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# Is Offshoring Beneficial or Detrimental to Innovation in Developed Countries?

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## Abstract

This paper empirically investigates the effects of offshoring on innovation in a sample of 18 developed countries. Offshoring of services relates positively to innovation, whereas offshoring of manufacturing affects innovation negatively. Solely offshoring manufacturing to high-income countries is harmful for domestic innovation, but not offshoring of manufacturing to lower-income countries. These results are robust to an instrumental variables approach. Two mechanisms are found to mitigate these negative effects of offshoring of manufacturing: skill upgrading and the position in the production chain, in particular upstreamness.

*Keywords:* offshoring, innovation, skill-upgrading, instrumental variables

*JEL codes:* F14, O30

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# 1 Introduction

A key development in international trade in the past decades has been the spectacular rise of offshoring (Feenstra and Hanson (1999)) and the increase of trade in intermediate goods and services (Hummels et al. (2001)). The literature has more recently focused on lower-income countries integrating into the world economy (Autor et al. (2013)). This paper argues that changes of offshoring to high-income countries are substantial as well, but are largely left unconsidered. Which implications has the increase of offshoring to different destinations for innovation activities in the offshoring countries?

Offshoring generally leads to fragmentation of production processes according to a country's comparative advantage. This involves further specialization - and higher innovation intensities in developed countries - with respect to offshoring to lower-income countries. But it is a priori unclear to which extent offshoring involves offshoring of R&D as well and how tacit knowledge can be shielded from being offshored - in particular in the case of offshoring to high-income countries. As innovation is a key driver of productivity growth (Griffith et al. (2004)), it is important to gain insights into the role of trade in intermediates in stimulating or hampering innovation.

This question has been addressed by the theoretical trade literature (e.g., Glass and Saggi (2001), Rodríguez-Clare (2010), Arkolakis et al. (2013), Acemoglu et al. (forthcoming)), but to a much smaller extent by the empirical trade literature. Görg and Hanley (2011) document that offshoring of services increases innovation activities, and Breunig and Bakhtiari (2013) stress the beneficial role of innovation-related offshoring as opposed to low-cost-oriented offshoring. Karpaty and Tingvall (2014) show that the direction of the innovation effect depends on offshoring destinations and the level of aggregation in the analysis. Colantone and Crinò (2014) report that newly imported inputs have a strong positive effect on the introduction of new products in Europe.

It is likely that adjustments - in terms of innovation activities - to offshoring critically depend on adjustments in the labor force and in particular the speed with which countries can reallocate workers from low-skilled occupations, such as production work, to high-skilled occupations, such as research (Rodríguez-Clare (2010), Arkolakis et al. (2013)). Hence, we analyze

distinct effects on innovation for offshoring by considering offshoring individually and by taking joint effects of offshoring and the skill composition into consideration. We also acknowledge that the position in the production chain might influence both offshoring and innovation and therefore rely on a recently developed measure on upstreamness (Fally (2012) and Antràs and Chor (2013)).

In this paper, we employ data for 18 developed countries on the country-industry level for the period 1995 to 2007. This paper adds to the literature along three lines. This paper is, to the best of my knowledge, the first to consider aggregate effects for several developed countries which allows us to present more general results than previous research. Secondly, we investigate innovation effects in a much more nuanced way than previous research. We differentiate offshoring of manufacturing from offshoring of services and split these again into offshoring destinations: high-income countries vs. lower-income countries. This differentiation holds novel insights. Lastly, we acknowledge that innovation effects should be analyzed jointly with changes in skill abundance and conditional on the position in the production chain.

We document substantial changes of offshoring over time in a large sample of developed countries. Growth rates of offshoring were larger than 30% in all countries except six. Furthermore, both offshoring of manufacturing and offshoring of services increased in almost all countries. We also find a pronounced rise of offshoring to lower-income countries, as expected.

This study finds a *negative* effect of offshoring of manufacturing on innovation activities - which drives the overall effect - and a *positive* effect for offshoring of services. The latter finding is related to the idea that the provision of business and financial services is important for increasing domestic innovation activities (Hsu et al. (2014), Nieto and Rodríguez (2014)). The estimated negative effect solely stems from offshoring manufacturing to *high-income countries*; offshoring of manufacturing to *lower-income countries* is found to positively relate to innovation activities, in line with theoretical predictions. We also document that the negatively estimated effect of offshoring of manufacturing goods can be mitigated if high-skilled workers are comparatively abundant and if an industry is comparatively upstream. Endogeneity concerns are addressed in two ways. First, we control for total factor productivity (TFP). Second, we deploy instrumental variables analysis. We draw on an instrument developed by Hummels et al. (2014) on world

export supply and use growth rates and changes of offshoring. The results using instrumental variables are similar to results found in baseline estimations.

The remainder of this paper is structured as follows. Section 2 discusses the related literature, section 3 the data, section 4 presents stylized facts and section 5 the empirical analysis. Section 6 concludes.

## 2 Related literature

The theoretical trade literature mostly analyzes the effects of offshoring on innovation in a North-South framework, in which offshoring involves production relocation from the developed country to the developing country. These models depict a static innovation gain which arises from a productivity effect (e.g., Glass and Saggi (2001), Rodríguez-Clare (2010), Acemoglu et al. (forthcoming)). The productivity effect occurs as a result of falling trade barriers which allow producers in the North to move production to the South where wages are lower. Rodríguez-Clare (2010) also features a world-efficiency effect because the country with the comparative advantage in innovation specializes in it after trade liberalization. Arkolakis et al. (2013) is closely related to our study as they build a model of multinational production with *many* developed countries. Countries can specialize in innovation or production activities. The equilibrium is determined by a country's productivity in innovation, by costs of offshoring and by costs associated with locating multinational production close to final consumers. They show that almost all developed countries gain from trade liberalization but that some developed countries become "production locations". These countries miss out on the dynamic effects from innovation and incur (albeit small) welfare losses.

Another strand of literature argues - in line with the last argument - that the effects of offshoring on innovation are not necessarily positive. Managers could, for instance, base their decision on short-term cost reduction motives and opt for offshoring thereby neglecting dynamic effects of innovation which stem from reduced feedback with affiliates (Naghavi and Ottaviano (2009)). Offshoring then diminishes innovation efforts, and this entails dynamic losses which are not fully internalized. Acemoglu et al. (forthcoming) highlight transition dynamics. They find

that offshoring always increases innovation activities in the long-run in the developed country. However, they note that in the short run innovation might come to a halt if trade barriers fall as offshoring projects are temporarily more profitable and are carried out at the expense of innovation projects.

It is noteworthy that these theoretical models do not consider trade in intermediates with developed countries although trade in intermediates with developed countries is much larger compared to trade in intermediates with lower-income destinations. Models describing trade (in final goods) between high-income countries typically feature other comparative statics based on technology levels, wages and various geographic barriers (Eaton and Kortum (2002)). Eaton and Kortum (2002) note that the fall of geographic barriers has non-linear effects on the manufacturing sector in developed countries as the manufacturing sector could expand or shrink depending on the magnitude in the reduction of geographic barriers. Hence, falling geographic barriers lead to new patterns of specialization which we hypothesize to affect spending on R&D and these effects could go either way.

The discussed literature does, additionally, not consider differences between offshoring of manufacturing and offshoring of services. Offshoring of services involves business services that could act as complements to offshoring of manufacturing. This can be interpreted as increasing the parameter  $\beta$ , the share of intermediates that are offshorable, in the theoretical model by Rodríguez-Clare (2010). This would unambiguously lead to higher productivity and innovation effects. This discussion highlights that trade in intermediates of manufacturing might have positive or negative effects on innovation, whereas offshoring of services is believed to have positive innovation effects.

Few empirical papers have considered the direct effect of offshoring on innovation. Görg and Hanley (2011) find that offshoring of services increases innovation activities in Irish firms and that effects for offshoring of manufacturing are weaker and less robust. Breunig and Bakhtiari (2013) document that low-cost-oriented offshoring damages future innovation, whereas innovation-related offshoring promotes future innovation. Karpaty and Tingvall (2014) show that the average firm effect of offshoring is negative. If regressions are reweighted with firm's employment to analyze aggregate effects, the estimated effect turns positive. They also show that

offshoring to Europe and EU15 countries has negative effects for domestic innovation, although only in unweighted regressions. Colantone and Crinò (2014) analyze product-level data on newly imported inputs which are highly important for the introduction of new products in Europe<sup>2</sup> <sup>3</sup>. We acknowledge that distinguishing between offshoring of manufacturing and services is important. Amiti and Wei (2009) document that offshoring of services exerts stronger and more robust effects on productivity than offshoring of manufacturing. Görg and Hanley (2011) present similar evidence for innovation. We differentiate offshoring with respect to host countries, namely high-income countries and lower-income countries similar to Karpaty and Tingvall (2014), but are additionally able to differentiate offshoring of services or manufacturing according to these destinations.

Several models explicitly describe labor market adjustments jointly with effects on innovation activities (e.g., Rodríguez-Clare (2010), Arkolakis et al. (2013)). These models stress the ability of developed countries to adjust their labor force by moving workers from production to innovation. Reaping the gains from increased offshoring therefore strongly depends on the speed of reallocation. Arkolakis et al. (2013) run simulations of falling trade costs with different degrees of labor market flexibility for OECD countries. They document that innovation rates in the Benelux increase by 77% with fully flexible labor markets and by 5.8% in the Benelux with rigid labor markets after trade liberalization. This suggests that labor market adjustments are crucial for transition dynamics. This paper also draws on a direct literature of offshoring effects on labor market outcomes. Offshoring tends to increase wages of high-skilled workers, whereas it decreases wages of low-skilled workers in developed countries<sup>4</sup>. This is largely in line with the idea that countries specialize in higher value-added parts of the production chain. Crinò (2012) and Breunig and Bakhtiari (2013) suggest that these effects are related by documenting effects of offshoring on the high-skilled *and* innovation output<sup>5</sup>.

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<sup>2</sup>See also Crinò (2012), Goldberg et al. (2010) and Bustos (2011) for effects of trade in intermediates on innovation activities in developing countries. Colantone and Crinò (2014) and Goldberg et al. (2010) stress that the effect works through increasing variety of imported inputs as well as higher quality of imported inputs.

<sup>3</sup>This study also relates to a much broader literature on productivity effects. Productivity effects are mostly found to be positive or insignificant (e.g., Egger and Egger (2006), Görg et al. (2008), Amiti and Wei (2009), Wagner (2011), Parteka (2013), Kasahara and Lapham (2013)).

