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The Effects of the Internationalisation of Firms on Innovation and Productivity*

Iulia Siedschlag[a,b], Xiaoheng Zhang[a,b] and Brian Cahill[c,d]

Abstract: This paper examines the effects of the internationalisation of firms via foreign direct investment and trade on their innovation and productivity performance. Our econometric results suggest that foreign affiliates and domestic exporters were more likely to invest in innovation and furthermore that they were more likely to be more successful in terms of innovation output and higher productivity than firms that served only the domestic market. On average, innovation output was positively associated with labour productivity over and above other determinants. Access to external knowledge flows explain to a large extent the innovation performance of firms, in particular co-operation with suppliers, with consultants, commercial labs or private R&D institutes, with universities or other higher education institutions.

Key words: Multinational Firms, Exporting, Knowledge Production, Productivity

JEL classification: F10, F23, O31

Corresponding author: iulia.siedschlag@esri.ie

[a] The Economic and Social Research Institute, Dublin; [b] Department of Economics, Trinity College, Dublin; [c] Forfás, [d] NUI Galway

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1 Introduction

The international trade and investment literature has established that firms with international linkages have a higher productivity in comparison to firms that serve only the domestic markets. Existing empirical evidence shows that foreign-owned firms are more productive than domestic firms (Doms and Jensen, 1998; Driffield, 1997; Griffith and Simpson, 2001; Ruane and Ugur, 2004; Girma and Görg, 2007). More recent studies have found that a large part of this productivity differential is between multinationals and non-multinationals (Griffith, 1999; Oulton, 2000; Temouri et al. 2008). Theoretical models of firm heterogeneity and international trade demonstrated that given fixed costs associated to entry on exports markets only firms with high productivity self-select into exporting (Bernard and Jensen, 1999; Melitz, 2003). While this literature has assumed that firm productivity is exogeneous, more recent theoretical contributions allow for the possibility of firms to increase their productivity through innovation activities (Yeaple, 2005; Bustos, 2005).

Empirical evidence on the sources of the productivity advantage of firms with international linkages relative to firms serving only domestic markets is still scarce. A large empirical literature has found a positive link between innovation investment, innovation output and productivity at firm level (Crépon et al, 1998; Griffith et al, 2006). However, these studies do not distinguish between firms with international linkages and firms that serve only the domestic market. This paper aims to contribute to filling this gap by linking the productivity of firms with international linkages to their innovation performance. To capture international linkages we consider foreign investment and exporting.

In particular, we ask the following research questions. Are firms with international linkages more productive? Are firms with international linkages more likely to invest in innovation and do they have a higher innovation expenditure intensity? Do firms with international linkages innovate more than firms serving only the domestic market?

To answer these questions we estimate an augmented structural model which builds on and expands previous research by Crépon et al. (1998) and Griffith et al. (2006). This approach allows us to account for the role of international linkages in explaining the innovation and productivity performance of firms in Ireland. In contrast with these two studies that are based on cross sectional data, we use panel data from two waves of the Community Innovation Survey for Ireland for the period 2004 – 2008. The panel data allow us to account for unobserved firm heterogeneity and capture causal links between innovation input, innovation output and productivity.

In contrast to Crépon et al. (1998) and many subsequent empirical studies and similar to Griffith et al. (2006), we estimate the model for all firms and not only for innovative firms. In this way, we can account for the selection bias which arises from the fact that while it is likely that all firms have some innovative effort, not all firms report innovation investment. In addition to using panel data we go beyond Crépon et al. (1998) and Griffith et al. (2006) in two ways. First, we add to the model explanatory variables which capture international linkages. In particular, we estimate whether and to what extent foreign affiliates and domestic exporters have a different innovation and productivity performance in comparison to firms that serve only the domestic market. Second, we consider all types of innovation (product, process and organisational innovation) as well as complementarities among them. We use improved econometric panel techniques and account for three econometric issues: (i) selection bias due to the fact that the set of firms which report innovation investment might be non-random; (ii) endogeneity, due to innovation investment, innovation output and productivity being endogenously determined; and (iii) omitted variable bias.

