Global Value Chain, Offshoring and Productivity

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March 7, 2017

Abstract

Offshoring is considered as key feature of the globalized economy with major impact on technological change, structural change, employment and growth, however the channels and the relative importance across the economy less well documented. Existing literature reports conflicting effects of offshoring on firm productivity. This paper explores the impact of offshoring on total factor productivity in a framework that consider both selection and simultaneous issues as heterogeneity as well. Applying the production model on a employer-employee data comprising the entire population of manufacturing firms in Sweden with 10 or more employees observed over a 14-year period, our results suggest positive impact of outsourcing on firm productivity, however we also find large heterogeneity across different categories of firms. The results also show a positive impact of offshoring on firm employment.

Keywords: Offshoring, innovation, routine jobs, productivity, panel data
JEL classification: D24, O33

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1 Introduction

Offshoring is commonly related to the global value chains (GVCs) process, which refers to a broad range off internationally joined-up production activities including trade in value-added, production sharing, supply chains, vertical integration or fragmented production. Despite the large recent attention on offshoring, still there is little existing research on how it affects productivity at the firm level

In this paper we study offshoring by using employer-employee data on all manufacturing firms in Sweden with 10 or more employees. A majority of the firms are small firm with less than 30 employees.We observe the firms over a period of 14 years between 2001 and 2014. In the empirical analysis, we consider both pooled and panel data estimators, and apply production function framework using the Wooldridge (2009) approach for calculating total factor productivity.

A challenging issue is to measure offshoring. Feenstra and Hanson (1996) proposed a method where offshoring is captured as imports of intermediate inputs from foreign suppliers. The approach has been applied in a series of paper using aggregate data from input-output statistics. Firm level studies, however require a different measurement and a main problem is to separate input supplied by domestic firms from imported inputs. A commonly used proxy is the e ratio between imports and intermediate products and apply appropriate deflators. For different applications of this method, see for instance Görg et al., 2008, Kashara and Rodrigue, 2008, and Akhmetova and Ferguson 2015)

Overall, our results suggest positive impact of outsourcing on firm productivity, however we also find large heterogeneity across different categories of firms. The paper aslo examine the impact on firm employment and find a positive effect.

The rest of the paper is structured as follows. Section 2 provides a brief literaure review. In Section 3, the data is presented. Section 4 introduces the methodological framework. Section 5 reports the empirical results. Section 6 concludes.

2 Background

Contracting out business activities has been undertaken since early days of the industrial society, and in many OECD countries the process of outsourcing increased in the lest decades of the 20-century. Many of the outsourced acivities were service related, and the process contributed to the emergence of the so callded service-economy. Since the 1990s, the phenomenon of contracting out business activities has entered a new stage with offshoring outsorcing. The interplay between three factors appears to be main reason: technological advances, institutional developments favouring trade liberalism and competitive pressures to reduce cost and improve productivity (Olsen, 2006).

The single most important factors is the digitalization of the economy. This has opened the potential for conduting business activities in entire new ways, and in an extended spatial area.where a supply chain of local, regional and international firms produce various inputs. Porter (1985) compare this value chain process with Ricardian principle of comparative advantage. In line with the theoretical fundation of Coase (1937),, he suggests that firms can can increase their productivity by focus on what they do best and outsource the rest.

Baldwin (2012) suggests that the outsorcing process can be decomposed into two phenomena: fractionalization and dispersion. When these phenomena are considered in a spatial perspective, they can be separated into relocation of jobs and processes to external providers within the country or to any foreign country.

Recent labour market research shows that offshoring might have potentail negative impact on both employment and wages. However, the literature distinguishes between possiblenegative short-term effect and long-term economic benefits trough increased productivity and reduced labour costs. While Acemoglu et al. (2015) show thatoffshoring contributes to job polarization in the industrialized world through skill-biased technical change inthe short run, Bloom et al. (2016), suggest that offshoring manufacturing jobs to developing countries allows firms in developed countries to specialize in innovative activity and thereby increase value added. Importing intermediate inputs from abroad may also allow the transfer of foreign technological know-how, and necessitate or induce adoption of better managerial and production practices and an updating in production technologies, all of which results in higher total factor productivity.

However, at firm level, little systematic research has been conducted on offshoring and its impact on productivity, and the few existing studies provide mixed results.While there are theoretical arguments for a positive impact of offshoring, previous studies on data from different countries report mixed results, which calls for further studies. Positive effects are reported by Blalock and Valeso 2007 (Indonesia), Yasar and Morrison Paul 2007 (Turkey), Görg et al. 2008 (Irland), Kasahara and Rodrigue (Chile) Halpern et al 2011 (Hungaria) and Zhang 2014 (Colombia). Studies reporting no offshoring effects includes Vogel and Wagner 2010 (Germany), and Akhmetova and Ferguson 2015 (Sweden) when not accounting for the impact of offshoring on relative skilled labour productivity

Recent literature suggests that insights into the link between outsourcing and productivity may also be derived from indirect analysis, such as the decision to outsource (Kimura 2002, Tomiura 2004) or how outsourcing affects the skill intensity in industries and establishments in different countries (Feenstra and Hanson 1999, Hijzen 2003, Hijzen, Görg and Hine 2003, Egger and Egger 2001, Head and Ries 2002)

3 Data

Our study a combined employer-employee data set. The data is obtained from Statistics Sweden and covers all firms within manufacturing (2-digit NACE Rev.2 codes 10-37) and their employees.. Similar to most other studies using Swedish trade data, we only consider firms with 10 or more employees, since the information provided for smaller firms might be less reliable. We use data for the period 2001-2014. The data contains information on sales, value-added, exports, intermediate inputs, capital stock, corporate ownership structure and the number of employees at the firm level. We merge the firm-level data with the employee data, which provides information on their level of education and occupation. We deflate our continous variables using deflators for exports, imports and producer prices provided by statistics Sweden. The Swedish firm level data is matched with patent data provided by European Patent Office and OECD.