<sup>4</sup>See for instance Feenstra and Hanson (1999), Grossman and Rossi-Hansberg (2008), Crinò (2012), Harrison and McMillan (2011), Becker et al. (2013), Baumgarten et al. (2013), Hummels et al. (2014), Ebenstein et al. (2014).

<sup>5</sup>These studies look at different outcomes, whereas we take interaction effects into account.

Lastly, we link our paper to a growing literature on the relative position in production chains (Fally (2012) and Antràs and Chor (2013)). Fally (2012) argues that upstreamness strongly negatively correlates with industry specificity. It might be therefore easier to offshore products that are more upstream and therefore more matured without incurring negative innovation effects. This would be in line with a product cycle theory in which offshoring only occurs for more mature products (Costinot et al. (2011)). We test this hypothesis in one of the extensions.

### 3 Data sources

This paper deploys data for 18 developed countries on the country-industry level for the period 1995 to 2007<sup>6</sup>. A list of covered countries can be found in the appendix (see Table 9). The main source for analyzing trade in intermediates is the World Input-Output Database (WIOD) (Timmer et al. (forthcoming))<sup>7</sup>. The database contains information on trade on the country-industry level and allows the construction of detailed offshoring measures for each industry in each country. Offshoring is defined as imported intermediates and scaled by value added<sup>8</sup>:

$$OS_{abt} = \frac{\sum_{ij} II_{ij,abt}}{VA_{abt}} \quad (1)$$

$OS_{abt}$  denotes offshoring by country  $a$  in industry  $b$  at time  $t$ . This is calculated as a summation over all intermediate imports of materials and services  $II_{ij}$  - where  $i$  indexes country and  $j$  industry - that  $ab$  sources and standardized by value added of  $ab$  in the respective time period (therefore by definition:  $i \neq a$ ). This corresponds to the broad measure of offshoring by Feenstra and Hanson (1999).

Offshoring can be further split into offshoring of manufacturing and services; the numerator is replaced by all imported intermediates in manufacturing or services<sup>9</sup>. Offshoring can also be split according to countries of origin; we differentiate between sourcing from high-income

<sup>6</sup>We classify countries as developed countries if they are considered to be high-income countries by the World Bank for the majority of years that the sample spans. Only pre-crisis years are considered to not confound our estimated effects with any crisis-specific shocks such as financial constraints.

<sup>7</sup>See <http://www.wiod.org> for information on the dataset, methodology etc.

<sup>8</sup>Trade in primary products is not included in our offshoring measure.

<sup>9</sup>We follow Amiti and Wei (2009) in defining trade in services by including the following industries: post and telecommunications, financial intermediation, renting of machinery and equipment and other business services.



countries, lower-income countries and the rest of the world (see Table 10 in the appendix for the classification). We also construct measures of narrow and broad offshoring, which sum to total offshoring of manufacturing. Narrow offshoring is defined as offshoring within the same industry, whereas broad offshoring only includes offshoring to other industries.

The EU-KLEMS database contains information on the total number of hours worked according to skill groups<sup>10</sup>. It also has capital stock data and reports on expenditures for information and communication technology. EU-KLEMS further allows to calculate total factor productivity from the data<sup>11</sup>.

I match these data with the ANBERD<sup>12</sup>. ANBERD provides information on private research and development expenditures<sup>13</sup>. Data on R&D expenditures in the service sector are scarce. We therefore drop the service sector. R&D expenditures are also largely concentrated in manufacturing industries, although the share of R&D expenditures in manufacturing in all R&D expenditures is declining over time. R&D expenditures in manufacturing account on average for 77% of a country's R&D spending in 1995 in our sample; this number decreases slightly to 70% in 2007. The share varies substantially between countries though. Germany's share is at 95% in 1995, whereas Australia's share is just 55%. In 2007 Taiwan has the highest share with 92% and Australia the lowest with 30%.

There are few zero values for R&D in the sample which we set equal to missing values. Zero values are usually preceded and followed by substantial spending on R&D so that it is likely that zero values are missing observations as opposed to zero R&D spending. In a next step, we match R&D data, which is reported on the two-digit level in ANBERD, with WIOD, which uses

<sup>10</sup>We use EU-KLEMS version ISIC Rev. 3 because it has the largest country coverage. See <http://www.euklems.net/> for information on the dataset, methodology etc.

<sup>11</sup>We deflate and convert all data, if necessary, into millions of US dollars with exchange rates given by EU-KLEMS. The EU-KLEMS database offers several deflators so that output, intermediate inputs and value added can each be deflated with their respective deflator.

<sup>12</sup>We use ANBERD version ISIC Rev. 3 because it has the largest country coverage. See <http://www.oecd.org/innovation/inno/anberdanalyticalbusinessenterpriseresearchanddevelopmentdatabase.htm> for information on the dataset, methodology etc. Cyprus, Denmark, Luxembourg, Malta and Sweden do not report on R&D spending. We additionally drop Ireland from our analysis as we do not want to include offshore financial centers in our sample (see the IMF classification for offshore financial centers in 2005: <https://www.imf.org/external/np/pp/eng/2005/022505.pdf>).

<sup>13</sup>Firms report either R&D spending in their main activity - the methodology used by most countries in the sample - or firms report on product fields. We prefer this richer information and use, therefore, data on the product field if available and resort to data reported for the main activity of the firm if this is the only data available.

two-digit level industries and groups of two-digit level industries. For instance, we aggregate industries C27 and C28 to one industry C27t28. We aggregate data in the following way: we sum over the respective industries in ANBERD to be consistent with the WIOD classification, and we set this aggregated value equal to missing if information on at least one of the two-digit industries in ANBERD is missing. We report in Table 11 a classification of industries according to WIOD.

## 4 Stylized facts

We present a set of stylized facts that highlight the increase in offshoring, R&D intensities and skills over time.

Table 1 reports information on different measures of offshoring in 1995 and 2007 for all sample countries. Information is aggregated to the country-level. Countries differ with respect to their offshoring shares. Larger countries tend to source fewer intermediates from abroad, and they experience smaller absolute changes in offshoring between 1995 and 2007. Offshoring has grown substantially between 1995 and 2007 for almost all countries. Germany doubled its level of offshoring from 29% in 1995 to 58% in 2007. Austria, Belgium, Slovenia and Taiwan increased their offshoring by more than 30% points. The largest part of offshoring stems from offshoring of manufacturing goods and to a much smaller extent from offshoring of services<sup>14</sup>. Aggregate trends in offshoring therefore reflect trends in offshoring of manufacturing. Offshoring of services has however greatly increased since 1995, see Belgium, Finland and Spain. Interestingly, larger changes are mostly observed for EU-countries. Not surprisingly, developed countries still source the largest part of their inputs from other high-income countries. Several countries reduce offshoring to high-income countries, and these countries are mostly non-EU countries. Offshoring to lower-income countries is small in 1995 for almost all countries. This picture has changed by 2007. Five countries report particularly large changes for offshoring to lower-income countries: Taiwan and Korea - which unsurprisingly closely relates to trade with China - as well as Belgium, Germany and Finland. Offshoring to lower-income countries has gained in relative importance to offshoring to high-income countries for all countries in the sample.

<sup>14</sup>Note that offshoring of services refers to offshoring of services in the manufacturing sector only. We are not concerned with offshoring of services in the service sector.

Table 1: Descriptive statistics

Country	Offsh. 1995	Offsh. 2007	Change Offsh.	Offsh. manu. 1995	Offsh. manu. 2007	Change Offsh. manu.	Offsh. services 1995	Offsh. services 2007	Change Offsh. services	Offsh. HI 1995	Offsh. HI 2007	Change Offsh. HI	Offsh. LI 1995	Offsh. LI 2007	Change Offsh. LI
Australia	21.65	28.49	6.83	20.56	27.08	6.53	1.10	1.40	0.31	13.81	13.11	-0.71	2.85	5.78	2.94
Austria	42.11	74.74	32.63	38.15	71.81	33.66	3.96	2.93	-1.03	34.45	55.48	21.03	3.77	12.11	8.34
Belgium	99.28	141.80	42.52	96.33	135.82	39.48	2.95	5.98	3.03	89.24	111.96	22.72	4.46	17.21	12.75
Canada	55.85	56.61	0.75	53.08	53.69	0.61	2.78	2.92	0.14	49.38	43.50	-5.88	3.67	8.04	4.37
Germany	29.27	57.55	28.28	28.45	55.45	27.00	0.83	2.10	1.27	22.30	34.48	12.19	3.92	15.20	11.28
Spain	34.43	57.82	23.39	32.80	53.09	20.29	1.63	4.74	3.10	29.64	41.81	12.17	2.11	8.16	6.06
Finland	37.88	59.12	21.24	32.83	48.38	15.55	5.05	10.74	5.69	30.80	34.57	3.77	3.44	14.95	11.51
France	44.04	65.66	21.61	42.17	62.72	20.54	1.87	2.94	1.07	37.55	50.03	12.48	2.28	7.80	5.52
Great Britain	37.06	41.38	4.32	35.70	39.18	3.48	1.36	2.20	0.84	30.11	29.79	-0.31	2.77	6.49	3.73
Greece	38.43	37.50	-0.93	37.47	35.07	-2.39	0.96	2.42	1.46	30.97	24.20	-6.77	5.06	7.41	2.35
Italy	32.80	46.65	13.85	31.61	44.14	12.52	1.19	2.51	1.32	24.99	29.11	4.12	3.45	8.38	4.93
Japan	6.33	15.86	9.53	6.11	15.33	9.22	0.22	0.52	0.30	3.51	6.05	2.54	1.49	5.30	3.81
Korea	40.63	53.47	12.84	39.87	51.10	11.23	0.76	2.36	1.61	28.01	24.96	-3.06	6.39	16.75	10.36
Netherlands	74.83	88.52	13.68	63.93	75.41	11.48	10.91	13.11	2.20	60.48	64.73	4.25	4.92	10.19	5.27
Portugal	54.78	74.14	19.35	52.03	71.72	19.69	2.75	2.41	-0.34	49.46	62.30	12.85	2.19	6.35	4.16
Slovenia	66.59	103.03	36.44	64.81	100.13	35.32	1.78	2.90	1.12	51.22	73.38	22.16	8.77	15.93	7.16
Taiwan	72.07	120.14	48.06	69.98	116.67	46.69	2.10	3.47	1.37	52.73	65.04	12.32	6.39	21.58	15.19
USA	19.73	26.12	6.38	18.41	24.44	6.03	1.32	1.68	0.36	12.98	12.92	-0.06	3.66	8.64	4.98

A list of countries and corresponding abbreviations can be found in Table 9. Change refers to % point changes between 1995 and 2007. Offshoring of manufacturing and offshoring of services sum to overall offshoring. Offshoring to HI (high-income countries), to LI (lower-income countries), and the rest of the world (not reported) also sum to overall offshoring. Offshoring refers to trade in intermediates. All offshoring measures are standardized by value added, i.e., offshoring reports the share of foreign inputs in value-added. All presented numbers are in percent. The first number in the upper left corner means that the share of foreign material and services inputs to industry value added is 21.65% in 1995 for Australia. This share increased to 28.49% in 2007. Hence, offshoring changes by 6.83% points between 1995 and 2007 in Australia.

