

Bursian, Dirk; Nagengast, Arne J.

Article — Published Version

OFFSHORING AND THE POLARIZATION OF THE DEMAND FOR CAPITAL

Economic Inquiry

Provided in Cooperation with:

John Wiley & Sons

Suggested Citation: Bursian, Dirk; Nagengast, Arne J. (2019) : OFFSHORING AND THE POLARIZATION OF THE DEMAND FOR CAPITAL, Economic Inquiry, ISSN 1465-7295, Wiley Periodicals, Inc., Boston, USA, Vol. 58, Iss. 1, pp. 260-282,
<https://doi.org/10.1111/ecin.12828>

This Version is available at:

<https://hdl.handle.net/10419/230124>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<http://creativecommons.org/licenses/by-nc-nd/4.0/>

OFFSHORING AND THE POLARIZATION OF THE DEMAND FOR CAPITAL

DIRK BURSIAI and ARNE J. NAGENGAST*

In the past decades, the importance of different capital goods has gradually changed, which has led to a structural shift in the composition of the demand for capital at the expense of more traditional capital inputs such as machinery and equipment. In this paper, we focus on a novel driver of this development by analyzing the effect of offshoring on the demand for capital by asset class using a rich country-sector panel dataset. Estimating a system of factor demand equations, we document that offshoring reduces the relative demand for non-ICT capital, thereby polarizing the demand for capital. (JEL F14, F62, E22)

I. INTRODUCTION

Most macroeconomic theory is based on aggregate production functions that combine the homogeneous input factors capital and labor to generate economy-wide output. However, input factors are typically characterized by a substantial degree of heterogeneity. The capital stock of an economy, for instance, represents an aggregate comprising multiple asset types that differ along several dimensions such as quality, the economic life cycle, or asset-specific productivity. In the past decades, the importance of different asset types has gradually changed. This is illustrated in Figure 1 using data from EU KLEMS (Jäger 2017).

The figure shows the evolution of gross-fixed capital formation related to information and communication technologies (ICT), non-ICT, and research and development (R&D) as the

share of total gross-fixed capital formation.¹ While the fraction of non-ICT capital showed a decrease by almost 10 percentage points between 1997 and 2014, the corresponding figures for ICT and R&D capital increased by around 6 percentage points and 5 percentage points, respectively, over the same time period. Overall, the importance of ICT and R&D capital has thus gradually increased over time at the expense of more traditional (non-ICT) capital goods such as machinery and equipment or buildings (see also, e.g., Colecchia and Schreyer 2002; Corrado, Hulten, and Sichel 2009).

Regarding the underlying economic forces, it is well documented that technological change has contributed to this development (e.g., Basanini and Scarpetta 2002). In this paper, we offer an additional explanation by linking the increase in the relocation of production abroad (i.e., offshoring) observed in the past decades to the structural change in the composition of the demand for capital.

1. For details on the classification of fixed capital and a description of the underlying data including the countries and sectors covered, see Section III.A. While the figure shows the simple arithmetic mean across sectors and countries, the results for individual countries are broadly similar.

*The authors would especially like to thank Thomas Knetsch and Philipp Meinen for valuable discussions. We would also like to thank the editor, Areendam Chanda, and two anonymous referees for insightful comments that greatly improved the paper. Comments and suggestions by Stefan Goldbach, Thomas Haertel, Matthias Hartmann, Thomas McClymont, Markus Roth, and seminar participants at the Deutsche Bundesbank are gratefully acknowledged. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Deutsche Bundesbank.

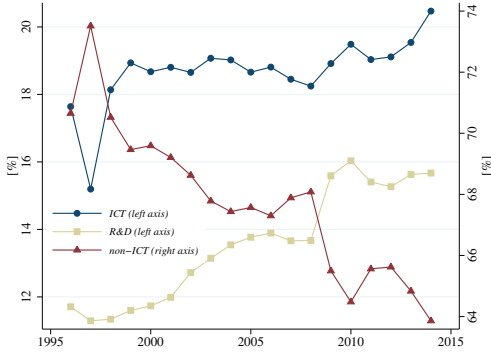
Bursian: Economist, DG Economics, Deutsche Bundesbank, 60431, Frankfurt am Main, Germany; Phone +49 69 9566 8879, Fax +49 69 9566 6734, E-mail dirk.bursian@bundesbank.de

Nagengast: Senior Economist, DG Economics, Deutsche Bundesbank, 60431, Frankfurt am Main, Germany; Phone +49 69 9566 8605, Fax +49 69 9566 6734, E-mail arne.nagengast@bundesbank.de

ABBREVIATIONS

CES: Constant Elasticity of Substitution
ICT: Information and Communication Technologies
OLS: Ordinary Least Squares
R&D: Research and Development
2SLS: Two-Stage Least Squares
SUR: Seemingly Unrelated Regression
WIOD: World Input-Output Database

FIGURE 1
Gross Fixed Capital Formation



Notes: Share of gross-fixed capital formation by asset class in total gross-fixed capital formation. The figure shows the simple arithmetic mean of the shares across 32 sectors in 11 countries (Section III.A).

The international fragmentation of production and its organization along global value chains has been a defining feature of the world economy in the recent past.² Firms typically offshore production if the savings accruing from factor price differences across countries outweigh the coordination and trade costs associated with the additional fragmentation of production (Feenstra and Hanson 1997; Grossman and Rossi-Hansberg 2008; Kohler 2004). In this regard, the literature has so far mainly focused on the effects of offshoring on domestic labor markets. Overall, a consensus has emerged in the empirical literature that offshoring contributes to the decline in the demand for low- and medium-skilled workers with a concomitant fall in their wages relative to those of high-skilled workers (Feenstra and Hanson 1997, 1999; Hijzen, Görg, and Hine 2005; Hummels et al. 2014; Morrison Paul and Siegel 2001; Strauss-Kahn 2004). The implications of offshoring for the demand for capital are less clear, however, with ambiguous results for R&D capital (Beladi, Marjit, and Yang 2012; Glass and Saggi 2001; Marjit and Mukherjee 2008) and little evidence on the relationship between offshoring and ICT capital (Abramovsky and Griffith 2006; Rasel 2017).³

2. According to data from the World Input–Output Database (WIOD), the share of imported intermediates in global production increased from 6.2% in 1995 to 8.3% in 2014. As a consequence, almost two-thirds of world trade in 2014 was in intermediate goods and services.

3. See Section IV.C for a discussion. Another strand of the literature examines the relationship between foreign and

In this paper, we provide a comprehensive analysis of the offshoring-induced effects on the domestic demand for capital by asset class. We apply and extend the approach of estimating relative factor demand equations stemming from a translog cost function using a rich panel of 32 sectors in 11 advanced economies between 1995 and 2014 including a detailed breakdown of capital into ten different asset classes. Our empirical results indicate that offshoring has a negative impact on non-ICT capital, thereby polarizing the demand for capital. Hence, offshoring is one factor behind the structural change in the composition of the demand for capital observed in advanced economies. In a number of sensitivity tests, we show that our main result is robust against a range of different specifications and methodological choices, including an instrumental variable approach in order to address endogeneity concerns using an instrument based on Hummels et al. (2014).

Several explanations may rationalize the polarizing effect of offshoring on the demand for capital. First, the offshoring-induced reduction in the relative demand for non-ICT capital may, in principle, reflect the direct relocation of capital-intensive stages of production abroad due to cross-country differences in the cost of non-ICT capital. Second, capital-labor complementarities (Griliches 1969) could explain the negative effect of offshoring on non-ICT capital even if the marginal product of capital was equalized across countries (i.e., when there are no immediate incentives for firms to offshore capital-intensive stages of production). In this case, offshoring of labor-intensive stages may bring about adjustments on the capital side due to input factor complementarities.

The remainder of the paper is structured as follows: Section II describes the methodology and Section III presents information on the dataset and descriptive statistics. The main results from our empirical analysis are discussed in Section IV and a comprehensive assessment of their robustness is provided in Section V. Section VI offers some concluding remarks.

II. METHODOLOGY

A. Derivation of Factor Share Equations

We analyze the relationship between offshoring and the demand for capital by estimating

domestic investment activity of multinational enterprises (for an overview, see Goldbach et al. 2019).

a system of relative factor demand equations derived from a translog cost function (Christensen, Jorgenson, and Lau 1971, 1973).⁴ Consider a production function at the sector level that combines labor, capital, and intermediate inputs in order to produce output:

$$Y_{i,j,t} = f(L_{i,j,t}, K_{i,j,t}, M_{i,j,t}, Z_{i,j,t}),$$

where $Y_{i,j,t}$ denotes gross output of sector j in country i at time t , $L_{i,j,t} \equiv L_{1,i,j,t}, \dots, L_{l,i,j,t}$ are different types of labor inputs, $K_{i,j,t} \equiv K_{1,i,j,t}, \dots, K_{k,i,j,t}$ are capital inputs by asset class, and $M_{i,j,t} \equiv M_{1,i,j,t}, \dots, M_{m,i,j,t}$ are different types of intermediate inputs. $Z_{i,j,t} \equiv Z_{1,i,j,t}, \dots, Z_{z,i,j,t}$ denote levels of technology which reflect how efficiently the inputs are combined in the production process.

Under standard assumptions, the duality of the firm's optimization problem implies that the cost function contains all economically relevant information on the production technology. Assuming that input prices are given and that the firm aims at producing a certain fixed level of gross output, Y , the cost function is given by

$$\begin{aligned} C(p_L, p_K, p_M, Y, Z) &\equiv \min_{\{L_n\}_{n=1}^l \{K_n\}_{n=1}^k \{M_n\}_{n=1}^m} \\ &\sum_{n=1}^l p_{n,L} L_n + \sum_{n=1}^k p_{n,K} K_n + \sum_{n=1}^m p_{n,M} M_n \\ &\equiv \min_{\{Q_n\}_{n=1}^N} \sum_{n=1}^N p_{n,Q} Q_n, \end{aligned}$$

where $p_L \equiv p_{1,L}, \dots, p_{l,L}$, $p_K \equiv p_{1,K}, \dots, p_{k,K}$, and $p_M \equiv p_{1,M}, \dots, p_{m,M}$ denote input prices of the labor, capital, and intermediate inputs, respectively, and Q is the set of input factors with $N = l + k + m$.⁵ Sector, country, and time subscripts are omitted for notational simplicity. As

4. The translog cost function can be viewed as a second-order Taylor approximation to an arbitrary twice-differentiable cost function. It places no a priori restrictions on the substitutability between input factors and nests, for instance, Cobb–Douglas or CES production technologies. For more recent work using translog functions see Crinò (2010), Senses (2010), Hakkala, Heyman, and Sjöholm (2014), and Kumbhakar and Tsionas (2016), among others.