The main target variables in empirical offshoring studies are wages, employment and productivity. The focus of this paper is productivity and prior studies uses value added or TFP estimated with approaches based on Olley and Pakes (1996), Levinsohn and Petrin (2003), or the ACF (Ackerberg et al., 2006) critique of both former paper applies the Wooldridge (2009) approach for calculating total factor productivity (TFP). In our study, We apply the latter.

Following existing literature, offshoring is measured as imports related to total investments. We also consider the so called Blinder-index on offshorability. A wide variety of national occupations in both manufacturing and services are vulnerable to offshoring to other countries. Blinder and Krueger (2013) estimate that the potential offshorability is about one quarter of all jobs in the 2004 US workforce. Blinder finds that jobs that can be broken down into simple, routine tasks are easier to offshore than other occupations. Their common characteristic is that they do not require face-to-face contact with end users.

Applying the classification method proposed Blinder and Krueger (2013), we first considered 430 job titles on the Swedish labor market and estimated their offshorability based on the Blinder-Index. For each and every occupation we classified whether it had a high risk of being moved abroad or not. We then calculated an offshorability measure for each firm in our data as the ratio of offshorable jobs to the total employment. In a similar way, we apply the Oborne-Frey index on routinization, and calculate for each occupation in each firm their likelihood of being replaced by computers or robots in the near future. We then create an Osborne-Frey index for each firm. We estimate residuals from a fully saturated Mincer equation, defined over traditional individual variables age, age squared, education and gender. This measure is used as a proxy variable for ability. Based on this we calculate the average ability measure for each firm, and we also distinguishes between above and below mean ability.

Prior studies suggest that insourcing intermediate inputs from abroad may allow for transfer of global technological knowledge (Keller, 2010). According to the absorptive capacity-hypothesis (Cohen and Levinthal, 1990), innovative firms have lager potential to benefit from knowledge spillovers than other firms. To account for the positive association between offshoring and knowledge spillovers, we include patent in the analysis assuming that the reflect innovativeness.

All our equations consider the importance of human capital and skills, and we apply two different measures. The first is the fraction of a firm's employment with 3 years or university education or more (human capital). The second is an alternative version where human capital expressed in number of employees (high-skilled labor). Using the first measure we include firm size (employment) in the model, while low-skilled labor is contrast high-skilled in the second alternative.

A growing number of studies shows the importance of considering corporate ownership structure in productivity studies. There are not only potential differences between domestically and foreign multinational firms, but also between various categories of domestic firms. Our study separates the firms in four ownership categories, namely non-affiliate domestic firms, uni-national domestic forms (belongs to a group with only domestic firms), and domestic and foreign firms.

To consider the impact of international trade, our main measure is the ratio of total exports to the total gross output of the firm, labeled as export intensity. The alternative measure is an export dummy. The study controls for industry specific effects (18 sni2-industries, 10-37), and time specific effects (14 years).

Descriptive statistics are reported in Table 1. The annual number of unique firms observed is about 7,000 which amounts up to 83,221 observations (Table 4). Using imports and intermediate inputs for creating the offshoring variable, 83 percent of all firms are relying on offshoring in their production function. Almost 30 percent of all jobs in Swedish manufacturing firms are potentially offshorable. 14 percent of the firms can be defined as innovators based on the international patent database PATSTAT. Three out of ten firms are domestically or foreign controlled multinational enterprises. One third of the manufacturing firms does not export, while a quarter export 30 percent or more of their production. More than 40 percent of the firms are within the size class 10-19 employees and only one out of 10 has more than 100 employees.

4 Methodology

Recent years have seen a surge in both theoretical and empirical studies on TFP, driven both by the increasing availability of firm-level data as well as by a number of methodological improvements that have emerged from the literature since the mid-1990s (Olley- Pakes 1996, Levinsohn-Petrin 2003, Ackerberg et al., 2007 and Wooldridge 2009).

Olley- Pakes, Levinsohn-Petrin, Ackerberg-Caves-Frazer have all contributed to the literature proposing two-steps estimation procedures, while Wooldridge showed how to perform a consistent estimation within a single step GMM framework. Most recently Miollisi and Rovigatte (2016) propose a new estimator, based on the Wooldridge approach, using dynamic panel instruments 'a la Blundell- Bond.

The main challenge in estimating TFP is that due to a positive productivity shocks, firms tend to respond by expanding their level of output and by demanding more input – and the opposite for a negative chock. The positive correlation between the observable input levels and the unobservable productivity shocks is a source of bias in OLS, TFP.