In a next step, we look at the dynamics of R&D intensities for selected countries (Table 2)<sup>15</sup>. R&D intensities are very heterogeneous between countries. France has R&D intensities of about 10% being the leading country in private sector spending on R&D. Other European countries tend to spend intensively on R&D as well, see Belgium, Germany and the Netherlands. All countries have increased their R&D intensity between 1995 and 2007. It is worth mentioning the changes observed for Korea and in particular for Taiwan. This could reflect that these countries offshored production to cheap locations such as China and South-East Asia while specializing in more sophisticated parts of the production chain. Results are not presented here to save space, but a large fraction of the changes in R&D intensities occur within high-technology industries.

Lastly, we present facts on the skill-composition across countries and changes in the skill composition over time within countries. Table 2 presents information on the labor force share according to skill type for the countries in our sample. It is striking how pronounced differences in the composition of the labor force are between different countries. Finland depicts the largest share of high-skilled labor (23%) followed by the US (22%) in 1995. Italy and Portugal rank on the lower end of the spectrum (with about 3%). We turn next to the % point changes in the labor force share by skill type. First, all countries increase their share of hours worked by high-skilled labor. The ordering of countries according to their high-skilled labor share stays roughly constant over time. Few countries seem to fundamentally change the composition of their labor force, such as Taiwan and Spain.

These results suggest thus far that a) offshoring is a prevalent phenomenon that has increased substantially in both manufacturing and services over time, b) R&D intensity also increased over time in our sample of developed countries and c) the composition of the labor force in terms of skills changed dramatically over recent years.

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<sup>15</sup>R&D-intensities are only available for 1998 and from 2002-2007 for Austria and from 1998-2007 for Taiwan. The following industries are missing for these countries: Finland 8, 14, 15; Great-Britain 4, 5, 6, 7; Japan 4, 5, 14; Portugal 8, 10, Slovenia 8, 14 and the US 4 and 5. We also drop several observations for Greece (sector 12) and Slovenia (sectors 7 and 15), when ANBERD provides more detailed data on the 3-digit level which is inconsistent with 2-digit level information.

Table 2: Descriptive statistics

Country	RD inten- sity 1995	RD inten- sity 2007	Change RD in- tensity	HHS 1995	HHS 2007	Change HHS	HMS 1995	HMS 2007	Change HMS	HLS 1995	HLS 2007	Change HLS
Australia	3.46	4.13	0.67	8.40	11.39	2.98	39.10	44.85	5.75	52.50	43.76	-8.73
Austria	4.58	6.73	2.15	7.91	14.86	6.95	66.85	65.82	-1.03	25.24	19.31	-5.92
Belgium	5.48	6.93	1.45	9.94	13.07	3.13	42.92	59.85	16.93	47.14	27.08	-20.06
Canada	3.59	4.36	0.78	12.45	17.77	5.32	80.02	78.58	-1.45	7.52	3.65	-3.88
Germany	6.75	7.36	0.61	17.50	21.10	3.60	61.88	61.50	-0.38	20.62	17.40	-3.22
Spain	1.69	2.95	1.26	15.42	28.15	12.73	14.32	22.91	8.59	70.26	48.94	-21.32
Finland	2.99	3.84	0.85	23.41	29.56	6.14	46.49	52.25	5.76	30.09	18.19	-11.91
France	9.66	9.77	0.11	15.27	25.04	9.77	45.01	48.46	3.45	39.72	26.50	-13.22
Great Britain	6.33	9.06	2.73	15.75	27.37	11.63	43.78	46.57	2.79	40.48	26.06	-14.42
Greece	0.67	1.04	0.38	9.04	14.86	5.82	32.60	40.30	7.70	58.37	44.85	-13.52
Italy	2.24	2.52	0.28	3.30	7.14	3.85	30.63	44.94	14.31	66.07	47.92	-18.16
Japan	5.73	8.24	2.51	16.19	20.00	3.81	61.98	67.85	5.87	21.83	12.15	-9.68
Korea	5.76	8.84	3.08	19.80	33.00	13.20	53.58	56.54	2.96	26.62	10.46	-16.16
Netherlands	5.38	5.60	0.23	11.04	20.36	9.32	46.07	45.73	-0.33	42.90	33.91	-8.99
Portugal	0.45	1.65	1.20	2.51	4.22	1.71	10.05	13.08	3.03	87.44	82.70	-4.74
Slovenia	2.53	3.80	1.27	8.09	11.40	3.31	64.42	68.18	3.75	27.49	20.42	-7.07
Taiwan	3.87	7.02	3.15	11.17	17.26	6.09	26.77	34.65	7.88	62.06	48.09	-13.97
USA	8.75	11.02	2.27	21.68	28.12	6.44	64.34	61.74	-2.60	13.98	10.14	-3.83

A list of countries and corresponding abbreviations can be found in Table 9. Change refers to % point changes between 1995 and 2007. R&D intensity is defined as R&D expenditures over value added. HHS is the share of high skilled labor in the workforce (in terms of hours worked). HMS (HLS) refers to the share of hours worked by the medium- (low-) skilled. All presented numbers are in percent.

## 5 Empirical analysis

### 5.1 Methodology

In the next step, we describe the empirical methodology. We estimate the following baseline estimation<sup>16</sup>:

$$R\&Dintensity_{ijt} = \alpha + \beta * Offshoring_{ijt} + \gamma' * \mathbf{X}_{ijt} + \kappa_1 * D_{it} + \kappa_2 * D_j + \varepsilon_{ijt} \quad (2)$$

where  $i$  indexes countries,  $j$  denotes industries and  $t$  stands for years. Standard errors are clustered at the country-year level<sup>17</sup>. R&D intensity is defined as the share of R&D expenditures over value added. Offshoring is similarly defined as the share of imported intermediate inputs (excluding primary inputs and particular services industries) over value added (see equation 1). A vector of control variables  $\mathbf{X}$  is also included.  $\mathbf{X}$  contains the share of high-skilled labor as well as the share of medium-skilled labor. We also control for the openness of the economy by including a measure for export intensity. This is defined as the share of exported intermediate and final goods scaled by value added. We include this variable to not confound the estimated coefficient on the offshoring variable with other factors that are related to trade openness and that also correlate with productivity (see Haller (2012) for sorting into different trade activities). There is also evidence that importing/offshoring and exporting are concentrated in the same firms (Bernard et al. (2007)), which makes it important to disentangle these two effects. Lastly, we also add a measure on capital intensity, defined as the capital stock divided by value added. We add country-time- ( $D_{it}$ ) and industry-fixed-effects ( $D_j$ ). We thereby try to capture that countries implement country-wide policies that are conducive to both trade and innovation. This could introduce omitted variables bias if these effects were not controlled for.

In subsequent specifications, we extend the baseline regression by including different offshoring measures. In a first step, we acknowledge the difference between offshoring of manufacturing and offshoring of services, which has been identified as being important in the literature (Amiti and Wei (2009)). We then turn to different specifications by including offshoring within the same industry (narrow offshoring) and offshoring to other industries (broad offshoring). In a

<sup>16</sup>See for similar estimation equations Görg and Hanley (2011) and Karpaty and Tingvall (2014).

<sup>17</sup>We do so because information about the share of high-skilled and medium-skilled people employed differs for some observations only on the country-year level and not according to industries.

last step, we split our offshoring variable with respect to the producing destination. We classify producing countries as either high-income countries - countries which likely produce high-quality goods and services - or lower-income countries - which are mostly low-cost destinations.

## 5.2 Baseline results

We now turn to the empirical analysis. Estimations of equation 2 are presented in Table 3<sup>18</sup>. Offshoring is found to have a negative effect on R&D intensity. The estimated coefficient is rather small and statistically significant. The share of high-skilled labor positively relates to innovation activities, whereas the opposite is true for medium-skilled labor. This finding is robust to different specifications. It is also an interesting finding as it suggests that skill upgrading per se might not be sufficient for increasing domestic innovation activities. This fits into a story of comparative advantage in which developed countries are specialized in the production of high-skilled labor-intensive goods. We also find that a larger export share is associated with higher innovation activities. This could be because firms that export learn from exporting (De Loecker (2013)). The coefficient for the capital share is in almost all specifications insignificant. Labor might hence be a more important input into the innovation process than capital.

In the following specifications, we split offshoring according to different sub-components. Offshoring can be divided into offshoring of manufacturing and offshoring of services. We find that this differentiation matters as offshoring of services exerts large and positive effects on R&D intensity, whereas the offshoring coefficient for manufacturing stays statistically significant and negative. We estimate a large coefficient for offshoring of services, which is more than ten-times the size of the estimated coefficient for offshoring of manufacturing. Amiti and Wei (2009) and Görg and Hanley (2011) find even stronger quantitative effects between offshoring of services and

<sup>18</sup>We document that our results on the effects of offshoring on innovation are unlikely to be driven by flawed data (Table 12). We therefore report effects of offshoring on TFP to document that we can replicate general findings of the literature (e.g., Egger and Egger (2006), Amiti and Wei (2009), Parteka (2013)). We calculate TFP from the data according to equation 3. We then regress TFP on offshoring, R&D intensity and the export share, as calculated before. Overall offshoring relates positively to TFP. This effect is driven by a positive effect of offshoring of services while offshoring of manufacturing is positive but weaker in terms of statistical significance (similar to Amiti and Wei (2009)). Offshoring within the same sector drives the positive effect of offshoring of manufacturing. We further report positive effects from offshoring manufacturing to high-income countries, which makes us confident that productivity and innovation effects are different. We further document a positive effect from offshoring manufacturing to lower-income countries, as proposed by the theoretical literature. Lastly, we document that offshoring of services is positive for all offshoring destinations, but only statistically significant for the rest of the world.

offshoring of manufacturing. Görg and Hanley (2011) also estimate a much larger coefficient for offshoring of services in similar regressions. The size of the estimated coefficient could be this large because offshoring of services is a relatively recent development in international trade, which might offer large gains in early stages. The largest part of sourced services are business services. Business services also include the sourcing of external R&D. We suspect that sourcing R&D externally can explain the large offshoring coefficient. Less-sensitive R&D could be offshored that is complementary to more advanced domestic innovation activities or external innovation has to be adapted in-house (Lai et al. (2009)). Firms could also exploit foreign, superior knowledge that stimulates firms to innovate more at home (Nieto and Rodríguez (2014)). A much smaller part of services offshoring relates to the provision of financial services. Several studies document the importance of financial sector development for innovation activities of firms (Brown et al. (2009), Brown et al. (2012), Hsu et al. (2014), Nanda and Nicholas (2014)). However, results are the most robust for offshoring of business services and somewhat weaker for financial services<sup>19</sup> and point to the unique role of business services for innovation activities. Note also that the estimated effect for overall offshoring can be understood as a composite effect of - the more prevalent - offshoring of manufacturing and -the rarer - offshoring of services.

