negative for newly offshoring firms (λ is negative). The latter effect is novel relative to Grossman and Rossi-Hansberg (2008): Since in their model the firm population is homogenous (firms are atomistic), the extensive firm margin is absent, and hence, using our terminology, all firms are *incumbent offshoring firms*. As pointed out in Section 3, the direct employment effect in newly offshoring firms, and the fact that it can be different from the effect in incumbent firms, is important for understanding the link between offshoring and job polarisation along the firm dimension.

The sum of the direct employment effects for the two groups of firms (incumbent and new offshorers) induces an indirect effect $\mu'(\eta)$, which represents second-round employment adjustments due to the changing market conditions and according to Eqs. (23) and (24) is the same for all firms. The fundamental logic behind the indirect effect is straightforward: A net employment loss in offshoring firms tends to put downward pressure on the wages of production workers. In response to lower wages all firms (including new entrants at the lower end of the productivity distribution) increase their domestic employment. The strength of the second-round effect $\mu'(\eta)$ is inversely related to the strength of the first-round employment response in offshoring firms, and it therefore becomes less positive as η increases. We show formally in the Appendix and illustrate in the right panel of Figure 3 that, consistent with this logic, $\mu'(\eta)$ is positive at $\eta = 0$, and it becomes negative for high values of η , provided that $\mu'(\eta) = 0$ has a solution in interval $(0, \eta_{int}]$.

This fundamental logic needs to be qualified, since workers losing their job due to a negative first-round effect can find employment in the service sector or become unemployed, thereby weakening the link between direct and indirect domestic firm-level employment effects. To ensure that these additional effects do not alter our results, we impose two parameter constraints, whose derivation is delegated to the Appendix. First, there is a minimum threshold for t , denoted by t_2 and implicitly defined by $\mu'(\eta_{tm}) = 0$. A larger t increases the elasticity of the variable offshoring cost schedule $T(\hat{\eta})$ and thus weakens the extensive task margin, ceteris paribus. With fewer foreign workers hired by incumbent offshorers in response to a fall in τ , relative foreign labour income increases by less and hence more firms start to offshore, thereby strengthening the extensive firm margin. This leads to a larger displacement of domestic workers by newly offshoring firms and thus provides a stronger impetus for the second-round reallocation of labour at η_{tm} .

Second, we need to impose a constraint on parameters θ , σ , and δ to ensure the existence of a

finite threshold t_2 and assume that

$$1 - \rho_\pi \frac{\xi}{k} - \rho_w(1 - \theta) \left(2 - \frac{\xi}{k} \right) < 0. \quad (28)$$

If labour markets are competitive, which requires $\theta = \vartheta = 0$, the parameter constraint in (28) reduces to $2\delta < \sigma(2\delta - 1)$. To understand this condition, it is worth noting that the labour requirement for the fixed cost of offshoring is the same for all firms. However, the displacement of workers by newly offshoring firms is larger ceteris paribus for firms with higher productivity, because these are the firms with larger domestic employment in each task prior to offshoring. For small new offshorers the displacement of domestic workers can therefore be dominated by the additional labour demand for the fixed cost of offshoring. Whereas a larger t strengthens the displacement of workers by newly offshoring firms, the additional displacement by the marginal offshoring firm decreases, because it is a firm with lower productivity. Hence, for high values of t it is possible that new offshorers actually increase their domestic labour demand, and to ensure that overall the labour demand of offshoring firms decreases, we must ensure that the displacement effect is not too small and, in addition, constrain the entry of small firms into offshoring. We can achieve the first goal by assuming $\delta > 1/2$ and the second one by introducing a lower threshold for σ , because a higher σ increases the elasticity of profits with respect to productivity and hence makes it more difficult for smaller firms to bear the fixed cost of offshoring. This implies that $\mu'(\eta_{tm}) > 0$ holds for all possible $t > t_2$.

With labour market imperfection, changes in σ interact with the extent of rent sharing. This can be inferred from our discussion in Section 5, where we have seen that θ affects the wage dispersion. Since the wage dispersion is directly linked to the labour market distortion from rent sharing, we must impose a joint constraint on θ , σ , and δ to make sure that the displacement of domestic workers by newly offshoring firms is neither offset by an increase in the labour demand for the fixed cost of offshoring nor offset by a strong increase in domestic unemployment due to an exacerbation of the labour market distortion.

Proposition 1 *Let $\underline{\eta}$ be implicitly defined by $\lambda'(\underline{\eta}) + \mu'(\underline{\eta}) = 0$ and let $\bar{\eta}$ be equal to η_{int} if $\mu'(\eta_{int}) > 0$ or implicitly defined by $\mu'(\bar{\eta}) = 0$ otherwise. Then, if $t > \max\{t_1, t_2\}$ and the parameter constraint in (28) holds, there exists an interval around η_{tm} with infimum $\underline{\eta}$ and supremum $\bar{\eta}$, such that a reduction of offshoring costs leads to job polarisation if $\eta \in (\underline{\eta}, \bar{\eta})$.*

Proof See the Appendix.

At the lower interval bound $\underline{\eta}$ employment in incumbent offshoring firms stays constant, as illustrated in Figure 3. Below this lower bound $\lambda'(\eta) + \mu'(\eta)$ is negative, and therefore reducing τ would

lead to less employment in (high-wage) incumbent offshoring firms, which is in contradiction to what is observed with job polarisation. At the upper interval bound $\bar{\eta}$ we have to distinguish the two possible cases $\bar{\eta} < \eta_{int}$ and $\bar{\eta} = \eta_{int}$. In the first case, employment in non-offshoring firms stays constant at $\eta = \bar{\eta}$, and $\eta > \bar{\eta}$ would imply $\mu'(\eta) < 0$ and thus less employment in non-offshoring firms if τ falls. Again, this is in contradiction to what is observed with job polarisation. In the second case, $\eta > \bar{\eta}$ is not possible. Inside the interval $\eta \in (\underline{\eta}, \bar{\eta})$ a reduction in τ leads to exactly the firm-level employment changes that is observed with job polarisation: lower employment in newly offshoring firms in the middle of the wage distribution and higher employment in non-offshoring firms as well as in incumbent offshoring firms at the two tails of the wage distribution.

We conclude the discussion in this section by linking our insights from the elasticity decomposition in Section 3 to the detailed theoretical analysis above. Recollecting the negative relationship between the extensive task margin η and the variable offshoring cost parameter τ , we can write the direct domestic employment effects of incumbent and new offshorers in (semi-)elasticity form as $\varepsilon_{\lambda}^I = \lambda'(\eta)d\eta/d\tau$ and $\varepsilon_{\lambda}^N = -\lambda(\eta)$, respectively, whereas the indirect effect is given by $\varepsilon_{\mu} = \mu'(\eta)d\eta/d\tau$. As explained in Section 3, for job polarisation to materialise the following three elasticity conditions have to be fulfilled: (i.) $\varepsilon_{\mu} < 0$, (ii.) $\varepsilon_{\lambda}^I + \varepsilon_{\mu} < 0$, and (iii.) $\varepsilon_{\lambda}^N + \varepsilon_{\mu} > 0$. Parameter constraint $t > t_1$ establishes $\varepsilon_{\lambda}^I > 0$ for high levels of η , and therefore allows for the direct domestic employment effects of incumbent and new offshorers to go into opposite directions. Parameter constraint $t > t_2$ establishes $\varepsilon_{\mu} < 0$ for sufficiently small levels of η and this is needed for the indirect effect to work in favor of job polarisation. The analysis in this section furthermore reveals that, under the additional parameter constraint in (28), $t > \max\{t_1, t_2\}$ ensures that the three elasticity conditions are fulfilled for intermediate levels of η .

8 Offshoring and unemployment

From the analysis above, we know that heterogeneity of firms in their wage payments is a prerequisite for studying job polarisation between firms. To accord with the empirical evidence that larger, more productive firms pay higher wages, we have imposed a rent sharing mechanism. This provides a rationale for firm-specific wages that is well established in the literature and makes unemployment an important determinant of wage dispersion in our setting. To further elaborate on the link between unemployment and wage dispersion in the North we can note from Eq. (9) that in equilibrium the domestic wage paid by the marginal firm is given by

$$w_n(\varphi_d) = \zeta \pi_d^{\theta}(\varphi_d) [(1 - u_n)\bar{w}_n]^{1-\theta} = \zeta(1 - u_n)\bar{w}_n, \quad (29)$$

where the second equality sign follows from indifference condition (16) and, as outlined above, ζ is a positive constant larger than or equal to one. Following this reasoning, the relationship between wage dispersion and unemployment in the South is established by foreign wage setting of the marginal offshoring producer, which in equilibrium is given by

$$w_s(\varphi_o) = \zeta \pi_o(\varphi_o)^\theta [(1 - u_n) \bar{w}_n]^{1-\theta} \omega^{1-\vartheta} = \zeta D(1 - u_s) \bar{w}_s, \quad (30)$$

where $D \equiv [\pi_o(\varphi_o)/\pi_d(\varphi_d)]^\theta = \kappa^{\theta\xi} \chi^{-\theta\xi/k} \omega^{-\vartheta} > 1$ comprises general equilibrium variables that are the same for all producers.

If $\zeta = 1$, which is the case, for instance, in the gift exchange model where the least productive firm sets the lowest possible wage that promises employment of the required number of workers and thus renders successful applicants indifferent between accepting and rejecting the job offer, there is a one-to-one linkage between wage heterogeneity and involuntary unemployment. There is involuntary unemployment of production workers in both countries, since only in this case it is possible (i) for the marginal firm with productivity φ_d to attract the desired number of workers, or indeed any workers, in the North by paying a wage $w_n(\varphi_d)$ that is lower than the average wage \bar{w}_n ; and (ii) for the marginal offshoring firm with productivity φ_o to attract the desired number of workers, or indeed any workers, in the South by paying the a wage $w_s(\varphi_o)$ that is lower than the average wage \bar{w}_s . It is easily checked in Eq. (29) and (30) that any equilibrium with $w_n(\varphi_d) < \bar{w}_n$, $w_s(\varphi_o) < \bar{w}_s$ must feature $u_n > 0$ and $u_s > 0$ if $\zeta = 1$, and this outcome can be achieved only if $\theta > 0$. The reasoning needs to be modified if $\zeta > 1$, which is the case in the search and matching model, in which even the least productive firm offers a wage higher than the expected labour income to compensate workers for the employer-specific risk of failing the screening process. This model features two forms of labour market distortion, namely search frictions and screening frictions, but only the latter are relevant for making wages firm specific. To put it differently, there would be involuntary unemployment in the search and matching model even if there were no screening, resulting in $\theta = 0$ and wage equalisation between firms (cf. Helpman and Itzhoki, 2010; Felbermayr et al., 2011).