5. l , k , and m depend on the degree of disaggregation of the labor, capital, and intermediate inputs, respectively. In the empirical analyses below, an aggregate measure of intermediate inputs and labor will always be used (i.e., $m = 1$ and $l = 1$). For capital inputs, however, different degrees of disaggregation are considered. In general, the capital input is split into three asset classes (ICT, non-ICT, and R&D capital), $k = 3$, but a higher level of disaggregation in which $k = 7$ is also considered as a robustness test (Section IV.A and Table S1).

indicated above, we assume that the associated cost function at the sector level can be approximated by a translog functional form⁶ which is given by

(1)

$$\begin{aligned} \ln(C) &= \alpha_0 + \sum_{n=1}^N \alpha_n \ln(p_{n,Q}) + \beta_y \ln(Y) + \sum_{n=1}^z \gamma_n Z_n \\ &+ \frac{1}{2} \sum_{n=1}^N \sum_{o=1}^N \alpha_{no} \ln(p_{n,Q}) \ln(p_{o,Q}) + \frac{1}{2} \beta_{yy} \ln(Y)^2 \\ &+ \frac{1}{2} \sum_{n=1}^z \sum_{o=1}^z \gamma_{no} Z_n Z_o + \sum_{n=1}^N \delta_{ny} \ln(p_{n,Q}) \ln(Y) \\ &+ \sum_{n=1}^N \sum_{o=1}^z \delta_{no} \ln(p_{n,Q}) Z_o + \sum_{n=1}^z \delta_{yn} \ln(Y) Z_n. \end{aligned}$$

We assume that input factors can adjust to cost-minimizing levels in the short run. In Section V.B, however, we show that this assumption is not crucial as allowing for a sluggish adjustment of the input factors does not have a bearing on our results. Linear homogeneity in input prices and symmetry imply that

$$\begin{aligned} \sum_{n=1}^N \alpha_n &= 1, \\ \sum_{n=1}^N \alpha_{no} &= \sum_{o=1}^N \alpha_{no} = \sum_{n=1}^N \delta_{ny} = \sum_{n=1}^N \delta_{no} = 0, \end{aligned}$$

and

$$\alpha_{no} = \alpha_{on}.$$

By Shephard's lemma, the demand for the input factors conditional on output can be

6. Note that the level of technology, Z , which is in general proxied by a measure for offshoring, does not enter the translog cost function in logs as it is already measured in percentages (Section III.A). Changes in the relative demand for the input factors may also be due to technological change per se. The literature on the relation between offshoring and labor demand therefore typically controls for technological change by including some measure of ICT or R&D intensity (e.g., Feenstra and Hanson 1999; Hijzen, Görg, and Hine 2005). Given that ICT and R&D factor shares are among the independent variables used in our empirical analysis, following this strategy does not seem to be appropriate. Our baseline specification controls for year fixed effects and, hence, accounts for technological change other than offshoring that is common across countries and sectors. This specification yields unbiased estimates if the part of technological change contained in the error term (i.e., technological change that is not captured by offshoring or year fixed effects) is uncorrelated with the explanatory variables. We show that explicitly controlling for technological change in a number of different ways does not have a bearing on our results (Section V.C).

obtained by differentiating the cost function with respect to input prices, that is, $\partial C / \partial p_{n,Q} = Q_n$, $\forall n = 1, \dots, N$. Hence, the partial derivative of the translog cost function with respect to the n th input price yields the cost share of input n in total cost:

(2)

$$S_n \equiv \frac{\partial \ln C}{\partial \ln p_{n,Q}} = \frac{p_{n,Q} Q_n}{C} = \alpha_n + \sum_{o=1}^N \alpha_{no} \ln(p_{o,Q}) + \delta_{ny} \ln(Y) + \sum_{o=1}^z \delta_{no} Z_o,$$

where $n = 1, \dots, N$.

B. User Costs of Capital

While prices for the labor input (i.e., wages) as well as intermediates are usually easy to obtain, market information on the price of the capital input (i.e., rental rates or user costs) is typically not available. Hence, user costs need to be estimated for all asset classes. In principle, the literature distinguishes between ex post and ex ante approaches for calculating the user costs of capital.

The ex post method exclusively builds on national accounts data and can be calculated in a straightforward way without the need for additional estimation steps. The approach relies only on realized data and no assumptions on the nature of the expectation formation process are required. Our baseline results rely on an ex post measure that was calculated under the standard assumption that the nominal rate of return is equalized across different assets in a particular sector (Jorgenson, Gollop, and Fraumeni 1987; Jorgenson and Griliches 1967). The resulting user costs of asset i at time t , $uc_{i,t}$, are given by

$$uc_{i,t} = q_{i,t-1} i_t + \delta_{i,t} q_{i,t} - (q_{i,t} - q_{i,t-1}),$$

where i_t is the nominal rate of return on alternative capital investments (i.e., the opportunity cost), $\delta_{i,t}$ is the depreciation rate, and $q_{i,t}$ is the investment price of asset i . Note that the composite term $q_{i,t} - q_{i,t-1}$ reflects asset-specific capital gains of investing in asset i . From a theoretical point of view, however, investment decisions are based on expected, rather than realized outcomes leading to the so-called ex ante user cost approach originally proposed by Diewert (1980). In the absence of taxation, the ex ante user costs of asset i at time t , $\tilde{uc}_{i,t}$, can be defined following

Auerbach (1983) as

$$\tilde{uc}_{i,t} = [r_t^e + \delta_{i,t} - (\pi_{i,t}^e - \pi_t^e)] \frac{q_{i,t}}{p_{y,t}},$$

where r_t^e is the expected real rate of return, $\pi_{i,t}^e$ is the expected asset-specific price inflation, π_t^e is the expected economy-wide price inflation, and $p_{y,t}$ is the value added price. Note that the composite term $\pi_{i,t}^e - \pi_t^e$ now reflects the expected relative capital gains of investing in asset i .⁷

Depreciation rates, $\delta_{i,t}$, investment prices, $q_{i,t}$, and value added prices, $p_{y,t}$, are directly taken from EU KLEMS. The nominal rate of return, i_t , is given by the sector-mean rate of return across all asset classes based on the EU KLEMS methodology. Asset price inflation, $\pi_{i,t}$, is measured as the percentage change in the investment price index, whereas economy-wide inflation, π_t , is based on the value-added deflator of the total economy. The ex ante approach requires estimates of the expected real rate of return, r_t^e , and asset-specific expected price gains, $\pi_{i,t}^e - \pi_t^e$. For both, first, we estimate autoregressive models using data up until t and, second, produce out-of-sample forecasts for $t+1$ using the estimated processes (e.g., Oulton 2007).

In both ex post and ex ante approaches, we compute user costs of capital at the most disaggregated level for all ten asset classes available in EU KLEMS. Aggregate measures of user costs are obtained by aggregating over user costs of individual assets according to their average share in the total compensation of the respective capital aggregate:

$$(3) \quad p_{i,K,t} = \sum_{j=1}^J \frac{(v_{j,t}^i + v_{j,t-1}^i)}{2} uc_{j,t},$$

where $p_{i,K,t}$ denotes the user costs for capital aggregate i comprising J subcomponents and $v_{j,t}^i$ denotes the j th asset's share in the compensation of capital aggregate i given by $uc_{j,t} K_{j,t} / \sum_{k=1}^J uc_{k,t} K_{k,t}$ for the ex post approach.⁸

7. Note that the ex ante user costs of capital are expressed in real terms, as is typically done in the literature. In contrast, we follow the EU KLEMS methodology and calculate the ex post measure in nominal terms (O'Mahony and Timmer 2009). We show in a robustness exercise that using price-adjusted ex post user costs does not qualitatively change the results (Section V.C).

8. Note that in Equation (3) $uc_{j,t}$ denotes user costs of the most disaggregated asset classes; $p_{i,K,t}$ refers to the user costs of the capital aggregates that enter the empirical analyses below.

Equivalent expressions for the ex ante approach are omitted for brevity.⁹

III. DATA AND DESCRIPTIVE STATISTICS

A. Data Sources and Construction

The main data sources are the EU KLEMS September 2017 release (Jäger 2017) and the WIOD release 2013 and 2016 (Timmer et al. 2015). EU KLEMS contains data on gross output, prices of intermediates, labor compensation, total hours worked by persons engaged, and a detailed breakdown of investment prices and the capital stock for the time period from 1995 to 2014¹⁰ for 11 countries: Austria, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, the United Kingdom, and the United States.¹¹ We consider a sample including information on 32 sectors (Table A1).¹² In principle, information on ten different asset classes is available in EU KLEMS (Figure A1), which we aggregate for each country-sector-year cell into the three broad asset classes: non-ICT (1: transport equipment; 2: other machinery equipment; 3: cultivated assets; 4: dwellings; 5: other buildings and structures; 6: residual: mineral exploration and artistic originals), ICT (7: computer hardware; 8: telecommunications equipment; 9: computer software and databases), and R&D capital (10: research and development).¹³ Average wages are computed as the ratio of labor compensation to total hours worked. The dependent variables in the empirical

analysis are the compensation shares of each production factor in total costs, which are computed as the labor compensation, capital compensation, or the intermediate inputs at current purchaser prices relative to total costs.

The 2016 release (2013 release) of the WIOD includes information on the source of imported intermediates for 43 (40) countries and 56 (35) sectors for the period 2000 to 2014 (1995 to 2011). We follow Berman, Bound, and Griliches (1994) and Campa and Goldberg (1997), and define offshoring in sector s of country c as the share of imported intermediates in gross output:

$$O_{cs} = \sum_{i \neq c}^C \sum_j^S \frac{M_{cs,ij}}{y_{cs}},$$

where $M_{cs,ij}$ denotes the intermediates used in the production of sector s of country c sourced from sector j of country i , y denotes gross output, and time subscripts are omitted for brevity.¹⁴ The offshoring measure is based on the 2016 release of WIOD for 2000 to 2014, and we extend the sample to 1995 by backcasting the time series using growth rates of the offshoring measure based on the 2013 release of WIOD. Correspondence tables between the sectors of the two WIOD releases and EU KLEMS are detailed in the appendix (Tables A2 and A3).

B. Descriptive Statistics

This section presents summary statistics on the offshoring measure as well as the factor shares and factor prices over time by country (Table A4) and sector (Table A5). The tables present the offshoring measure and the levels of the input factor shares in 2000 as well as changes of the respective variables over time between 2000 and 2014. For factor prices, annual price changes of the input factors between 2000 and 2014 are shown. Prices of the capital inputs are based on estimates of the user costs of capital from the ex post approach detailed in Section II.B.

Overall, the evolution of the variables shows a substantial degree of heterogeneity across countries and, particularly, across sectors, but some general patterns are also discernible. The degree of offshoring amounted to around 10% by 2000 across the sample of countries and increased on

9. For all ex ante measures of the user costs of capital, we use predicted shares based on out-of-sample forecasts from autoregressive models.

10. This is true for most of the countries and industries. In some cases, however, certain variables are only available for shorter time periods.

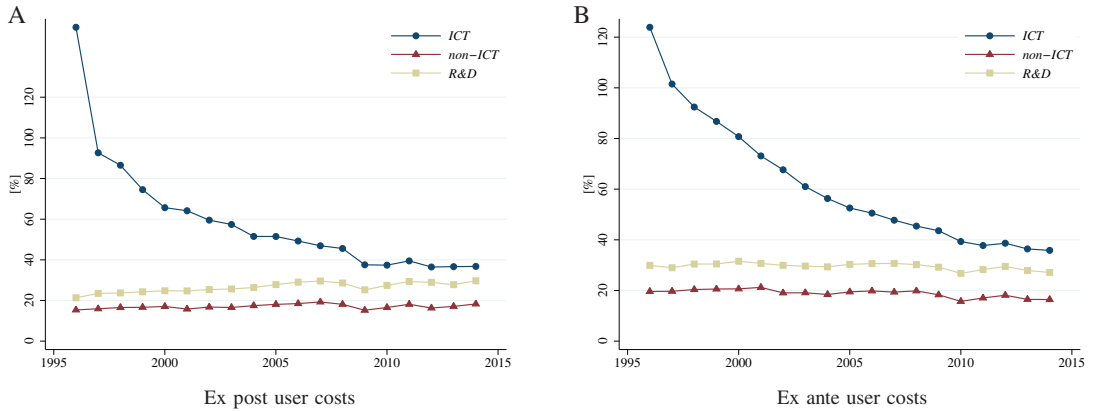
11. Data for other EU countries is available, but lacks the detailed breakdown required for our analysis, with the exception of the Czech Republic and Slovakia, which were excluded given that they are more commonly considered offshoring destinations.

12. We drop sectors T ("Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use") and U ("Activities of extraterritorial organizations and bodies").

13. We disaggregate the capital input into its ICT, non-ICT, and R&D components in order to ensure comparability of our results with the previous literature. Note that our paper is based on the September 2017 release of the EU KLEMS Growth and Productivity Accounts. While previous versions of EU KLEMS inter alia did not recognize expenditures on R&D as investment, the concepts, and methodologies in the 2017 release are in line with the current version of the European System of National Accounts introduced in September 2014. Expenditures on R&D are now, for instance, counted as investment and therefore add to GDP.