Our research relates to Criscuolo et al (2010) who estimate a knowledge production function to analyse the role of global engagement on the innovation performance of firms in the United Kingdom using data from two waves the CIS survey over the period 1994-2000. In contrast to Criscuolo et al (2010), we model in addition to knowledge production two additional stages which are part of the innovation behaviour of firms: the decision to invest in innovation and the effect of innovation output on productivity. Castellani and Zanfei (2007) show that firms with international linkages in Italy had better productivity and innovation performance in comparison to purely domestic firms. However, they use cross-sectional data and cannot account for the fact that productivity and innovation output may

be simultaneously determined. Finally, our analysis goes beyond Doran et al. (2010) who use cross-sectional data from the Community Innovation Survey for Ireland over the period 2004-2006 to estimate the relationships between innovation investment, innovation output and productivity without modelling the role of international linkages.

Our key findings are as follows. Foreign owned firms and domestic exporters were more likely to invest in innovation and furthermore, they were more likely to be more successful in terms of innovation output (product, process, and organisational innovations) and higher productivity than firms that served only the Irish market. Innovation output was positively associated with labour productivity over and above other determinants such as foreign linkages, firm size as well as unobserved industry, firm and time specific effects. Innovation expenditure intensity was not significantly associated with innovation output over and above other determinants such as international linkages, firm size, external knowledge flows, as well as unobserved industry, firm and time specific effects. For all types of innovations, knowledge flows from co-operations with suppliers, with consultants, commercial labs or private R&D institutes, and with universities or other higher education institutions were positively associated with innovation output over and above other determinants. Co-operation with other enterprises from the same group was positively associated with product and process innovation. Co-operation with customers was positively associated with product innovation. We find both similarities and differences in the relationships between innovation investment, innovation output and productivity for manufacturing and services, and for technological and non-technological innovation.

The rest of the paper is organised as follows. Section 2 discusses our empirical methodology and econometric issues. Section 3 describes the data set and summary statistics. Econometric results are discussed in Section 4. Section 5 concludes.

2 Empirical Methodology and Econometric Issues

To explain the innovation and productivity performance differential of firms with international linkages we estimate an augmented structural model by extending the econometric framework proposed by Crépon et al. (1998) and Griffith et al. (2006). This modelling framework accounts for the following firm behaviour: in the first stage, firms decide whether and how much to invest in innovation; in the next stage, firms produce knowledge (innovation outputs) using innovation inputs; finally, knowledge (innovation outputs) is used together with other inputs to produce final output.

This model consists of the following equations:

The first equation models the decision of firm *i* to invest in innovation:

$$(1) \qquad y_{it}^{*} = x_{1it}'\beta + \lambda_j + \mu_t + \varepsilon_{it}$$

where y_{it}^{*} is an unobserved latent variable measuring the predicted utility of engaging in innovation, x_{1it} is a vector of firm-level characteristics, β is the related vector of coefficients, λ_j is a vector of industry fixed effects, μ_t is a vector of time fixed effects and ε_{it}, the error term.

To account for the fact that we only observe what the firms report as innovation effort, we estimate the following selection equation which describes the propensity of firms to invest in innovation:

$$(2) \qquad y_{it} = \begin{cases} 1 \ \text{if} \ y_{it}^{*} = x_{1it}'\beta + \lambda_j + \mu_t + \varepsilon_{it} > a \\ 0 \ \text{if} \ y_{it}^{*} = x_{1it}'\beta + \lambda_j + \mu_t + \varepsilon_{it} \le a \end{cases}$$

where y_{it} is the observed innovation expenditure.

Further, conditional on investing in innovation we estimate the innovation expenditure intensity as follows:

$$(3) \quad w_{it} = \begin{cases} y_{it}^{*} = x_{2it}'\beta + \lambda_j + \mu_t + \varphi_{it} & \text{if } y_{it} = 1 \\ 0 & \text{if } y_{it} = 0 \end{cases}$$

The equations (2) and (3) are jointly estimated as a generalized Tobit model by a maximum likelihood assuming that ε_{it} and φ_{it} are bivariate normal with zero mean, variances $\sigma_{\varepsilon}^2 = 1$ and σ_{φ}^2 and the correlation coefficient $\rho_{\varepsilon\varphi}$ [1].