In a next step, we split offshoring of manufacturing into narrow (offshoring within the same industry) and broad (offshoring to other industries) offshoring. We find that the coefficient for narrow offshoring is about double the size of the coefficient for broad offshoring and that both are negative. We next investigate the negative coefficient on offshoring of manufacturing. We split our sample for this purpose into offshoring according to type (manufacturing or services) and offshoring destinations (high-income countries, lower-income countries or the rest of the world). We gain novel insights from this differentiation. Offshoring of manufacturing is significantly and positively estimated only for offshoring to lower-income countries and the rest of the world. This is in line with the predictions of the theoretical models that offshoring is productivity-enhancing and allows countries to restructure towards higher value-added activities (e.g., Glass and Saggi (2001), Rodríguez-Clare (2010), Arkolakis et al. (2013), Acemoglu et al. (forthcoming)). We also document that offshoring of manufacturing to high-income countries is not beneficial - in terms of innovation - for developed countries. This could be for two reasons. Less productive coun-

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<sup>19</sup>Results are not reported here to save space, but are available from the author upon request.



tries/industries source from more advanced countries because this is productivity-enhancing (for instance because new varieties are imported), but this does not necessarily result in higher spending on R&D<sup>20</sup>. This effect would be in line with Arkolakis et al. (2013) who argue that countries might get trapped in production stages of the production chain thereby harming domestic innovation activities. It could also simply document that countries that still source from high-income countries are worse off than countries that source from lower-income countries because sourcing from the latter country group entails larger productivity effects due to larger wage gaps. On a more positive note, this could be a temporary adjustment effect (Acemoglu et al. (forthcoming)) which does not entail long-run dynamic losses (Naghavi and Ottaviano (2009)). Note also that Karpaty and Tingvall (2014) find similar effects for offshoring to EU15-countries. When we turn to the results for offshoring of services, we observe that domestic innovation is positively related to offshoring to high-income and lower-income countries. This suggests that offshoring of services is beneficial to domestic innovation irrespective of the sourcing destination. We speculate that it might be in general in the interest of companies to conduct some R&D abroad as this likely complements production abroad. This should be particularly important if tacit knowledge from the production process is required to improve products. This does however not erode innovation activities at home. It is also likely that other business services, such as accounting and financial services, are best sourced locally when firms source manufacturing intermediates from abroad.

We run a battery of robustness checks of these baseline regressions, in particular of columns (1) and (2) of Table 3. These are presented in Tables 14 to 19 in the appendix<sup>21</sup>.

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<sup>20</sup>Colantone and Crinò (2014) document for a sample of European countries that trade in newly imported inputs increases product variety in developed countries. They do not document, however, that this also leads to increases in R&D spending.

<sup>21</sup>In a first step, we try to rule out that sample selection is a problem. We drop each industry subsequently and analyze whether a particular industry drives our results. This is not the case. We then drop countries individually which does not change our results either. We then move on and drop Austria and Taiwan as observations are only available for particular time periods for these countries. The results are robust to the exclusion of these countries. We also drop all countries for which particular industries are missing (Finland, Great Britain, Japan, Portugal, Slovenia and the US). Baseline results do not change. We also drop the top 1% of observations for offshoring of manufacturing and offshoring of services. This does not influence our results either. We also consider adding country-time and industry-time fixed effects, which leaves the results unaltered. This is a particularly restrictive specification as different time trends are captured by fixed effects. We test our baseline specification with lagged values for the offshoring variables which again does not change results. Finally, we also try a different standardization by scaling with output instead of scaling by value added. Again, our results are robust to this specification. The disadvantage of scaling with output is that offshoring influences output by definition, whereas value added is only affected if the firm shifts its own production abroad.

Table 3: Baseline results - Offshoring and innovation

<i>Dep. var. R&amp;D intensity</i>	(1)	(2)	(3)	(4)
Offshoring	-0.028*** (0.005)			
Offshoring manufacturing		-0.038*** (0.004)		
Offshoring services		0.516*** (0.016)	0.497*** (0.018)	
Offshoring narrow			-0.048*** (0.004)	
Offshoring broad			-0.021*** (0.006)	
Offsh. manu. HI				-0.061*** (0.005)
Offsh. manu. LI				0.070*** (0.019)
Offsh. manu. ROW				0.072*** (0.021)
Offsh. services HI				0.536*** (0.087)
Offsh. services LI				1.252*** (0.422)
Offsh. services ROW				0.058 (0.444)
High skilled share	0.148*** (0.017)	0.166*** (0.018)	0.158*** (0.018)	0.174*** (0.017)
Medium skilled share	-0.169*** (0.032)	-0.166*** (0.033)	-0.164*** (0.033)	-0.142*** (0.031)
Export share	0.011*** (0.001)	0.009*** (0.002)	0.009*** (0.001)	0.008*** (0.001)
Capital share	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000* (0.000)
Observations	2853.00	2853.00	2853.00	2853.00
R squared	0.68	0.74	0.74	0.75

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance. HI stands for high-income countries, LI for lower-income countries and ROW for rest of the world.

### 5.3 Confounding factors

In this section, we document that the presented results are not to be confounded with other factors. The factors under consideration are productivity shocks, technical change - proxied by the use of information and communication technology - and import competition.

First, we control for total factor productivity. It could be that offshoring simply increases total factor productivity which strongly correlates with R&D intensity. EU-KLEMS data allow

to compute total factor productivity from available data so that we do not have to estimate a production function using certain parameter restrictions. We then back out the dependent variable from the following calculation for each variety  $ij$  at time  $t$ , where  $i$  indexes countries and  $j$  denotes industries:

$$\ln(TFP) = \ln(VA) - CC * \ln(CS) - HSC * \ln(HHS) - MSC * \ln(HMS) - LSC * \ln(HLS). \quad (3)$$

$VA$  denotes value added,  $CC$  is capital compensation as a share of value added,  $CS$  refers to the capital stock,  $HSC$  ( $MSC$ ,  $LSC$ ) is the share of high-skilled (medium-skilled, low-skilled) labor compensation in value added,  $HHS$  ( $HMS$ ,  $HLS$ ) is the number of hours worked by the high-skilled (medium-skilled, low-skilled). We include the dependent variable from this calculation as a further control in equation 2. This allows to control for a) exogenous TFP shocks and b) control for productivity increases due to offshoring. If we nevertheless find effects of offshoring on innovation then offshoring has additional beneficial effects that are unrelated to TFP effects. We document that our results are robust to the inclusion of total factor productivity in Table 4 (as computed in equation 3)<sup>22</sup>. Productivity strongly positively relates to innovation activities as expected, but does not change our baseline results. In fact, the estimated coefficients depict very similar magnitudes as in the baseline estimations. The estimated coefficient for services offshoring to lower-income countries is however much larger. The results overall suggest that productivity and innovation effects of offshoring are somewhat unrelated, for instance because firms channel cost savings immediately into innovation activities. This result corroborates previous and similar findings by Görg and Hanley (2011).

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<sup>22</sup>We drop in these specifications all observations for which capital compensation as a share of value added is negative. This is a well-known problem with EU-KLEMS data.

Table 4: Robustness check: Total factor productivity

<i>Dep. var. R&amp;D intensity</i>	(1)	(2)	(3)	(4)
Offshoring	-0.035*** (0.004)			
Offshoring manufacturing		-0.040*** (0.004)		
Offshoring services		0.476*** (0.022)	0.453*** (0.025)	
Offshoring narrow			-0.048*** (0.004)	
Offshoring broad			-0.025*** (0.006)	
Offsh. manu. HI				-0.062*** (0.005)
Offsh. manu. LI				0.067*** (0.020)
Offsh. manu. ROW				0.075*** (0.021)
Offsh. services HI				0.421*** (0.110)
Offsh. services LI				5.846*** (1.246)
Offsh. services ROW				-0.735*** (0.275)
High skilled share	0.153*** (0.017)	0.166*** (0.018)	0.158*** (0.018)	0.185*** (0.018)
Medium skilled share	-0.170*** (0.032)	-0.164*** (0.033)	-0.162*** (0.033)	-0.144*** (0.031)
Export share	0.012*** (0.001)	0.010*** (0.001)	0.010*** (0.001)	0.009*** (0.001)
Capital share	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000** (0.000)
TFP	0.846*** (0.187)	0.625*** (0.189)	0.627*** (0.189)	0.650*** (0.190)
Observations	2830.00	2830.00	2830.00	2830.00
R squared	0.70	0.72	0.72	0.74

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance. HI stands for high-income countries, LI for lower-income countries and ROW for rest of the world. TFP is total factor productivity.

We check for two other potentially confounding factors. The first is a measure of technical change. ICT likely causes offshoring, but could also have a direct effect on innovation (Bartel et al. (2007), Brynjolfsson et al. (2011)). ICT is measured as ICT expenditures scaled by value added.

We also consider import competition. Offshoring and import competition are likely trig-

gered by the same events, such as falling transport and communication costs or tariff cuts. Hence these variables are expected to be highly correlated. There is furthermore evidence that competition fosters innovation activities in firms. Fernandes and Paunov (2013) argue that import competition induces Chilean firms to upgrade product quality. Bloom et al. (forthcoming) document that import competition from China leads to more innovation in firms in developed countries. Remember that offshoring was defined as trade in *intermediates*. We define import competition as trade in *final* goods<sup>23</sup>. Import competition in country  $a$  and industry  $b$  at time  $t$  is then defined as follows:

$$IC_{abt} = \frac{\sum_i FI_{ib,at}}{VA_{abt}}. \quad (4)$$

The numerator sums over all final imports of industry  $b$  that country  $a$  sources from abroad, irrespective of the producing country  $i$ . This value is subsequently scaled by value added of country  $a$  and industry  $b$  at time  $t$ . Import competition for Germany’s textile industry is thus defined as the value of all final goods in the textile industry imported for final consumption in Germany, and this is then scaled by value added of the German textile industry. Hence, import competition can - by definition - never take place in services. We then include offshoring and import competition jointly in the model to check for the robustness of the estimated effect on offshoring.