14. Alternative definitions of offshoring such as dividing imported intermediates by domestic value-added instead of gross output exist in the literature (Hijzen, Görg, and Hine 2005), but do not qualitatively change our results (Section V.C).

FIGURE 2
Median User Costs of Capital (in % of Replacement Costs in 2010)



average by 2.6 percentage points until 2014. Services sectors had a lower share of imported intermediates than manufacturing sectors in 2000 and also offshored less in absolute terms between 2000 and 2014. For the average country, the labor share declined (-1.1 percentage points), while wages increased noticeably ($+2.9\%$ per year). The share of intermediate inputs in gross output, which includes both domestic and imported intermediates, also increased on average ($+1.9$ percentage points) and became more expensive overall ($+1.9\%$ per year).

On the capital side, non-ICT capital makes up the largest share in capital compensation, followed by ICT and R&D capital. The share of non-ICT capital in total costs was 15.3% on average in 2000, while it stood at 1.9% and 1.7% for ICT and R&D capital, respectively. Overall, there was a tendency to reduce non-ICT and to increase R&D capital relative to the remaining input factors, with no clear tendency observable for ICT capital. Turning to price developments, ICT capital became, on average, less expensive over time (-4.1% per year), while prices for non-ICT and R&D capital increased slightly ($+0.8\%$ and $+1.6\%$ per year, respectively).

As indicated above, estimates of the user costs of capital are subject to uncertainty. Figure 2 compares the median price developments of non-ICT, ICT, and R&D capital from the baseline (ex post) and an alternative (ex ante) approach.¹⁵ Overall, differences in estimated

user costs as a fraction of replacement costs are rather small, and, on average, estimates are similar from a qualitative point of view. The user costs of ICT capital show a clear downward trend from above 120% (of replacement costs in 2010) at the beginning of the sample to below 40% in 2014. While the user costs for non-ICT capital remained broadly unchanged over time at around 20% , the user costs for R&D capital showed a moderate upward trend in the baseline version from 20% at the beginning of the sample period to around 30% in 2014. In the alternative version, however, the user costs for R&D capital changed only very little.

IV. BASELINE RESULTS

This section presents the results from estimating the factor share equations given by Equation (2). We estimate the system of share equations jointly using a seemingly unrelated regression (SUR) estimator, which yields more efficient results compared to equation-by-equation estimations when the error terms are correlated across equations (Zellner 1962).¹⁶ In

using out-of-sample forecasts from $AR(1)$ -models (Section II.B).

16. As the cost shares add up to unity by construction, that is, $\sum_{n=1}^N S_n = 1$, one equation has to be dropped in order to avoid the singularity of the disturbance covariance matrix. The system of share equations is estimated with an iterative Zellner efficient procedure such that the choice of the equation that is dropped is arbitrary. In all tables, the coefficients of the corresponding share equation were recovered by making use of the cross-equation adding-up constraints.

15. These ex ante user costs are based on time-varying sector-specific rates of return and expectations were obtained

most of the variants presented below, year and country \times sector fixed effects are controlled for and standard errors are clustered at the country-sector level. The baseline results rest upon a cost function with one labor and one intermediate input along with capital disaggregated into ICT, non-ICT, and R&D categories.

A. *Ex Post User Costs*

The results based on ex post user costs of capital are presented in Table 1.¹⁷ As we are primarily interested in the relationship between offshoring and factor demand, the sign and statistical significance of the estimated coefficients on offshoring are of main interest.

In line with the previous literature, we find that offshoring has a negative effect on the demand for labor and a positive effect on the demand for intermediate inputs (Foster-McGregor, Stehrer, and de Vries 2013; Hijzen, Görg, and Hine 2005).¹⁸ Similar to previous work, the share of intermediates encompasses both domestic and imported intermediates. Therefore, the coefficient on offshoring in the equation for intermediates captures the composite effect of offshoring on both domestic and imported intermediates. A positive coefficient of offshoring on the demand for intermediate inputs implies that offshoring does not simply substitute domestic intermediates one-to-one. However, the fact that the coefficient differs from unity suggests that the offshoring measure captures both the reduction in sectoral value added as well as changes from domestic to international suppliers.¹⁹

17. The estimated translog cost function (or equivalently, the estimated share equations) should be consistent with economic theory. The results suggest that our estimates are in line with economic theory in the sense that the own-price elasticities are negative and statistically significant for all input factors (Allen 1938; Uzawa 1962). It should be noted that negative own-price elasticities constitute a necessary condition for concavity of a cost function in input prices.

18. Comparing the coefficient estimates for labor and intermediate inputs to those in the literature is only possible to a limited extent. First, in this paper, we assume that capital is a variable input factor instead of being quasi-fixed, as is typically assumed in most of the existing body of the literature on the effects of offshoring on labor demand. Second, most of the previous literature disaggregates the labor input by skill type, which is not the focus of our paper. Third, we proxy offshoring as the share of imported intermediates in gross output while alternative definitions exist in the literature (Section V.C).

19. Under the assumption that the prices of domestic and imported intermediates are the same, the offshoring coefficient in the intermediates equation in Table 1 implies that a 1 percentage point increase in offshoring reduces domestic intermediates by 0.686 percentage points

Turning to the demand for capital by asset class, we find that offshoring significantly reduces the demand for non-ICT capital. An increase in the share of imported intermediates by 1 percentage point is associated with a decrease in the non-ICT capital share by 0.145 percentage point. Furthermore, the results suggest that offshoring also has a statistically significant negative impact on R&D capital. However, the effect is quantitatively small. The offshoring coefficient for non-ICT capital is roughly five times larger in absolute terms than the offshoring coefficient on R&D capital. Interestingly, offshoring does not seem to impact ICT capital in a statistically significant way.²⁰

These results suggest that offshoring changes the composition of the demand for capital. While non-ICT capital has been squeezed by offshoring in the recent past, the relative demand for R&D and ICT capital has been affected much less or not at all by the restructuring of the domestic production process.²¹ In line with the terminology used for compositional effects of offshoring on labor demand for different skill levels, we refer to this phenomenon as the polarization of the demand for capital.

B. *Ex Ante User Costs*

The results above relied on ex post user costs that were calculated in line with the EU KLEMS methodology. From a practical point of view, the ex post approach has the advantage that it is comparatively straightforward and transparent, since user costs can be directly obtained from national accounts data without involving additional estimation steps. However, the ex post measure also has some potential drawbacks. First, investment decisions are typically based on expected rather than realized outcomes as implied in the ex post

($0.314 - 1 = -0.686$) since offshoring increases imported intermediates by definition one-to-one. Therefore, offshoring appears to have a substantially negative effect on *domestic* intermediates.

20. The offshoring elasticities (e.g., Foster-McGregor, Stehrer, and de Vries 2013) corresponding to the results in Table 1 are: non-ICT (-1.108^{***}), ICT (0.105), and R&D (-1.600^{***}). *** indicates significance at the 1% level. Note that the elasticity for R&D capital is comparatively large given its small average share in total factor compensation (Table A4). However, the absolute and not the relative response of the demand for capital by asset class to changes in offshoring is the relevant measure for the polarization result.

21. Further disaggregating the capital input corroborates this conclusion. The corresponding results from estimating the factor share equations of a cost function including nine input factors are shown in Table S1.

TABLE 1
Baseline Specification

	Factor Shares				
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates
Price labor	0.069*** (0.009)	−0.025*** (0.003)	−0.006*** (0.002)	−0.001 (0.001)	−0.036*** (0.009)
Price non-ICT	−0.025*** (0.003)	0.040*** (0.004)	0.004*** (0.001)	0.003** (0.001)	−0.021*** (0.003)
Price ICT	−0.006*** (0.002)	0.004*** (0.001)	0.004*** (0.001)	0.000 (0.000)	−0.002 (0.003)
Price R&D	−0.001 (0.001)	0.003** (0.001)	0.000 (0.000)	0.001 (0.001)	−0.003** (0.001)
Price intermediates	−0.036*** (0.009)	−0.021*** (0.003)	−0.002 (0.003)	−0.003** (0.001)	0.062*** (0.010)
Gross output	−0.043*** (0.007)	−0.018** (0.008)	−0.010*** (0.004)	0.001 (0.003)	0.069*** (0.012)
Offshoring	−0.144*** (0.029)	−0.145*** (0.028)	0.002 (0.009)	−0.028*** (0.010)	0.314*** (0.048)
Observations	5,634				

Notes: Standard errors in parentheses are clustered at the country-sector level. Year and country \times sector fixed effects are controlled for, but are not shown for brevity.

***Significant at 1%; **significant at 5%.

approach. Second, the calculation of ex post user costs assumes that the total value of capital services equals gross value added net of labor compensation, that is, the total capital compensation in the ex post approach is a residual. To the extent that the return to capital is contaminated with other factors such as profits²² in the underlying national accounts data, this may, in principle, have an impact on the ex post measure of the user costs of capital.

To address both concerns, we compute ex ante measures of the user costs of capital. First, the ex ante measure takes uncertainty confronting investors when assessing the profitability of investment projects into account. Second, the ex ante approach links rates of return directly to assets and is therefore less prone to picking up profits. Our main specification is based on time-varying sector-specific rates of return and expectation formation using out-of-sample forecasts from $AR(1)$ -models (Table 2).²³

Overall, the estimated coefficients from the specification using ex ante user costs of capital confirm the finding on the polarization of the demand for capital. Compared to the results

based on the ex post measure, it is worth noting that the offshoring coefficient on non-ICT capital is somewhat smaller (in absolute terms). In principle, this may be due to the methodological differences regarding the forward-looking nature of investment and measurement issues described above. On one hand, an additional estimation using asset-specific country \times sector time trends suggests that measurement issues in the ex post approach do not play a considerable role.²⁴ On the other hand, using a hybrid version of the user costs of capital, which includes forward-looking elements, but is still subject to potential measurement issues regarding capital services, yields an even larger offshoring coefficient on non-ICT (in absolute terms) than in the baseline specification (Table S5).²⁵ Overall, this suggests that we are not able to trace the source of the differences between the coefficient estimates in the ex post and the ex ante approach. Most importantly, however, our main result on the relationship between

22. For example, a recent literature has found evidence for rising profit margins and an increase in market concentration (e.g., Autor et al. 2017a, 2017b; De Loecker and Eeckhout 2017, 2018).

23. The results are qualitatively similar if expectations are modeled using $AR(2)$ -processes (Table S2) or exponential smoothing, which mimics the concept of adaptive expectations (Table S3).

24. Assume that for some types of assets (e.g., ICT or R&D capital), it is more likely that measured returns to capital are confounded with profits, and that this mismeasurement steadily increases over time. In such a scenario, the effects stemming from mismeasurement should be captured in the empirical analyses by including asset-specific country-sector time trends (Table S4). However, the results remain qualitatively unchanged, suggesting that potential mismeasurement issues have a negligible effect on our main result.

25. In the hybrid method (Oulton 2007), the rates of return are derived a priori and the prices are forecasted as in the ex ante method, except that the returns to capital sum to the observed capital compensation as in the ex post method.

TABLE 2
Ex Ante User Costs of Capital

	Factor Shares				
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates
Price labor	0.069*** (0.008)	−0.021*** (0.004)	−0.006** (0.003)	0.001 (0.002)	−0.044*** (0.008)
Price non-ICT	−0.021*** (0.004)	0.027*** (0.005)	0.004*** (0.001)	0.001 (0.001)	−0.011*** (0.003)
Price ICT	−0.006** (0.003)	0.004*** (0.001)	0.001 (0.002)	0.001 (0.001)	0.000 (0.003)
Price R&D	0.001 (0.002)	0.001 (0.001)	0.001 (0.001)	0.004** (0.002)	−0.007*** (0.002)
Price intermediates	−0.044*** (0.008)	−0.011*** (0.003)	0.000 (0.003)	−0.007*** (0.002)	0.061*** (0.010)
Gross output	−0.040*** (0.006)	−0.019** (0.008)	−0.014*** (0.004)	−0.001 (0.003)	0.074*** (0.011)
Offshoring	−0.145*** (0.031)	−0.093*** (0.022)	0.009 (0.007)	−0.023*** (0.008)	0.255*** (0.042)
Observations	5,545				

Notes: Ex ante user costs of capital were estimated based on time-varying sector-specific rates of return and expectations were obtained using out-of-sample forecasts from *AR*(1)-models (Section II.B). Standard errors in parentheses are clustered at the country-sector level. Year and country \times sector fixed effects are controlled for, but are not shown for brevity.