Further, we estimate the following knowledge production function (innovation output):

$$(4) \quad z_{it} = f(\hat{w}_{it}^{*\prime}\gamma + x_{3it}'\delta + \lambda_j + \mu_t + \eta_i + \omega_{it})$$

The latent innovation input $\hat{w}_{it}^{*}$ enters the above equation as an explanatory variable, together with other firm-level characteristics collected in x_{it} as well as time-invariant unobserved industry (λ_j), and individual firm specific effects (η_i) and common time specific effects (μ_t). Since $\hat{w}_{it}^{*}$ is predicted by equations (2) and (3) for all firms, we are able to recover the expenditures for those firms that do not report positive expenditures, and hence (4) is estimated for all firms in the sample. This procedure allows the estimates to be free from selection bias. In addition, by using the predicted innovation input as an explanatory variable in the innovation output equation we alleviate the endogeneity arising from the fact that innovation investment and innovation output may be determined simultaneously. For example, innovation investment may be correlated with the error term if part of this innovation input is attributed to unobserved firm-specific effects.

The last equation is an augmented Cobb-Douglas production function with constant returns to scale:

$$(5) \quad \pi_{it} = \hat{z}_{it}'\alpha + x_{4it}'\phi + \lambda_j + \mu_t + \eta_i + \upsilon_{it}$$

π_{it} denotes turnover per worker in firm i at time t. $\hat{z}_{it}$ is the predicted probability of having any type of innovation or the predicted innovation output. For a similar reason as argued for

[1] See Heckman (1979) and Cameron and Trivedi (2005) for more details. We use the STATA –Heckman procedure to estimate the model.

using predicted innovation input, potential endogeneity of innovation output is also reduced[2].

The model is estimated as a recursive system consisting of equations (2), (3), (4) and (5). Given that not all firms are surveyed in both periods we estimate weighted regressions, with weights calculated using the distribution of employment across industries. In addition, we estimate standard errors that are clustered at industry level to account for the fact that error terms may be correlated within industries. For example, it is likely that firms belonging to the same industry share a common part of the utility (or production) functions described by equations (2) to (5). Usually this common part is unobservable and it enters the error term in each equation. The consequence is that error terms are correlated within industries. As shown by Moulton (1986, 1990) this correlation leads to downward biased standard errors and thus spurious statistical significance. To account for this bias we follow Pepper (2002) and Cameron *et al*. (2006) and compute standard errors clustered at NACE two-digit industry level.

3 Data, Variables and Summary Statistics

We use data from two waves the Irish Community Innovation Survey (CIS), namely CIS 2006 and CIS 2008. This survey is part of a harmonized framework across EU countries coordinated by Eurostat, for the purpose of investigating the innovation performance of firms, and providing a cross-country comparison. CIS 2006 and CIS 2008 were jointly conducted by Forfás and the Central Statistics Office (CSO) of Ireland in 2006 and 2008. For these two surveys, information on 1,974 and 2,181 firms, respectively, were obtained separately, yielding response rates of 47.6 and 46.9 per cent, respectively. CIS 2006 covers the innovation activities of firms from 2004 to 2006 and CIS 2008 covers those from 2006 to 2008.[3] All firms appearing in both surveys are used to construct a balanced panel of two time points, made up of 723 firms.

In the CIS surveys, firms are requested to report whether they are in an enterprise group and whether they sell goods or services to local, national or foreign markets. Further, firms

[2] Firm-level data on capital stocks are not available to us from the CIS surveys or another firm-level datasets.
[3] For more information about the CIS data see Forfás (2006, 2008 and 2009).

are asked whether they have introduced product, process or organisational innovation, or have on-going innovation or abandoned innovation during a previous three-year period. Only those firms that had successful, on-going or abandoned innovation activities (termed as innovators) were asked to answer more questions in relation to their R&D and other innovation expenditures, and co-operation for innovation activities with other enterprises or institutions over the three-year period. Information on ownership, turnover and the number of employees were added to the dataset from other surveys conducted by Forfás and the CSO.