Table 5 presents the results<sup>24</sup>. ICT turns out to be an important determinant of R&D intensity. The estimated coefficient is large and highly significant. However, it does not change the estimated coefficients on the different offshoring variables, neither in significance nor in magnitude. We can also estimate separate effects on the offshoring as well as the import competition estimates. Increasing import competition is found to be negatively related to R&D intensity. This is at odds with findings by Bloom et al. (forthcoming). We do not control for competition from lower-income countries only though, and increasing competition from high-income countries does not necessarily induce firms to “escape competition”. Most importantly, the offshoring effects are very similar to the effects in the baseline estimations.

<sup>23</sup>We include in the definition for the consumption of final goods: a) final consumption expenditure by households, b) final consumption expenditure by non-profit organizations serving households (NPISH), c) final consumption expenditure by government and d) gross fixed capital formation. We do not include changes in inventories and valuables as this number might well reflect measurement error.

<sup>24</sup>Note that we lose many observations for which information on ICT is not available.

Table 5: Robustness checks: Technical change and import competition

<i>Dep. var. R&amp;D intensity</i>	(1)	(2)	(3)	(4)	(5)	(6)
Offshoring	-0.028*** (0.006)			-0.024*** (0.005)		
ICT	0.277*** (0.062)	0.237*** (0.062)	0.237*** (0.061)			
Offshoring manu- facturing		-0.039*** (0.005)			-0.035*** (0.004)	
Offshoring services		0.498*** (0.023)	0.474*** (0.024)		0.502*** (0.017)	0.478*** (0.019)
Offshoring narrow			-0.051*** (0.006)			-0.047*** (0.004)
Offshoring broad			-0.024*** (0.006)			-0.015** (0.007)
Import competi- tion				-0.003*** (0.001)	-0.002*** (0.001)	-0.002*** (0.001)
High skilled share	0.172*** (0.026)	0.204*** (0.026)	0.192*** (0.026)	0.140*** (0.017)	0.160*** (0.018)	0.150*** (0.018)
Medium skilled share	-0.049 (0.047)	-0.038 (0.045)	-0.043 (0.045)	-0.173*** (0.033)	-0.169*** (0.034)	-0.167*** (0.034)
Export share	0.007*** (0.002)	0.006*** (0.002)	0.005*** (0.002)	0.010*** (0.002)	0.008*** (0.002)	0.008*** (0.001)
Capital share	0.002** (0.001)	0.001 (0.001)	0.001 (0.001)	0.003*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Observations	1784.00	1784.00	1784.00	2853.00	2853.00	2853.00
R squared	0.76	0.79	0.79	0.69	0.74	0.74

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

## 5.4 Instrumental variables regressions

Potential endogeneity concerns can be further reduced by using instrumental variables. To identify the effect of offshoring on innovation, we need to exploit exogenous variation which drives the endogenous variable - offshoring - but not innovation except for the effects through offshoring. The instrument has to be relevant, i.e., sufficiently correlated with the endogenous variable, and valid, i.e., not correlated with the error term. We construct an instrument similar to Hummels et al. (2014) on world export supply and use differences as well as growth rates of offshoring.

Although our data is not as detailed as data by Hummels et al. (2014)<sup>25</sup>, we use a similar

<sup>25</sup> Autor et al. (2013) deploy a similar instrument by instrumenting offshoring to China from the US with offshoring

measure and argue that firm-level results should be broadly applicable to industry-level data. World export supply  $WES_{ij,at}$  is country  $i$ 's total supply in industry  $j$  to the world market, minus its supply to country  $a$ , at time  $t$ .  $WES$  measures comparative advantage for the exporting country, arising from changes in product price, quality or variety. We only consider  $WES$  of manufacturing and selected services industries as defined above (of manufacturing industries to high-income countries) for the offshoring instrument (offshoring of manufacturing instrument).  $s_{ij,ab}$  denotes the share of  $ij$  in total *intermediate* imports - that is imports of manufacturing as well as selected services imports - (in total manufacturing *intermediate* imports from high-income countries, respectively) of country  $a$  and industry  $b$  in the year 1995 for instrumenting offshoring (offshoring of manufacturing). We then construct the instrument for  $ab$  as follows  $I_{abt} = \sum_{ij} s_{ij,ab} * WES_{ij,at}$ . We argue that for some reason (e.g., trade barriers, quality, cost competitiveness)  $ab$  sources a particular input  $j$  from country  $i$  and that this sourcing structure depicts some persistence over time. Hummels et al. (2014) refer to established business relationships for this argument, which is admittedly harder to make in our more aggregated case, but we argue that the general argument still holds at the industry level. If competitiveness changes over time for a particular industry  $j$  in country  $i$  due to various reasons, then these are reflected in changing export supply to the world as a whole. As  $ab$  uses  $ij$  more intensively than the same industry in other countries,  $ab$  disproportionately profits from this development. Note that we construct separate instruments for offshoring (offshoring of manufacturing) based on  $WES$  which refers to manufacturing and services exports (manufacturing exports to high-income countries only) and shares based on manufacturing and services import shares (manufacturing import shares from high-income countries only).

We next discuss the validity of the  $WES$  instrument. The instrument should be correlated with offshoring, but should be independent of innovation.

We are particularly concerned with the aggregate level at which we identify effects. We cannot document that the exact assumptions made by Hummels et al. (2014) apply equally to our analysis as we are unable to document evidence for persistence in supplier relations in our data. It is however likely that the aggregate data that we are looking at is not too different from

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measures to China for other high-income countries. See for other recent applications Baumgarten et al. (2013), Ebenstein et al. (2014), Balsvik et al. (forthcoming).

the firms considered by Hummels et al. (2014). They only focus on firms for which they observe changes in the intensity of offshoring due to the construction of the instrument. They do not analyze adjustments along the extensive margin. They likely look at a sample of heavily globally engaged firms which import and export extensively. These firms should account for large trade volumes (Bernard et al. (2007)) and hence also constitute a large part of the data that we rely on, albeit on a more aggregated level. There will be a part of trade that relates to switchers into offshoring though. It is however unlikely that firms that offshore for the first time, should experience other dynamics than firms that have some experience in offshoring. We do therefore believe that if the exclusion restriction holds in the sample of continuous offshorers, it should also hold for firms switching into offshoring<sup>26</sup>.

Secondly, country policies could influence both offshoring and innovation. Labor market policies are particularly likely to affect both offshoring and innovation if they affect, for instance, the skill composition or wages within the country. Country-time fixed effects control for these policy changes. They also take into account country-specific demand-side shocks that could be related to offshoring and innovation. We would additionally like to rule out that demand shocks from other countries explain our results. We therefore control for export intensity which should absorb these effects.

Thirdly, the inclusion of large countries could drive our results as these countries can strategically influence prices. Price changes can in turn affect offshoring and innovation. This should be less of a concern as the sample largely consists of small countries. We drop Germany, Japan and the US separately from the IV regressions, and also drop all three countries as a robustness check<sup>27</sup>. We find that our instrumental variables results stay the same except that if the US and all three countries are dropped the offshoring of manufacturing coefficient becomes insignificant, but stays similar in terms of magnitude.

We compute three additional instruments: the change in offshoring between  $t$  and  $t - 1$ , the change in offshoring of manufacturing between  $t$  and  $t - 1$  and the growth rate of services offshoring between  $t$  and  $t - 1$ . These instruments are highly correlated with contemporaneous

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<sup>26</sup>These firms do not rely on long-term supplier relations. We can nevertheless argue that exogenous offshoring opportunities arise for these firms which are similar to the opportunities experienced by continuously offshoring firms in the same industry and country.

<sup>27</sup>The results are available from the author upon request.



offshoring, but should not have a direct effect on innovation. This is the case as controls for different demand-side driven shocks are already included in the estimations.

We now discuss results presented in Table 6. The effect of offshoring is similar in the IV estimations compared to baseline results (see Table 3). The estimated coefficients for offshoring of manufacturing and services are also comparable to the results presented in the baseline estimations. The same holds for the coefficients of the control variables. F-tests are equal to 10 or larger, indicating that instruments should be relevant. The Hansen J test suggests that the hypothesis that instruments are valid cannot be rejected. Table 13 presents first stage results. *WES* positively relates to offshoring as expected, capturing increased competitiveness from variety  $ij$  (country  $i$  and industry  $j$ ), and so does our second instrument, the change in offshoring. In columns 2 and 3, we document that *WES* in manufacturing to high-income countries relates positively to offshoring of manufacturing and that higher growth rates/changes relate positively to offshoring of manufacturing and services. This is in line with expectations. The results in Table 6 show that our baseline results are robust to an instrumental variables approach. The estimated effects are economically relevant. We calculate that offshoring of services explains 46% of all R&D spending<sup>28</sup>. We find an effect of manufacturing which is at -33% equally large<sup>29</sup>. Other studies have also documented that trade has pronounced effects on domestic innovation. Bloom et al. (forthcoming) argue that import competition from China accounts for 15% of European technology upgrading between 2000 and 2007. Crinò (2012) finds that importers have a 12 to 16 percentage points higher probability of engaging in innovation activities, while Gorodnichenko et al. (2010) present even larger effects using the same sample.

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<sup>28</sup>We multiply the estimated coefficient for offshoring 0.6206451 with the mean of offshoring of services 2.977415 and then divide by mean spending on R&D 4.005855.

<sup>29</sup>This is calculated as follows  $(-0.0282554 * 46.55225)/4.005855$ .