***Significant at 1%; **significant at 5%.

offshoring and the demand for capital by asset class remains fully intact. As before, offshoring significantly reduces the demand for non-ICT capital, while R&D capital is only mildly and ICT capital not significantly affected. We also find that offshoring has a negative effect on the demand for labor and a positive effect on the demand for intermediate inputs.

One shortcoming of the ex ante version of the user costs of capital above is that it abstracts from tax considerations. It can be argued that investors also take into account the expected effects of tax rebates or subsidies specific to particular assets when making investment decisions (e.g., Auerbach 1983). These may include, for instance, differences in the time profile of economic depreciation and the depreciation scheme relevant for taxation purposes. One simplistic and easy-to-implement approach to address differences in the tax treatments across countries and industries is to control for country \times year and sector \times year fixed effects (Table S6 for ex post user costs and Table S7 for ex ante user costs). An alternative and more sophisticated approach is based on a variant of ex ante user costs of capital in which the expected real rate of return was replaced by cost of capital estimates, that is, the required pretax real rate of return which an investment project has to yield in order to be profitable (Table S8). Data are sourced from Spengel, Elschner, and Endres (2012), who provide industry-specific cost of capital estimates for different asset classes across countries and time based on the Devereux

and Griffith methodology (Devereux and Griffith 1999, 2003) that explicitly takes into account tax considerations.²⁶ In all specifications, the effect of offshoring on the demand for capital by asset class remains qualitatively unchanged, suggesting that the differential tax treatment of capital assets is not spuriously driving our main results.

C. Discussion

Overall, we can draw the conclusion that offshoring has—similar to the demand for labor by skill type—a polarizing effect on the demand for capital by asset class.²⁷ Empirically, offshoring reduces the domestic demand for non-ICT capital, while ICT capital is not affected in a statistically significant way. In addition, the demand for R&D capital is also reduced by offshoring, albeit only to a moderate extent. While the size of the offshoring coefficients on non-ICT and R&D capital slightly differ across the various specifications—not least due to the uncertainty surrounding user costs estimates—the polarization result always persists.

Wage differentials are usually thought to be one of the main driving forces behind offshoring.

26. For studies that include the tax component in user cost estimates for the United States, see, for example, Gilchrist and Zakrajsek (2007), Chirinko and Wilson (2008), and Chanda and Panda (2016).

27. This result is robust to endogeneity concerns and a variety of methodological choices. Details are provided in Section V and the Supporting Information.

Therefore, a negative effect of offshoring on the labor share is to be expected. However, it is less clear why this should be the case for non-ICT capital. In principle, two channels are conceivable to explain the result on the polarization of the demand for capital.²⁸ First, offshoring is likely to take place if the resulting efficiency gains and cost savings outweigh the coordination and trade costs associated with the additional fragmentation of the production process (Feenstra and Hanson 1997; Grossman and Rossi-Hansberg 2008; Kohler 2004). The offshoring literature has so far typically abstracted from potential efficiency gains deriving from cross-country differences in the cost of capital. However, lower rental rates for non-ICT capital abroad may, in principle, bring about offshoring of non-ICT capital-intensive stages of production and could therefore rationalize our empirical findings.²⁹ Second, the offshoring-induced reduction in the relative demand for non-ICT capital observed in the data may reflect adjustments on the capital side to a changing labor intensity of domestic production due to capital-skill complementarities (Griliches 1969). Offshoring of labor-intensive stages of production can polarize the demand for capital if non-ICT capital is more complementary to labor than ICT capital; or, put differently, if the elasticity of substitution between non-ICT capital and labor is smaller than the corresponding elasticity between ICT capital and labor. The observed polarization of the demand for capital would then be a by-product of the cost savings on the labor side.

Additionally, it is noteworthy that we do not find a positive or negative association between offshoring and ICT in any of the specifications. At first glance, this result appears to be at odds with the existing literature on the relationship between ICT and offshoring, which tends to support the view that both are positively correlated.³⁰ It should be noted, however, that

comparing our results to the literature is somewhat complicated, as we estimate the effect of offshoring on different capital asset classes by employing relative factor demand equations. The latter gauge the composition effect of offshoring on different input factors. In contrast, studies focusing, for instance, on ICT investment additionally include scale effects of offshoring on output resulting from productivity gains associated with the reorganization of production (Amiti and Wei 2009; Grossman and Rossi-Hansberg 2008). Hence, were we to take these scale effects into account, the net impact on ICT and R&D investment associated with our estimation results may well be positive, given that the corresponding offshoring coefficients are close to zero.

Finally, our results also provide evidence that offshoring and R&D are mildly negatively associated.³¹ In this respect, the literature is somewhat inconclusive. For instance, Glass and Saggi (2001) analyze the effects of increased offshoring to a low-wage country and find that it creates greater incentives for innovation. While their results suggest that offshoring and expenditures on R&D should be positively correlated, offshoring and R&D may be either complements or substitutes depending on the degree of competition, the size of the market, and the specific type of R&D investment (Beladi, Marjit, and Yang 2012; Marjit and Mukherjee 2008). According to Marjit and Mukherjee (2008), R&D-reducing offshoring occurs, for instance, in industries with lower competition. Hence, the negative association between offshoring and R&D found in our empirical analyses may be linked to a limited degree of competition in the underlying markets. Note that this explanation would also be consistent with the recent literature that finds evidence for a decrease in competition (see, e.g., Autor et al. 2017a, 2017b; De Loecker and Eeckhout 2017, 2018).³²

28. We sketch these two channels in some more detail in the context of simple variants of the trade-in-tasks model by Grossman and Rossi-Hansberg (2008) in the working paper version of this article (Bursian and Nagengast 2018).

29. Whether or not the marginal product of capital is equalized across countries has been a matter of some debate (e.g., Banerjee and Duflo 2005; Caselli and Feyrer 2007). Credit frictions on international capital markets are proposed as one of the reasons that may hamper an efficient cross-country allocation of capital and, thus, may cause the marginal product of capital to differ across countries (e.g., Portes and Rey 2005; Reinhart and Rogoff 2004; Stulz 2005).

30. Abramovsky and Griffith (2006), for instance, show that more ICT-intensive firms in the United Kingdom are

more likely to offshore business services than less ICT-intensive firms. Broadly similar results for Germany are obtained by Rasel (2017), who also points toward a positive relationship between ICT and firms' offshoring decisions. However, note that the existing literature focuses on the other direction of causality than this article.

31. Note, however, that the results from an instrumental variable estimation (Section V.A) cast some doubt on the statistical significance of this association.

32. Furthermore, an alternative explanation relates to the composition of R&D. Beladi, Marjit, and Yang (2012) show that offshoring tends to be a substitute for process R&D, while it is a complement for product R&D.

V. ROBUSTNESS ANALYSES

A. Endogeneity Concerns

Drawing conclusions about a causal relationship between offshoring and factor demand can be challenging as time-varying shocks to technology or productivity within a certain sector can potentially affect both the relative demand for input factors and the returns to offshoring (and thus the extent of offshoring itself).³³ Hence, the simultaneity of offshoring and factor demand decisions might be a source of endogeneity. To address this issue, an instrument is needed that is correlated with offshoring decisions, but uncorrelated with the regression error term (i.e., only indirectly associated with factor demand via offshoring). In this section, we exploit the exogenous variation of the world export supply of intermediate inputs as predictors for changes in offshoring, a variant of which was proposed by Hummels et al. (2014). More specifically, for any country c that purchases intermediate inputs from foreign suppliers, the world export supply, wes_{ijt}^c , is defined as country i 's exports of sector j to the world market (excluding exports to country c) in period t , EX_{ijt}^c , relative to the exports from all countries (excluding country c):

$$wes_{ijt}^c = \frac{EX_{ijt}^c}{\sum_{i \neq c} EX_{ijt}^c}.$$

Consequently, wes_{ijt}^c is a measure of world export market shares capturing changes in the comparative advantage of a particular supplier, for example, related to changes in prices, quality, or technology. To obtain an instrument with country-sector-time variation for sector s in country c , I_{cst} , we aggregate wes_{ijt}^c using the presample (i.e., 1995) share of imported intermediates, φ_{csij} , sourced from sector j in country i in total imported intermediates:

$$I_{cst} = \sum_{i \neq c} \sum_j^s \varphi_{csij} wes_{ijt}^c.$$

The regional and industrial sourcing structure of a given sector is fairly constant over time, allowing us to use fixed presample weights of the imported intermediates in constructing our instrument. As a result, our estimates are unaffected by shocks that may affect both

import composition and subsequent offshoring decisions. The resulting instrument is exogenous to the domestic sectors in our dataset, while it contains rich variation across offshoring destinations and sectors given the existing differences in their sourcing structure.

The results from a two-stage least squares (2SLS) instrumental variable estimation of our baseline specification are shown in Table 3.³⁴ The F -statistic on excluded instruments in the first stage is well above 10, suggesting that our instrument is sufficiently strongly correlated with offshoring and that the 2SLS estimation does not suffer from weak instruments (Stock, Wright, and Yogo 2002). Similar to the results in Section IV, offshoring has a negative impact on labor demand and a positive impact on the demand for intermediates, as expected. Furthermore, offshoring reduces the demand for non-ICT capital, while ICT capital is not affected in a statistically significant way. In contrast to the baseline results, we find no statistically significant effect of offshoring on the demand for R&D capital. While the size of the coefficients is larger than in the baseline specification, the 2SLS estimates are economically plausible. An exogenous increase in the offshoring measure by 1 percentage point is associated with a decrease in value added over gross output by around 1 percentage point and a corresponding increase in the intermediate share of production by the same magnitude.³⁵ This is what one would expect if the increase in imported intermediates derived exclusively from offshoring value added of a given sector, while leaving the share of intermediates sourced from domestic suppliers unaffected.

For the instrument to satisfy the exclusion restriction, unobservable technology and productivity shocks in trade partners used to construct the world export supply variable should not be correlated with shocks in the offshoring countries in our dataset. To evaluate the robustness of our results to the potential presence of, for instance, regional shocks, we exclude certain

34. The corresponding first-stage results can be found in Table A6. Note that the 2SLS results in Table 3 were obtained using separate regressions for each factor share without imposing cross-equation constraints. For better comparability with the baseline results, we report the coefficients for the baseline estimated with OLS and without cross-equation constraints in Table S9.

35. The offshoring effect on value added over gross output corresponds to the sum of the offshoring coefficients in the share equations for labor, non-ICT, ICT, and R&D. The resulting coefficient and the offshoring coefficient in the share equation for intermediates are statistically indistinguishable from -1 and 1 , respectively.

33. For example, investment in ICT capital is thought to reduce communication costs and hence increase offshoring (Abramovsky and Griffith 2006; Baldwin 2016).

TABLE 3
Instrumental Variable Approach

	Factor Shares				
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates
Price labor	0.093*** (0.015)	-0.017 (0.018)	0.006 (0.005)	0.012** (0.006)	-0.093*** (0.022)
Price non-ICT	-0.032*** (0.006)	0.032*** (0.007)	0.004** (0.002)	0.005** (0.002)	-0.011 (0.007)
Price ICT	-0.008** (0.004)	0.002 (0.004)	0.004*** (0.001)	0.000 (0.001)	0.002 (0.005)
Price R&D	-0.001 (0.002)	0.002 (0.002)	0.000 (0.000)	0.001 (0.001)	-0.002 (0.002)
Price intermediates	0.021 (0.026)	0.037 (0.034)	0.004 (0.010)	-0.021** (0.010)	-0.038 (0.040)
Gross output	-0.038*** (0.008)	-0.013 (0.009)	-0.009*** (0.003)	-0.001 (0.003)	0.060*** (0.014)
Offshoring	-0.674** (0.281)	-0.717** (0.360)	-0.019 (0.098)	0.112 (0.102)	1.273*** (0.428)
Observations	5,634				
F-statistic	14.385				

Notes: The table presents estimates from a two-stage least squares (2SLS) regression in which world export supply is used as an instrument for offshoring. The *F*-statistic refers to the test for significance of the coefficients on the instrument in the first-stage regression. Standard errors in parentheses are clustered at the country-sector level. Year and country \times sector fixed effects are controlled for, but are not shown for brevity.

