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Determinants of R&D offshoring

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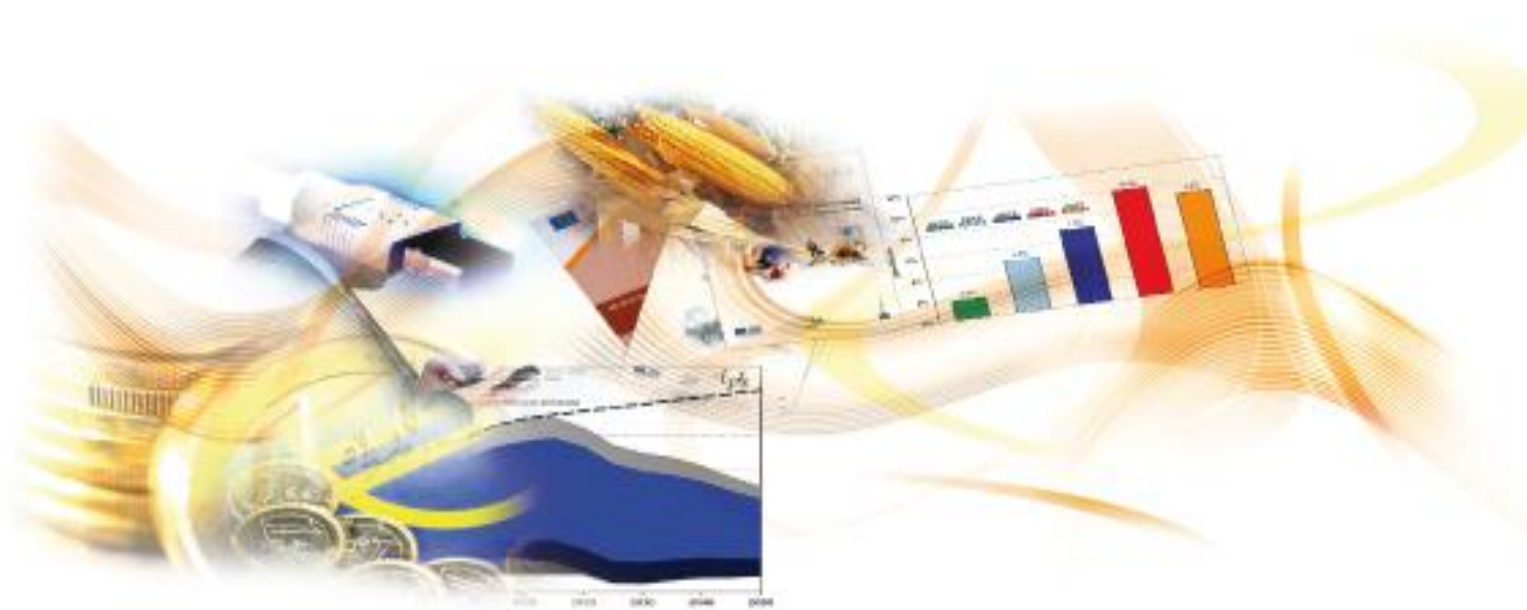
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Determinants of R&D offshoring

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Abstract

We analyse determinants of an enterprise's decision to offshore R&D activities using a novel data set for enterprises in Ireland over the period 2001-2006. Our results suggest that, on average, other things equal, enterprises integrated in international production and innovation networks, and enterprises which used information and communication technologies (ICT) more intensively were more likely to offshore R&D. Furthermore, characteristics of the import source region had an important influence on enterprise offshoring behaviour, with offshoring to regions outside of the advanced European Union's economies being less likely.

Abstract

We analyse determinants of an enterprise's decision to offshore R&D activities using a novel data set for enterprises in Ireland over the period 2001-2006. Our results suggest that, on average, other things equal, enterprises integrated in international production and innovation networks, and enterprises which used information and communication technologies (ICT) more intensively were more likely to offshore R&D. Furthermore, characteristics of the import source region had an important influence on enterprise offshoring behaviour, with offshoring to regions outside of the advanced European Union's economies being less likely.

Keywords: Global production and innovation networks; International sourcing of R&D.

JEL Classification: F14, F23, D22

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1 Introduction

Over the past two decades, technological advances have led to the reduction of transport and communication costs which in turn have enabled a greater fragmentation and internationalisation of production. In recent years, there has been an increasing trend in the international outsourcing of R&D. The internationalisation of R&D is not new, however its speed and extent have increased in recent years in response to intensified global competition, technological change, and the availability and costs of skills (Abramovsky et al. 2008; Siedschlag et al. 2013). While the traditional role of foreign R&D investment has been demand-driven, linked to adapting products and services to local market conditions, knowledge-sourcing has become an important supply-driven motivation for investing in R&D internationally (Ambos 2005; Belderbos et al. 2008; OECD 2008; Siedschlag et al. 2013; Dachs 2014).

Notwithstanding a growing research interest on understanding the determinants and impacts of the internationalisation of corporate R&D and innovation, systematic evidence to inform research and innovation policies is still limited. This paper contributes to filling this gap by providing empirical evidence on links between firm and location characteristics and the propensity of enterprises to offshore business activities, including R&D. To this purpose, we use a novel data set obtained by linking three enterprise surveys conducted by the Central Statistics Office (CSO) of Ireland: the International Sourcing Survey (ISS), the Census of Industrial Production (CIP), and the Annual Services Inquiry (ASI). This evidence informs enterprise strategy and policy design aiming at maximizing benefits from global sourcing and integration in global value chains.