Whereas always strictly positive, the unemployment rate in the South decreases monotonically in η , because Southern workers can only be employed in the production of offshored tasks. A richer pattern arises for the relationship between η and the unemployment rate in the North. From Eq. (29) it is immediate that the unemployment rate of Northern production workers can be written as

$$u_n = 1 - \frac{1}{\zeta} \frac{w_n(\varphi_d)}{\bar{w}_n}, \quad (31)$$

meaning it increases in wage dispersion, measured by the ratio of the average wage of employed

workers and the wage paid by the marginal firm. The monotonic link between unemployment and wage dispersion is intuitive, because higher wage dispersion reflects a stronger labour market distortion from rent sharing, resulting in a higher rate of unemployed production workers. As we show in the Appendix, one can substitute for the endogenous wage ratio $w_n(\varphi_d)/\bar{w}_n$ to express u_n as a function of model parameters and η :

$$u_n = \frac{\theta\xi + (k - \xi) [1 - \iota(\eta)]}{\theta\xi + (k - \xi)}, \quad (32)$$

with $\iota(0) = 1$. For strictly positive but small values of η we have $\iota(\eta) > 1$. The intuition for this result is straightforward: Starting from autarky, offshoring leads to the destruction of high-wage jobs in the North, and therefore to a reduction in the wage dispersion, which in turn reduces the labour market distortion from rent sharing and lowers the unemployment rate of production workers. We also show that $\iota(\eta) < 1$ if η is high, because a further increase of η from an already high level leads to the creation of high-wage jobs in incumbent offshoring firms, increasing the wage dispersion and therefore exacerbating the labour market distortion from rent sharing. Hence, offshoring reduces the unemployment rate of domestic production workers relative to autarky if η is low, while the opposite is true if η is high. We show in the Appendix that there exists a unique threshold η_u , such that offshoring decreases (increases) the unemployment rate of production workers if $\eta < (>)\eta_u$.

Whereas the public debate of offshoring is primarily concerned about adverse effects on unemployment in the source country of offshoring, studying changes in unemployment rate u_n is not sufficient for addressing the reservations raised by its critics. The reason is that due to the occupational choice mechanism in our model production workers can choose a different career path, thereby avoiding the risk of unemployment. The economy-wide unemployment rate for the North is therefore smaller than u_n , and it is given by $U_n \equiv u_n L/N_n$. The number of production workers falls monotonically in η , because the more tasks are put offshore, the lower is the share of revenues attributed to workers in the source country of offshoring, and hence the more agents leave the sector of production workers in the North. With u_n decreasing in η as well if η is low, we know that unemployment U_n definitely falls in this case. However, a further increase of η from an already high level is accompanied by an increase in u_n and therefore the effect on economy-wide unemployment U_n is not clear a priori in this case. We show in the Appendix that depending on parameter values indeed either effect can be dominant. The following proposition summarises our insights regarding the effects of offshoring on economy-wide unemployment.

Proposition 2 *A reduction of offshoring costs lowers economy-wide unemployment in the North if η is low. An increase in unemployment relative to autarky is possible if η is high.*

Proof See the Appendix.

9 Conclusion

Using linked employer-employee data for Germany, we find evidence for job polarisation in the years after the millennium. However, the observed job polarisation is not due to a movement of workers between occupations, but due to a movement of workers between firms. Our findings further point to offshoring as an important determinant of this labour reallocation, and we put forward a rationale for this result that is rooted in two well-documented empirical facts: the selection of more productive firms into offshoring; and the positive link between firm performance measures and wage payments. We propose an offshoring model that accords with these two observations and show that in our framework the decrease in variable offshoring costs implies that more firms choose offshoring, and they choose it for a wider range of tasks. At intermediate levels of offshoring costs this leads to job polarisation in the source country of offshoring, since the following three things happen: newly offshoring producers, which have intermediate productivity, reduce the number of domestic jobs, while incumbent offshoring producers with high productivity as well as low-productivity non-offshoring firms increase the number of domestic jobs under the then more advantageous labour market conditions. At least one of these three effects fails to materialise if offshoring costs are very high or very low, and hence our model allows us to describe the conditions under which job polarisation between firms can be expected to occur.

Wage differences between firms in our model are the result of a labour market distortion from rent sharing that also leads to involuntary unemployment among production workers, and we show that changes in offshoring costs lead to non-monotonic effects on the rate of involuntary unemployment of production workers in the source country of offshoring. Accounting for the endogenous adjustment in the supply of production workers due to an occupational choice mechanism, we also show that lower offshoring costs lead to lower economy-wide unemployment when offshoring costs are high, whereas the opposite can happen when offshoring costs are already low.

To the best of our knowledge, this paper provides the first attempt to highlight movements of workers between firms that offer different wages as an important channel through which offshoring can generate job polarisation. The evidence reported in this paper is indicative of the relevance of this phenomenon, and we therefore hope that our model can stimulate future research on the importance of job polarisation between firms relative to the routinisation hypothesis that explains job polarisation by the movement of workers between occupations with differing task compositions.

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A Theoretical appendix

A.1 Models of rent sharing

A.1.1 The Search and matching model

We consider a model with search frictions that combines features of the models by [Helpman et al. \(2010\)](#) and [Rogerson et al. \(2005\)](#). In this model, firms post wages to attract applicants, who direct their search to the job offer promising the highest expected return. Workers therefore apply for a job only if the expected return from doing so is at least as high as their outside option, which is the return they can expect from applying for a job elsewhere. Since firms do not benefit from offering wages higher than those necessary to fill their vacancies, they will offer exactly the workers' outside option. This pins down the offered wage in the home country according to:

$$z(\hat{\eta}, v) \frac{l(\hat{\eta}, v)}{h(\hat{\eta}, v)} w(\hat{\eta}, v) = (1 - u) \bar{w}, \quad (\text{A.1})$$

where $z(\hat{\eta}, v)$ denotes a worker's probability of being screened by firm v for task $\hat{\eta}$, whereas the probability of being successful in the screening process equals the number of jobs filled, $l(\hat{\eta}, v)$, relative to the number of vacancies for this task, $h(\hat{\eta}, v)$. Furthermore, $w(\hat{\eta}, v)$ is the wage that firm v posts for workers performing task $\hat{\eta}$. The workers' outside option is given by average labour income, equaling the ex ante probability to find a job $1 - u$ multiplied by the average wage \bar{w} of employed production workers. Similar to [Helpman et al. \(2010\)](#), we assume that labour productivity, a , has a match-specific component, which is unobservable to workers and firms prior to the application and drawn in a lottery from a Pareto distribution of the form $B(a) = 1 - (a_{min}/a)^\beta$, where $a_{min} > 0$ and $\beta > 1$ are two distribution parameters. Firms can improve the quality of workers actually employed by defining a threshold ability $\hat{a}(\eta, v)$ for each task and installing a screening technology that selects those applicants that feature a match-specific ability higher than or equal to this threshold. Installing the screening technology imposes a fixed cost which increases in the ability threshold: $s\hat{c}\hat{a}^\alpha/\alpha$, with $c, \alpha > 0$ being constants and s is a service fee that is common to all producers. The firm benefits from screening through achieving a higher average ability of its workforce: $\tilde{a}(\hat{\eta}, v) = \hat{a}(\hat{\eta}, v)\beta/(\beta - 1)$. Aside from the screening expenditures, hiring causes further costs, associated with the installation of vacancies and with the advertisement necessary to bring the open vacancies to the attention of applicants. These hiring costs are given by $sb[\vartheta/(1 - \vartheta)]z(\hat{\eta}, v)^{\frac{1-\vartheta}{\vartheta}}$, where s is a service fee, b is a positive constant, and $\vartheta \in (0, 1)$ captures the elasticity of hiring costs with respect to labour market tightness $z(\hat{\eta}, v)$ (cf. [Helpman et al., 2010](#)). Whereas hiring has been only discussed for the home market so far, we assume a symmetric hiring problem for offshoring firms in the foreign market, with an asterisk used to indicate foreign variables in the subsequent.

Using the assumptions from above, we can write the operating profits of firm v as follows:

$$\begin{aligned} \pi(v) = A^{\frac{1}{\sigma}} \left\{ \varphi(v) \exp \left[\int_0^1 \ln [l(\hat{\eta}, v)^\delta \tilde{a}(\hat{\eta}, v)] d\hat{\eta} \right] \right\}^{\frac{\sigma-1}{\sigma}} &- \int_0^1 s \frac{c}{\alpha} [\hat{a}(\hat{\eta}, v)]^\alpha d\hat{\eta} \\ &- \left(\frac{1}{a_{min}} \right)^\beta \int_0^1 \hat{c}(\hat{\eta}, v) l(\hat{\eta}, v) \hat{a}(\hat{\eta}, v)^\beta d\hat{\eta} \end{aligned} \quad (\text{A.2})$$

where $\bar{a}(\hat{\eta}, v) = \tilde{a}(\hat{\eta}, v)$ if task $\hat{\eta}$ is produced domestically and $\bar{a}(\hat{\eta}, v) = \tilde{a}(\hat{\eta}, v)/T(\hat{\eta})$ if it is produced abroad, and

$$\hat{c}(\hat{\eta}, v) \equiv \begin{cases} sb \frac{\vartheta}{1-\vartheta} z(\hat{\eta}, v)^{\frac{1-\vartheta}{\vartheta}} + \frac{(1-u)\bar{w}}{z(\hat{\eta}, v)} & \text{if } \hat{\eta} \text{ is produced at home} \\ sb \frac{\vartheta}{1-\vartheta} z(\hat{\eta}, v)^{\frac{1-\vartheta}{\vartheta}} + \frac{(1-u^*)\bar{w}^*}{z(\hat{\eta}, v)} & \text{if } \hat{\eta} \text{ is produced abroad} \end{cases}. \quad (\text{A.3})$$