***Significant at 1%; **significant at 5%.

countries when calculating wes_{ijt}^c and I_{cst} for an additional instrumental variable estimation. Specifically, we exclude all countries belonging to the European Union for Austria, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, and the United Kingdom, while we exclude Canada and Mexico for the United States.³⁶ The results from this additional 2SLS regression are shown in Table S10 and the corresponding first-stage results in Table S11. The use of the restricted instrument group leaves the 2SLS results by and large unaffected, suggesting that the effect of correlated shocks across countries is negligible.

Overall, instrumenting for offshoring using variations in the comparative advantage of offshoring destinations confirms our main results on the offshoring-induced polarization of the demand for capital by asset class. The 2SLS estimates cast some doubt on the results on the offshoring coefficient on R&D capital, which is not statistically different from zero once endogeneity concerns are addressed. All things considered, endogeneity issues do not seem to be of major concern for the main conclusions of our empirical analysis.

36. This is similar to the identification strategy used by Autor, Dorn, and Hanson (2013), who instrument U.S. imports from China by Chinese exports to other high-income countries. See also Dauth, Findeisen, and Suedekum (2014) and Bloom, Draca, and Van Reenen (2016).

B. Sluggish Adjustment of Input Factors

The baseline analysis assumes that all input factors can adjust to their respective cost-minimizing levels in the short-run conditional on the level of output. Or, put differently, the observed time series used for the estimation can be thought of as representing the equilibrium paths of the variables of interest. In this section, we assess whether this assumption is crucial for obtaining the main result by resorting to a data-driven approach for dynamic adjustment that allows for long-run (i.e., equilibrium) and short-run (i.e., off-equilibrium) dynamics of the factor inputs.

The observed input quantities may depart from their equilibrium values for a variety of reasons such as regulatory restrictions or costs of adjustment (Chirinko 1993). In what follows, we are agnostic regarding the specific factors for off-equilibrium behavior in the short run and let the data pin down the dynamics without imposing overly strong restrictions on the nature of the adjustment process *ex ante*.

In the most general form, the system of long-run (static) share equations for a generic country can be expressed in matrix notation as

$$(4) \quad M_t = BX_t,$$

where $M_t = (S_{1,t}, \dots, S_{N,t})'$, $X_t = (1, p_{1,Q}, \dots, p_{N,Q}, Z_1, \dots, Z_z, Y_t)'$, and B is a $N \times N + z + 2$ coefficient matrix. According to Anderson and

Blundell (1982), a first-order dynamic version of (4) is then given by

$$(5) \quad \Delta M_t = A\Delta\tilde{X}_t - C[M_{t-1} - BX_{t-1}] + \varepsilon_t,$$

where ε_t denotes a vector of error terms. A , B , and C are coefficient matrices conformable with the dimensions of M_t , X_t , and \tilde{X}_t . Note that \tilde{X}_t is identical to X_t except for the constant term which is excluded in \tilde{X}_t . This and similar dynamic models have sometimes been applied in empirical research in the context of factor share analyses (e.g., Friesen 1992; Holly and Smith 1989). While the short-run adjustment process is governed by the coefficient matrices A and C , the long-run coefficient matrix is given by B . As in the static case, the system of dynamic share equations is singular as the column sum of M_t equals unity by construction. One equation has thus to be deleted in order to obtain an estimable form of Equation (5), which is equivalent to deleting one element in M_t and the rows corresponding to the deleted element in B and C . An estimable form then reads

$$(6) \quad \Delta M_t^* = A^*\Delta\tilde{X}_t - C^*[M_{t-1}^* - B^*X_{t-1}] + \varepsilon_t^*,$$

where asterisks denote vectors (matrices) with one element (row) deleted. The coefficients governing the short-run adjustment cannot be recovered (Anderson and Blundell 1982). The long-run (static) coefficients in B —which we are interested in—are, however, identified. Due to the curse of dimensionality and data limitations, we estimate a first-order process as was done in previous applied work.

The choice of the specific econometric estimator used in such a dynamic setting is not obvious. When a static translog function is considered as in Section IV, pooled and mean group estimators are both consistent and yield unbiased estimates of the coefficient means (see Zellner 1969, among others).³⁷ This rests on the assumptions that the regressors are strictly exogenous and that the coefficients differ randomly and are also distributed independently of the regressors across groups. In the dynamic case that is considered here, however, a pooled estimator can yield biased results as highlighted by Pesaran and Smith (1995).³⁸ Therefore, we

consider the mean group estimator—which is consistent even in dynamic settings—for the analyses using the dynamic translog function. The mean group estimator involves, first, estimating individual regressions for each country and, second, averaging the estimated coefficients across countries.

The unweighted averages of the long-run parameter estimates from B are shown in Table 4.³⁹ As before, offshoring has a positive impact on the demand for intermediates, while the offshoring coefficient for labor is still negative, but no longer statistically significant. More importantly, offshoring still has a negative effect on the demand for non-ICT capital, a weakly negative impact on R&D capital, and no significant effect on ICT capital. Overall, we conclude that the main result concerning offshoring and its polarizing effect on the demand for capital remains unchanged when allowing for a sluggish adjustment of the input factors to their long-run levels.

C. Further Robustness Analyses

In this section, we assess the robustness of our main result by estimating a range of different specifications and using alternative measures of offshoring. First, one concern is that offshoring and the year fixed effects included in our baseline specification do not fully capture the effects of technological change, such that our results would suffer from an omitted variable bias. To control for this, we additionally include four commonly used proxies for technological change: R&D intensity⁴⁰, the ICT capital stock⁴¹, country-sector time trends (Foster-McGregor, Stehrer, and de Vries 2013), and a Solow residual⁴² (Table S12–S15). Second, estimating the system of equations given by Equation (2) in a panel setting assumes that the same cost function

averages of the estimated micro-parameters and their standard errors calculated explicitly” (page 102).

39. Estimated coefficients in A^* and C^* are omitted for brevity. Results stem from a translog cost function without imposing symmetry and homogeneity.

40. R&D intensity is defined as the nominal gross-fixed capital formation for research and development over gross output and varies over time at the country-sector level (Hijzen, Görg, and Hine 2005; Machin and Van Reenen 1998).

41. The variable for the ICT capital stock is defined as the nominal ICT capital stock over value added and varies over time at the country-sector level.

42. The Solow residual is derived using country-sector production functions with time-varying capital and labor shares corresponding to their empirical values.

37. As expected, our baseline results in Section IV are qualitatively and, in general, quantitatively the same when a mean group estimator (Pesaran and Smith 1995) is applied.

38. The authors conclude that “(t)he lesson for applied work is that when large T panels are available, the individual micro-relations should be estimated separately and the

TABLE 4
Dynamic Translog

	Factor Shares				
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates
Price labor	0.063*** (0.022)	−0.012 (0.022)	−0.005 (0.009)	0.028** (0.013)	−0.075** (0.033)
Price non-ICT	0.009 (0.014)	0.051*** (0.009)	−0.005 (0.004)	−0.001 (0.005)	−0.055*** (0.017)
Price ICT	−0.020* (0.011)	0.029*** (0.009)	0.015*** (0.004)	0.000 (0.004)	−0.026** (0.013)
Price R&D	−0.020 (0.023)	−0.003 (0.014)	0.009 (0.006)	0.012 (0.008)	0.003 (0.025)
Price intermediates	−0.036** (0.018)	−0.018 (0.014)	0.001 (0.004)	−0.006 (0.006)	0.054** (0.022)
Gross output	−0.044*** (0.013)	−0.015* (0.008)	−0.010*** (0.003)	−0.008 (0.005)	0.078*** (0.016)
Offshoring	−0.051 (0.075)	−0.162*** (0.060)	0.003 (0.018)	−0.054* (0.032)	0.276*** (0.102)
Observations	5,303				

Notes: The table presents mean group estimates in line with Pesaran and Smith (1995). Unweighted averages of the long-run coefficient estimates (i.e., the elements of the matrix B obtained using country-specific regressions) are shown. Standard errors in parentheses correspond to the linear combination of the individual coefficient estimates and are clustered at the sector level. Year and sector fixed effects are controlled for at the country level, but are not shown for brevity.

***Significant at 1%; **significant at 5%; *significant at 10%.

applies across sectors. In order to allow for sectoral heterogeneity, we estimate two separate regressions for the manufacturing and services sectors, respectively (Table S16). Third, as an additional robustness test we also estimate a specification that excludes mining and quarrying, real estate activities, and sectors dominated by nonmarket activities due to their idiosyncratic characteristics (Table S16). Fourth, it has been argued that the expansion of cross-border production networks may have slowed since the onset of the global financial crisis (Hoekman 2015). To assess whether our main result varies over time, we perform a sample split and run separate regressions for pre- and postcrisis samples (Table S16). Fifth, previous studies have sometimes estimated the system of share equations in first differences (Foster-McGregor, Stehrer, and de Vries 2013), or even in long differences to smooth out measurement error (Michaels, Natraj, and Van Reenen 2014). Accordingly, we provide coefficients from estimations in annual differences (Table S17) and differences between values in 2014 and 2000 (Table S18). Sixth, Feenstra and Hanson (1999) distinguish between narrow and broad offshoring, with the former referring to the share of imported intermediates originating from the same sector as the offshoring sector, and the latter to the share of imported intermediates originating from all sectors other than the offshoring sector (Table S19).

In addition, some studies (e.g., Hijzen, Görg, and Hine 2005) define offshoring as the share of imported intermediates relative to value added instead of gross output (Table S19). Seventh, given that certain types of assets are unlikely to be subject to offshoring, we report estimates from a setup in which dwellings were omitted when computing user costs of capital and the real estate sector was excluded in the estimation (Table S20). Finally, we estimate a specification in which we use price-adjusted ex post user costs instead of ex post user costs in nominal terms as in the baseline specification (Table S21). Tables S12–S21 show that all alternative specifications leave the coefficients on offshoring by and large unchanged in terms of significance and sign. Although the size of the coefficients varies slightly, we maintain a highly significant and negative effect of offshoring on the demand for non-ICT capital, while offshoring has no statistically significant effect on the demand for ICT and only a rather small negative impact on the demand for R&D capital.

VI. CONCLUDING REMARKS

In this paper, we examine the effect of offshoring on the demand for capital by asset class using a rich dataset spanning information on 11 advanced economies and 32 sectors across

20 years. Our paper differs from the existing literature by providing a comprehensive analysis of the offshoring-induced effects on the capital side, while previous work has focused on the impact of offshoring on the skill structure of labor demand. Estimating a system of factor demand equations, we document that offshoring has a polarizing effect on the demand for capital. While non-ICT capital is squeezed by offshoring, this is less or not the case for R&D and ICT capital. These results are robust against a wide range of different specifications and methodological choices including an instrumental variable approach to address endogeneity concerns. Hence, offshoring

is—along with technological change—one factor behind the structural change in the composition of the demand for capital observed in advanced economies (Bassanini and Scarpetta 2002; Colecchia and Schreyer 2002; Corrado, Hulten, and Sichel 2009). Potential explanations for the polarizing effect of offshoring on the demand for capital by asset class include (1) the direct offshoring of capital-intensive stages of production and (2) capital-labor complementarities. While we sketch two conceivable channels for the heterogeneous effect of offshoring on the demand for different asset classes, more work in this area is a useful direction for future research.