Table 6: Instrumental variables

<i>Dep. var. R&amp;D intensity</i>	(1)	(2)
Offshoring	-0.048** (0.019)	
Offshoring manufacturing		-0.028* (0.017)
Offshoring services		0.621** (0.267)
High skilled share	0.137*** (0.020)	0.175*** (0.027)
Medium skilled share	-0.195*** (0.036)	-0.167*** (0.038)
Export share	0.015*** (0.004)	0.006 (0.005)
Capital share	0.000 (0.000)	0.000 (0.000)
F-test Offshoring	12.08	
F-test Offshoring manu.		10.00
F-test Offshoring services		11.83
Underidentification (p-value)	0.0392	0.0030
Hansen J test (p-value)	0.1876	0.8147
Observations	2654.00	2654.00
R squared	0.08	0.24

Reported coefficients are from 2SLS-estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

## 5.5 Extensions

Offshoring is believed to influence labor markets markedly, both in terms of employment and wage effects. Suggestive evidence reports that the skill-bias that is associated with offshoring also leads to higher innovation output (Crinò (2012) and Breunig and Bakhtiari (2013)). We test this hypothesis for the first time explicitly acknowledging that a wide theoretical literature has asked this question before (e.g, Rodríguez-Clare (2010), Arkolakis et al. (2013)). We do so by introducing an interaction term of offshoring with the share of high-skilled labor (Table 7). We do not test the predictions by Rodríguez-Clare (2010) and Arkolakis et al. (2013) directly as we do not exploit variation over time in our analysis<sup>30</sup>. Column 1 reports the results for an interaction term between overall offshoring and the high-skilled share. We find that the magnitude of the

<sup>30</sup>We obtain similar results when additionally including industry-time fixed effects. Variation between different countries within the same industry is then used to estimate the joint effect; this effect also drives the results presented here.

offshoring effect is somewhat stronger, and reassuringly, that a higher share of the high-skilled mitigates the adverse effect of offshoring. This implies that the potentially adverse effect of offshoring on innovation can be reversed if the share of high-skilled is large enough<sup>31</sup>. This could suggest that if high-skilled labor is accumulated fast enough, repercussions on R&D spending are unlikely to occur.

We then look at the effect in more detail and split offshoring in offshoring of manufacturing and services as before. This gives more insightful results. We find significant effects, as before in the baseline regressions, for both offshoring variables. The coefficients on the different offshoring variables are similar to previous estimates. The negative effects for offshoring of manufacturing are again mitigated by a highly skilled workforce. The interaction term is estimated to be positive for the interaction between offshoring of services and the high-skilled labor share. This is an interesting finding as offshoring of services complements skill accumulation. This result would be in line with the idea that external R&D should be complemented by a highly-skilled domestic workforce to reap the largest benefits from cooperation. We also point out that we do no longer find a statistically significant effect of the high-skilled labor share.

It is possible that the interaction term just captures underlying time trends. We aim to rule out this possibility. Offshoring and import competition are undoubtedly driven by the same underlying factors, as argued before. Furthermore, we are confident that we can differentiate effects between the two variables (see Table 5). In order to test whether an underlying time trend influences our results or whether we capture an interaction between offshoring and skills, we deploy a pseudo-interaction term. Import competition lends itself to be an ideal candidate as this variable is closely related to offshoring and is thus very likely to depict the same interaction effect. Column 3 documents reassuring results. The same effects for offshoring and import competition are established as before. At the same time, we do not find that the interaction term is statistically significantly estimated. The estimated effect is also much smaller than the one presented for the interaction terms with different offshoring measures. This suggests that we report an interaction effect that is not driven by third factors but the variables of interest.

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<sup>31</sup>We compute the mean of all offshoring observations and ask which share of high-skilled labor offsets the negative effect of offshoring. We therefore solve the following equation for the share of high-skilled labor  $x$ :  $-0.0757655 * 49.52967 + 0.0043389 * 49.52967 * x = 0$ .  $x$  equals 17.4619. Germany, Finland, Korea and the US are on average already above the critical share in 1995 (see Table 2).

Table 7: Extension 1: Labor market adjustments

<i>Dep. var. R&amp;D intensity</i>	(1)	(2)	(3)
Offshoring	-0.076*** (0.008)		-0.023*** (0.005)
Offsh. * High skilled	0.004*** (0.001)		
Offshoring manufacturing		-0.078*** (0.007)	
Offshoring services		0.379*** (0.070)	
Offshoring manu. * High skilled		0.004*** (0.001)	
Offshoring services * High skilled		0.006* (0.004)	
Import competition	-0.003*** (0.001)	-0.002** (0.001)	-0.007** (0.003)
Import competition * High skilled			0.000 (0.000)
High skilled share	0.008 (0.024)	0.040 (0.027)	0.121*** (0.019)
Medium skilled share	-0.187*** (0.029)	-0.180*** (0.030)	-0.178*** (0.033)
Export share	0.008*** (0.002)	0.007*** (0.001)	0.009*** (0.002)
Capital share	0.002*** (0.001)	0.001** (0.001)	0.003*** (0.001)
Observations	2853.00	2853.00	2853.00
R squared	0.71	0.76	0.69

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

Lastly, we test whether the position in the production chain matters for offshoring effects on innovation. We deploy a measure on upstreamness which has recently been proposed by Fally (2012) and Antràs and Chor (2013). Upstreamness measures the average position of a variety in the production chain and can be defined for each individual variety  $ab$  at each point in time as follows:

$$US_{ab} = 1 + \sum_{ij=1}^N \frac{d_{ab,ij}Y_{ij}}{Y_{ab}} U_{ij}, \quad (5)$$

where  $d_{ab,ij}Y_{ij}/Y_{ab}$  is the share of variety  $ab$ 's total output that is purchased by variety  $ij$ <sup>32</sup>.  $N$  denotes the total number of varieties, i.e., the total number of country-industry combinations.

This system can be written compactly in matrix notation as  $US = [I - \Delta]^{-1}\mathbf{1}$ , where  $\Delta$  is the

<sup>32</sup>Upstreamness is therefore 1 if production is equal to final demand and larger the more upstream the respective variety is ranked.

matrix with  $d_{ab,ij}Y_{ij}/Y_{ab}$  in entry  $(ab, ij)$  and  $\mathbf{1}$  is a column vector of ones.

As documented by Fally (2012), upstreamness strongly negatively correlates with the specificity of a particular variety and R&D intensity, albeit not statistically significantly for the latter measure. Our results are similar in that upstreamness is associated with lower R&D intensity (see Table 8). More interesting results emerge when upstreamness and interaction terms with different offshoring measures are considered to assess whether the position in the production chain influences offshoring effects. We find that this is indeed the case. Upstreamness reduces the adverse effects of offshoring on innovation activities. This is in line with a product cycle theory. It is optimal for highly-complex products to remain integrated and to only offshore if production has matured (Costinot et al. (2011))<sup>33</sup>. Acemoglu et al. (2010) find that the R&D intensity of upstream industries negatively correlates with intra-firm trade. They consider intra- vs. inter-firm trade, whereas we analyze offshoring. But we argue that both measures - inter-firm trade and offshoring - broadly reflect fragmentation. Although their dependent variable is intra-firm trade and we are looking at the effect on R&D intensity, our results are similar in terms of the correlations found. We report that offshoring increasingly substitutes for R&D intensity in more downstream industries<sup>34</sup>. In column 2, we find that the negative effect of offshoring of manufacturing is mitigated by a variety being more upstream. The position in the production chain does not matter for the effects of offshoring of services. We find that the mitigation channel through upstreamness is not unique to offshoring, but is also found for import competition. We are nevertheless confident that our results in columns 1 and 2 are meaningful as we control for import competition.

<sup>33</sup>We also split industries according to the OECD classification into high-tech (industries 9, 13, 14, 15) and low-tech sectors (all other industries), see <http://www.oecd.org/sti/ind/48350231.pdf> and construct interaction terms with a dummy for high-tech sectors. We obtain similar results as high-tech industries are more severely affected by offshoring.

<sup>34</sup>Upstreamness reduces the negative offshoring effect on average by about one half. Offshoring has a negative effect of -2.141 ( $= -0.0432267 * 49.52967$ ) on R&D intensity. When taking into account the effect of upstreamness, we obtain a value of -1.174 for average offshoring and upstreamness. This is computed as  $-0.0432267 * 49.52967 + 0.0086889 * 49.52967 * 2.246835 = -1.174$ .

Table 8: Extension 2: Upstreamness

<i>Dep. var. R&amp;D intensity</i>	(1)	(2)	(3)
Offshoring	-0.043*** (0.011)		-0.026*** (0.005)
Offsh. * Upstreamness	0.009** (0.004)		
Upstreamness	-1.176*** (0.277)	-1.188*** (0.267)	-1.183*** (0.231)
Offshoring manufacturing		-0.055*** (0.010)	
Offshoring services		0.441*** (0.067)	
Offshoring manu. * Upstreamness		0.009** (0.004)	
Offshoring services * Upstreamness		0.029 (0.031)	
Import competition	-0.003*** (0.001)	-0.002** (0.001)	-0.017*** (0.002)
Import competition * Upstreamness			0.007*** (0.001)
High skilled share	0.151*** (0.017)	0.172*** (0.019)	0.157*** (0.017)
Medium skilled share	-0.169*** (0.033)	-0.163*** (0.034)	-0.168*** (0.033)
Export share	0.010*** (0.002)	0.009*** (0.002)	0.010*** (0.002)
Capital share	0.003*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Observations	2853.00	2853.00	2853.00
R squared	0.69	0.74	0.70

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

## 6 Conclusion

This paper empirically investigates the effects of offshoring on innovation from the perspective of developed countries. Offshoring of services has strong and positive effects on innovation activities as does offshoring of manufacturing to lower-income countries - in line with theoretical predictions (e.g., Glass and Saggi (2001)). We document that offshoring can have detrimental effects on innovation, particularly in the case of shifting *production*, but not services, to other high-income countries. Our analysis is short-term though, so that long-term effects might be different (Acemoglu et al. (forthcoming)). These adverse effects can be mitigated by engaging in

skill-upgrading. We also find that more upstream sectors incur smaller adverse effects.

This paper furthermore highlights that productivity effects and innovation effects are not the same. Policy makers should therefore take various factors, and not just productivity considerations, into account when designing a regulatory framework for future trade liberalization. Our findings highlight substantial gains associated with trade in services, in particular trade in business services. This is an interesting finding given that trade in services is still fairly restricted, and this suggests that there are potentially large gains from further trade liberalization in this sector.