In this analysis, offshoring or international sourcing is defined as in the ISS, namely “the total or partial movement of business functions currently performed in-house or currently domestically sourced by the resident enterprise to either non-affiliated or affiliated enterprise located abroad”.

Ireland is one of the most globalised economies in the world.¹ Given the extensive engagement of its firms in international sourcing, Ireland is a relevant case for the purpose of our analysis. Among the countries covered by the International Sourcing Survey in 2007,² Ireland had the highest proportion of firms³ engaged in international sourcing of business activities, 38%. In comparison, the corresponding EU average was 15%. The proportion of firms with international

¹ The 2014 edition of the KOF Index of Globalisation ranks Ireland the first among 207 countries. Ireland ranks second after Singapore with respect to economic globalisation. The rankings are based on data for 2011.

² The other countries surveyed in 2007 were: the Czech Republic, Denmark, Finland, Germany, Italy, the Netherlands, Portugal, Slovenia, Sweden, United Kingdom, and Norway. The reference period covered by the survey was 2001-2006. Alajääskö (2009) discusses the key findings from the International Sourcing Survey 2007.

³ The surveyed firms included those with 100 and more employees.

sourcing of R&D over the same reference period was 6.2% in Ireland, three times higher than the corresponding EU average, 2.1%.

More specifically, we find that, on average other things equal, larger, more productive enterprises, enterprises with international activities, and enterprises with higher ICT investment per employee and those which had a website were more likely to offshore business activities. The characteristics of the import source region appear to matter, with offshoring to regions outside of the advanced European Union's economies (EU15)⁴ being less likely. In addition, we find that core business activities were more likely to be offshored compared with other business functions.

Further, our results suggest that, on average, other things equal, enterprises integrated in international production and innovation networks, and enterprises which used information and communication technologies (ICT) more intensively were more likely to offshore R&D. Furthermore, characteristics of the import source region had an important influence on enterprise offshoring behaviour, with R&D offshoring to regions outside of the EU15 economies being less likely.

The rest of this paper is structured as follows. Section 2 discusses the theoretical and empirical underpinnings of our analysis. Section 3 presents our empirical methodology. Next, in Section 4 we discuss the data that we use. Section 5 discusses the empirical results. Finally, Section 6 concludes.

2 Theoretical and Empirical Framework

In this section we discuss theoretical and empirical insights that underpin our analysis of determinants of offshoring of R&D.

The decision to outsource certain business activities previously undertaken in-house has been first analysed by Coase (1937). However, the interest in understanding factors driving international outsourcing or “offshoring” is more recent (Grossman and Helpman 2002; Antràs and Helpman 2004; Grossman and Rossi-Hasenbergs 2008).

One of the main motivations for offshoring identified in the theoretical literature is the opportunity for enterprises to save on production costs. Grossman and Rossi-Hansberg (2008) develop a model that examines the potential productivity gains which accrue from offshoring that is motivated by international factor cost differentials. In their model, firms can benefit from

⁴ Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom.

labour cost differentials in different countries by offshoring tasks that are produced by low skilled labour more cheaply abroad than at home. However, the benefits of offshoring must be weighed against the coordination and monitoring costs of completing the task abroad. They find that firms that use low skilled labour intensively can gain relatively more in terms of profits and productivity and increase demand for the less offshorable labour inputs.

In the closely related theoretical literature on the determinants of the firm's organisation mode, Grossman and Helpman (2002) and Antràs and Helpman (2004) are particularly relevant. Grossman and Helpman (2002) examine the choice between outsourcing and firm integration. In determining their organisational mode, firms, which are assumed to be equally productive, are faced with the trade off between the costs of running a large and less specialised organisation versus the search and monitoring costs of an input supplier. The authors show that outsourcing is likely to be more prevalent in some industries than in others. Outsourcing is more likely to be viable in large firms and in large economies. Also, in competitive markets outsourcing requires a high per unit cost advantage for specialised input producers relative to integrated firms, while in markets with less competition, outsourcing depends on the comparison of the fixed costs between specialised producers and integrated firms.

Antràs and Helpman (2004) model organisation choices of profit-maximising firms, accounting for the behaviour of the input supplier, given imperfect contract enforcement. Each input sourcing mode is associated with a respective fixed cost which only the more productive firms can overcome. In this framework, decisions regarding trade, investment and organisational choices are interdependent. Görg et al. (2008) also emphasise that "better" firms are more likely to offshore given that upfront sunk costs are involved. Wagner (2011) analyses the effects of offshoring on German manufacturing firms performance and shows that "better" firms self-select into offshoring. He identifies offshoring firms as being larger, more productive, more human capital intensive and more export intensive relative to non-offshoring firms.

We earlier acknowledged that the most productive firms are capable of overcoming the fixed costs associated with offshoring. Implicit in our discussion was that the source country characteristics affect the cost of offshoring and influence the offshoring decision. Also the costs of offshoring to potential source countries are likely to differ by source country. Movement towards greater global integration through trade agreements involving the reduction of tariffs and non-tariff barriers between countries has had a dramatic impact on trade costs between countries. This, in turn, has increased the relative viability of offshoring to countries covered by such agreements. However, with the elimination of these trade barriers there is limited scope for potential gains from future trade agreements. In this context, a recent strand of the literature emphasises the importance of country trade facilitation characteristics such as the efficiency of

customs, ports, transport infrastructure, regulation, and ICT infrastructure. Such factors influence the speed, efficiency and cost with which inputs are delivered and are particularly important in global supply chains where delays and costs can be transmitted throughout the value chains, Nordas et al. (2006).