APPENDIX

TABLE A1
Sectors in EU KLEMS

Code	Sector	Type
A	Agriculture, forestry, and fishing	<i>M</i>
B	Mining and quarrying	<i>M</i>
10-12	Food products, beverages, and tobacco	<i>M</i>
13-15	Textiles, wearing apparel, leather, and related products	<i>M</i>
16-18	Wood and paper products; printing and reproduction of recorded media	<i>M</i>
19	Coke and refined petroleum products	<i>M</i>
20-21	Chemicals and chemical products	<i>M</i>
22-23	Rubber and plastics products, and other nonmetallic mineral products	<i>M</i>
24-25	Basic metals and fabricated metal products, except machinery and equipment	<i>M</i>
26-27	Electrical and optical equipment	<i>M</i>
28	Machinery and equipment n.e.c.	<i>M</i>
29-30	Transport equipment	<i>M</i>
31-33	Other manufacturing; repair and installation of machinery and equipment	<i>M</i>
D-E	Electricity, gas, and water supply	<i>S</i>
F	Construction	<i>S</i>
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	<i>S</i>
46	Wholesale trade, except motor vehicles and motorcycles	<i>S</i>
47	Retail trade, except motor vehicles and motorcycles	<i>S</i>
49-52	Transport and storage	<i>S</i>
53	Postal and courier activities	<i>S</i>
I	Accommodation and food service activities	<i>S</i>
58-60	Publishing, audiovisual and broadcasting activities	<i>S</i>
61	Telecommunications	<i>S</i>
62-63	IT and other information services	<i>S</i>
K	Financial and insurance activities	<i>S</i>
L	Real estate activities	<i>S</i>
M-N	Professional, scientific, technical, administrative, and support service activities	<i>S</i>
O	Public administration and defense; compulsory social security	<i>S</i>
P	Education	<i>S</i>
Q	Health and social work	<i>S</i>
R	Arts, entertainment and recreation	<i>S</i>
S	Other service activities	<i>S</i>

Notes: Manufacturing (*M*) and services (*S*).

TABLE A2
Correspondence between Sectors in WIOD (Release 2016) and EU KLEMS

WIOD		EUKLEMS	
Code	Sector	Code	Sector
A01	Crop and animal production, hunting, and related service activities	A	Agriculture, forestry, and fishing
A02	Forestry and logging	A	Agriculture, forestry, and fishing
A03	Fishing and aquaculture	A	Agriculture, forestry, and fishing
B	Mining and quarrying	B	Mining and quarrying
C10-C12	Manufacture of food products, beverages, and tobacco products	10-12	Food products, beverages, and tobacco
C13-C15	Manufacture of textiles, wearing apparel, and leather products	13-15	Textiles, wearing apparel, leather, and related products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	16-18	Wood and paper products; printing and reproduction of recorded media
C17	Manufacture of paper and paper products	16-18	Wood and paper products; printing and reproduction of recorded media
C18	Printing and reproduction of recorded media	16-18	Wood and paper products; printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products	19	Coke and refined petroleum products
C20	Manufacture of chemicals and chemical products	20-21	Chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	20-21	Chemicals and chemical products
C22	Manufacture of rubber and plastic products	22-23	Rubber and plastics products, and other nonmetallic mineral products
C23	Manufacture of other nonmetallic mineral products	22-23	Rubber and plastics products, and other nonmetallic mineral products
C24	Manufacture of basic metals	24-25	Basic metals and fabricated metal products, except machinery and equipment
C25	Manufacture of fabricated metal products, except machinery and equipment	24-25	Basic metals and fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products	26-27	Electrical and optical equipment
C27	Manufacture of electrical equipment	26-27	Electrical and optical equipment
C28	Manufacture of machinery and equipment n.e.c.	28	Machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers, and semitrailers	29-30	Transport equipment
C30	Manufacture of other transport equipment	29-30	Transport equipment
C31-C32	Manufacture of furniture; other manufacturing	31-33	Other manufacturing; repair and installation of machinery and equipment
C33	Repair and installation of machinery and equipment	31-33	Other manufacturing; repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply	D-E	Electricity, gas and water supply
E36	Water collection, treatment, and supply	D-E	Electricity, gas, and water supply
E37-E39	Sewage; waste collection, treatment, and disposal activities; materials recovery; remediation activities and other waste management services	D-E	Electricity, gas, and water supply
F	Construction	F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except motor vehicles and motorcycles	46	Wholesale trade, except motor vehicles and motorcycles
G47	Retail trade, except motor vehicles and motorcycles	47	Retail trade, except motor vehicles and motorcycles
H49	Land transport and transport via pipelines	49-52	Transport and storage
H50	Water transport	49-52	Transport and storage
H51	Air transport	49-52	Transport and storage
H52	Warehousing and support activities for transportation	49-52	Transport and storage
H53	Postal and courier activities	53	Postal and courier activities
I	Accommodation and food service activities	I	Accommodation and food service activities
J58	Publishing activities	58-60	Publishing, audiovisual, and broadcasting activities

TABLE A2
Continued

WIOD		EUKLEMS	
Code	Sector	Code	Sector
J59-J60	Motion picture, video and television program production, sound recording, and music publishing activities; programming and broadcasting activities	58-60	Publishing, audiovisual, and broadcasting activities
J61	Telecommunications	61	Telecommunications
J62-J63	Computer programming, consultancy and related activities; information service activities	62-63	IT and other information services
K64	Financial service activities, except insurance and pension funding	K	Financial and insurance activities
K65	Insurance, reinsurance, and pension funding, except compulsory social security	K	Financial and insurance activities
K66	Activities auxiliary to financial services and insurance activities	K	Financial and insurance activities
L68	Real estate activities	L	Real estate activities
M69-M70	Legal and accounting activities; activities of head offices; management consultancy activities	M-N	Professional, scientific, technical, administrative, and support service activities
M71	Architectural and engineering activities; technical testing and analysis	M-N	Professional, scientific, technical, administrative, and support service activities
M72	Scientific research and development	M-N	Professional, scientific, technical, administrative, and support service activities
M73	Advertising and market research	M-N	Professional, scientific, technical, administrative, and support service activities
M74-M75	Other professional, scientific, and technical activities; veterinary activities	M-N	Professional, scientific, technical, administrative, and support service activities
N	Administrative and support service activities	M-N	Professional, scientific, technical, administrative, and support service activities
O64	Public administration and defense; compulsory social security	O	Public administration and defense; compulsory social security
P85	Education	P	Education
Q	Human health and social work activities	Q	Health and social work
R-S	Other service activities	R	Arts, entertainment and recreation
R-S	Other service activities	S	Other service activities

Notes: In case of multiple correspondences, the data was either (a) aggregated across WIOD subsectors to match those of EU KLEMS or (b) the same values for WIOD variables were imputed in EU KLEMS subsectors.

TABLE A3
Correspondence between Sectors in WIOD (Release 2013) and EU KLEMS

WIOD		EUKLEMS	
Code	Sector	Code	Sector
AtB	Agriculture, hunting, forestry, and fishing	A	Agriculture, forestry, and fishing
C	Mining and quarrying	B	Mining and quarrying
15t16	Food, beverages, and tobacco	10-12	Food products, beverages, and tobacco
17t18	Textiles and textile products	13-15	Textiles, wearing apparel, leather, and related products
19	Leather, leather, and footwear	13-15	Textiles, wearing apparel, leather, and related products
20	Wood and products of wood and cork	16-18	Wood and paper products; printing and reproduction of recorded media
21t22	Pulp, paper, paper, printing, and publishing	16-18	Wood and paper products; printing and reproduction of recorded media
23	Coke, refined petroleum, and nuclear fuel	19	Coke and refined petroleum products
24	Chemicals and chemical products	20-21	Chemicals and chemical products
25	Rubber and plastics	22-23	Rubber and plastics products, and other nonmetallic mineral products
26	Other nonmetallic mineral	22-23	Rubber and plastics products, and other nonmetallic mineral products
27t28	Basic metals and fabricated metal	24-25	Basic metals and fabricated metal products, except machinery and equipment
30t33	Electrical and optical equipment	26-27	Electrical and optical equipment
29	Machinery, n.e.c.	28	Machinery and equipment n.e.c.
34t35	Transport equipment	29-30	Transport equipment
36t37	Manufacturing, n.e.c.; recycling	31-33	Other manufacturing; repair and installation of machinery and equipment
E	Electricity, gas, and water supply	D-E	Electricity, gas, and water supply
F	Construction	F	Construction
50	Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
51	Wholesale trade and commission trade, except motor vehicles and motorcycles	46	Wholesale trade, except motor vehicles and motorcycles
52	Retail trade, except motor vehicles and motorcycles; repair of household goods	47	Retail trade, except motor vehicles and motorcycles
60	Inland transport	49-52	Transport and storage
61	Water transport	49-52	Transport and storage
62	Air transport	49-52	Transport and storage
63	Other supporting and auxiliary transport activities; activities of travel agencies	49-52	Transport and storage
64	Post and telecommunications	53	Postal and courier activities
H	Hotels and restaurants	I	Accommodation and food service activities
64	Post and telecommunications	58-60	Publishing, audiovisual and broadcasting activities
64	Post and telecommunications	61	Telecommunications
64	Post and telecommunications	62-63	IT and other information services
J	Financial intermediation	K	Financial and insurance activities
70	Real estate activities	L	Real estate activities
71t74	Renting of M&Eq and other business activities	L	Real estate activities
O	Other community, social, and personal services	M-N	Professional, scientific, technical, administrative, and support service activities
L	Public admin and defense; compulsory social security	O	Public administration and defense; compulsory social security
M	Education	P	Education
N	Health and social work	Q	Health and social work
O	Other community, social, and personal services	R	Arts, entertainment, and recreation
O	Other community, social, and personal services	S	Other service activities

Notes: In case of multiple correspondences, the data was either (a) aggregated across WIOD subsectors to match those of EU KLEMS or (b) the same values for WIOD variables were imputed in EU KLEMS subsectors.

TABLE A4
Summary Statistics by Country

Factor Shares/Offshoring in 2000 (in %)						
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates	Offshoring
Austria	33.4	16.2	1.7	1.5	47.2	12.1
Denmark	32.5	15.4	1.9	1.6	48.3	13.4
Finland	28.8	13.9	1.1	2.6	53.4	10.2
France	31.6	14.6	2.2	2.3	49.3	9.1
Germany	33.1	13.2	2.2	1.9	49.4	9.1
Italy	25.8	16.7	1.8	0.9	54.7	7.7
Netherlands	31.6	12.4	1.4	1.5	52.9	13.2
Spain	27.9	15.9	2.0	0.9	53.2	10.8
Sweden	27.3	15.9	2.9	3.3	50.6	11.8
United Kingdom	32.9	17.0	1.6	0.5	47.6	7.3
United States	33.9	17.2	2.3	1.6	44.6	3.5
Mean	30.8	15.3	1.9	1.7	50.1	9.9

Changes in Factor Shares/Offshoring 2000–2014 (in PP)						
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates	Offshoring
Austria	−3.0	−2.3	0.2	0.4	4.7	3.6
Denmark	−1.7	−2.5	0.1	0.9	3.2	4.1
Finland	−1.7	−2.3	0.1	0.5	3.4	4.0
France	0.4	−1.4	−0.2	−0.6	1.8	2.4
Germany	−2.6	1.0	−0.8	0.7	1.7	3.4
Italy	1.4	−1.8	−0.4	0.1	0.8	1.6
Netherlands	−0.7	−1.3	0.3	−0.2	1.9	6.6
Spain	−2.0	−0.2	−0.2	0.5	1.8	0.5
Sweden	0.5	−0.6	−0.4	0.5	−0.1	0.5
United Kingdom	−0.6	−1.1	−0.0	0.1	1.7	1.4
United States	−2.2	1.9	−0.1	0.4	−0.1	0.9
Mean	−1.1	−1.0	−0.1	0.3	1.9	2.6

Annual Price Changes 2000–2014 (in %)					
	Labor	Non-ICT Capital	ICT Capital	R&D Capital	Intermediates
Austria	2.9	1.2	−0.0	0.9	1.9
Denmark	3.2	0.6	−2.7	3.1	1.7
Finland	3.0	−0.3	−6.2	3.2	1.8
France	2.8	−1.8	−1.7	−0.2	1.7
Germany	1.9	3.6	−9.0	2.9	1.1
Italy	2.5	−0.5	−0.6	−0.8	2.3
Netherlands	2.7	0.5	−6.3	1.8	1.8
Spain	2.6	0.9	−5.9	0.5	2.1
Sweden	3.5	0.7	−4.1	1.7	2.1
United Kingdom	3.2	2.0	−2.6	2.4	1.9
United States	3.1	2.0	−5.7	2.2	2.5
Mean	2.9	0.8	−4.1	1.6	1.9

Notes: Country values are weighted averages by each sector's share in gross output. "Mean" refers to the unweighted average across countries. "PP" refers to percentage points.