Furthermore, in Eq. (A.2) it has been assumed that services required for hiring and screening come from the firm's home country. The firm chooses $z(\hat{\eta}, v)$, $\hat{a}(\hat{\eta}, v)$, and $l(\hat{\eta}, v)$ to maximise Eq. (A.2), subject to the participation constraint of workers in Eq. (A.1), and we can solve the three first-order conditions for

$$z(\hat{\eta}, v) = \begin{cases} \left(\frac{(1-u)\bar{w}}{sb} \right)^{\vartheta} & \text{if } \hat{\eta} \text{ is produced at home} \\ \left(\frac{(1-u^*)\bar{w}^*}{sb} \right)^{\vartheta} & \text{if } \hat{\eta} \text{ is produced abroad} \end{cases}, \quad (\text{A.4})$$

$$l(\hat{\eta}, v) = \begin{cases} \frac{\sigma-1}{\sigma} \delta \frac{r(v)(1-\vartheta)}{(sb)^{\vartheta} [(1-u)\bar{w}]^{1-\vartheta}} \left(\frac{a_{min}}{\hat{a}(\hat{\eta}, v)} \right)^{\beta} & \text{if } \hat{\eta} \text{ is produced at home} \\ \frac{\sigma-1}{\sigma} \delta \frac{r(v)(1-\vartheta)}{(sb)^{\vartheta} [(1-u^*)\bar{w}^*]^{1-\vartheta}} \left(\frac{a_{min}}{\hat{a}(\hat{\eta}, v)} \right)^{\beta} & \text{if } \hat{\eta} \text{ is produced abroad} \end{cases}, \quad (\text{A.5})$$

and

$$\hat{a}(\hat{\eta}, v) = \left\{ \frac{\sigma-1}{\sigma} \frac{(1-\delta\beta)r(v)}{sc} \right\}^{\frac{1}{\alpha}} \equiv \hat{a}(v), \quad (\text{A.6})$$

where $r(v)$ are the revenues of the firm and

$$\rho_{\pi} \equiv \frac{\pi(v)}{r(v)} = \frac{\sigma\alpha - (\sigma-1)[1 + \alpha\delta(1-\theta)]}{\sigma\alpha}, \quad \theta \equiv \frac{\beta}{\alpha}, \quad (\text{A.7})$$

is the share of revenues accruing to operating profits. A few remarks are in order here. First, as shown in the main text, indifference of agents in their occupational choice requires $(1-u)\bar{w} = s$. Furthermore, offshoring is only attractive if $(1-u)\bar{w} > (1-u^*)\bar{w}^*$, and hence $b > 1$ is sufficient for an outcome with $z(\hat{\eta}, v) < 1$ for all firms. Second, whereas it is a priori not clear that all firms screen in equilibrium, an interior solution with $\hat{a}(\hat{\eta}, v) > a_{min}$ for all producers can be guaranteed by considering a sufficiently small cost factor c or a sufficiently small ability floor a_{min} , and $\delta\beta < 1$. Third, from inspection of the first-order conditions in Eqs. (A.5) and (A.6) we see that more profitable firms have higher task-level employment than less profitable ones only if $\beta < \alpha$ and thus $\theta < 1$. This is, what we assume throughout our analysis.

The wage bill for task $\hat{\eta}$ is given by

$$w(\hat{\eta}, v)l(\hat{\eta}, v) = \begin{cases} \frac{(1-u)\bar{w}}{z(\hat{\eta}, v)} l(\hat{\eta}, v) \left(\frac{\hat{a}(v)}{a_{min}} \right)^{\beta} & \text{if } \hat{\eta} \text{ is produced at home} \\ \frac{(1-u^*)\bar{w}^*}{z(\hat{\eta}, v)} l(\hat{\eta}, v) \left(\frac{\hat{a}(\hat{\eta}, v)}{a_{min}} \right)^{\beta} & \text{if } \hat{\eta} \text{ is produced abroad} \end{cases}. \quad (\text{A.8})$$

Accounting for Eqs. (A.4) and (A.5), the share of revenues accruing to production workers can

thus be expressed as

$$\rho_w \equiv \frac{l(\hat{\eta}, v)w(\hat{\eta}, v)}{r(\hat{\eta}, v)} = (1 - \vartheta)\delta \frac{\sigma - 1}{\sigma}, \quad (\text{A.9})$$

and Eq. (8) follows from the constant splitting rule akin to monopolistic competition models featuring isoelastic demand. Furthermore, Eq. (9) can be established by combining Eqs. (A.5)-(A.9), and accounting for

$$b_w \equiv s \left[b^\vartheta \left(\frac{\sigma - 1}{\sigma} \frac{1 - \delta\beta}{\rho_\pi c} \right)^\theta \left(\frac{1}{a_{min}} \right)^\beta \right]^{\frac{1}{1-\theta}} \left(\frac{(1-u)\bar{w}}{s} \right)^{\frac{1-\vartheta}{1-\theta}} \quad (\text{A.10})$$

and $b_w^* \equiv b_w \{(1 - u^*)\bar{w}^*/[(1 - u)\bar{w}]\}^{(1-\vartheta)/(1-\theta)}$. Finally, substitution of Eqs. (A.4)-(A.6) into Eq. (A.2) gives $\pi(v)$ from the main text, with

$$b_r \equiv \left[\frac{\rho_w}{\rho_\pi^\theta b_w^{1-\theta}} \right]^\delta \frac{\beta}{\beta - 1} \left[\frac{(\sigma - 1)(1 - \delta\beta)}{\sigma cs} \right]^{\frac{1}{\alpha}}, \quad (\text{A.11})$$

$\xi \equiv \alpha(\sigma - 1)/\{\sigma\alpha - (\sigma - 1)[1 + \alpha\delta(1 - \theta)]\}$. The latter implies $\xi\rho_\pi = \rho_w/[(1 - \vartheta)\delta] = (\sigma - 1)/\sigma$. This completes the proof.

A.1.2 The gift exchange model

Following [Akerlof and Yellen \(1990\)](#), we assume that workers exert full effort, normalised to one, if and only if they are paid at least the wage they consider fair, \hat{w} , while they reduce their effort proportionally if the wage falls short of the fair wage. The functional relationship between effort e and wage rate w is therefore given by

$$e = \min \left\{ \frac{w}{\hat{w}}, 1 \right\}. \quad (\text{A.12})$$

Firms set w in order to minimise the cost per efficiency unit of labour. Given Eq. (A.12), firms have no incentive to pay less than \hat{w} , since effort would fall proportionally with the wage. Paying more than \hat{w} would increase the wage per efficiency unit of labour, and therefore firms would not do that either, unless it were necessary in order to attract the optimal number of workers. Attracting workers is clearly no issue for firms in the presence of involuntary unemployment, and we therefore have $w = \hat{w}$ whenever such unemployment exists in equilibrium.

Workers' subjective evaluation of a fair wage depends on a firm-internal and a firm-external reference point. Following [Egger and Kreickemeier \(2012\)](#) and [Egger et al. \(2013\)](#), we associate the firm-external reference point with the income a worker can expect outside the job, which equals the average labour income in the economy, $(1 - u)\bar{w}$, i.e. the ex ante probability to find a job $1 - u$ multiplied by the average wage \bar{w} of employed production workers. The firm-internal reference point is the operating profit of the firm, $\pi(v)$. Via this firm-specific reference point, rent sharing co-determines the fair wage in our model, and it therefore influences wage setting at the firm level. Modelling the fair wage as a weighted geometric average of the two components we obtain

$$\hat{w}(v) = \pi(v)^\theta [(1 - u)\bar{w}]^{1-\theta}, \quad (\text{A.13})$$

where $\theta \in (0, 1)$ captures the strength of the rent-sharing motive in the fair-wage considerations of workers and ϑ is equal to θ , because it is assumed that the labour market condition is fully reflected in the average labour income $(1 - u)\bar{w}$. We show below that the equilibrium in our model features involuntary unemployment in both markets. Therefore, all firms, even those with low productivity, are able to attract workers by paying the fair wage, and hence we have $w(v) = \hat{w}(v)$. The same reasoning as above applies to the foreign economy, where workers have the same rent-sharing preferences, captured by θ , have the same firm-internal point of reference, $\pi(v)$, due to international rent sharing, but have a different firm-external reference point, namely $(1 - u^*)\bar{w}^*$ instead of $(1 - u)\bar{w}$. This implies that the intra-firm wage differential $w^*(v)/w(v)$ does not differ between firms:

$$\frac{w^*(v)}{w(v)} = \left[\frac{(1 - u^*)\bar{w}^*}{(1 - u)\bar{w}} \right]^{1-\theta}, \quad (\text{A.14})$$

and Eq. (9) follows directly from Eq. (A.13), setting $b_w = (1 - u)\bar{w}$ and $b_w^* = (1 - u^*)\bar{w}^*$. Furthermore, the employment levels in Eq. (8) are the solution of maximising operating profits

$$\pi(v) = A^{\frac{1}{\sigma}} \left\{ \varphi(v) \exp \left[\int_0^1 \ln [l(\hat{\eta}, v)^\delta \bar{a}(\hat{\eta}, v)] d\hat{\eta} \right] \right\}^{\frac{\sigma-1}{\sigma}} - \int_0^1 w(\hat{\eta}, v) l(\hat{\eta}, v) d\hat{\eta} \quad (\text{A.15})$$

with respect to $l(\hat{\eta}, v)$. Thereby, $w(\hat{\eta}, v) = w(v)$ and $\bar{a}(\hat{\eta}, v) = 1$ if task $\hat{\eta}$ is produced at home, whereas $w(\hat{\eta}, v) = w^*(v)$ and $\bar{a}(\hat{\eta}, v) = 1/T(\hat{\eta})$ if task $\hat{\eta}$ is produced abroad, and the constant shares of revenues accruing to production workers and operating profits are given by $\rho_w \equiv \delta(\sigma - 1)/\sigma$ and $\rho_\pi \equiv 1 - \rho_w$, respectively. Substituting Eq. (8) into Eq. (A.15) establishes $\pi(v)$ from the main text, with

$$b_r \equiv \left\{ \frac{\rho_w}{\rho_\pi^\theta [(1 - u)\bar{w}]^{1-\theta}} \right\}^\delta. \quad (\text{A.16})$$

This completes the proof.