Access to skilled talent and specialised technologies in the source country are also expected to influence firms' offshoring behaviour. These factors are strategic considerations faced by firms which enable them to benefit from the science and technology infrastructure of the host country (Farrell et al. 2006; Bunyaratavej et al 2007; Manning, 2008; Ceci and Masciarelli 2010).

Bunyaratavej et al. (2007) investigate the determinants of the location of services offshoring. Drawing on the international business research, they identify the cost of doing business abroad, liability of foreignness and institutional factors as defining the rationale for offshoring. Lower labour costs and human capital are found to matter in choosing a location for services outsourcing while the use of telecommunications technology lessens the need of firms to be near major markets. In line with the institutional theory literature, which emphasises the role institutions play in lowering transaction costs and information costs and facilitating interactions, they find that firms have a higher propensity to offshore to locations where culture, education and infrastructure closely resemble their home country.

The specific role of information and communication technology (ICT) on the offshoring activity of firms has come in for particular attention in the literature. This is unsurprising given it is considered one of the key drivers of global trade and financial integration (Rae and Sollie, 2007). There are a number of channels through which ICT can directly reduce trade-related costs of offshoring.⁵ First, ICT which is a General Purpose Technology, enables sellers to adapt and tailor their service to closely match the requirements of the buyers of the service. Second, ICT better facilitates the matching of producers and purchasers, (Grossman and Helpman, 2002). Finally, Autor et al. (2003) argue that ICT allows for the compartmentalisation of jobs into tasks some of which may be offshorable.

The empirical literature which examines the link between ICT and offshoring at the enterprise level is limited but results tend to suggest a positive relationship. (Abramovsky and Griffith, 2006; Rasel, 2012; Tomiura, 2005).⁶ Abramovsky and Griffith (2006) investigate the effect of ICT on the enterprise's choice of organisational form for a sample of UK enterprises for the period 2001-2002. They show that enterprises with greater ICT investment and enterprises which order goods and services online are more likely to outsource and offshore business

⁵ For a more extensive review of the impact of ICT on offshoring, see Rasel (2012).

⁶ Benefratello et al (2009) in their analysis of a sample of Italian firms find the relationship between ICT investment and offshoring to be negative.

services. More recently, Rasel (2012) examines the relationship between ICT usage and the enterprise's offshoring decision. She distinguishes between the types of ICT used by the enterprise and whether the ICT-offshoring relationship differs between manufacturing and services enterprises. Basing her analysis on the ICT Survey 2010 of German enterprises, she finds enterprises that use more software systems (i.e. ICT intensive enterprises) are more likely to offshore compared with less ICT intensive enterprises. The use of software solutions for supply chain management systems is particularly important for manufacturing enterprises who decide to offshore. For service enterprises, Enterprise Resource Planning software and e-commerce purchases are also found to be relevant for offshoring.

Biewen et al. (2012) analyse the impact of cost pressures and financial constraints on the decision to offshore services for German multinational enterprises over the period 2002-2008. They find that an enterprise is less likely to begin offshoring if it faces internal cost pressures due to a drop in sales and sales per employee, while enterprises who already offshore are likely to intensify offshoring activity. External credit conditions appear to have no significant impact on offshoring activity. They also find that firms source from countries with high GDP and low wages in the sector that supplies the service.

International outsourcing of R&D allows firms to access specialised knowledge to accelerate product innovation and shorten product life cycles (Cesaroni 2004). However, sourcing R&D internationally may involve non-trivial integration as well as monitoring and co-ordination costs (Veugelers, 1997; Veugelers and Cassiman 1999).

Existing evidence suggests that the propensity to outsource R&D internationally is higher for firms integrated in global production and innovation networks. (García-Vega and Huergo 2011; Jabbour and Zuniga 2009).

In summary, our review of the theoretical and empirical literature highlights factors both internal and external to the enterprise which are likely to influence its offshoring decision, including offshoring of R&D. Factors internal to the enterprise include labour productivity, size, ICT investment and usage, human capital intensity, trading experience, ownership. Factors external to enterprise that are likely to matter include the competitive pressure faced by the enterprise in an industry, other industry characteristics, host country characteristics and the location of the enterprise. The influence of these factors may differ depending on the type of business function offshored. Also the determinants of offshoring activity may differ for manufacturing and services firms.

3 Empirical Methodology

To analyse the determinants of an enterprise's offshoring decision, we estimate the following probit model specified on the basis of the theoretical and empirical background discussed in Section 2:

$$Pr(OFF_{ijsc} = 1|Z) = \Phi(Z\beta + \delta_j + \lambda_s + \varphi_c + \vartheta_n + \varepsilon_{isc}) \quad (1)$$

$Pr(.)$ refers to the probability of the outcome and $\Phi(.)$ is the normal cumulative distribution function. The dependent variable OFF_{ijsc} is a binary variable that is equal to one if an enterprise i , in sector j , offshores a business function s to region c during the analysed period, and it is zero otherwise. Z is a vector of enterprise characteristics which are expected to influence its decision to offshore. The explanatory variables included in the model specification are: size (SIZE), labour productivity (LPROD), wages per employee (WEMP), ICT investment per employee (ICT), ICT usage⁷ (a dummy variable equal to 1 for firms having a website), ownership (FOREIGN), domestic exporter dummy (DOMEXP), and industry competition (HHI).