In this paper, we apply the Wooldridge approach in two empirical models. The first a IV-fixed effects estimator, where lag of offshoring intensity considered as endogenous. The other model is CMP estimation of two-equation Heckman selection model, which outcome equation is is specified as follows:

$$\begin{aligned} \log TFP_{i,t} = {} & \beta_0 + \beta logOFFS_{i,t-1} + \theta FO_{i,t} + \gamma BI_{i,t} + \beta_3 MINCER_{i,t} + \beta_4 SIZE_{i,t} + \\ & \beta_5 METRO_{i,t} + \beta_6 INNO_{i,t} + \zeta(OFFS \times FO)_{i,t} + \theta(OFFS \times BI)_{i,t} + \\ & \phi_1(OFFS \times SIZE)_{i,t} + \mu(OFFS \times METRO)_{i,t} + \mu(OFFS \times INNO)_{i,t} + \\ & \kappa(OFFS \times YEAR)_i, t + \psi_k INDUSTRY_k + \tau_t YEAR_t + \varepsilon_{i,t} \end{aligned} \tag{1}$$

where the TFP measure is the Wooldridge (2009) approach, OFFS is the lagged offshoring variable, FO is the Osborne-Frey (2013) computerization index, BI is the Blinder offshorability index, MINCER is the residual from a fully saturated Mincer equation, SIZE is an indicator variable for five size classes, METRO is an indicator variable for the three largest cities in Sweden, and INNO is an indicator variable for patent application. FO, BI and MINCER is calculated as firm average. We also include six interaction variables. Additional variables are year and industry dummies and the model accounts for idiosyncratic errors. In the selection equation, we estimate the likelihood that a firm is participation in global value chain trough imports with SIZE, FI, BI, METRO, INNO, log exports and human capital as explanatory variables. We also estimate the selection model with log employment as the dependent variable.

5 Results

In this section, we present the regression results and report marginal plots for selected estimates. The equations are estimated recognizing the selection problem in estimating a wage equation, we employ a Heckman-style model on a sub-sample in order to gauge the importance of the labor force participation decision on wage determination. We estimate wage levels over the period 2001-2012.

Table 12 contains the results from an IV panel data regression with fixed effects, where TFP computed according to Wooldridge (2009) is regressed on the independent variables reported in Table 2 and the variable of main interest, offshoring intensity. We find that the effect from offshoring on productivity is positive and statistically significant, which is robust in different specification and also holds if we define a binary variable ($d = 1,$ if $Offs > 0$) and apply endogenous dummy variable models. In a second step we also estimate the model with Roodman (2011)'s cmp procedure for conditional mixed processes, where *Offs* is endogenously determined in a second equation. The results are reported in Table 13. The main conclusion holds that offshoring positively impacts on firm productivity.

Looking at the controls, Table 12 reports a negative association between productivity and a non-exploited potential for replacing employees with computers and robots (OF), while the size of the offshorability variable is negligible and the estimate non significant. Notable is that the innovation-indicator is non-significant in the fixed-effects model.

Table 13 reports that offshoring has a positive impact on both TFP and employment, at the firm level. As could be expected, the Osborne-Frey index has the opposite impact on productivity and employment. Ability, innovation and location in a metropolitan area are all positively associated with TFP and employment, respectively.

Figures 1 to 4 show how the marginal effect of offshoring on *TFP* changes when *Offs* is interacted with the corresponding variable. In general, the changes in the marginal effects are minor compared to the base effect that *Offs* has on *TFP*.

6 Conclusions

Since the 1990s, the phenomenon of contracting out business activities has entered a new stage with offshoring outsourcing. The interplay between three factors appears to be main reason: technological advances, institutional developments favoring trade liberalism and competitive pressures to reduce cost and improve productivity. The single most important factor is the digitization of the economy. This has opened the potential for conducting business activities in entire new ways, and in an extended spatial area.where a supply chain of local, regional and international firms produce various inputs. However, at firm level, little systematic research has been conducted on offshoring and its impact on productivity and employment.

In this paper we study offshoring by using employer-employee data on all manufacturing firms in Sweden with 10 or more employees. A majority of the firms are small firm with less than 30 employees.We observe the firms over a period of 14 years between 2001 and 2014. In the empirical analysis, we consider both pooled and panel data estimators, and apply production function framework using the Wooldridge (2009) approach for calculating total factor productivity. Overall, our results suggest positive impact of outsourcing on firm productivity, however we also find large heterogeneity across different categories of firms. The paper also examine the impact on firm employment and find a positive effect.

The results we present in this paper are preliminary. In our future analysis, we will complement the selection model with dynamic approaches that accounts for both state dependency and endogeneity. Moreover, in further study we will examine whether offshoring might have an indirect influence in TFP trough ability of innovation.

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Appendix I

Tables

Table 1: Summary statistics

Variable	*Obs*	*Mean*	*Std Dev*	*Min*	*Max*
Calculated					
TFP WDRG, log	83,221	14.191	0.714	4.947	20.368
TFP OP/ACF, log	83,221	11.549	0.473	2.643	16.325
TFP LP/ACF, log	83,221	11.549	0.473	2.643	16.325
Mincer, all, log	83,221	12.392	0.188	11.207	12.998
Mincer estimate, skilled, log	44,287	12.754	0.232	11.639	13.240
Mincer estimate unskilled, log	83,218	12.374	0.186	11.207	12.877
BI: Blinder-index	83,221	49.488	16.301	0	94
FO: Frey-Osborne	83,221	0.560	0.161	0.009	0.99
Observed					
Offs: Imports/Investments, ratio	83,221	0.474	0.475	0	1
Imports/Materials, ratio	83,221	0.683	0.704	0	10
Value added, log	83,221	16.617	1.286	6.966	24.392
Capital, log	83,221	15.423	1.900	11.313	20.795
Investments, log	83,221	13.469	1.9745	9.131	18.807
Materials, log	83,221	13.093	1.954	8.775	18.450
Firm size, log	83,221	3.524	1.007	2.397	6.862
Skill intensity, ratio	83,221	0.067	0.132	0	1
High skilled labor, log	83,221	3.4736	1.022	0	10.0506
Low skilled labour, log	83,221	0.902	1.143	0	9.151
Imports, log	83,221	5.330	19.400	1	150.000
Exports, log	83,221	2.110	7.020	1	50.900
Innovator, fraction	83,221	0.108	0.310	0	1