A.2 Derivation of Eq. (20)

The global wage bill is the aggregate labour income of production workers in the North and the South and, in view of the constant splitting rule from above, proportional to global operating profits:

$$(1 - u_n)L\bar{w}_n + (1 - u_s)N_s\bar{w}_s = N_n \frac{\rho_w}{\rho_\pi} \left[\int_{\varphi_d}^{\varphi_o} \pi_d(\varphi) dG(\varphi) + \int_{\varphi_o}^{\infty} \pi_o(\varphi) dG(\varphi) \right]. \quad (\text{A.17})$$

Making use of $\pi_o(\varphi_o)/\pi_d(\varphi_o) = \kappa^\xi$ and $\pi_d(\varphi_o)/\pi_d(\varphi_d) = \chi^{-\xi/k}$ from the main text, we can compute

$$(1 - u_n)L\bar{w}_n + (1 - u_s)N_s\bar{w}_s = M \frac{\rho_w}{\rho_\pi} \frac{k(1 + \chi)}{k - \xi} \pi_d(\varphi_d). \quad (\text{A.18})$$

In a similar vein, we can compute the wage bill accruing to domestic workers, according to

$$\begin{aligned} (1 - u_n)L\bar{w}_n &= N_n \frac{\rho_w}{\rho_\pi} \left[\int_{\varphi_d}^{\varphi_o} \pi_d(\varphi) dG(\varphi) + \eta \int_{\varphi_o}^{\infty} \pi_o(\varphi) dG(\varphi) \right] \\ &= M \frac{\rho_w}{\rho_\pi} \frac{k}{k - \xi} \left[1 + (1 - \hat{\eta})\chi - \hat{\eta}\chi^{\frac{k-\xi}{k}} \right] \pi_d(\varphi_d). \end{aligned} \quad (\text{A.19})$$

Dividing Eq. (A.19) by Eq. (A.18) and subtracting the resulting expression from one establishes γ in Eq. (20). This completes the proof.

A.3 Derivation of L as a function of N_n

Combining Eqs. (20) and (A.19) gives:

$$(1 - u_n)L\bar{w}_n = M \frac{\rho_w (1 + \chi)k}{\rho_\pi (k - \xi)} (1 - \gamma)\pi_d(\varphi_d), \quad (\text{A.20})$$

which can be further simplified by considering $\pi_d(\varphi_d) = (1 - u_n)\bar{w}_n$ from the indifference condition in Eq. (16). Since each firm spends a constant fraction $1 - \rho_\pi - \rho_w$ of its revenues on hiring and screening, we can express the resource constraint in the North as follows:

$$N_n = (1 - \rho_\pi - \rho_w)M \frac{(1 + \chi)k}{k - \xi} \frac{r_d(\varphi_d)}{s} + M(1 + \chi) + L,$$

which can be further simplified by considering $r_d(\varphi_d)/s = 1/\rho_\pi$ from Eq. (16) and the definition of ρ_π :

$$N_n = \frac{k}{k - \xi} \frac{1 - \rho_\pi \xi/k - \rho_w}{\rho_\pi} (1 + \chi)M + L \quad (\text{A.21})$$

Eqs. (A.20) and (A.21) together can be used to solve for

$$L = \frac{\rho_w(1 - \gamma)}{1 - \rho_w\gamma - \rho_\pi\xi/k} N_n, \quad (\text{A.22})$$

with $dL/d\gamma < 0$ due to $\rho_w \leq 1 - \rho_\pi$. This completes the proof.

A.4 Derivation of Eqs. (23) and (24)

From Eqs. (8) and (9), we have

$$\frac{l_d(\varphi)}{l_d(\varphi_d)} = \frac{\pi_d(\varphi)/w_d(\varphi)}{\pi_d(\varphi_d)/w_d(\varphi_d)} = \left[\frac{\pi_d(\varphi)}{\pi_d(\varphi_d)} \right]^{1-\theta}. \quad (\text{A.23})$$

Substitution of $\pi_d(\varphi)/\pi_d(\varphi_d) = (\varphi/\varphi_d)^\xi$ and taking logs results in:

$$\ln l_d(\varphi) = \ln l_d(\varphi_d) + (1 - \theta)\xi [\ln \varphi - \ln \varphi_d]. \quad (\text{A.24})$$

Constant markup pricing establishes $w_d(\varphi_d)l_d(\varphi_d) = [\rho_w/\rho_\pi]\pi_d(\varphi_d)$, whereas the solution to the occupational choice problem in combination with wage-setting from Eq. (9) gives $w_d(\varphi_d) = \zeta\pi_d(\varphi_d)$, with $\zeta = 1$ in the gift-exchange model and

$$\zeta = b^\vartheta \left(\frac{\sigma - 1}{\sigma} \frac{1 - \delta\beta}{\rho_\pi c} \right)^\theta \left(\frac{1}{a_{min}} \right)^\beta \quad (\text{A.25})$$

in the search and matching model. From Eq. (A.6), it follows that $\zeta > 1$ holds in the search and matching model, provided that all firms – including the least productive ones – provide some screening effort. Putting together, we obtain $l_d(\varphi_d) = \zeta^{-1}\rho_w/\rho_\pi$. Furthermore, cutoff productivity

φ_d is linked to the mass of firms by means of $M/N_n = \varphi_d^{-k}$. To determine M/N_n , we can combine Eqs. (A.20) and (A.22) and obtain

$$\frac{M}{N_n} = \frac{\rho_\pi(k - \xi)/k}{(1 + \chi)[1 - \rho_\pi\xi/k - \gamma\rho_w]}. \quad (\text{A.26})$$

Taking logs and substituting Eq. (20) for γ , we obtain $(1 - \theta)\xi \ln \varphi_d = [(1 - \theta)\xi/k]\{\ln \rho_\pi + \ln(k - \xi) - \ln k\} + \mu(\eta)$, where $\mu(\eta)$ is given by Eq. (26). Substitution into Eq. (A.24) establishes Eq. (23), where $\ell_0 \equiv -\ln \zeta + \ln \rho_w - \ln \rho_\pi + [(1 - \theta)\xi/k]\{\ln \rho_\pi + \ln(k - \xi) - \ln k\}$. Thereby, we express firm-level employment (in logs) as a function of φ and the market effects common to all firms, depending solely on the level of η .

To determine the domestic employment level of offshoring firms, we make use of Eq. (8) to express domestic employment of domestic and offshoring producers as functions of their operating profits. This gives

$$l_d(\varphi) = \frac{\rho_w \pi_d(\varphi)}{\rho_\pi w_d(\varphi)} \quad \text{and} \quad l_o(\varphi) = (1 - \eta) \frac{\rho_w \pi_o(\varphi)}{\rho_\pi w_o(\varphi)}, \quad (\text{A.27})$$

respectively, using the fact that offshoring firms produce only a fraction $1 - \eta$ of their tasks domestically. Accounting for Eqs. (9) and (15), we can express the firm-level employment effect of offshoring (in logs) as follows:

$$\ln l_o(\varphi) - \ln l_d(\varphi) = \ln(1 - \eta) + (1 - \theta)\xi \ln \kappa. \quad (\text{A.28})$$

Substituting Eq. (14) for κ , we obtain $\lambda(\eta) = \ln l_o(\varphi) - \ln l_d(\varphi)$ in Eq. (25). Eq. (24) is then obtained by adding $\lambda(\eta)$ to Eq. (23). This completes the proof.

A.5 The Properties of $\lambda(\eta)$ and the characterisation of t_1

Differentiating $\lambda(\eta)$, we can show that there exists a unique $\eta_{tm} = 1/a$, with $a \equiv t(1 - \theta)\delta\xi$, such that $\lambda'(\eta) >, =, < 0$ if $\eta >, =, < \eta_{tm}$. Then, $\eta_{tm} < 1$ requires $a > 1$. However, this is not sufficient for $\eta_{tm} < \eta_{int}$. From Eqs. (18) and (25), we can infer that $\eta_{tm} = \eta_{int}$ is reached if

$$\Gamma(a) = -\frac{1}{1 - \theta} \left[a \ln \left(\frac{a - 1}{a} \right) + 1 \right] - \ln 2 = 0, \quad (\text{A.29})$$

where $\Gamma(a) = 0$ can be transformed into Eq. (27), when substituting $a = t(1 - \theta)\delta\xi$. Since $\lim_{a \rightarrow 1} \Gamma(a) = \infty$, $\lim_{a \rightarrow \infty} \Gamma(a) = -\ln 2$ and $\Gamma'(a) < 0$, we know that $\Gamma(a) = 0$ has a unique solution in a and, in extension, also in t , which we denote by t_1 . Finally, $\eta_{tm} < \eta_{int}$ requires $\Gamma(a) < 0$ and thus $t > t_1$. This completes the proof.

A.6 Properties of $\mu(\eta)$ and characterisation of $\bar{\eta}$

From Eq. (18) we can infer that

$$\chi'(\eta) = t\delta k \chi(\eta)^{\frac{k-\xi}{k}} \left[1 + \chi(\eta)^{\frac{\xi}{k}} \right] \frac{\eta}{1 - \eta}. \quad (\text{A.30})$$

Differentiation of $\mu(\eta)$ then gives

$$\mu'(\eta) = -\frac{(1-\theta)\xi}{k} \frac{\chi'(\eta)f(\eta)}{(1-\rho_\pi\xi/k)[1+\chi(\eta)] - \rho_w\eta\chi(\eta)[1+\chi(\eta)^{-\xi/k}]}, \quad (\text{A.31})$$

with

$$f(\eta) \equiv 1 - \rho_\pi \frac{\xi}{k} - \rho_w + \rho_w \left[1 - \eta - \frac{1}{t\delta k} \frac{1-\eta}{\eta} - \frac{k-\xi}{k} \eta \chi(\eta)^{-\frac{\xi}{k}} \right]. \quad (\text{A.32})$$

In view of $\chi'(\eta) > 0$, it is immediate that $\mu'(\eta) >, =, < 0$ if $0 >, =, < f(\eta)$. From $\lim_{\eta \rightarrow 0} f(\eta) = -\infty$, we can thus conclude that $\mu(\eta)$ increases at low levels of η . This leaves two possible outcomes: $\mu'(\eta) > 0$ for all possible η ; $\mu'(\eta) = 0$ at some $\eta \in (0, 1)$. In the latter case, $\mu(\eta)$ has an interior extremum, and we show in the following that if an interior extremum exists, it is unique and, in view of $\mu'(0) > 0$, a maximum. This is equivalent to showing that $f(\eta) = 0$ has a unique interior solution, provided that it has a solution at all.