3.1 Dependent Variables

In equation (2) the dependent variable is innovation input. We construct four alternative variables to measure innovation input. Two dummy variables indicate whether a firm reports positive in-house R&D expenditure or innovation expenditure, respectively. Innovation expenditure is a broader measure of innovation input and includes in addition to in-house R&D expenditure, purchase of external R&D, acquisition of machinery, equipment and software, and other external knowledge. It measures all observable efforts a firm exerts on innovation. In equation (3) the dependent variable is the intensity of innovation input. We use two continuous variables to measure this intensity, i.e. R&D expenditures or innovation expenditures per employee. They are expressed in 2004 prices. To deflate the monetary values we use producer price indices at industry level for manufacturing and the GDP deflator for services[4].

In equation (4) the dependent variable is innovation output. We construct nine alternative measures of innovation output. Three of them are dummy variables indicating whether a firm had product, process or organisational innovation. Based on these three variables, we derive another five dummy variables by generating different combinations of the three types of innovation. The broadest innovation measure indicates whether a firm had any one of the above mentioned three types of innovations. The narrowest measure requires a firm to have all types of innovation at the same time. The remaining three indicators are for the combinations of any two types of innovations. The last innovation output variable is the share of innovative products or services in total turnover for the last year of each survey. To

[4] The results do not change when we use the consumer price index for services

account for the fact that the share is bounded between 0 and 1, we transform this dependent variable by using a logit transformation.

In equation (5) the dependent variable is labour productivity measured as turnover in constant prices divided by the number of employees.

3.2 Explanatory Variables

Since the primary objective of this study is to investigate the effects of the internationalisation of firms on innovation input, innovation output and productivity, we construct two variables to account for international linkages. In the CIS questionnaire, all firms are asked to report whether they are part of an enterprise group, the location of the head office of the group, and whether they sell products or services to local/national, EU countries and other countries of the world. With this information, we can group the firms into two broad categories: *foreign-owned firms* if they are in an enterprise group and its head office is located in countries other than Ireland[5], and the rest of firms are *domestic firms*. The domestic firms are further broken down into *domestic exporters* (if they export to Northern Ireland or the UK, or other countries) or *domestic non-exporters*. Firms that serve only the domestic market are the reference group in our analysis.

In equation (4) we include seven dummy variables to proxy the following types of external knowledge flows: i) from other enterprises within the same enterprise group; ii) from suppliers of equipment, material, components or software; iii) from clients or customers; iv) from competitors or other enterprises in the same sector; v) from consultants, commercial labs or private R&D institutes; vi) from universities or other higher education institutions and vii) from government or public research institutes.

Other control variables include firm size (measured as number of employees), and the distance to the global technology frontier (GTF). The distance to the GTF is the absolute difference between the turnover per employee of a firm in the CIS and the global technology frontier (GTF).[6] The measure of the GTF is computed by pooling data on firms from 17 OECD countries. It is the turnover per employee of the 90 percentile of global

[5] The information provided in the Community Innovation Survey allows us to identify whether or not a firm is foreign-owned. However there is no information on the share of foreign ownership in a firm.
[6] In most cases Irish firms had a lower labour productivity than the GTF. Following common practice, the difference is set to be zero in the remaining cases.

firms in constant 2004 prices. It is available at NACE two- or three-digit level. The logarithm of the distance to GTF enters equation (2). In addition, we control for unobserved industry fixed effects and year fixed effects by including industry dummies[7] and a year dummy for 2008. Detailed definitions and data sources for each variable are given in Table A1 in the Appendix.

We have 723 firms in the panel sample and these can be categorised in terms of international and domestic linkages as follows: 245 foreign-owned firms (34 per cent), 282 domestic exporters (39 per cent) and 196 domestic non-exporters (27 per cent).

Table 1 shows the distribution of firms by industry for the panel sample (the industry classification is NACE rev. 1.1). The manufacturing sector covers NACE 15 to NACE 37 industries and the service sector covers NACE 50 to NACE 74 industries. All 23 manufacturing industries are represented in the panel sample. Food products and beverages accounts for the highest share, eight per cent, followed by Manufacture of chemicals and chemical products, with five per cent. For the service sector, there are no firms represented in the following industries: sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel; retail trade, except of motor vehicles and motorcycles; repair of personal and household goods; hotels and restaurants; real estate activities; renting of machinery and equipment; research and development.