Table 2: Variables used in regressions

Variable	*mean*	*sd*	*min*	*max*
lnTFP	14.1919	.7140462	4.947682	20.36897
Offs	.060574	.1002132	0	.764485
FO	.5607381	.1610287	.009645	.99
BI	49.48827	16.30148	0	94
mincer	12.39253	.1886015	11.20795	12.9984
lnExport	10.59029	7.483882	0	24.99917
human capital	.0536274	.0875534	0	1
innovator	.108338	.3108087	0	1

Table 4: Distribution over years

Year	*Freq.*	*Percent*	*Cum.*
2001	5,920	7.11	7.11
2002	6,029	7.24	14.36
2003	6,168	7.41	21.77
2004	6,476	7.78	29.55
2005	6,665	8.01	37.56
2006	6,691	8.04	45.60
2007	6,581	7.91	53.51
2008	6,324	7.60	61.11
2009	5,543	6.66	67.77
2010	5,614	6.75	74.51
2011	5,693	6.84	81.35
2012	5,437	6.53	87.89
2013	5,325	6.40	94.29
2014	4,755	5.71	100.00
Total	83,221	100.00	

Table 6: Different size classes

Size	*Freq.*	*Percent*	*Cum.*
1: 0-15 empl	23,319	28.44	28.44
2: 16-25 empl	19,366	23.62	52.07
3: 26-50 empl	16,865	20.57	72.64
4: 51-100 empl	10,888	13.28	85.92
5: >100 empl	11,543	14.08	100.00
Total	81,981	100.00	

Table 8: Sector classification

Sector	*Freq.*	*Percent*	*Cum.*
na	2,239	2.69	2.69
1	4,547	5.46	8.15
2	18,455	22.18	30.33
3	32,042	38.50	68.83
4	25,938	31.17	100.00
Total	83,221	100.00	

Table 10: Locations

Location	*Freq.*	*Percent*	*Cum.*
Large city (Stockholm, Malmö, Gothenburg)	11,289	13.57	13.57
Close to large city	13,786	16.57	30.13
Larger city	8,715	10.47	40.60
Rural	49,431	59.40	100.00
Total	83,221	100.00	

Table 12: IV fixed effects regression, endogenous variable offshoring intensity (*Offs*)

VARIABLES	(1) ***lnTFP***
Offs	6.573***
	(0.968)
FO	-0.0942***
	(0.0217)
BI	0.000185
	(0.000203)
mincer	0.121***
	(0.0351)
size=2	0.0227***
	(0.00787)
size=3	0.0320**
	(0.0145)
size=4	0.0280
	(0.0294)
size=5	-0.00496
	(0.0499)
innovator	-0.00914
	(0.0131)
location=2	0.0404
	(0.0377)
location=3	0.0385
	(0.0497)
location=4	-0.0808**
	(0.0363)
Constant	12.67***
	(0.470)
Observations	62,738
Number of Id	10,334

Firm fixed effects and year fixed effects included
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: CMP estimation of two-equation system

Equation (1): Dep var	Model (A) ***lnTFP***	Model (B) ***lnEmp***
Offs	7.643***	1.752***
	[0.208]	[0.069]
FO	-0.056**	0.085***
	[0.024]	[0.011]
BI	-0.001**	-0.001***
	[0.000]	[0.000]
Mincer	0.633***	0.086***
	[0.015]	[0.012]
Size=2	0.082***	0.442***
	[0.010]	[0.005]
Size=3	0.126***	0.995***

. . . continued

Equation (1): Dep var	Model (A) ***lnTFP***	Model (B) ***lnEmp***
	[0.012]	[0.005]
Size=4	0.168***	1.591***
	[0.016]	[0.007]
Size=5	0.495***	2.843***
	[0.021]	[0.008]
innovator	0.127***	0.143***
	[0.011]	[0.005]
location=2	-0.082***	-0.064***
	[0.012]	[0.006]
location=3	-0.020	-0.019***
	[0.014]	[0.007]
location=4	-0.071***	-0.059***
	[0.010]	[0.005]
Equation (2), dependent variable *Offs*		
Constant	7.429***	1.658***
	[0.183]	[0.149]
size=2	0.005***	0.002*
	[0.001]	[0.001]
size=3	0.020***	0.013***
	[0.001]	[0.001]
size=4	0.043***	0.031***
	[0.001]	[0.001]
size=5	0.060***	0.047***
	[0.001]	[0.001]
FO	-0.017***	-0.023***
	[0.003]	[0.003]
BI	0.000***	-0.000
	[0.000]	[0.000]
log(export)	0.002***	0.004***
	[0.000]	[0.000]
human capital	0.173***	0.043***
	[0.004]	[0.005]
innovator	-0.001	-0.001
	[0.001]	[0.001]
location=2	0.009***	0.004***
	[0.001]	[0.001]
location=3	-0.005***	-0.009***
	[0.002]	[0.002]
location=4	-0.001	-0.009***
	[0.001]	[0.001]
Constant	-0.059***	-0.028***
	[0.003]	[0.003]
Observations	62,738	62,738
Parameters atanh ρ and $\ln \sigma^{c,d}$		
$\ln \sigma_1$	-0.208***	-0.936***
	[0.020]	[0.007]
$\ln \sigma_2$	-2.395***	-2.408***
	[0.003]	[0.003]
atanh ρ_{12}	-1.241***	-0.416***
	[0.024]	[0.016]
Observations	62738	62738