Differentiation of $f(\eta)$ gives

$$f'(\eta) = -\frac{\rho_w}{1-\eta} \left\{ 1 - \eta - \frac{1}{t\delta k} \frac{1-\eta}{\eta} - \frac{k-\xi}{k} \eta \chi(\eta)^{-\frac{\xi}{k}} - \frac{1}{t\delta k} \left(\frac{1-\eta}{\eta} \right)^2 + \frac{k-\xi}{k} \chi^{-\frac{\xi}{k}} g(\eta) \right\}, \quad (\text{A.33})$$

with $g(\eta) \equiv 1 - t\delta\xi\eta^2\chi(\eta)^{-\xi/k}[1 + \chi(\eta)^{\xi/k}]$. Evaluated at $f(\eta) = 0$, we find that the first three terms in the bracket expression add up to $[f(\eta) - 1 + \rho_\pi\xi/k - \rho_w]/\rho_w = -[1 + \rho_\pi\xi/k - \rho_w]/\rho_w < 0$. Thus, $g(\eta) \leq 0$ is sufficient for an extremum of $\mu(\eta)$ to be a maximum and, if $g(\eta) \leq 0$ holds for all possible η , this maximum must be unique. Substituting $\chi(\eta)$ from the main text we can compute $\lim_{\eta \rightarrow 0} g(\eta) = -1$ and $g(1) = 1 - t\delta\xi < 0$, where the negative sign of $g(1)$ follows from assumption $t > t_1$ and the observation that $t > t_1$ requires $t(1-\theta)\delta\xi > 1$ (see Appendix A.6). Furthermore, we can compute $g'(\eta) = \left\{ 2 + [g(\eta) - 1](1-\eta)^{t\delta\xi-1} \exp[\eta t\delta\xi] \right\} [g(\eta) - 1]/\eta$. Since $g(\eta) = 1$ is ruled out for any $\eta \geq 0$, we can readily conclude that $g'(\eta) = 0$ is only possible if $g(\eta) < 0$. Accordingly, $g(\eta)$ is either monotonic in η or has a (not necessarily unique) extremum with negative function value. In both cases, $g(0) = -1$ and $g(1) = 1 - t\delta\xi < 0$ are sufficient for $g(\eta)$ to have a negative sign for all possible η . Together with our earlier results this implies that $\mu(\eta)$ has unique maximum, which is either in the interior of interval $(1, \eta_{int})$ and determined by $\mu'(\eta) = 0$ or it is given by the corner solution η_{int} if $\mu'(\eta) > 0$ for all possible η . For either case, we denote the maximum of $\mu(\eta)$ by $\bar{\eta}$. This completes the proof.

A.7 Characterisation of t_2 and the ranking of $\bar{\eta}$ and η_{tm}

We now show that under parameter constraint (28), there exists a unique t_2 , such that $0 >, =, < f(\eta_{tm})$ and thus $\mu'(\eta_{tm}) >, =, < 0$ if $t >, =, < t_2$. Evaluating $f(\eta)$ at $\eta_{tm} = [t(1-\theta)\delta\xi]^{-1}$ gives $f(\eta_{tm}) = 1 - \rho_\pi\xi/k - \rho_w + \rho_w[(k-\xi)/k]f_0(a)$, with

$$f_0(a) \equiv \left[\frac{k - (1-\theta)\xi}{k - \xi} - \frac{1}{n(a)} \right] \frac{a-1}{a}, \quad n(a) \equiv (a-1) \left\{ \left(\frac{a-1}{a} \right)^{-\frac{a}{1-\theta}} \exp \left[-\frac{1}{1-\theta} \right] - 1 \right\},$$

and $a \equiv t(1-\theta)\delta\xi > 1$. Hence, $f(\eta_{tm}) < 0$ requires $1 - \rho_\pi\xi/k - \rho_w + \rho_w[(k-\xi)/k]f_0(a) < 0$. Under parameter constraint (28), function $f_0(a)$ has the following two properties, which we formally show

in the Technical Appendix, that is available upon request:

1. There exists a unique $\underline{a} \in (1, \infty)$, such that $f_0(a) >, =, < 0$ if $\underline{a} >, =, < a$;
2. If $f_0(a)$ has an extremum at $a > \underline{a}$, this must be a minimum.

From property 1 it follows that $\lim_{a \rightarrow \infty} f_0(a) = \theta k / (k - \xi) - (1 - \theta) < 0$. To see this, note that parameter constraint (28) can be rewritten as $1 - \rho_\pi \xi / k - \rho_w + \rho_w [(k - \xi) / k] \lim_{a \rightarrow \infty} f_0(a) < 0$, and for this inequality to hold it must be true that $\lim_{a \rightarrow \infty} f_0(a) < 0$. Furthermore, from property 2, we can infer that either $f_0(a)$ is negatively sloped over the whole interval (\underline{a}, ∞) or there exists a unique $\hat{a}_0 > \underline{a}$, such that $f_0(a)$ decreases over subinterval $(\underline{a}, \hat{a}_0)$ and increases over subinterval (\hat{a}_0, ∞) . Combining these two results, it follows that – under parameter constraint (28) – condition $1 - \rho_\pi \xi / k - \rho_w + \rho_w [(k - \xi) / k] f_0(a_2) = 0$ establishes a unique $a_2 > \underline{a}$ and in extension a unique $t_2 = a_2 / [(1 - \theta) \delta \xi]$, such that $0 >, =, < 1 - \rho_\pi \xi / k - \rho_w + \rho_w [(k - \xi) / k] f_0(a)$ and thus $\mu(\eta_{tm}) >, =, < 0$ if $t >, =, < t_2$. This completes the proof.

A.8 Characterisation of $\underline{\eta}$

Let $\underline{\eta}$ be implicitly defined by $\lambda'(\eta) + \mu'(\eta) = 0$. Then, existence of $\underline{\eta} \in (0, \eta_{tm})$ is guaranteed if (i) $\lambda'(0) + \mu'(0) < 0$ and (ii) $\lambda'(\eta_{tm}) + \mu'(\eta_{tm}) > 0$ hold. The second condition follows from the observation that (by definition) $\lambda'(\eta_{tm}) = 0$ and $\mu'(\eta_{tm}) > 0$ if parameter constraint (28) and $t > \max\{t_1, t_2\}$ hold. To show that the first condition is also fulfilled, we can compute

$$\begin{aligned} \lambda'(\eta) + \mu'(\eta) = & -[1 - t(1 - \theta)\delta\xi] \frac{1}{1 - \eta} - t(1 - \theta)\delta\xi \\ & - \frac{(1 - \theta)\xi}{k} \frac{\chi'(\eta)f(\eta)}{(1 - \rho_\pi \xi / k)[1 + \chi(\eta)] - \rho_w \eta \chi(\eta)[1 + \chi(\eta)^{-\xi/k}]}, \end{aligned} \quad (\text{A.34})$$

according to Eqs. (25) and (A.31). This establishes

$$\lim_{\eta \rightarrow 0} [\lambda'(\eta) + \mu'(\eta)] = -1 - \frac{(1 - \theta)\xi}{k} \frac{1}{1 - \rho_\pi \xi / k} \lim_{\eta \rightarrow 0} \chi'(\eta)f(\eta). \quad (\text{A.35})$$

From Eq. (A.30) it follows that $\lim_{\eta \rightarrow 0} \chi'(\eta) = 0$. Substituting Eq. (A.32) for $f(\eta)$, we can then compute

$$\begin{aligned} \lim_{\eta \rightarrow 0} [\lambda'(\eta) + \mu'(\eta)] = & -1 + t(1 - \theta)\delta\xi \frac{k - \xi}{k} \frac{\rho_w}{1 - \rho_\pi \xi / k} \lim_{\eta \rightarrow 0} \frac{\eta^2}{1 - \eta} \chi(\eta)^{1 - 2\frac{\xi}{k}}, \\ = & -1 + 2(1 - \theta) \frac{k - \xi}{k} \frac{\rho_w}{1 - \rho_\pi \xi / k} \lim_{\eta \rightarrow 0} \left\{ (1 - \eta)^{-t\delta\xi} \exp[-\eta t \delta \xi] - 1 \right\}^{\frac{k - \xi}{\xi}}, \end{aligned} \quad (\text{A.36})$$

which establishes $\lambda'(0) + \mu'(0) = -1$ and completes the proof.

A.9 Derivation of Eq. (32)

Adding up domestic employment over all purely domestic and offshoring firms in the source country gives

$$(1 - u_n) L = N_n \left[\int_{\varphi_d}^{\varphi_o} l_d(\varphi) dG(\varphi) + \int_{\varphi_o}^{\infty} l_o(\varphi) dG(\varphi) \right]. \quad (\text{A.37})$$

Substituting Eqs. (23) and (24), we can compute

$$(1 - u_n)L = Ml_d(\varphi_d)\varepsilon(\eta)\frac{k}{k - (1 - \theta)\xi}, \quad (\text{A.38})$$

with $\varepsilon(\eta) \equiv 1 + \chi(\eta)^{1-(1-\theta)\xi/k} \{\exp[\lambda(\eta)] - 1\}$. Furthermore, making use of Eqs. (8), (20), and (A.19), we can express the total wage bill in the North as follows:

$$(1 - u_n)L\bar{w}_n = Ml_d(\varphi_d)w_d(\varphi_d)(1 - \gamma)[1 + \chi(\eta)]\frac{k}{k - \xi}, \quad (\text{A.39})$$

Together Eqs. (A.38) and (A.39) determine the wage ratio $w_d(\varphi_d)/\bar{w}_n = \iota(\eta)(k - \xi)/[k - (1 - \theta)\xi]$, where we have used $\iota(\eta) \equiv \varepsilon(\eta)/\{(1 - \gamma)[1 + \chi(\eta)]\}$. Substitution into Eq. (31) then establishes Eq. (32).