TABLE A5
Summary Statistics by Sector

	Factor Shares/ Offshoring in 2000 (in %)				Changes in Factor Shares/ Offshoring 2000–2014 (in PP)				Annual Price Changes 2000–2014 (in %)								
	Labor	Non- ICT	ICT	R&D	Int.	Off- shoring	Labor	Non- ICT	ICT	R&D	Int.	Off- shoring	Labor	Non- ICT	ICT	R&D	Int.
Agriculture, forestry, and fishing	38.2	12.7	0.3	0.1	48.6	7.9	-5.5	-1.3	-0.0	-0.0	6.9	4.0	2.7	2.2	-5.4	2.1	3.0
Mining and quarrying	18.0	32.7	1.0	0.7	44.0	9.3	-2.4	1.2	-0.1	0.2	1.0	2.5	3.6	0.3	-4.2	2.3	2.5
Food products, beverages, and tobacco	16.3	9.5	0.8	0.5	72.8	9.8	-2.0	-1.4	-0.2	0.2	3.4	4.5	2.7	0.9	-4.5	1.7	2.1
Textiles, wearing apparel, leather, and related products	25.7	7.0	0.7	0.5	66.1	20.6	-0.3	-0.8	0.0	0.4	0.6	8.9	3.4	0.4	-4.2	1.9	1.5
Wood and paper products; printing and reproduction of recorded media	22.9	10.9	1.5	0.5	64.3	14.6	-1.4	-3.6	-0.5	0.3	5.2	3.4	2.6	-1.4	-4.9	0.6	1.5
Coke and refined petroleum products	3.8	7.2	0.6	0.8	87.6	41.5	-1.4	-4.3	-0.4	-0.6	6.6	13.0	3.5	-3.5	-8.0	-3.1	6.2
Chemicals and chemical products	16.1	11.8	1.1	7.0	64.0	19.3	-2.6	-2.7	-0.1	2.8	2.7	8.6	3.4	0.8	-3.5	2.2	2.4
Rubber and plastics products, and other nonmetallic mineral products	25.6	11.5	1.0	1.3	60.6	16.4	-2.7	-2.9	-0.1	0.5	5.2	5.9	2.8	-0.5	-4.4	1.0	2.2
Basic metals and fabricated metal products, except machinery and equipment	25.2	9.1	1.0	0.9	63.8	18.9	-3.5	-1.6	-0.2	0.1	5.2	5.5	2.8	0.4	-4.3	1.5	2.6
Electrical and optical equipment	19.9	6.4	2.2	7.9	63.6	21.7	3.2	-1.4	-0.2	2.8	-4.3	5.4	3.2	-2.2	-4.9	-0.3	-0.0
Machinery and equipment n.e.c.	24.6	7.2	1.4	3.0	63.8	18.2	-2.3	-0.5	-0.1	2.0	0.8	6.1	3.2	1.5	-3.2	2.4	1.4
Transport equipment	18.1	5.3	1.0	3.6	72.0	24.8	-1.8	-0.1	-0.1	0.9	1.0	6.0	3.4	0.3	-2.4	2.1	1.2
Other manufacturing; repair and installation of machinery and equipment	32.3	7.1	1.1	2.0	57.4	14.6	-1.0	0.6	0.2	0.7	-0.4	3.1	3.1	2.2	-3.0	2.8	1.5
Electricity, gas, and water supply	15.4	27.4	1.6	0.9	54.7	11.5	-2.4	-2.8	-0.0	-0.5	5.8	2.2	2.8	1.3	-3.8	1.5	3.0
Construction	32.9	7.7	0.4	0.1	58.9	9.9	0.5	-0.7	0.0	-0.0	0.2	2.0	2.9	0.8	-3.6	2.1	2.2
Wholesale and retail trade and repair of motor vehicles and motorcycles	40.2	12.1	1.1	0.1	46.5	10.9	1.2	0.2	-0.1	0.0	-1.3	2.0	3.7	1.3	-2.5	4.2	1.7
Wholesale trade, except motor vehicles and motorcycles	36.0	16.3	3.3	1.0	43.4	6.3	-2.1	1.7	0.2	0.3	-0.1	1.7	3.0	3.6	-2.0	4.3	1.8
Retail trade, except motor vehicles and motorcycles	48.1	14.3	2.5	0.1	35.1	3.9	-4.3	-0.3	-0.4	0.0	5.0	1.3	3.1	2.1	-3.4	3.4	1.8
Transport and storage	30.8	14.3	1.6	0.1	53.2	12.3	-3.7	-1.4	-0.7	0.0	5.7	3.8	3.0	1.0	-3.8	1.6	2.2
Postal and courier activities	53.3	5.5	2.0	0.3	38.9	4.7	-10.4	-0.9	-0.6	0.1	11.8	3.4	3.5	2.1	-0.9	1.9	0.8
Accommodation and food service activities	37.3	12.4	0.8	0.0	49.4	4.6	1.6	-1.6	-0.2	0.0	0.2	1.7	2.5	0.8	-4.7	0.3	2.0
Publishing, audiovisual and broadcasting activities	26.6	10.1	4.9	0.8	53.4	6.4	1.4	-1.2	0.7	0.6	-1.2	0.9	2.5	-0.4	-3.5	0.9	1.2
Telecommunications	18.6	18.5	10.2	1.2	51.4	7.7	-2.5	-0.2	-0.5	0.6	2.6	2.7	3.0	0.1	-3.2	1.6	-0.6
IT and other information services	45.0	3.1	6.8	1.4	43.6	5.9	-2.5	0.9	0.8	0.8	-0.0	1.7	2.9	2.5	-2.0	4.2	1.0
Financial and insurance activities	32.2	15.5	5.8	0.4	46.0	3.5	-2.8	1.4	0.6	0.7	0.0	0.4	3.0	4.1	-2.1	3.8	1.1
Real estate activities	5.1	67.9	0.2	0.0	26.8	1.8	-0.2	-1.7	0.1	-0.0	1.8	0.1	2.3	1.8	-4.3	0.9	2.6
Professional, scientific, technical, administrative, and support service activities	40.3	9.4	3.3	2.8	44.2	5.8	3.0	-2.0	-0.9	-0.1	0.1	1.3	2.6	-1.4	-5.4	0.2	1.5
Public administration and defense; compulsory social security	50.3	13.2	2.0	1.4	33.0	4.8	-2.4	0.7	-0.3	0.0	2.0	-0.2	3.2	0.4	-4.1	1.9	1.9
Education	68.3	4.2	1.2	4.6	21.7	1.8	-1.5	-0.3	-0.1	0.2	1.6	0.5	2.7	0.9	-4.5	1.5	2.0
Health and social work	59.5	8.2	0.9	0.7	30.8	4.4	-2.4	-0.5	-0.0	-0.1	3.0	1.9	2.7	1.1	-4.3	2.2	1.6
Arts, entertainment, and recreation	40.0	12.0	1.9	1.0	43.8	4.6	-0.7	-0.5	-0.5	-0.1	1.9	0.9	2.4	0.7	-4.8	1.8	1.9
Other service activities	49.1	10.8	1.6	0.5	38.0	4.5	4.5	-3.2	-0.6	-0.1	-0.6	0.8	3.2	-1.4	-5.0	-0.6	1.6

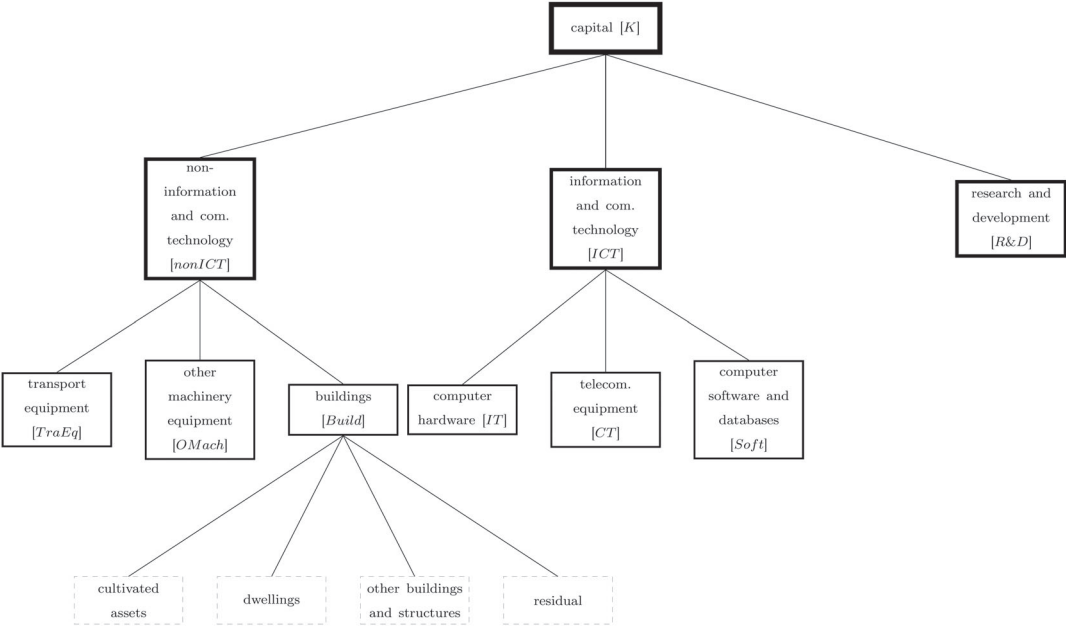
Notes: Sector values are unweighted averages across countries. "PP" refers to percentage points and "Int." to intermediates.

TABLE A6
First-Stage Results of 2SLS Regression (Table 3)

	Offshoring
Price labor	−0.002 (0.016)
Price non-ICT	−0.014*** (0.004)
Price ICT	−0.004 (0.004)
Price R&D	−0.000 (0.001)
Price intermediates	0.075*** (0.023)
Gross output	0.010 (0.010)
World export supply	0.772*** (0.204)
Observations	5,634
F-statistic	14.385

Notes: Standard errors in parentheses are clustered at the country-sector level. Year and country \times sector fixed effects are controlled for, but are not shown for brevity.
***Significant at 1%.