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## Appendix

Table 9: Country coverage

Country	Abbreviation	Number of obs.
Australia	AUS	182
Austria	AUT	98
Belgium	BEL	182
Canada	CAN	146
Germany	DEU	182
Spain	ESP	182
Finland	FIN	143
France	FRA	182
Great Britain	GBR	130
Greece	GRC	155
Italy	ITA	182
Japan	JPN	144
Korea	KOR	182
Netherlands	NLD	179
Portugal	PRT	155
Slovenia	SVN	139
Taiwan	TWN	140
USA	USA	150
Total		2853

Table 10: Country classification

Country	Classification
Australia	HIGH-INCOME
Austria	HIGH-INCOME
Belgium	HIGH-INCOME
Bulgaria	LOWER-INCOME
Brazil	LOWER-INCOME
Canada	HIGH-INCOME
China	LOWER-INCOME
Cyprus	HIGH-INCOME
Czech Republic	LOWER-INCOME
Germany	HIGH-INCOME
Denmark	HIGH-INCOME
Spain	HIGH-INCOME
Estonia	LOWER-INCOME
Finland	HIGH-INCOME
France	HIGH-INCOME
Great Britain	HIGH-INCOME
Greece	HIGH-INCOME
Hungary	LOWER-INCOME
Indonesia	LOWER-INCOME
India	LOWER-INCOME
Ireland	HIGH-INCOME
Italy	HIGH-INCOME
Japan	HIGH-INCOME
Korea	HIGH-INCOME
Lithuania	LOWER-INCOME
Luxembourg	HIGH-INCOME
Latvia	LOWER-INCOME
Mexico	LOWER-INCOME
Malta	HIGH-INCOME
Netherlands	HIGH-INCOME
Poland	LOWER-INCOME
Portugal	HIGH-INCOME
Romania	LOWER-INCOME
Russia	LOWER-INCOME
Slovak Republic	LOWER-INCOME
Slovenia	LOWER-INCOME
Sweden	HIGH-INCOME
Turkey	LOWER-INCOME
Taiwan	LOWER-INCOME
USA	HIGH-INCOME
RoW	RoW

Table 11: Industry coverage

Industry	Industry (WIOD)	Number	Nace 2	Number of obs.
Food, Beverages and Tobacco	3		15t16	225
Textiles and Textile Products	4		17t18	182
Leather, Leather and Footwear	5		19	181
Wood and Products of Wood and Cork	6		20	198
Pulp, Paper, Printing and Publishing	7		21t22	206
Coke, Refined Petroleum and Nuclear Fuel	8		23	188
Chemicals and Chemical Products	9		24	225
Rubber and Plastics	10		25	212
Other Non-Metallic Mineral	11		26	215
Basic Metals and Fabricated Metal	12		27t28	211
Machinery, Nec	13		29	225
Electrical and Optical Equipment	14		30t33	175
Transport Equipment	15		34t35	193
Manufacturing, Nec; Recycling	16		36t37	217
Total				2853

Table 12: TFP regressions

<i>Dep. var. TFP</i>	(1)	(2)	(3)	(4)
Offshoring	0.001** (0.001)			
Offshoring manufacturing		0.001* (0.001)		
Offshoring services		0.026*** (0.007)	0.027*** (0.007)	
Offshoring narrow			0.001* (0.001)	
Offshoring broad			0.001 (0.001)	
Offsh. manu. HI				0.002** (0.001)
Offsh. manu. LI				0.007** (0.003)
Offsh. manu. ROW				-0.010*** (0.003)
Offsh. services HI				0.011 (0.015)
Offsh. services LI				0.111 (0.111)
Offsh. services ROW				0.072* (0.038)
RD intensity	0.014*** (0.003)	0.011*** (0.003)	0.012*** (0.003)	0.012*** (0.003)
Export share	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Observations	2830.00	2830.00	2830.00	2830.00
R squared	0.62	0.62	0.62	0.63

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance. TFP stands for total factor productivity.

Table 13: First stage regression results for excluded instruments

<i>Dep. var. 1st stage</i>	(1)	(2)	(3)
	Offshoring	Offshoring manufactur- ing	Offshoring services
WES	0.000*** (0.000)		
Delta offshoring	0.330** (0.128)		
WES manu. (to high-income coun- tries)		0.001*** (0.000)	-0.000*** (0.000)
Delta offsh. manu.		0.351*** (0.129)	-0.005 (0.005)
Growth rate offsh. services		-2.111 (3.725)	1.431*** (0.396)

Clustered standard errors are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance. WES stands for world export supply.

Table 14: Excluding individual industries

<i>Excluded industry</i>	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Offshoring	-0.029*** (0.005)	-0.029*** (0.005)	-0.028*** (0.005)	-0.028*** (0.005)	-0.028*** (0.005)	-0.042*** (0.005)	-0.021*** (0.005)	-0.028*** (0.005)	-0.028*** (0.005)	-0.029*** (0.005)	-0.029*** (0.005)	-0.033*** (0.004)	-0.015** (0.006)	-0.029*** (0.005)
High skilled share	0.143*** (0.016)	0.162*** (0.019)	0.157*** (0.016)	0.145*** (0.018)	0.167*** (0.019)	0.156*** (0.020)	0.166*** (0.026)	0.150*** (0.017)	0.153*** (0.017)	0.149*** (0.017)	0.149*** (0.017)	0.095*** (0.017)	0.139*** (0.017)	0.148*** (0.017)
Medium skilled share	-0.175*** (0.035)	-0.154*** (0.036)	-0.158*** (0.034)	-0.187*** (0.034)	-0.165*** (0.032)	-0.196*** (0.033)	-0.222*** (0.048)	-0.164*** (0.033)	-0.167*** (0.033)	-0.167*** (0.035)	-0.172*** (0.035)	-0.089*** (0.021)	-0.176*** (0.030)	-0.179*** (0.033)
Export share	0.011*** (0.002)	0.012*** (0.002)	0.011*** (0.002)	0.011*** (0.002)	0.011*** (0.000)	0.017*** (0.001)	0.008*** (0.001)	0.011*** (0.001)	0.011*** (0.002)	0.011*** (0.002)	0.012*** (0.002)	0.010*** (0.001)	0.010*** (0.002)	0.011*** (0.002)
Capital share	0.000 (0.000)	0.000 (0.000)	0.000* (0.000)	0.000 (0.000)	0.000 (0.000)	0.005*** (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	0.000 (0.000)
Observations	2628.00	2671.00	2672.00	2655.00	2647.00	2665.00	2628.00	2641.00	2638.00	2642.00	2628.00	2678.00	2660.00	2636.00
$R^2$	0.68	0.68	0.69	0.68	0.68	0.71	0.68	0.68	0.68	0.68	0.69	0.66	0.70	0.68

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.



Table 15: Excluding individual industries

<i>Excluded industry</i>	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Offshoring manufacturing	-0.039*** (0.004)	-0.039*** (0.004)	-0.039*** (0.004)	-0.038*** (0.004)	-0.038*** (0.004)	-0.049*** (0.004)	-0.031*** (0.004)	-0.038*** (0.004)	-0.038*** (0.004)	-0.039*** (0.004)	-0.038*** (0.004)	-0.035*** (0.004)	-0.029*** (0.005)	-0.039*** (0.004)
Offshoring services	0.520*** (0.016)	0.520*** (0.016)	0.519*** (0.016)	0.521*** (0.016)	0.520*** (0.016)	0.495*** (0.018)	0.518*** (0.017)	0.522*** (0.016)	0.518*** (0.016)	0.520*** (0.016)	0.513*** (0.016)	0.282*** (0.064)	0.507*** (0.016)	0.526*** (0.016)
High skilled share	0.170*** (0.016)	0.182*** (0.016)	0.172*** (0.016)	0.165*** (0.016)	0.185*** (0.016)	0.179*** (0.018)	0.188*** (0.017)	0.168*** (0.016)	0.170*** (0.016)	0.166*** (0.016)	0.167*** (0.016)	0.099*** (0.064)	0.152*** (0.016)	0.166*** (0.016)
Medium skilled share	-0.160*** (0.018)	-0.147*** (0.018)	-0.158*** (0.017)	-0.187*** (0.019)	-0.164*** (0.020)	-0.189*** (0.021)	-0.229*** (0.026)	-0.159*** (0.018)	-0.166*** (0.018)	-0.163*** (0.018)	-0.170*** (0.018)	-0.086*** (0.018)	-0.174*** (0.018)	-0.177*** (0.018)
Export share	0.009*** (0.037)	0.010*** (0.036)	0.009*** (0.035)	0.009*** (0.035)	0.009*** (0.033)	0.014*** (0.034)	0.006*** (0.049)	0.009*** (0.035)	0.009*** (0.034)	0.009*** (0.037)	0.009*** (0.036)	0.009*** (0.022)	0.008*** (0.031)	0.010*** (0.034)
Capital share	0.000 (0.002)	0.000 (0.002)	0.000* (0.002)	0.000 (0.002)	0.000 (0.002)	0.004*** (0.002)	0.000 (0.001)	0.000 (0.001)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)	0.000 (0.001)	0.000* (0.002)	0.000 (0.002)
Observations	2628.00	2671.00	2672.00	2655.00	2647.00	2665.00	2628.00	2641.00	2638.00	2642.00	2628.00	2678.00	2660.00	2636.00
$R^2$	0.74	0.74	0.75	0.74	0.74	0.76	0.75	0.74	0.74	0.74	0.74	0.66	0.76	0.74

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

Table 16: Excluding individual countries

<i>Excluded Country</i>	AUS	AUT	BEL	CAN	DEU	ESP	FIN	FRA	GBR	GRC	ITA	JPN	KOR	NLD
Offshoring	-0.029*** (0.005) 0.144***	-0.030*** (0.005) 0.149***	-0.021*** (0.007) 0.162***	-0.028*** (0.005) 0.147***	-0.026*** (0.005) 0.151***	-0.028*** (0.005) 0.142***	-0.030*** (0.005) 0.152***	-0.031*** (0.005) 0.156***	-0.025*** (0.005) 0.160***	-0.030*** (0.005) 0.139***	-0.029*** (0.005) 0.139***	-0.026*** (0.005) 0.140***	-0.028*** (0.005) 0.166***	-0.044*** (0.004) 0.158***
High skilled share														
Medium skilled share	(0.017) -0.166***	(0.017) -0.168***	(0.017) -0.171***	(0.016) -0.145***	(0.017) -0.164***	(0.017) -0.165***	(0.017) -0.169***	(0.017) -0.185***	(0.017) -0.186***	(0.017) -0.167***	(0.017) -0.166***	(0.019) -0.152***	(0.018) -0.161***	(0.017) -0.190***
Export share	(0.032) 0.011***	(0.032) 0.012***	(0.032) 0.012***	(0.025) 0.010***	(0.032) 0.011***	(0.032) 0.011***	(0.033) 0.012***	(0.032) 0.010***	(0.031) 0.010***	(0.032) 0.011***	(0.032) 0.011***	(0.034) 0.010***	(0.039) 0.011***	(0.034) 0.017***
Capital share	(0.002) 0.000	(0.002) 0.000	(0.002) 0.000	(0.001) 0.000	(0.002) 0.000	(0.002) 0.000	(0.002) 0.000	(0.001) 0.000	(0.001) 0.000	(0.001) 0.000	(0.002) 0.000	(0.001) 0.000	(0.002) 0.000	(0.001) 0.000
Observations	(0.000) 2671.00	(0.000) 2755.00	(0.000) 2671.00	(0.000) 2707.00	(0.000) 2671.00	(0.000) 2671.00	(0.000) 2710.00	(0.000) 2671.00	(0.000) 2723.00	(0.000) 2698.00	(0.000) 2671.00	(0.000) 2709.00	(0.000) 2671.00	(0.000) 2674.00
$R^2$	0.68	0.68	0.68	0.69	0.68	0.69	0.68	0.68	0.70	0.69	0.69	0.67	0.68	0.71