. . . continued

Equation (1): Dep var	Model (A) ***lnTFP***	Model (B) ***lnEmp***
Industry effects (in all equations)	Yes	Yes
Year effects (in all equations)	Yes	Yes
Model *df*	56	56
χ^2-test	65683.59	144887.84
p-value	0.000	0.000

[a] Standard errors in brackets, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[b] $\operatorname{atanh} \rho$ and $\ln \sigma$ are transformations of parameters ρ and σ, respectively

[c] $._{ij}$ stands for equations i and j

Figures

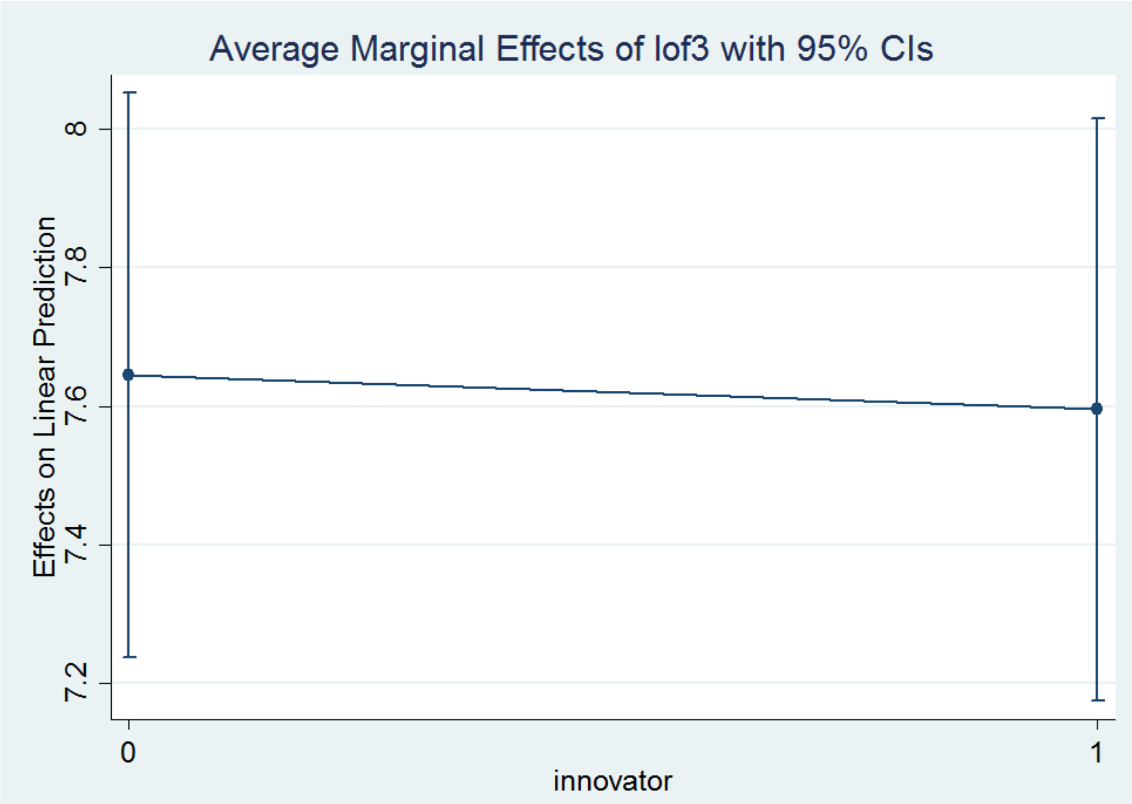

Figure 1: Marginal effects of offshoring for innovating/non-innovating firms

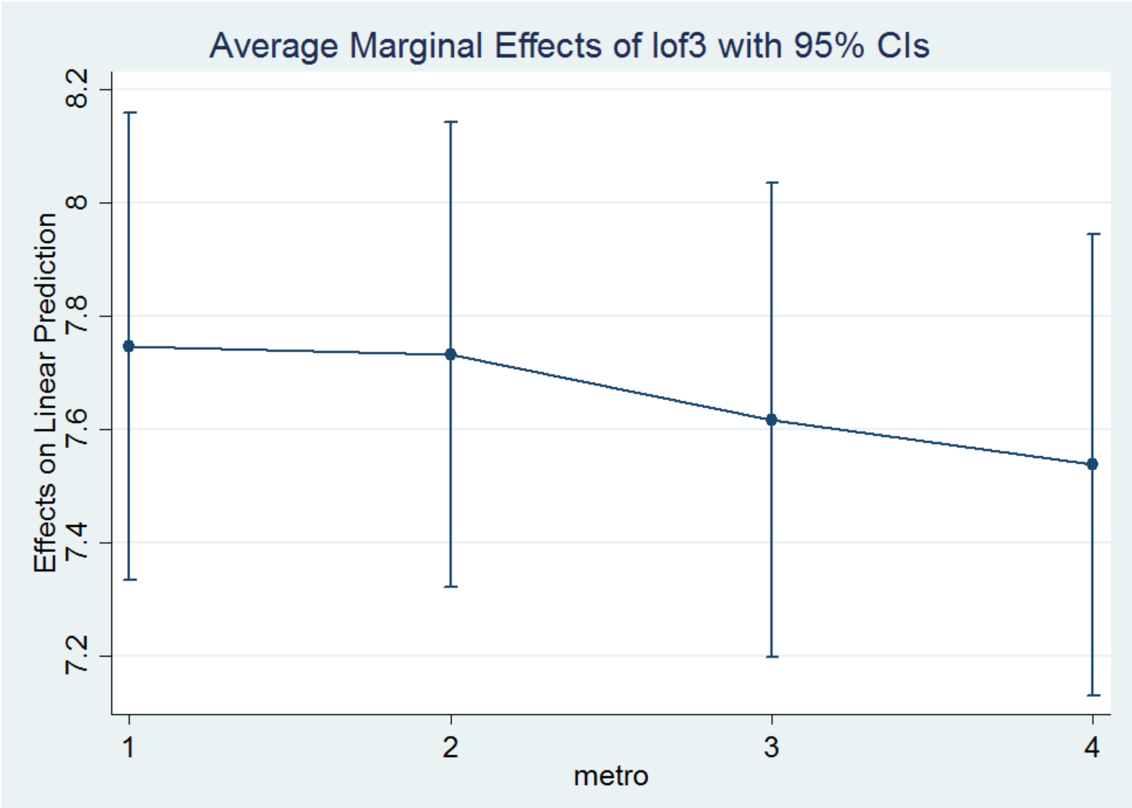

Figure 2: Marginal effects of offshoring for different locations, see Table 10