3.3 Summary Statistics

Tables 2A, 2B and 2C report summary statistics for foreign-owned, domestic exporters and domestic non-exporters for all firms, and for manufacturing and services firms respectively. With respect to innovation inputs, on average, 30.8 per cent of all firms report positive spending on in-house R&D. The average R&D expenditure per employee in 2004 prices was €2,723. Foreign-owned firms had the highest propensity to invest in innovation as well as innovation expenditure intensity, while domestic non-exporters had the lowest figures, as expected. The share of all firms reporting innovation expenditure was 44.5 per cent and the intensity of innovation expenditures was more than twice that of in-house R&D

[7] Since the sample covers 34 industries at NACE 2-digit level, it is reasonable to aggregate relevant industries so as to reduce the number of dummy variables. The rule we use is: 15-16, 17-19, 20, 21-22, 23-25, 26, 27-28, 29, 30-33, 34-35, 36, 37, 51, 60-63, 64, 65-67, 72 and 74. Because the industry dummies are invariant over the two-year period, they cannot be estimated in a fixed-effect OLS model without any treatment. We interact each aggregate industry dummy with year dummies to make them time variant.

expenditures. These descriptive statistics suggest that a large portion of innovation expenditures was spent on obtaining external knowledge, such as purchase of external R&D, acquisition of machinery, equipment and software and other external knowledge.

Turning to innovation output, we find that the shares of firms having different types of innovation output range from 22.8 per cent to 64.7 per cent, while, on average, the share of innovative turnover is ten per cent. Again foreign-owned firms had the best innovation performance. It is noteworthy that while 64.7 per cent of firms indicated that they had innovation output (any innovation type), only 44.5 per cent of firms report innovation expenditures. This fact can be explained by two situations: (i) innovation output in a number of firms, in particular foreign-owned firms, uses knowledge produced outside Ireland; (ii) some firms tend not to report innovation expenditure if this was below a certain threshold as suggested by Griffith et al. (2006).

With respect to external knowledge flows, on average, 11.6 per cent of firms report co-operation with other enterprises in the same enterprise group and the share is much higher for foreign-owned firms, 24.7 per cent. This can be seen as evidence of the advantage of being in an international enterprise group, in terms of giving a firm more chance to access external knowledge. In comparison, lower proportions of domestic firms co-operate with enterprises within the same group. Foreign-owned firms rank first with respect to all the other external knowledge flows with the exception of government sourced knowledge. Overall, firms with international linkages are much more likely to engage in some co-operation, compared with domestic non-exporters.

Finally, it appears that foreign-owned firms are more productive and closer to the global technology frontier than other types of firms.

4 Estimation Results

4.1 Innovation Input

We estimate equations (2) and (3) using in-house R&D expenditures and innovation expenditures separately. The two sets of estimates are similar in terms of the direction of the impact of international linkages, employment and the distance to the GTF on the innovation propensity and the intensity of innovation expenditure with some differences in terms of magnitude and significance level. Table 3 shows the results obtained for innovation expenditure.[8] The figures reported for each explanatory variable are marginal effects evaluated at the median so as to give them straightforward economic meaning. In column 1, the propensity of investing in innovation appears positively associated with foreign-owned firms and domestic exporters. More specifically, on average, in comparison to firms that served only the Irish market, foreign-owned firms were more likely to invest in innovation by 13 percentage points and domestic exporters by 23 percentage points, respectively. In addition, in line with the relevant literature we find that the propensity to invest in innovation increased with firm size and proximity to the global technology frontier. With respect to obstacles to innovation investment, we find that perceived high costs of innovation were negatively related to the propensity of firms to invest in innovation, while the need to meet government regulations acted as an incentive to engage in innovation. Further, foreign-owned firms had a significantly higher innovation expenditure intensity in comparison to firms that served only the domestic market. A one per cent reduction of the distance to the technology frontier was associated with a 7.5 per cent higher innovation expenditure intensity.

[8] The results obtained with in-house R&D expenditures are available from the authors upon request.