As discussed in Section 2, characteristics of the location country are likely to influence the firms' decision to offshore. For instance, some countries may have better trade facilitation infrastructure or large pools of skilled labour that increase the feasibility of an enterprise offshoring. We account for these differences in source country characteristics by including source country dummies (i.e. φ_c). To control for possible effects of enterprise location and industry-specific effects, we include dummy variables for regions⁸ and industries⁹ (ϑ_n and δ_j respectively). To account for the type of business function that is offshored, we include dummy variables for each business function type (i.e. λ_s). The explanatory variables are averaged over the analysed period, 2001-2006.

In our analysis, we first pool each of the business function offshoring decisions together and estimate how the enterprise characteristics relate to its decision to offshore a business function to a particular country for the full set of our enterprise observations. We next analyse determinants of offshoring of R&D. To put the results for offshoring of R&D into perspective, we also estimate separate model specifications for the offshoring of the following business functions: (i) core business activities; (ii) distribution and logistics; (iii) marketing, sales and

⁷ We distinguish between inter-firm ICT adoption (measured by ICT investment per employee) and intra-firm ICT usage (proxied by the usage of a website). Haller and Siedschlag (2011) provide more details on the theoretical and empirical underpinnings of this distinction.

⁸ Regions classified as NUTS 2.

⁹ At the two digit level, NACE Rev. 1.1 classification.

after sales services; (iv) ICT services; (v) administration and management functions; (vi) engineering and related technical services.

4 Data and Summary Statistics

To conduct our analysis, we merge data from three separate enterprise level surveys collected by the Central Statistics Office of Ireland. The datasets we use are the International Sourcing Survey (ISS), the Annual Services Inquiry (ASI) and the Census of Industrial Production (CIP). The ISS provides information on enterprise domestic outsourcing and offshoring activities and the factors that influence such behaviour over the period 2001 to 2006. The survey was sent to all enterprises within selected economic activities that had a hundred or more employees in 2007.¹⁰ A total of 636 enterprises out of 1292 responded to the survey.

We primarily focus on the survey questions related to international sourcing (offshoring). International sourcing is defined in the survey as “the total or partial movement of business functions currently performed in-house or currently domestically sourced by the resident enterprise to either non-affiliated or affiliated enterprise located abroad”. This definition of offshoring enables us to construct an accurate and direct measure of whether an enterprise has offshored or not. Further, the survey asked enterprises to distinguish between core and support business functions such as (i) distribution and logistics; (ii) marketing, sales and after sales services; (iii) ICT services; (iv) administrative and management functions; (v) engineering and related technical services; (vi) research and development (R&D); and (vii) other types of service support functions.¹¹ A subsequent question asks enterprises to identify the country/region where the business function was offshored to. The identified regions/countries were: EU15, EU12¹², other European countries¹³, China, India, other Asian countries and Oceania, USA and Canada, South and Central America and Africa.

We match the enterprise sourcing data with additional enterprise information taken from the ASI for service enterprises and from the CIP for manufacturing enterprises. The ASI collects service enterprise information annually. It surveys all enterprises with 20+ employees plus a random sample of the smaller units with 2 to 19 persons engaged. The sample is stratified by

¹⁰ The CSO used the Business Register to identify enterprises with more than 100 employees in 2007.

¹¹ Core business functions are defined in the ISS as the “production of final goods or services intended for the market/for third parties carried out by the enterprise and yielding income. Core business function equals in most cases the primary activity of the enterprise”. Support business functions as those functions which are “carried out in order to permit or facilitate production of goods or services intended for the market/for third parties by the enterprise. The outputs of the support business functions are not themselves intended directly for the market/for third parties”.

¹² Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, the Slovak Republic, Slovenia.

¹³ Switzerland, Norway, Turkey, Russia, Belarus, Ukraine and the Balkan states.

activity (NACE Rev 1.1. classification), employment size class and NUTS2 region. The CIP is a census of all manufacturing, mining and utilities plants. We use data from the more detailed survey which is completed by enterprises with more than 20 persons engaged. From these datasets, we use information on enterprise ownership, value of sales, share of exports in total sales, number of employees, regional location and investment in ICT capital. We take the average of the available data for the enterprise variables over the period 2001-2006 before merging them with the ISS data. Descriptions of the variables used in our analysis are presented in Table A1 in the Appendix.

To account for potential selection bias, we estimate weighted regressions. To calculate the weights, we first merge the CIP and ASI datasets and then, for each year we sum the number of enterprises in each two-digit Nace Rev 1.1 industry. For service enterprises, we sum the grossing factor based on the number of enterprises provided in the ASI to calculate the number of enterprises in each two-digit NACE Rev 1.1 service industry. The maximum value of the sum of enterprises in each industry over the period 2001 to 2006 is taken and divided by the sum of the enterprises in each two-digit NACE Rev 1.1 industry in the regression sample.

The merged data resulted in a sample of 503 enterprises. Table 1 presents the average values of the offshoring measure by type of business function offshored for (i) all enterprises; (ii) manufactures; and (iii) service enterprises. The measure is also broken down by five different types of enterprise in our sample: all enterprises, foreign-owned, domestic-owned enterprises, all exporting firms, and domestic exporters.