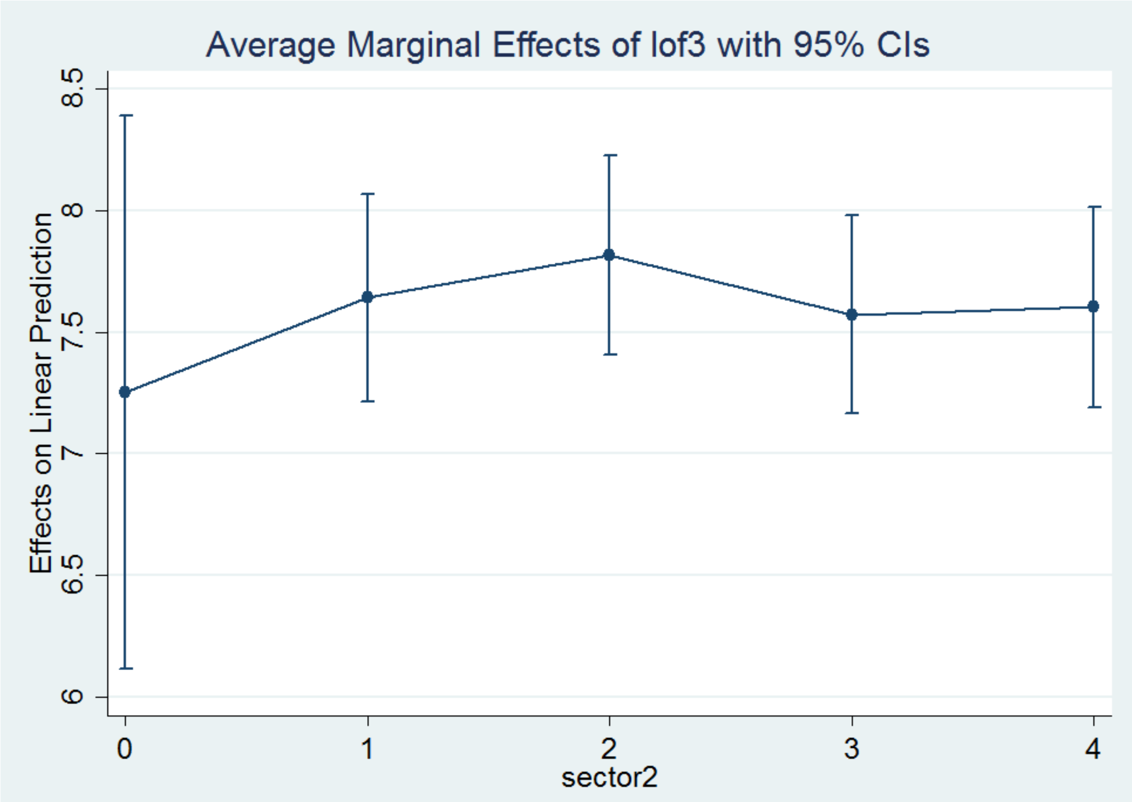

Figure 3: Marginal effects of offshoring for different sectors, see Table 8

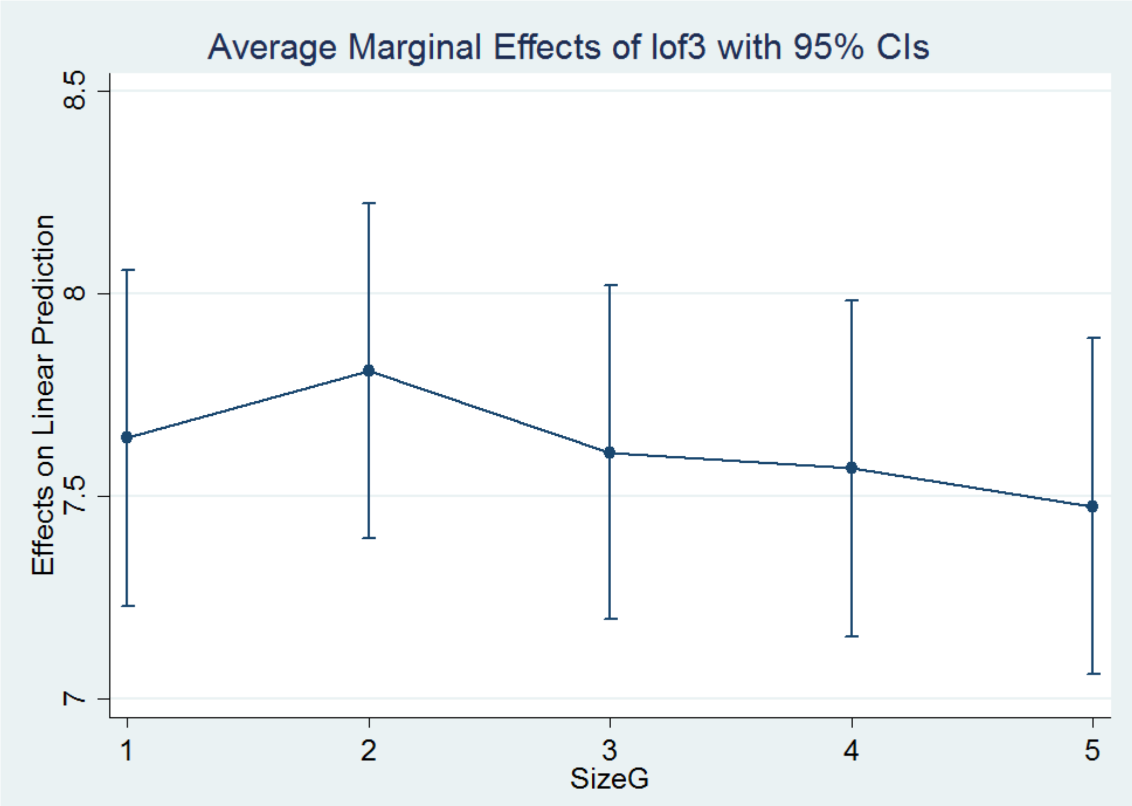

Figure 4: Marginal effects of offshoring for different size classes of firms, see Table 6

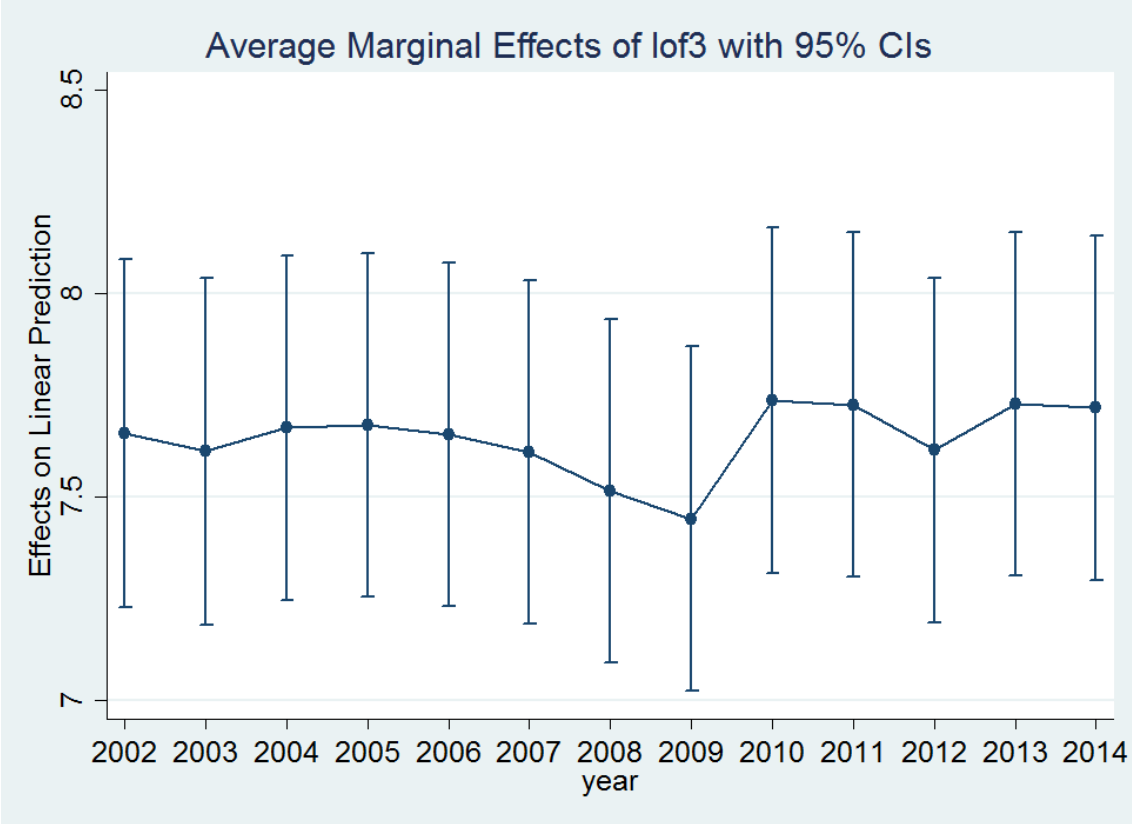

Figure 5: Marginal effects of offshoring for different size classes of firms, see Table 4