A.10 Offshoring and the unemployment rate of production workers u_n

From Eq. (32), we can infer that offshoring decreases (increases) unemployment rate u_n relative to autarky, if $\iota(\eta) > (<)1$. Substituting Eqs. (18), (20), and (25) for $\chi(\eta)$, γ , and $\lambda(\eta)$, respectively, and accounting for $\varepsilon(\eta)$ from Appendix A.9, it follows that $\iota(\eta) >, =, < 1$ is equivalent to

$$\begin{aligned} & \left\{ (1 - \eta)^{-t\delta\xi} \exp[-t\delta\xi\eta] - 1 \right\}^{\frac{k-\xi}{\xi} + \theta} \left\{ (1 - \eta)^{1-t(1-\theta)\delta\xi} \exp[-\eta t(1 - \theta)\delta\xi] - 1 \right\} \\ & >, =, < \left\{ (1 - \eta)^{-t\delta\xi} \exp[-\eta t\delta\xi] - 1 \right\}^{\frac{k-\xi}{\xi}} \left\{ (1 - \eta)^{1-t\delta\xi} \exp[-\eta t\delta\xi] - 1 \right\}. \end{aligned} \quad (\text{A.40})$$

Let us define

$$\psi(\eta) \equiv \left\{ (1 - \eta)^{-t\delta\xi} \exp[-\eta t\delta\xi] - 1 \right\}^\theta, \quad \psi_1(\eta) \equiv (1 - \eta)^{1-t\delta\xi} \exp[-\eta t\delta\xi] - 1, \quad (\text{A.41})$$

$$\psi_2(\eta) \equiv (1 - \eta)^{1-t(1-\theta)\delta\xi} \exp[-\eta t(1 - \theta)\delta\xi] - 1. \quad (\text{A.42})$$

Then, $\psi_1(\eta) = 0$ characterises a unique $\eta_b^1 > 0$, such that $\psi_1(\eta) >, =, < 0$ if $\eta >, =, < \eta_b^1$. Furthermore, we know from the main text that $\psi_2(\eta)$ has a unique minimum at η_{tm} , whereas $\psi_2(\eta) = 0$ characterises a unique $\eta_b^2 > \eta_b^1$, such that $\psi_2(\eta) >, =, < 0$ if $\eta >, =, < \eta_b^2$. It is worth noting that $t > \max\{t_1, t_2\}$ is sufficient for $\eta_{tm} < \eta_{int}$, but not for $\eta_b^1, \eta_b^2 < \eta_{int}$.

Let us now define $\hat{\psi}(\eta) \equiv \psi_1(\eta)/\psi_2(\eta)$. We can then infer from (A.40) that $\iota(\eta) >, =, < 1$ is equivalent to $\hat{\psi}(\eta) >, =, < \psi(\eta)$ if $\eta < \eta_b^2$, whereas $\iota(\eta) >, =, < 1$ is equivalent to $\psi(\eta) >, =, < \hat{\psi}(\eta)$ if $\eta > \eta_b^2$. We can distinguish the following cases, regarding the sign and size of $\hat{\psi}(\eta)$: (i) $0 > \psi_1(\eta) > \psi_2(\eta)$ and thus $\hat{\psi}(\eta) \in (0, 1)$ if $\eta < \eta_b^1$; (ii) $\psi_1(\eta) > 0 > \psi_2(\eta)$ and thus $\hat{\psi}(\eta) < 0$ if $\eta \in (\eta_b^1, \eta_b^2)$; (iii) $\psi_1(\eta) > \psi_2(\eta) > 0$ and thus $\hat{\psi}(\eta) > 1$ if $\eta > \eta_b^2$.¹⁹ We can thus safely conclude that $\psi(\eta) > \hat{\psi}(\eta)$ and thus $\iota(\eta) < 1$ if $\eta \in (\eta_b^1, \eta_b^2)$, whereas $\psi(\eta) < \hat{\psi}(\eta)$ and thus $\iota(\eta) < 1$ if $\eta > \eta_b^2$ and at the same time $\eta < \eta_{int}$. The latter follows from the observation that $\psi(\eta) < 1$ for all $\eta < \eta_{int}$. In both cases (and hence whenever $\eta \geq \eta_b^1$), the unemployment rate of production workers in the North is higher under offshoring than in autarky. We now look at the remaining domain and note first that $\psi(\eta)$ increases over interval $(0, \eta_{int})$ from a minimum level of $\psi(0) = 0$ to a maximum level of $\psi(\eta_{int}) = 1$. Hence, showing that $\hat{\psi}(\eta)$ falls monotonically over interval

¹⁹For completeness, we also have $\lim_{\eta \rightarrow 0} \hat{\psi}(\eta) = 1$, $\hat{\psi}(\eta_b^1) = 0$, $\lim_{\eta \rightarrow \eta_b^2-} \hat{\psi}(\eta) = -\infty$, and $\lim_{\eta \rightarrow \eta_b^2+} \hat{\psi}(\eta) = \infty$.

$[0, \eta_b^1]$ from a maximum level of $\hat{\psi}(0) = 1$ to a minimum level of $\hat{\psi}(\eta_b^1) = 0$, suffices to prove that $\psi(\eta) = \hat{\psi}(\eta)$ has a unique solution $\eta_u < \eta_{int}$, such that $\psi(\eta) >, =, < \hat{\psi}(\eta)$ if $\eta >, =, < \eta_u$. This can be done by using higher differentials of $\hat{\psi}(\eta)$ and a detailed proof for this result is provided in a technical supplement, which is available upon request. We can thus safely conclude that $1 >, =, < \iota(\eta)$ if $\eta >, =, < \eta_u$. This completes the proof.

A.11 Proof of Proposition 2

We can write the economy-wide unemployment in the North as $U_n = \Lambda U_n^A$, with

$$\Lambda(\eta) \equiv \frac{u_n L}{u_n^A L^A} = \frac{\theta \xi + (k - \xi) [1 - \iota(\eta)]}{\theta \xi} \frac{(1 - \rho_\pi \xi/k)(1 - \gamma)}{1 - \rho_w \gamma - \rho_\pi \xi/k} \quad (\text{A.43})$$

and superscript A referring to autarky. That offshoring increases the economy-wide rate of unemployment in the North at low levels of η then follows from the observation that $\iota(\eta) > 1$ and thus $u < u^A$ if $\eta < \eta_u$ (see above) and the fact that the number of production workers decreases monotonically in η . Furthermore, the economy-wide rate of unemployment U is larger (smaller) at $\eta = \eta_{int}$ and thus $\chi = 1$ than under autarky if $\Lambda(\eta_{int}) > (<)1$, which is equivalent to

$$1 - \frac{\theta \xi (1 - \rho_\pi \xi/k - \rho_w)}{\theta \xi (1 - \rho_\pi \xi/k - \rho_w) + (k - \xi)(1 - 2^{-\theta})(1 - \rho_\pi \xi/k)} > (<)\eta_{int}. \quad (\text{A.44})$$

Taking into account that η_{int} is implicitly defined as function of t by $\chi = 1$ and thus by $\{(1 - \eta_{int})^{-t\delta\xi} \exp[-\eta_{int}t\delta\xi] - 1\}^{k/\xi} = 1$, it follows that $\lim_{t \rightarrow 0} \eta_{int} = 1$, $\lim_{t \rightarrow \infty} \eta_{int} = 0$, and $d\eta_{int}/dt < 0$. Hence, there exists a unique t for which (A.44) holds with equality. This critical t is denoted t_U and given by

$$t_U \equiv -\frac{\ln 2}{\delta \xi (1 - \zeta_U + \ln \zeta_U)}, \quad \zeta_U \equiv \frac{\theta \xi (1 - \rho_\pi \xi/k - \rho_w)}{\theta \xi (1 - \rho_\pi \xi/k - \rho_w) + (k - \xi)(1 - 2^{-\theta})(1 - \rho_\pi \xi/k)}. \quad (\text{A.45})$$

For $t >, =, < t_U$, we have $\Lambda(\eta_{int}) >, =, < 1$. This completes the proof.

B Data appendix

In this Appendix, we provide further details on the data input and discuss robustness checks for the estimation results reported in Tables 1 and 2.

B.1 Data description

As outlined in Section 2, we use the linked employer-employee dataset (LIAB) from the Institute for Employment Research (IAB) to collect evidence on job polarisation in Germany and to provide insights into key determinants of this employment pattern.²⁰

Employer information in LIAB stems from the IAB Establishment Panel, which is based on a high-quality annual survey. The sample of establishment is stratified along three dimensions:

²⁰We use the LIAB Cross-Sectional Model 2, 1993-2008 in this study. The LIAB is confidential but not exclusive, available for non-commercial research by visiting the Research Data Centre (FDZ) of the Federal Employment Agency at the Institute of Employment Research in Nuremberg, Germany. For further information, we refer to <http://fdz.iab.de>.

establishment size, region and industry. Larger establishments are over-represented and the IAB provides weights that allow to make the sample of establishments representative for the German economy. We use these sample weights in one of our robustness checks. The data has been collected since 1993 and the coverage of establishments has increased over time. The first wave of the IAB Establishment Panel has included around 4,000 establishments in Western Germany. Since 1996 the sample also covers Eastern Germany. For our purpose, the information on offshoring at the establishment level in the waves 1999, 2001 and 2003 is especially important. To acknowledge that not all imports of intermediates are due to production shifting, we add information on restructuring events due to shutting down, selling off, or spinning off part of the establishment around the years, in which the decision on the import of intermediates has been made. Our sample starts in 1999, the first year for which we have information on the usage of foreign intermediates, and we distinguish between incumbent and new offshoring producers. Since we lack information on when an establishment has started to import intermediates for the year 1999, we associate incumbent offshorers with establishments reporting the usage of foreign intermediates in the first year of our sample. New offshorers are establishments that have not conducted offshoring in 1999, but have started to use imported intermediate goods and have reported an event of restructuring between 2000 and 2003.