[Table 1 about here]

A number of interesting results emerge from Table 1. First, some business functions are more likely to be offshored than others. Column 1 in Table 1 shows that for all enterprises (the top section of Table 1), the average value of the offshoring measure ranges from 0.35 down to 0.03 with core business functions having the highest values, while other business functions have the lowest values. Second, manufacturing enterprises are more likely to offshore each business function compared with services enterprises (based on comparison of middle and bottom section of column 1). Third, there are differences in the ranking of the offshoring business function measure for manufacturing and services enterprises. The offshoring of distribution and engineering service support functions is more prevalent amongst manufacturing enterprises while the offshoring of marketing, ICT and distribution services are more likely amongst the services enterprises. Finally, offshoring patterns differ according to enterprise ownership characteristics and exporting activity. For the full sample of manufacturing and service enterprise observations (top section of Table 1), we find that foreign-owned enterprises and domestic exporters are more likely to offshore than domestic non-exporting enterprises for

each business function, with the exception of the “other” business function category. This pattern holds when we examine service enterprises separately (see the middle section of Table 1). However, for manufacturing enterprises (the bottom section of Table 1), the pattern is not as clear cut, with domestic non-exporting enterprises exhibiting a higher propensity to offshore a number of business functions compared with domestic exporters.

Enterprises integrated in international production networks (foreign-owned and exporters) are more likely to offshore R&D than domestic-owned enterprises. Thus, while 15 % of foreign-owned enterprises and 12 % of exporters reported offshoring of R&D, only 9% of all firms offshored R&D.

Additional descriptive statistics of the variables used in our analysis are presented in Tables A2 and A3 in the Appendix.

5 Empirical Results

In this section, we present the estimates of our analysis on the links between enterprise characteristics and offshoring decisions. Column 2 in Table 2 presents the estimates of the probit model described above where we pool all enterprise observations. Specifically, the dependent variable is a binary variable equal to one if the enterprise offshored a particular business function to a particular destination. The estimates shown in Table 2 are average marginal effects with robust standard errors reported in parentheses. We present the estimation results in a stepwise fashion: we include the foreign ownership dummy, domestic exporter dummy, location dummy and industry dummies as our initial set of controls and add one explanatory variable at a time. The final column contains the full model specification.

[Table 2 about here]

The results shown in Table 2 indicate that larger and more productive enterprises are more likely to offshore business activities. This positive link between an enterprise’s productivity and its propensity to trade is well established in the international trade literature.¹⁴ Furthermore, foreign-owned enterprises and domestic exporters are each 3 percentage points more likely to offshore business activities compared with domestic enterprises and domestic exporters serving only the home market, respectively. The important role of ICT for offshoring appears to be confirmed, with the ICT intensity variable being positively associated with an enterprise’s propensity to offshore business activities. Enterprises that have a website are 1.3 percentage

¹⁴ Most of the research in this area has focused on the link between productivity and the exporting of goods. Recent research by Vogel and Wagner (2010) has found a positive link between productivity and importing. Also, Biewen et al. (2012) find evidence that more productive firms are more likely to import services from abroad.

points more likely to offshore business activities. We find that enterprises that are solely located in the Border, Midland and Western (BMW) region have a relatively lower propensity to offshore.

The characteristics of the source region controlled for by the source country dummies are significantly related to enterprise offshoring behaviour, with offshoring to country/regions outside of the EU15 found to be less likely.¹⁵ This result is unsurprising as the fixed entry costs into offshoring to the EU15 group of countries are likely to be lower given their relative proximity and the strong trade and financial linkages. We also find that support business functions had a lower propensity of being offshored when compared with the omitted reference group, i.e. core business functions.

Columns 1-7 in Table 3 show the estimates of determinants of offshoring for each type of business function that was offshored.¹⁶ The dependent variable is a binary variable equal to one if the enterprise offshored each business function to a particular destination and equal to zero if it did not.

[Table 3 about here]

We find that foreign-owned enterprises and domestic-owned exporters had a relatively greater propensity to offshore each type of service support function. Further, our results indicate that larger enterprises were more likely to offshore distribution, marketing, ICT, and administration functions, while more productive enterprises offshored distribution and marketing functions.

The ICT intensity variable is positively associated with an enterprise's propensity to offshore core business functions only. Enterprises with a website had a relatively greater propensity to offshore core, ICT, engineering, and research and development business functions. We continue to find that the propensity to offshore to destinations outside of the EU15 was lower. Also, enterprises located in the BMW region were less likely to offshore core, distribution, engineering, and R&D business functions.

With respect to offshoring of R&D, our estimates suggest that enterprises integrated in international production and innovation networks, are more likely to offshore R&D. Being a foreign-owned enterprise increases the propensity of offshoring R&D by 3 percentage points, while exporters are more likely to offshore R&D by 4 percentage points. Furthermore, having a website increases the probability of offshoring R&D by nearly 2 percentage points. With respect to the location of the headquarters, relative to enterprises located in the BMW region are less

¹⁵ Given the important economic ties between Ireland and the UK, it would have been particularly useful if the survey separated the UK from the other EU15 old member states. We could then have examined if the strong ties with Ireland-UK were driving this result.

¹⁶ The model specification for 'other' business could not be estimated due to collinearity and sample size.

likely to offshore R&D relative to those located in the South and Eastern region (which includes the capital city). With respect to sourcing locations, it appears that Ireland's offshoring of R&D is less likely from any other region outside the EU15.

6 Conclusions

In this paper we investigated the factors that are expected to influence an enterprise's decision to offshore business functions, in particular R&D activities. More specifically, we used Irish survey data for the period 2001-2006 for over 500 enterprises to consider how factors, internal and external to the enterprise, relate to its propensity to offshore eight different types of business functions, including R&D.