FIGURE A1
Classification of Fixed Capital



REFERENCES

- Abramovsky, L., and R. Griffith. "Outsourcing and Offshoring of Business Services: How Important Is ICT?" *Journal of the European Economic Association*, 4(2–3), 2006, 594–601.
- Allen, R. G. D. *Mathematical Analysis for Economists*. London: MacMillan Press, 1938.
- Amiti, M., and S.-J. Wei. "Service Offshoring and Productivity: Evidence from the US." *The World Economy*, 32(2), 2009, 203–20.
- Anderson, G. J., and R. W. Blundell. "Estimation and Hypothesis Testing in Dynamic Singular Equation Systems." *Econometrica*, 50(6), 1982, 1559–71.
- Auerbach, A. J. "Taxation, Corporate Financial Policy, and the Cost of Capital." *Journal of Economic Literature*, 21(3), 1983, 905–40.
- Autor, D., D. Dorn, and G. Hanson. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States." *American Economic Review*, 103(6), 2013, 2121–68.
- Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. Van Reenen. "Concentrating on the Fall of the Labor Share." *American Economic Review*, 107(5), 2017a, 180–5.
- . "The Fall of the Labor Share and the Rise of Superstar Firms." NBER Working Paper No. 23396, 2017b.
- Baldwin, R. *The Great Convergence*. Cambridge, MA: Harvard University Press, 2016.
- Banerjee, A. V., and E. Dufo. "Chapter 7: Growth Theory through the Lens of Development Economics," in *Handbook of Economic Growth*, Vol. 1. Elsevier, 2005, 473–552.
- Bassanini, A., and S. Scarpetta. "Growth, Technological Change, and ICT Diffusion: Recent Evidence from OECD Countries." *Oxford Review of Economic Policy*, 18(3), 2002, 324–44.
- Beladi, H., S. Marjit, and L. Yang. "Outsourcing: Volume and Composition of R&D." *Review of International Economics*, 20(4), 2012, 828–40.
- Berman, E., J. Bound, and Z. Griliches. "Changes in the Demand for Skilled Labor within US Manufacturing: Evidence from the Annual Survey of Manufactures." *Quarterly Journal of Economics*, 109(2), 1994, 367–97.
- Bloom, N., M. Draca, and J. Van Reenen. "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity." *Review of Economic Studies*, 83(1), 2016, 87–117.
- Bursian, D. and A. J. Nagengast. "Offshoring and the Polarisation of the Demand for Capital." Deutsche Bundesbank Discussion Paper No. 17/2018, 2018.
- Campa, J. and L. S. Goldberg. "The Evolving External Orientation of Manufacturing Industries: Evidence from Four Countries." NBER Working Paper No. 5919, 1997.
- Caselli, F., and J. Feyrer. "The Marginal Product of Capital." *Quarterly Journal of Economics*, 122(2), 2007, 535–68.
- Chanda, A., and B. Panda. "Productivity Growth in Goods and Services across the Heterogeneous States of America." *Economic Inquiry*, 54(2), 2016, 1021–45.
- Chirinko, R. S. "Business Fixed Investment Spending: Modeling Strategies, Empirical Results, and Policy Implications." *Journal of Economic Literature*, 31(4), 1993, 1875–911.
- Chirinko, R. S., and D. J. Wilson. "State Investment Tax Incentives: A Zero-Sum Game?" *Journal of Public Economics*, 92(12), 2008, 2362–84.
- Christensen, L. R., D. W. Jorgenson, and L. J. Lau. "Conjugate Duality and the Transcendental Logarithmic Production Function." *Econometrica*, 39(4), 1971, 225–56.
- . "Transcendental Logarithmic Production Frontiers." *Review of Economics and Statistics*, 55(1), 1973, 28–45.
- Colecchia, A., and P. Schreyer. "ICT Investment and Economic Growth in the 1990s: Is the United States a Unique Case? A Comparative Study of Nine OECD Countries." *Review of Economic Dynamics*, 5(2), 2002, 408–42.
- Corrado, C., C. Hulten, and D. Sichel. "Intangible Capital and US Economic Growth." *Review of Income and Wealth*, 55(3), 2009, 661–85.
- Crinò, R. "Service Offshoring and White-Collar Employment." *Review of Economic Studies*, 77(2), 2010, 595–632.
- Dauth, W., S. Findeisen, and J. Suedekum. "The Rise of the East and the Far East: German Labor Markets and Trade Integration." *Journal of the European Economic Association*, 12(6), 2014, 1643–75.
- De Loecker, J. and J. Eeckhout. "The Rise of Market Power and the Macroeconomic Implications." NBER Working Paper No. 23687, 2017.
- . "Global Market Power." NBER Working Paper No. 24768, 2018.
- Devereux, M. and R. Griffith. "The Taxation of Discrete Investment Choices." IFS Working Paper W98/16, 1999.
- Devereux, M. P., and R. Griffith. "Evaluating Tax Policy for Location Decisions." *International Tax and Public Finance*, 10(2), 2003, 107–26.
- Diewert, W. E. "Aggregation Problems in the Measurement of Capital," in *The Measurement of Capital*. Chicago, IL: University of Chicago Press, 1980, 433–538.
- Feenstra, R. C., and G. H. Hanson. "Foreign Direct Investment and Relative Wages: Evidence from Mexico's Maquiladoras." *Journal of International Economics*, 42(3), 1997, 371–93.
- . "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979–1990." *Quarterly Journal of Economics*, 114(3), 1999, 907–40.
- Foster-McGregor, N., R. Stehrer, and G. J. deVries. "Offshoring and the Skill Structure of Labour Demand." *Review of World Economics*, 149(4), 2013, 631–62.
- Friesen, J. "Testing Dynamic Specification of Factor Demand Equations for US Manufacturing." *Review of Economics and Statistics*, 74(2), 1992, 240–50.
- Gilchrist, S. and E. Zakrajsek. "Investment and the Cost of Capital: New Evidence from the Corporate Bond Market." NBER Working Paper No. 13174, 2007.
- Glass, A. J., and K. Saggi. "Innovation and Wage Effects of International Outsourcing." *European Economic Review*, 45(1), 2001, 67–86.
- Goldbach, S., A. J. Nagengast, E. Steinmüller, and G. Wamser. "The Effect of Investing Abroad on Investment at Home: On the Role of Technology, Tax Savings, and Internal Capital Markets." *Journal of International Economics*, 116, 2019, 58–73.
- Griliches, Z. "Capital-Skill Complementarity." *Review of Economics and Statistics*, 51(4), 1969, 465–8.
- Grossman, G. M., and E. Rossi-Hansberg. "Trading Tasks: A Simple Theory of Offshoring." *American Economic Review*, 98(5), 2008, 1978–97.
- Hakkala, K. N., F. Heyman, and F. Sjöholm. "Multinational Firms, Acquisitions and Job Tasks." *European Economic Review*, 66, 2014, 248–65.
- Hijzen, A., H. Görg, and R. C. Hine. "International Outsourcing and the Skill Structure of Labour Demand in the United Kingdom." *Economic Journal*, 115(506), 2005, 860–78.
- Hoekman, B., ed.. *The Global Trade Slowdown: A New Normal?* CEPR Press, 2015.
- Holly, S., and P. Smith. "Interrelated Factor Demands for Manufacturing: A Dynamic Translog Cost Function

- Approach." *European Economic Review*, 33(1), 1989, 111–26.
- Hummels, D., R. Jørgensen, J. Munch, and C. Xiang. "The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data." *American Economic Review*, 104(6), 2014, 1597–629.
- Jäger, K. "EU KLEMS Growth and Productivity Accounts 2017 Release—Description of Methodology and General Notes." The Conference Board, 2017.
- Jorgenson, D. W., and Z. Griliches. "The Explanation of Productivity Change." *Review of Economic Studies*, 34(3), 1967, 249–83.
- Jorgenson, D. W., F. M. Gollop, and B. Fraumeni. *Productivity and US Economic Growth*. Cambridge, MA: Harvard University Press, 1987.
- Kohler, W. "International Outsourcing and Factor Prices with Multistage Production." *Economic Journal*, 114(494), 2004, C166–85.
- Kumbhakar, S., and E. Tsionas. "The Good, the Bad and the Technology: Endogeneity in Environmental Production Models." *Journal of Econometrics*, 190(2), 2016, 315–27.
- Machin, S., and J. Van Reenen. "Technology and Changes in Skill Structure: Evidence from Seven OECD Countries." *Quarterly Journal of Economics*, 113(4), 1998, 1215–44.
- Marjit, S., and A. Mukherjee. "International Outsourcing and R&D: Long-Run Implications for Consumers." *Review of International Economics*, 16(5), 2008, 1010–22.
- Michaels, G., A. Natraj, and J. Van Reenen. "Has ICT Polarized Skill Demand? Evidence from Eleven Countries over Twenty-Five Years." *Review of Economics and Statistics*, 96(1), 2014, 60–77.
- Morrison Paul, C. J., and D. S. Siegel. "The Impacts of Technology, Trade and Outsourcing on Employment and Labor Composition." *The Scandinavian Journal of Economics*, 103(2), 2001, 241–64.
- O'Mahony, M., and M. P. Timmer. "Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database." *Economic Journal*, 119(538), 2009, F374–403.
- Oulton, N. "Ex Post Versus ex Ante Measures of the User Cost of Capital." *Review of Income and Wealth*, 53(2), 2007, 295–317.
- Pesaran, M. H., and R. Smith. "Estimating Long-Run Relationships from Dynamic Heterogeneous Panels." *Journal of Econometrics*, 68(1), 1995, 79–113.
- Portes, R., and H. Rey. "The Determinants of Cross-Border Equity Flows." *Journal of International Economics*, 65(2), 2005, 269–96.
- Rasel, F. "ICT and Global Sourcing—Evidence for German Manufacturing and Service Firms." *Economics of Innovation and New Technology*, 26(7), 2017, 634–60.
- Reinhart, C. M., and K. S. Rogoff. "Serial Default and the 'Paradox' of Rich-to-Poor Capital Flows." *American Economic Review*, 94(2), 2004, 53–8.
- Senses, M. Z. "The Effects of Offshoring on the Elasticity of Labor Demand." *Journal of International Economics*, 81(1), 2010, 89–98.
- Spengel, C., C. Elschner, and D. Endres. "On Demand Report 2012—Effective Tax Levels at the Industry Level Using the Devereux/Griffith Methodology." On-Demand Analysis for the EU Commission TAXUD/2008/CC/099, 2012.
- Stock, J. H., J. H. Wright, and M. Yogo. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business & Economic Statistics*, 20(4), 2002, 518–29.
- Strauss-Kahn, V. "The Role of Globalization in the Within-Industry Shift Away from Unskilled Workers in France," in *Challenges to Globalization: Analyzing the Economics*. Chicago, IL: University of Chicago Press, 2004, 209–34.
- Stulz, R. M. "The Limits of Financial Globalization." *Journal of Finance*, 60(4), 2005, 1595–638.
- Timmer, M. P., E. Dietzenbacher, B. Los, R. Stehrer, and G. J. deVries. "An Illustrated User Guide to the World Input-Output Database: The Case of Global Automotive Production." *Review of International Economics*, 23(3), 2015, 575–605.
- Uzawa, H. "Production Functions with Constant Elasticities of Substitution." *Review of Economic Studies*, 29(4), 1962, 291–9.
- Zellner, A. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Journal of the American Statistical Association*, 57(298), 1962, 348–68.
- . "On the Aggregation Problem: A New Approach to a Troublesome Problem," in *Economic Models, Estimation and Risk Programming: Essays in Honor of Gerhard Tintner*. Berlin: Springer-Verlag, 1969, 365–74.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1: Specification with nine input factors

Table S2: Ex ante user costs of capital: AR(2)-models

Table S3: Ex ante user costs of capital: Adaptive expectations

Table S4: Asset-specific country \times sector time trends

Table S5: Hybrid user costs of capital

Table S6: Ex post baseline (Table 1) with country \times year and sector \times year fixed effects

Table S7: Ex ante baseline (Table 2) with country \times year and sector \times year fixed effects

Table S8: Ex ante user costs of capital: Tax considerations

Table S9: Baseline estimated with OLS without cross-equation constraints

Table S10: Instrumental variable approach with restricted instrument group

Table S11: First-stage results of 2SLS regression with restricted instrument group (Table S10)

Table S12: Controlling for technological change: R&D intensity

Table S13: Controlling for technological change: ICT capital stock

Table S14: Controlling for technological change: Country \times sector time trends

Table S15: Controlling for technological change: Solow residual

Table S16: Estimation for sub-samples

Table S17: Estimation in first differences ($\Delta_{t,t-1}$)

Table S18: Estimation in long differences ($\Delta_{2014;2000}$)

Table S19: Alternative offshoring measures

Table S20: Baseline specification with dwellings and real estate industry excluded

Table S21: Baseline specification with price-adjusted ex post user costs of capital