Employee information comes from Integrated Employment Biographies (IEB) that covers administrative data from the German Federal Employment Agency (BA), including inter alia all workers subject to social security contributions. This gives detailed worker-level data for 80 percent of the German labour force (excluding the self-employed, civil servants, workers in marginal employment, and family workers). The data contains information on wages, age, gender, tenure and over 330 occupations (*Berufsordnungen*) according to the German nomenclature from 1988 (KldB88, 3-digit) at the worker-level. Establishments are required by law to report these data at least once a year. We follow [Fitzenberger et al. \(2006\)](#) and impute missing educational data for individuals by using information of the same worker in previous or following years. Furthermore, an important feature of the data is the right-censoring of wages. Wages are reported up to the upper limit for statutory pension insurance. To deal with this censoring problem, we proceed as recommended in the literature and impute the missing wage information. For this purpose, we run a Tobit regression for the year 1999 (the only year for which we need wage information) and replace wages above the threshold with their predicted values (cf. [Schafer, 1997](#); [Dustmann et al., 2009](#); [Klein et al., 2013](#)). Details on the wage imputation are available upon request. From the available employee data, we exclude all part-time workers, home workers, observations with one-time income, interns, workers during vocational training or retraining, and all observations with unreasonably low wages. Beyond that, we also exclude workers lacking wage or educational information. Workers are matched successfully to their employer for the vast majority of establishments, using a common identifier. Our preferred sample is an unbalanced sample of 7,434 establishments, originating from the sample of establishments in the year 1999.²¹

To isolate the offshoring channel on employment from technological change, we consider a measure of routineness of production at the establishment level, acknowledging the argument of

²¹We exclude all establishments with more (less) than 50 employees, for which the number of reported full time employees from the IAB establishment panel deviates by more than 30% (10 workers) from the corresponding number in LIAB.

Autor et al. (2003) that technological change is often associated with the replacement of routine tasks in the production process. The routineness measure can be constructed when complementing LIAB with data from German Qualification and Career Surveys collected by BiBB-BAuA. The BiBB-BAuA data is based on representative surveys of up to 34,434 German workers that have been conducted in six-to-eight year intervals since 1979, and it provides information on the activities of workers at their workplace. We use the 1999 survey, distinguish 13 activities, and classify three of them as routine and the rest as non-routine (cf. Spitz-Oener, 2006; Becker et al., 2013; Becker and Muendler, 2015).²² Table B.1 gives an overview on the tasks. Possible answers to the question on whether a task has been conducted are either *often*, *sometimes*, and *never* or *yes* and *no*. We count a task as being conducted by a worker if the answer is *often*, *sometimes* or *yes* and compute the share of routine tasks at the occupation level by adding up the routine tasks of all workers in this occupation and dividing the respective sum by the total number of routine plus non-routine tasks conducted by these workers. This gives a routine task share that varies between 0 and 1. For distinguishing professions, we rely on the 3-digit KldB88 classification and compute the share of routine tasks for 303 occupations. For 269 occupations the computation of the routineness measure is based on the responses of at least three interviewees and for these occupations data protection rules of the Institute for Employment Research allow us to merge the routineness measure from BIBB-BAuA to LIAB, relying on the occupational information. In a final step, we then compute the share of routine tasks at the establishment level by computing the mean over all workers employed in an establishment.

Another important employment dimension of technological change discussed in the literature is the increased use of information and communication technologies (ICT) – see, e.g., Michaels et al. (2014). If the ICT-based explanation for job polarisation were crucial in our sample, we would expect establishments in industries with a stronger ICT growth to be more strongly affected, potentially dominating our offshoring channels. We follow Michaels et al. (2014) and draw our ICT measure from the EU KLEMS database, which provides the relevant information for ICT capital divided by value added at the industry level. We merge this additional information to the LIAB, using the NACE Rev. 1 and the German Wirtschaftszweige Classification 1993 (WZ93). Due to a structural break during our sample period, we are able to consistently merge and use only 16 industries in our empirical analysis. In a robustness check, we consider changes in real gross fixed capital formation per worker for computing and communications equipment (also available from EU KLEMS) as an alternative measure for ICT (cf. Dauth et al., 2017).

B.2 Robustness checks

In this section, we present further evidence on job polarisation between establishments and its determinants by showing that the main results are robust to changes in the sample period, the number and definition of wage groups, and the choice of the establishment sample. Beyond that, we show that our findings do not suffer from an attrition bias, because of establishments leaving the sample prior the last sample year, and that our results are not an artefact of the over-representation of larger establishments in our dataset or a consequence of differences in the skill composition of establishments. Moreover, we employ an alternative measure of ICT advancements, allow for

²²As recommended by Spitz-Oener (2006), we only keep workers older than 18 and younger than 65 and drop self-employed and unemployed persons as well as employees with agricultural occupations.

Table B.1: *Task definitions*

Nr.	Description	Possible answers	Routine
1	Train, Teach	often/sometimes/never	no
2	Consult, Inform	often/sometimes/never	no
3	Measure, Inspect	often/sometimes/never	yes
4	Monitor	often/sometimes/never	no
5	Repair	often/sometimes/never	yes
6	Purchase, Sell	often/sometimes/never	no
7	Organise	often/sometimes/never	no
8	Negotiate	often/sometimes/never	no
9	Develop	often/sometimes/never	no
10	Produce Goods	often/sometimes/never	no
11	Look After, Serve, Take Care of	often/sometimes/never	yes
12	Apply Labour Law, Collective Bargaining Law	yes/no	no
13	Apply Other Law	yes/no	no

different time trends in the employment changes of manufacturing and other industries, control for the export status of establishments, and restrict the analysis to single-plant establishments, which can be classified as firms. Finally, we also study to what extent the lack of evidence for job polarisation between occupations is a robust finding in our dataset. The results from these robustness checks are summarised in Tables B.2-B.5.

Table B.2 shows our first set of sensitivity analyses, where we report estimation results for alternative sample periods and different numbers of wage groups. While Column 1 reestablishes the results from the preferred specification of the main text (see Table 2, Column 5), Column 2 and 3 display the estimation results when dividing establishments into 100 or 10 groups, respectively. We can infer from the estimates in these columns that our results are robust to changes in the number of wage groups. Furthermore, in Columns 4 and 5 we report estimation results for different time intervals keeping the number of wage groups at its initial level of 20. The results from our analysis are robust to these changes.

Table B.3 contains the results from four further robustness checks. To facilitate the comparison with the preferred specification from the main text, we repeat the results from Table 2, Column 5, in the first column of Table B.3. In the second column, we report the estimation results for a balanced sample of establishments that covers only those establishments which we observe in 1999 and 2005. The balanced sample contains a substantially smaller number of observations than the unbalanced sample. Hence, the standard errors for the offshoring variables become larger due to an efficiency loss in the estimation. Still, the size and significance level of all coefficients remain very similar, except for the effect of incumbent offshorers that turns insignificant. We learn from the theory section that it is not material to establish a positive and significant effect for incumbent offshorers, but that a significant difference between the employment effects for incumbent and new offshorers is crucial for the existence of job polarisation between establishments. Hence, we test for null hypothesis of equality of these two offshoring coefficients and report the results for this test in Tables B.3 and B.4. Note that we can always reject this null hypothesis. This is an important take-away from our empirical analyses, corroborating our theoretical model.

Our sample shares a common feature with many other firm-level panel datasets. We only

Table B.2: *Offshoring and Job Polarisation between Establishments – Robustness I*

	1999-2005			1999-2003	1999-2007
	20 groups	100 groups	10 groups	20 groups	
Initial wage	-0.230 (0.163)	-0.148** (0.038)	-0.342 (0.189)	-0.142 (0.186)	-0.255 (0.155)
Initial wage squared	0.055 (0.040)	0.038** (0.007)	0.085 (0.047)	0.030 (0.047)	0.063 (0.040)
Incumbent offshorer	0.046* (0.016)	0.046** (0.014)	0.045* (0.017)	0.034* (0.014)	0.051** (0.017)
New offshorer	-0.204** (0.054)	-0.203** (0.056)	-0.205* (0.069)	-0.166** (0.051)	-0.220** (0.057)
Overlap	Yes	Yes	Yes	Yes	Yes
Share of routine tasks	Yes	Yes	Yes	Yes	Yes
ICT	Yes	Yes	Yes	Yes	Yes
No. of observations	7,384	7,384	7,384	7,384	7,384

Notes: The dependent variable is the log employment change by establishment between the base year 1999 and the last year the establishment is observed during the sample period. Columns 1, 2, and 3 cover the time period 1999-2005 and report estimation results for different numbers of wage groups. Columns 4 and 5 cover different time intervals and 20 wage groups. The explanatory variables are the same as those reported in Table 1. Standard errors are clustered at the wage-group level and reported in parentheses. Significance levels are indicated by $^{\circ}$ $p < 0.1$, * $p < 0.05$, and ** $p < 0.01$, respectively.

observe a fraction of all establishments over the whole sample period, because some establishments leave the sample due to nonresponse and others due to market exit. To see whether concerns about attrition are justified or not, we employ an Inverse Probability Weighting (IPW) estimator. As suggested by Wooldridge (2010), we proceed in two steps. First, we split the panel into annual cross-sections and estimate for each cross-section the probability of establishments to remain in the sample in the next period due to non-closure.²³ We then construct the probability of observing establishment i in year t (*observation probability*, in short) by multiplying all fitted selection probabilities from the first year up to year t .²⁴ In a second step, we weight our observations with the inverse of the observation probability that varies across time and establishments. Note that the sample size increases to 33,953 observations due to multiple establishment observations over time, but the attrition sample is built on the same 7,384 establishments for which we have all control variables in the base year 1999. The dependent variable, here computed as the cumulative yearly log employment change from 1999 to year t , is again a function of the determinants captured by Table 2.