Our results can be summarised as follows. We find that for the full sample of enterprises the likelihood of offshoring was positively associated with the size and labour productivity of the enterprise. Furthermore, international linkages through foreign-ownership and exporting increased the likelihood of offshoring. ICT intensity and ICT usage was also found to matter, with ICT investment per employee and having a website being positively associated with an enterprise's propensity to offshore. Further, we find that core business functions were more frequently offshored compared with support service functions. The location where business functions were offshored to is also important, with the propensity to offshore to destinations outside of the EU15 being lower.

Finally, we find that the strength of the associations between an enterprise's characteristics and its decision to offshore differ according to the type of business function that was offshored.

With respect to offshoring of R&D, our estimates suggest that enterprises integrated in international production and innovation networks are more likely to offshore R&D. Being a foreign-owned enterprise increases the propensity of offshoring of R&D by 3 percentage points, while exporters are more likely to offshore R&D by 4 percentage points. Furthermore, having a website increases the probability of offshoring R&D by nearly 2 percentage points. With respect to the location of the headquarters, relative to enterprises located in the Border, Midlands, Western (BMW) region are less likely to offshore R&D relative to those located in the South and Eastern region (which includes the capital city). With respect to sourcing locations, it appears that Ireland's offshoring of R&D is less likely from any other region than EU15.

The analysed data does not allow the establishment of the date when firms' offshoring had started. This implies that, although the identified links between the offshoring propensity and characteristics of firms and sourcing locations may be indicative of causal relationships, they

can at best be interpreted as structural links. These research results help to understand what types of firms are more likely to offshore R&D, and more generally, provide evidence on the factors driving the integration of firms in international production and innovation networks. This evidence informs enterprise strategy and policy design aiming at maximizing benefits from international sourcing and global value chains.

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Table 1: Offshoring by enterprise type, Ireland, 2001-2006

Offshored business function	All firms	Foreign-owned enterprises	Domestic-owned enterprises	All exporting firms	Domestic-owned exporters
All enterprises					
Core	0.35	0.48	0.26	0.45	0.37
Distribution	0.20	0.31	0.12	0.28	0.21
Marketing	0.16	0.24	0.1	0.19	0.14
ICT	0.15	0.25	0.07	0.17	0.08
Administration	0.11	0.20	0.04	0.12	0.05
Engineering	0.17	0.24	0.11	0.23	0.20
Research and Development	0.09	0.15	0.04	0.12	0.05
Other	0.03	0.03	0.03	0.02	0.01
Observations	503	215	288	278	118
Services					
Core	0.25	0.39	0.19	0.33	0.35
Distribution	0.13	0.25	0.07	0.20	0.19
Marketing	0.14	0.24	0.08	0.20	0.22
ICT	0.13	0.24	0.07	0.16	0.14
Administration	0.10	0.22	0.03	0.11	0.08
Engineering	0.11	0.19	0.06	0.15	0.19
Research and Development	0.04	0.07	0.03	0.05	0.08
Other	0.03	0.02	0.03	0.00	0.00
Observations	303	99	204	92	37
Manufacturing					
Core	0.50	0.55	0.43	0.49	0.40
Distribution	0.31	0.36	0.24	0.32	0.24
Marketing	0.19	0.23	0.13	0.19	0.12
ICT	0.18	0.25	0.08	0.16	0.06
Administration	0.13	0.17	0.06	0.11	0.04
Engineering	0.26	0.28	0.23	0.26	0.21
Research and Development	0.15	0.22	0.06	0.14	0.04
Other	0.04	0.04	0.04	0.03	0.01
Observations	200	116	84	176	67

Notes: Own calculations based on data from the International Sourcing Survey (ISS) 2007. Sample is derived from merging the Annual Services Inquiry (ASI), Census of Industrial Production (CIP) and ISS datasets provided by the Central Statistics Office of Ireland. The summary measure in each cell is the mean value for each of the binary offshoring measures used in the analysis.

Table 2: Determinants of offshoring in Ireland, 2001-2006 – Average marginal effects, all business functions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foreign	0.033*** (0.004)	0.032*** (0.004)	0.032*** (0.004)	0.034*** (0.004)	0.031*** (0.004)	0.031*** (0.004)	0.029*** (0.004)	0.030*** (0.004)
Domestic exporter	0.033*** (0.007)	0.029*** (0.007)	0.030*** (0.007)	0.030*** (0.007)	0.026*** (0.007)	0.026*** (0.007)	0.026*** (0.007)	0.027*** (0.006)
BMW location	-0.014*** (0.002)	-0.013*** (0.002)	-0.014*** (0.002)	-0.013*** (0.002)	-0.012*** (0.002)	-0.012*** (0.002)	-0.012*** (0.002)	-0.011*** (0.002)
Size	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003** (0.001)	0.003** (0.001)
Labour productivity		0.005*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)
Wage per employee			-0.002 (0.004)	-0.004 (0.004)	-0.005 (0.004)	-0.005 (0.004)	-0.005 (0.004)	-0.005 (0.004)
ICT investment per employee				0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Website					0.015*** (0.004)	0.015*** (0.004)	0.015*** (0.003)	0.013*** (0.004)
Herfindahl index						-0.002 (0.003)	-0.002 (0.003)	-0.002 (0.003)
EU12							-0.109*** (0.019)	-0.110*** (0.017)
Rest of Europe							-0.122*** (0.019)	-0.123*** (0.017)
China							-0.120*** (0.019)	-0.122*** (0.017)
India							-0.123*** (0.019)	-0.124*** (0.017)
Other Asia & Oceania							-0.124*** (0.019)	-0.126*** (0.017)
USA & Canada							-0.121*** (0.019)	-0.121*** (0.017)
South and Central America							-0.134*** (0.019)	-0.134*** (0.017)
Africa							-0.132*** (0.019)	-0.133*** (0.017)
Distribution								-0.055*** (0.008)
Marketing								-0.065*** (0.008)
ICT								-0.065*** (0.008)
Administration								-0.060*** (0.010)
Engineering								-0.052*** (0.010)
R&D								-0.064*** (0.010)
Other								-0.080*** (0.008)
Pseudo R ²	0.085	0.087	0.087	0.096	0.098	0.098	0.265	0.344
N	35784	35784	35784	33840	33840	33840	33840	33840