Appendix II: Blinder Index and Osborne-Frey Index

In the spirit of Joseph Schumpeter, most economists believe innovation is good for job, growth and welfare because workers displaced in one occupation or industry will find new options producing goods and services with higher value added. The challenge is the adjustment process from the old and obsolete to the new. In their book *The Second Machine*, Brynjolfsson and McAfee (2014) argue that without upgrading, some people will have nothing that employers will want even at a salary of a few dollars per hour, referring to the horse example that they were never able to adjust to the invention of the tractor.

This Appendix considers two major consequences of disruptive technological innovations on the modern labor market. The first is that technological progress has been the main driver towards increased fragmentation of firms' production. Firms are increasingly organized within global value chains where the different stages of the production process are located across different countries (De Backer et al., 2016). The second consequence is restless transform of tasks jobs, occupations and industries across the whole economy due to is advances in digitization.

We study the offshorability of Swedish occupations and the sensitivity of jobs to computerization. We follow Blinder et al. (2009) in order to calculate how many Swedish jobs that are potentially offshorable, and Frey and Osborne (2017) to estimate how many jobs that are of risk for being replaced by advanced robotics or computers with massive amounts of cheap processing power programmed with clever algorithms.

Blinder (2009) estimates that about a quarter of all jobs in the U.S. labor market are offshorable. Ali-Yrkkö et al. (2016) find a similar result for Finland. Concerning computerization, Frey and Osborne (2017) estimate that close to half of the total U.S. employment is in the high risk category. In a corresponding study for Finland, Parjarinen and Rouvinen calculate a substantially lower fraction (36 percent). Our results are somewhat lower than these estimations for the U.S. and Finland. Using a dataset consisting of 4.2 million employees in 430 different occupations, we find that 22.8 percent of the occupations are offshorable, and 32 percent are highly sensitive for computerization.

Table 14: Selected occupations ranked by different degrees of offshorability based on the Blinder-methodology

Occupation	Offshorablity Index
Category I: Highly Offshorable, Index 76-100	
System analysts and ICT-architect	93
Games and digital media developers	92
ICT support technicians	92
Category II: Offshorable, Index 51-75	
Chemists	66
Machine-tool operators	61
Directors and chief executives	55
Category III: Hard to offshore, Index 26-50	
Personnel and human resources specialist	46
Bank Clerk	25
Architects	25
Category IV: Non-offshorable, Index 0-25	
Engineering professionals in building construction	0
Dentists	0
Bus and tram drivers	0

Table 16: Selected occupations ranked by different degrees of Frey Osborne Index

Occupation	Index
Category I: Highly computerization probability, Index 0.71-1.00	
Accounting and bookkeeping clerks	0.970
Cement, stone and other mineral products machine operators	0.880
Information and communications technology operations technicians	0.780
Category II: Medium computerisation probability, Index 0.30-0.70	
Miners and quarries	0.696
Hotel receptionists	0.575
Business services agents	0.298
Category IV: Low computerisation probability, Index 0.00-0.29	
Early childhood educators	0.079
Web technicians	0.030
Research and development managers	0.018

Table 18: Four main occupational categories based on the Blinder Offshorable Index

Category	Description	Number of occupations	Average Blinder Index	Employment Percentage
I	Highly offshorable	30	87.8	5.1 %
II	Offshorable	103	63.6	17. 7%
III	Hard to offshore	44	39.2	8.4 %
IV	Non-offshorable	253	1.0	68.8 %
All		**430**	**25.9**	**100.0 %**

Note: Replication of Blinder 2009, table 1 with data for Sweden and comparisons with Bliner 2009

Table 20: Three main occupational categories based on the Frey-Osborne Index measuring how potentially automatable the occupations are

Category	Description	Number of occupations	Average Frey-Osborne Index	Employment Percentage
I	High	122	0.87	35.5 %
II	Medium	111	0.27	32.3 %
III	Low	186	0.09	32.2 %
All		**429**	**0.43**	**100.0 %**

Note: Note: Replication of Frey Osborne (2013), with data for Sweden.

Table 22: "Offshorability" of Swedish labor market

Category	Number of employees and share of employment	Offshorable Index 51-75	Highly offshorable Index 76-100
Manufacturing	867 164	39.4%	3.7%
Private services	1 675 516	19.3%	8.9%
Primary industry	34 933	7.4%	1.9%
Public sector	1 611 130	4.7%	1.9%
Other	25 813	6.2%	1.5%
Higher education	1 106 375	18.4%	5.8%
Other education	3 108 181	17.5%	4.8%
Females	2 067 235	11.1%	5.6%
Males	2 147 321	24.1%	4.6%
Total	**4 214 554**	**17.7%**	**5.1%**

Table 24: Probability of computerization, Swedish labour market