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

Table 17: Excluding individual countries

<i>Excluded country</i>	PRT	SVN	TWN	USA	AUS	AUT	BEL	CAN	DEU	ESP	FIN	FRA	GBR	GRC
Offshoring	-0.020*** (0.005)	-0.030*** (0.006)	-0.026*** (0.006)	-0.026*** (0.005)	-0.038***	-0.040***	-0.034***	-0.038***	-0.036***	-0.038***	-0.039***	-0.041***	-0.034***	-0.040***
Offshoring manufac- turing					(0.004) 0.518***	(0.004) 0.523***	(0.005) 0.517***	(0.004) 0.536***	(0.004) 0.508***	(0.004) 0.505***	(0.004) 0.513***	(0.004) 0.530***	(0.004) 0.514***	(0.004) 0.516***
Offshoring services					(0.017) 0.164***	(0.016) 0.167***	(0.017) 0.178***	(0.014) 0.171***	(0.017) 0.167***	(0.017) 0.160***	(0.017) 0.169***	(0.016) 0.175***	(0.017) 0.180***	(0.017) 0.157***
High skilled share	0.141***	0.143***	0.150***	0.123***										
Medium skilled share	(0.017) -0.161***	(0.017) -0.174***	(0.020) -0.159***	(0.026) -0.184***	(0.018) -0.163***	(0.018) -0.166***	(0.018) -0.167***	(0.017) -0.146***	(0.018) -0.161***	(0.018) -0.162***	(0.018) -0.165***	(0.018) -0.184***	(0.017) -0.183***	(0.017) -0.165***
Export share	(0.031) 0.011***	(0.033) 0.010***	(0.036) 0.010***	(0.049) 0.011***	(0.034) 0.009***	(0.034) 0.010***	(0.034) 0.010***	(0.026) 0.008***	(0.033) 0.009***	(0.033) 0.009***	(0.034) 0.010***	(0.034) 0.008***	(0.033) 0.008***	(0.033) 0.009***
Capital share	(0.002) 0.000	(0.002) 0.003***	(0.002) 0.000	(0.002) 0.000	(0.002) 0.000	(0.002) 0.000	(0.002) 0.000	(0.001) 0.000	(0.002) 0.000	(0.002) 0.000	(0.002) 0.000	(0.001) 0.000	(0.001) 0.000	(0.002) 0.000
Observations	(0.000) 2698.00	(0.001) 2714.00	(0.000) 2713.00	(0.000) 2703.00	(0.000) 2671.00	(0.000) 2755.00	(0.000) 2671.00	(0.000) 2707.00	(0.000) 2671.00	(0.000) 2671.00	(0.000) 2710.00	(0.000) 2671.00	(0.000) 2723.00	(0.000) 2698.00
$R^2$	0.71	0.68	0.69	0.66	0.74	0.73	0.73	0.76	0.73	0.75	0.74	0.75	0.76	0.75

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

Table 18: Excluding individual countries

<i>Excluded Country</i>	ITA	JPN	KOR	NLD	PRT	SVN	TWN	USA
Offshoring manufactur- ing	-0.038*** (0.004)	-0.036*** (0.004)	-0.038*** (0.004)	-0.046*** (0.004)	-0.031*** (0.004)	-0.042*** (0.004)	-0.037*** (0.004)	-0.035*** (0.004)
Offshoring services	0.502*** (0.017)	0.516*** (0.017)	0.522*** (0.017)	0.463*** (0.063)	0.493*** (0.017)	0.515*** (0.017)	0.521*** (0.017)	0.519*** (0.017)
High skilled share	0.159*** (0.018)	0.154*** (0.020)	0.181*** (0.020)	0.162*** (0.018)	0.157*** (0.017)	0.162*** (0.018)	0.184*** (0.021)	0.136*** (0.027)
Medium skilled share	-0.165*** (0.033)	-0.152*** (0.035)	-0.172*** (0.040)	-0.186*** (0.034)	-0.159*** (0.032)	-0.173*** (0.034)	-0.137*** (0.037)	-0.174*** (0.052)
Export share	0.009*** (0.002)	0.008*** (0.001)	0.009*** (0.002)	0.015*** (0.002)	0.009*** (0.002)	0.009*** (0.002)	0.008*** (0.002)	0.009*** (0.002)
Capital share	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.002*** (0.001)	0.000 (0.000)	0.000 (0.000)
Observations	2671.00	2709.00	2671.00	2674.00	2698.00	2714.00	2713.00	2703.00
$R^2$	0.74	0.73	0.73	0.71	0.76	0.74	0.75	0.72

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included. \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

Table 19: Robustness in different samples

<i>Specification</i>	Austria and Tai- wan excl.	Countries with missing industries dropped	Top 1% of offshoring dropped	Country- time and industry- time f.e.	Lagged offshoring	Output- scaled	Austria and Tai- wan excl.	Countries with missing industries dropped	Top 1% of offshoring manu. services dropped	Country- time and industry- time f.e.	Lagged offshoring	Output- scaled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Offshoring	-0.028*** (0.006)	-0.011** (0.006)	-0.022*** (0.007)	-0.032*** (0.005)		-0.067*** (0.006)						
Offshoring lagged					-0.024*** (0.006)							
Offshoring manufactur- ing							-0.039***	-0.022***	-0.037***	-0.041***		-0.069***
Offshoring services							(0.004) 0.529***	(0.004) 0.488***	(0.005) 0.436***	(0.004) 0.506***		(0.005) 0.391***
Offshoring manu. lagged							(0.017)	(0.020)	(0.052)	(0.018)	-0.033***	(0.026)
Offshoring services lagged											(0.007) 0.516***	
High skilled share	0.152*** (0.021)	0.101*** (0.033)	0.153*** (0.017)	0.144*** (0.017)	0.148*** (0.017)	0.047*** (0.006)	0.187*** (0.021)	0.108*** (0.034)	0.165*** (0.017)	0.162*** (0.018)	0.167*** (0.018)	0.052*** (0.006)
Medium skilled share	-0.156*** (0.036)	-0.167*** (0.055)	-0.169*** (0.032)	-0.163*** (0.031)	-0.176*** (0.034)	-0.075*** (0.009)	-0.134*** (0.038)	-0.155*** (0.059)	-0.177*** (0.033)	-0.163*** (0.032)	-0.173*** (0.035)	-0.074*** (0.009)
Export share	0.011*** (0.002)	0.009*** (0.001)	0.011*** (0.002)	0.012*** (0.002)	0.010*** (0.002)	0.014*** (0.002)	0.009*** (0.002)	0.007*** (0.001)	0.011*** (0.002)	0.010*** (0.002)	0.008*** (0.002)	0.016*** (0.001)
Capital share	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	0.000 (0.000)	0.001* (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	0.000 (0.000)	0.001 (0.000)
Observations	2615.00	2131.00	2824.00	2853.00	2654.00	2853.00	2615.00	2131.00	2795.00	2853.00	2654.00	2853.00
$R^2$	0.68	0.69	0.69	0.69	0.68	0.73	0.74	0.75	0.71	0.75	0.74	0.75

Reported coefficients are from OLS estimations. Clustered standard errors at the country-year level are in parentheses. Country-time and industry dummies included except for specifications (4) and (10). \* 10% significance, \*\* 5% significance, \*\*\* 1% significance.

Table 20: Summary statistics

	Mean	Std. dev.	Min.	Max.	Number of observations
Offshoring	49.53	40.001	0.766	386.749	2853
Offshoring manu.	46.552	38.706	0.712	373.641	2853
Offshoring services	2.977	3.821	0.055	59.76	2853
Offshoring narrow	24.152	26.8	0.029	232.772	2853
Offshoring broad	22.4	20.833	0.19	227.366	2853
Offsh. manu. HI	34.812	33.129	0.303	319.9	2853
Offsh. manu. LI	6.153	5.259	0.091	45.947	2853
Offsh. manu. ROW	5.587	5.732	0.222	62.095	2853
Offsh. services HI	2.156	2.644	0.036	43.645	2853
Offsh. services LI	0.207	0.421	0.003	12.125	2853
Offsh. services ROW	0.614	1.054	0.002	20.914	2853
R&D intensity	4.006	5.831	0.008	50.41	2853
High skilled share	15.923	7.945	2.002	45.916	2853
Medium skilled share	48.127	16.977	8.220	87.327	2853
Export share	139.493	114.459	1.141	941.13	2853
Capital share	222.626	700.882	36.476	36768.813	2853
TFP	2.491	0.832	-0.888	4.885	2830
IT share	3.528	2.165	0.069	15.328	1784
Import competition	94.146	620.86	0.74	32302.822	2853
Upstreamness	2.247	0.541	1.088	3.934	2853
<i>Instruments</i>					
WES	2360.938	45984.244	6.171	2400784.75	2853
Change offshoring	1.117	11.285	-326.395	165.955	2654
WES manufacturing (to high-income countries)	1506.239	29757.615	3.836	1548061	2853
Change offsh. manufac-turing	1.038	11.037	-324.402	162.737	2654
Growth rate offsh. ser-vices	0.059	0.221	-0.866	2.382	2654

Offshoring is defined as foreign intermediate inputs as a share of industry value added excluding foreign primary inputs and foreign services which are not defined as services inputs according to Amiti and Wei (2009). Offshoring of manufacturing and offshoring of services adds to total offshoring. Narrow offshoring is defined as foreign inputs sourced from the same industry. Broad offshoring is defined as foreign inputs sourced from other industries. Narrow and broad offshoring sum to offshoring of manufacturing. We further split offshoring according to offshoring locations (to high-income countries, lower-income countries and the rest of the world). Offshoring to these countries sums again to total offshoring. R&D intensity is defined as R&D-expenditures over value added. Share of high-skilled (medium-skilled) labor is the share of hours worked by high-skilled (medium-skilled) persons engaged in total hours worked. High-skilled labor is defined as people with tertiary education. Medium-skilled labor is defined as people who completed at least upper secondary education but not tertiary education. Exports refer to exports of final and intermediates, and exports are scaled by value added. Capital is defined as the capital stock and is scaled by value added. IT refers to ICT expenditures and is scaled by value added. Import competition is defined as goods imported for final consumption from other countries scaled by industry value added. Upstreamness proxies for the position in the production chain. WES refers to world export supply (see instrument section). Change in offshoring is the % point change between the current observation and the previous year's observation. The growth rate is computed as current value minus previous year's value divided by previous year's value.