In a further step, we extend our attrition estimator by combining our IPW-weights with the sample design weights provided by the IAB to ensure simultaneously no attrition bias and the

²³In these probit regressions the likelihood of being observed in period t is explained by total employment (log), past insourcing (dummy), past outsourcing (dummy), high technology status relative to competitors (dummy), exporter status (dummy), single establishment (dummy), and negative business outlook (dummy) as well as a set of size and industry dummies in period $t - 1$.

²⁴Since the full cross-section of establishments in 1999 serves as our starting point, the survival probability for this first wave is by construction 1 and the first fitted selection probability refers to the year 2000.

representativeness of our empirical results. While it is common to multiply in such a setting two weights and, then again, inversely weight observations with this new weight, we caution against putting a strong emphasis on the interpretation of the size of these coefficients, since weights of small, surviving establishments can become very large, when following this procedure. By and large, relying on two different IPW estimators does not change the main results of our analysis. In particular, all variables remain (in)significant, except for the incumbent offshorer dummy.

Table B.3: *Offshoring and Job Polarisation between Establishments (1999-2005) – Robustness II*

	Preferred 20 groups	Balanced 20 groups	Attrition I 20 groups	Attrition II 20 groups	Residual 20 groups
Initial wage	-0.0230 (0.163)	-0.316° (0.155)	-0.972 (0.628)	-1.249 (1.174)	-1.034** (0.170)
Initial wage squared	0.055 (0.040)	0.074° (0.039)	0.231 (0.152)	0.262 (0.309)	0.549** (0.081)
Incumbent offshorer	0.046* (0.016)	0.043 (0.034)	-0.097 (0.112)	0.242 (0.158)	0.058** (0.012)
New offshorer	-0.204** (0.054)	-0.198* (0.071)	-0.467** (0.046)	-0.730** (0.136)	-0.195** (0.063)
Incumbent \neq New	Yes	Yes	Yes	Yes	Yes
Overlap	Yes	Yes	Yes	Yes	Yes
Share of routine tasks	Yes	Yes	Yes	Yes	Yes
ICT	Yes	Yes	Yes	Yes	Yes
No. of observations	7,384	2,860	33,953	33,953	7,384

Notes: The dependent variable is the log employment change by establishment between the base year 1999 and the last year the establishment is observed during the sample period. Columns 1 and 5 are based on an unbalanced sample covering all establishments observed in 1999. Column 2 is based on a balanced sample, covering only establishments observed in 1999 and 2005. Column 3 reports the results when inversely weighting all observations by the (estimated) survival probabilities of establishments. In Column 4, we combine the attrition weight with the sampling weight provided by the IAB to ensure that the results are representative. In Column 5, residual instead of actual wages are used for the computation of the initial wage group. The explanatory variables are the same as those reported in Table 2. Standard errors are clustered at the wage-group level and reported in parentheses. Significance levels are indicated by ° $p < 0.1$, * $p < 0.05$, and ** $p < 0.01$, respectively.

In Column 5, we report the estimation results from the unbalanced panel underlying Table 2, when relying on residual wages for the construction of wage groups. To determine the residual wages, we formulate an augmented Mincer regression, in which we explain log individual wages in 1999 by individual factors (age, age squared, tenure, tenure squared, experience, experience squared, six education dummies), state, and industry dummies. We then predict residual wages, take the exponential and construct the 20 wage groups based on these residuals. Contrasting the results in Columns 1 and 5, we see that our coefficients of main interest are very similar when relying on residual instead of actual wages. This indicates that workforce heterogeneity is not crucial for our results.²⁵

²⁵In another extension, not reported here, we have further augmented the Mincer regression by incorporating a full set of occupation dummies. Again, the results are robust to this modification, which makes us confident that the

Table B.4: *Offshoring and Job Polarisation between Establishments (1999-2005), Unbalanced Sample – Robustness III*

	Preferred 20 groups	Model II 20 groups	Model III 20 groups	Model IV 20 groups	Model V 20 groups
Initial wage	-0.0230 (0.163)	-0.252 (0.159)	-0.206 (0.168)	-0.268** (0.057)	-0.431** (0.112)
Initial wage squared	0.055 (0.040)	0.060 (0.040)	0.050 (0.042)	0.050** (0.014)	0.124** (0.032)
Incumbent offshorer	0.046* (0.016)	0.049* (0.017)	0.019 (0.015)	0.013 (0.014)	0.059** (0.019)
New offshorer	-0.204** (0.054)	-0.207** (0.054)	-0.213** (0.054)	-0.240** (0.067)	-0.276** (0.083)
Incumbent \neq New	Yes	Yes	Yes	Yes	Yes
Overlap	Yes	Yes	Yes	Yes	Yes
Share of routine tasks	Yes	Yes	Yes	Yes	Yes
ICT	Yes	No	Yes	Yes	Yes
ICT (Alternative)	No	Yes	No	No	No
Manufacturing	No	No	Yes	No	No
Exporting	No	No	No	Yes	No
Firms only	No	No	No	No	Yes
No. of observations	7,384	7,384	7,384	5,652	5,047

Notes: The dependent variable is the log employment change by establishment between the base year 1999 and the last year the establishment is observed during the sample period. All estimates are based on an unbalanced sample covering all establishments observed in 1999. The explanatory variables are the same as those reported in Table 2, if not indicated otherwise. Manufacturing stands for a time trend for establishments in the manufacturing sector. Exporting refers to two dummy variables for incumbent and new exporters. Column 5 restricts our estimates to establishments that can be classified as firms. Standard errors are clustered at the wage-group level and reported in parentheses. Significance levels are indicated by $^{\circ}$ $p < 0.1$, * $p < 0.05$, and ** $p < 0.01$, respectively.

We continue our extensive sensitivity analyses in Table B.4, where we report the results from four additional robustness checks along with the results from our preferred specification from the main text. First, we employ an alternative measure of ICT advancement and a comparison between Column 1 and 2 reveals that our results are robust to this modification. Second, since the manufacturing sector might have been on a different growth path than other sectors during the sample period, we incorporate a dummy for the manufacturing sector in Column 3. Given that our dependent variable captures employment changes over time, this is equivalent to allowing the time trend for manufacturing employment to differ from other sectors. In Column 4, we incorporate two additional control variables at the establishment-level. Analogously to our offshoring variables, we consider two variables on export status of establishments, one for incumbent exporters in the base year 1999 and one for new exports during the sample period. Finally, we restrict our estimation in the last column to single-plant establishments, i.e. establishments that can be classified as firms. Most importantly, our main insight of a significant difference between the two offshoring

employment changes at the establishment level do not materialise because establishments differ in the occupational composition of their workforce.

coefficients also holds true for this further set of empirical specifications.

To complete our discussion, we finally provide further sensitivity analyses to our baseline regression models for job polarisation between establishments and occupations in Table 1. In Panel A of Table B.5, we report the results for the baseline regression for different time periods and different numbers of wage groups, relying on the unbalanced sample of establishments. In Panel B, we report the results for estimations similar to those in Panel A, but considering average residual wages instead of actual wages (see also Table B.3, Column 5). In Panel C and D of Table B.5, we show further results on (the lack of) job polarisation between occupations. In Panel C, we consider 86 main occupation groups at the KldB88 2-digit level instead of the more than 330 occupations at the KldB88 3-digit level used in Figure 1 and Table 1. Since we cannot rule out *a priori* that jobs associated with the same occupation cover different tasks in different industries, we follow Goos and Manning (2007) and Goos et al. (2009) and associate jobs with occupation-industry cells (*jobs*, in short), rank these cells according to the average wage paid in 1999, and divide them into 20, 100, and 10 groups of equal size, respectively. We then estimate log employment changes of the 596 occupation-industry cells between the first and last year of observation as a function of the average wages per wage group and its squared term and report the results in Panel D of Table B.5. To sum up the empirical evidence from Figure 1, Table 1, and Table B.5, it is clear that after the millennium job polarisation between establishments has been much more relevant for Germany than job polarisation between occupations, for which conclusive evidence cannot be found in our data.

Table B.5: *Job Polarisation between Establishments and Occupations in Germany – Robustness IV*

	1999-2005			1999-2003	1999-2007
	20 groups	100 groups	10 groups	20 groups	
Panel A (Establishments)					
Initial wage	-0.123* (0.0058)	-0.126* (0.033)	-0.145° (0.074)	-0.085 (0.052)	-0.120* (0.050)
Initial wage squared	0.032* (0.012)	0.033** (0.007)	0.038* (0.015)	0.021* (0.010)	0.031* (0.010)
No. of observations	7,434	7,434	7,434	7,434	7,434
Panel B (Establishments)					
Initial wage	-0.790** (0.130)	-0.653** (0.214)	-0.773** (0.107)	-0.584** (0.071)	-0.776** (0.142)
Initial wage squared	0.425** (0.077)	0.338** (0.122)	0.412** (0.058)	0.305** (0.042)	0.409** (0.084)
No. of observations	7,434	7,434	7,434	7,434	7,434
Panel C (Occupations)					
Initial wage	0.248 (0.259)	0.308° (0.177)	0.180 (0.187)	0.099 (0.304)	-0.007 (0.306)
Initial wage squared	-0.030 (0.037)	-0.038 (0.025)	-0.019 (0.027)	-0.019 (0.045)	0.005 (0.043)
No. of observations	86	86	86	86	86
Panel D (Occupations)					
Initial wage	-0.246 (0.161)	-0.189 (0.319)	-0.243 (0.142)	-0.330 (0.257)	-0.414* (0.149)
Initial wage squared	0.049° (0.025)	0.039 (0.048)	0.048° (0.022)	0.053 (0.039)	0.073** (0.025)
No. of observations	596	596	596	601	596

Notes: The dependent variable is the log employment change by establishment (Panel A and B) or occupation (Panel C and D) between the base year 1999 and the last year of the sample period. The variable *Initial wage* refers to the average wage and the average residual wage across establishments (Panels A and B, respectively) or across occupations (Panels C and D, respectively) of a given wage group in the base year 1999. A constant is estimated but not reported. Standard errors are clustered at the wage-group level and reported in parentheses. Significance levels are indicated by ° $p < 0.1$, * $p < 0.05$, and ** $p < 0.01$, respectively.