Notes: The estimates were obtained with a probit estimator. Robust standard errors are shown in parentheses. *, **, ***: significant at the 10%, 5% and 1% level respectively. The dependent variable is a binary variable equal to 1 if enterprise offshores a business function to a host country and zero otherwise. 2 digit industry dummies are included. Weights are calculated for each 2-digit NACE Rev 1.1 sector.

Table 3: Determinants of offshoring, Ireland, 2001-2006 – Average marginal effects by business function

	Core	Distribution	Marketing	ICT	Administration	Engineering	R & D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Size	0.006 (0.005)	0.006** (0.003)	0.007*** (0.002)	0.007** (0.003)	0.008** (0.003)	-0.001 (0.003)	0.001 (0.003)
Labour productivity	0.010 (0.007)	0.022*** (0.004)	0.006* (0.003)	0.006 (0.004)	0.008 (0.005)	-0.002 (0.005)	0.006 (0.005)
Wage per employee	-0.009 (0.015)	-0.017* (0.010)	-0.010 (0.008)	-0.013 (0.011)	-0.014 (0.013)	0.011 (0.012)	-0.001 (0.013)
ICT investment per employee	0.008*** (0.002)	-0.000 (0.001)	0.000 (0.001)	-0.000 (0.001)	-0.002* (0.001)	0.001 (0.001)	-0.000 (0.001)
Website	0.066*** (0.012)	-0.020 (0.019)	-0.008 (0.011)	0.014* (0.008)	0.012 (0.009)	0.021** (0.009)	0.016** (0.006)
Herfindahl index	-0.006 (0.017)	-0.006 (0.008)	-0.003 (0.004)	-0.003 (0.008)	-0.005 (0.007)	0.001 (0.008)	0.004 (0.006)
Foreign	0.051*** (0.016)	0.068*** (0.015)	0.035*** (0.010)	0.041*** (0.012)	0.040*** (0.011)	0.037*** (0.011)	0.032*** (0.011)
Domestic exporter	0.029 (0.020)	0.095*** (0.029)	0.026* (0.014)	0.028* (0.017)	0.047** (0.023)	0.059** (0.024)	0.039* (0.023)
BMW location	-0.053*** (0.010)	-0.013** (0.006)	-0.001 (0.005)	0.007 (0.010)	0.005 (0.009)	-0.015** (0.006)	-0.013** (0.005)
EU12	-0.195*** (0.062)	-0.118*** (0.020)	-0.067*** (0.021)	-0.106*** (0.019)	-0.124*** (0.040)	-0.184*** (0.052)	-0.147*** (0.045)
Rest of Europe	-0.231*** (0.062)	-0.143*** (0.018)	-0.091*** (0.018)	-0.100*** (0.020)	-0.138*** (0.038)	-0.200*** (0.052)	-0.152*** (0.045)
China	-0.203*** (0.062)	-0.130*** (0.019)	-0.100*** (0.017)	-0.110*** (0.019)	-0.142*** (0.038)	-0.205*** (0.052)	-0.147*** (0.045)
India	-0.251*** (0.061)	-0.149*** (0.018)	-0.097*** (0.017)	-0.082*** (0.023)	-0.139*** (0.038)	-0.198*** (0.052)	-0.142*** (0.044)
Other Asia & Oceania	-0.228*** (0.062)	-0.133*** (0.019)	-0.100*** (0.017)	- (0.039)	-0.146*** (0.039)	-0.210*** (0.052)	-0.147*** (0.045)
USA & Canada	-0.240*** (0.061)	-0.135*** (0.019)	-0.088*** (0.018)	-0.099*** (0.020)	-0.136*** (0.038)	-0.200*** (0.052)	-0.136*** (0.044)
South and Central America	-0.284*** (0.061)	-0.149*** (0.018)	-0.099*** (0.017)	-0.110*** (0.019)	- (0.052)	-0.210*** (0.052)	- (0.045)
Africa	-0.277*** (0.061)	-0.146*** (0.018)	-0.101*** (0.017)	- (0.052)	- (0.052)	-0.209*** (0.052)	-0.148*** (0.045)
Pseudo R ²	0.298	0.471	0.342	0.296	0.441	0.431	0.504
N	4212	3996	4041	3108	3094	4077	3024

Notes: The estimates were obtained with a probit estimator. Robust standard errors are shown in parentheses. *, **, ***: significant at the 10%, 5% and 1% level respectively. The dependent variable is a binary variable equal to 1 if an enterprise offshores a business function (denoted at the top of the column) to a particular destination and zero otherwise. 2-digit industry dummies are included. Weights are calculated for each 2-digit NACE Rev 1.1 sector. Regressions where host country estimates are missing are due to no observations of offshoring to that destination. Due to small number of enterprises and limited variation we were unable to accurately estimate the offshoring equation for “other” business functions.

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Appendix

Table A1: Variable descriptions

Variable	Description	Notes
Offshoring	Dummy variable equal to 1 if enterprise offshored a particular function to a particular country and zero otherwise.	
Size	Natural log of average total employees in the enterprise.	We scale the variable by dividing it by 1000 before calculating its natural log.
Labour productivity	Natural log of average turnover per employee.	We scale the variable by dividing it by 100,000 before calculating its natural log.
Wage per employee	Natural log of average wage per employee.	We scale the variable by dividing it by 1000 before calculating its natural log.
ICT investment per employee	Natural log of average ICT capital investment per employee. ICT is averaged over the period 2005-2006, the period for which data is only available for both service and manufacturing enterprises	We scale the variable by dividing it by 10,000 and replace zeros with 0.00001 before calculating its natural log.
HHI	Natural log of Herfindahl Index constructed at the NACE 2-digit level.	
BMW location	Dummy variable equal to 1 if enterprise has a plant located in Border, Midland and Western (BMW) region and zero otherwise.	
Website	Dummy variable equal to 1 if enterprise has a website in any year over the period, zero otherwise.	
Foreign	Dummy variable equal to 1 if enterprise is owned by a foreign entity in any year over the period, zero otherwise.	
Domestic exporter	Dummy variable equal to 1 if a domestically owned enterprise exported in any year over the period, zero otherwise.	

Notes: Unless otherwise stated, variables are based on data taken from the Annual Services Inquiry (ASI), Census of Industrial Production (CIP) surveys and the International Sourcing Survey (ISS) provided by the Central Statistics Office of Ireland. Data is averaged over available observations over the period 2001-2006.

Table A2: Descriptive statistics

	Variable	Obs.	Mean	Std. Dev	Min	Max
All enterprises	Turnover (Euro, '000)	503	115000.00	314000.00	374.42	2960000.00
	Total employees ('000)	503	0.36	0.68	0.00	9.99
	Labour productivity ('00000)	503	3.53	8.25	0.11	91.42
	Wage per employee, ('000)	503	30.76	18.59	2.55	309.16
	ICT capital investment per employee ('0000)	479	0.07	0.14	0.00	1.15
	Exports per turnover	502	0.30	0.41	0.00	1.00
	Website	499	0.91	0.29	0.00	1.00
	Herfindahl index	503	0.07	0.11	0.00	0.97
	Foreign	503	0.43	0.49	0.00	1.00
	Domestic exporter	503	0.23	0.42	0.00	1.00
	BMW location	503	0.18	0.39	0.00	1.00
Services	Turnover (Euro, '000)	303	82200.00	239000.00	374.42	2300000.00
	Total employees ('000)	303	0.38	0.82	0.00	9.99
	Labour productivity ('00000)	303	2.94	7.10	0.11	78.73
	Wage per employee, ('000)	303	29.22	22.15	5.19	309.16
	ICT capital investment per employee ('0000)	303	0.06	0.12	0.00	0.99
	Exports per turnover	303	0.09	0.24	0.00	1.00
	Website	303	0.86	0.34	0.00	1.00
	Herfindahl index	303	0.03	0.08	0.00	0.57
	Foreign	303	0.33	0.47	0.00	1.00
	Domestic exporter	303	0.16	0.36	0.00	1.00
	BMW location	303	0.12	0.33	0.00	1.00
Manufacturing	Turnover (Euro, '000)	200	164000.00	396000.00	952.00	2960000.00
	Total employees ('000)	200	0.32	0.40	0.01	3.77
	Labour productivity ('00000)	200	4.43	9.66	0.19	91.42
	Wage per employee, ('000)	200	33.09	10.81	2.55	68.72
	ICT capital investment per employee ('0000)	200	0.08	0.16	0.00	1.15
	Exports per turnover	200	0.63	0.41	0.00	1.00
	Website	200	0.98	0.14	0.00	1.00
	Herfindahl index	200	0.13	0.12	0.01	0.97
	Foreign	200	0.58	0.49	0.00	1.00
	Domestic exporter	200	0.36	0.48	0.00	1.00
	BMW location	200	0.28	0.45	0.00	1.00

Notes: Own calculations based on data taken from the Annual Services Inquiry (ASI), Census of Industrial Production (CIP) surveys and International Sourcing Survey (ISS) provided by the Central Statistics Office of Ireland. Data is averaged over available observations over the period 2001-2006.

Table A3: Pairwise correlations of variables included in regressions

	Offshore dummy variable	Total employees ('000)	Labour Productivity ('00000)	Wage per employee, ('000)	ICT capital investment per employee ('0000)	Website dummy variable	Herfindahl Index	Foreign ownership dummy	Domestic- owned exporter dummy	NUTS2 BMW location dummy
Offshoring	1									
Total employees ('000)	0.03	1								
Labour productivity ('00000)	0.05	0.02	1							
Wage per employee, ('000)	0.05	0.05	0.61	1						
ICT capital investment per employee ('0000)	0.05	0.11	0.22	0.34	1					
Website	0.03	0.22	0.08	0.24	0.29	1				
Herfindahl index	0.07	0.15	0.42	0.39	0.27	0.12	1			
Foreign ownership	0.08	0.27	0.24	0.26	0.15	0.20	0.40	1		
Domestic exporter	0.00	-0.08	0.15	0.13	0.10	0.11	0.14	-0.48	1	
BMW location	0.01	-0.13	-0.07	-0.23	-0.01	-0.07	0.04	-0.09	0.15	1

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