4.2 Innovation Output

We predict the intensity of innovation expenditure from equation (3) and use it in equation (4) to estimate innovation output. To avoid selection bias we estimate equation (4) for all firms (innovators and non-innovators). We account for unobserved firm heterogeneity by employing random effects estimators[9]. The results are reported in Tables 4A and 4B. In Table 4A, each column shows the estimates of a probit model for different types of innovation output. In comparison to firms serving only the domestic market, foreign-owned firms and domestic exporters were more likely to have innovation output. On average, foreign-owned firms were more likely to have any type of innovation by 28 percentage points and domestic exporters by 24 percentage points. With respect to different types of innovation, the highest effects were for product innovation in the case of foreign-owned firms, while in the case of domestic exporters the highest effect was for organisational innovation. It appears that, with the exception of organisational innovation[10], innovation expenditure intensity had no significant effect on the innovation output over and above other determinants such as international linkages, firm size and external knowledge flows, as well as unobserved industry, firm and time specific effects[11]. For all types of innovation, knowledge flows from co-operations with suppliers, with consultants, commercial labs or private R&D institutes, and with universities or other higher education institutions were positively associated with innovation output over and above other determinants. Co-operation with customers was positively associated with product innovation.

Table 4B reports the results of estimates of equation (4) for various combinations of innovation output and the continuous measure of innovation. The last column reports estimates of regressions using a continuous measure of innovation, the share of innovative turnover. These results are broadly qualitatively similar to those reported in Table 4B.

[9] Given the limited time variation of our variables the assumption of random individual effects is appropriate
[10] On average, the marginal effect of innovation expenditure intensity on the probability of organisational innovation is 0.057 and is significant at the 10 per cent level.
[11] The partial correlation between innovation expenditure intensity and innovation output is positive for all types of innovation, with the exception of process innovation. These estimates are available from the authors upon request.

4.3 Productivity

In the last stage of the estimated model we explain labour productivity as a function of predicted innovation output, foreign linkages and control for labour input, as well as unobserved industry and time specific effects. The estimates are shown in Table 5. Labour productivity in firms with international linkages was higher in comparison to firms serving only the domestic market. Further, we uncover a positive link between innovation output and labour productivity for all types of innovation. The effect of the innovation output on productivity is the highest in the case of organisational innovation. These results are in line with other studies. For example, Schmidt and Rammer (2007) found that the positive effect on the profit margin of firms is mainly due to the combination of product innovation and organisational innovation. Polder *et al*. (2010) find that only organisational innovation contributes to labour productivity alone, while product and process innovation have to be combined with organisational innovation to have positive effects on labour productivity.

Further, we allow for heterogeneous effects for manufacturing and services. Tables 6-8 report the estimates for manufacturing firms and Tables 9- 11 show the estimates for firms in services. We find both similarities and differences in the relationships between innovation investment, innovation output and productivity for firms in manufacturing and services.

Similarities for firms in manufacturing and services could be summarized as follows. Domestic exporters were more likely to invest in innovation in comparison to firms which served only the Irish market. Propensity to invest in innovation increased with firm size. Innovation expenditure intensity was not significantly associated with innovation output over and above other determinants. There was a positive link between innovation output and labour productivity for all types of innovations. Foreign-owned firms and domestic exporters were more productive than firms serving only the Irish market.

It appears that firms in manufacturing and services had a different behaviour with respect to the relationships between innovation investment, innovation output and productivity. While foreign owned firms in manufacturing were more likely to invest in innovation we find no significant link in the case of services. While more productive firms in services were more likely to invest in innovation, there was no significant link in the case of manufacturing.

Perceived obstacles to invest in innovation for manufacturing firms were high innovation costs and excessive risks. In contrast, there was no significant effect of the analysed obstacles in the case of services firms. While external knowledge flows played an important role on the innovation performance of firms in manufacturing, they appear less important in the case of firms in services. For example, while knowledge flows from universities were positively associated with all types of innovation output in manufacturing firms, we find no significant effect in services firms. Product innovation in manufacturing was positively associated with knowledge flows from customers and universities; in services, product innovation was associated with knowledge flows from other enterprises within the same group; from suppliers; from customers; from consultants, commercial labs and private R&D; Organisational innovation in manufacturing was positively associated with knowledge flows from suppliers, from consultants and from universities. In contrast, there was no significant effect of knowledge flows on organisational innovation in the case of services.

5 Conclusions

This paper examines the effects of the internationalisation of firms, via foreign direct investment and trade, on their innovation and productivity performance. We use micro data from two waves of the Community Innovation Survey of enterprises in Ireland covering the period 2004-2008 and estimate a structural model to analyse the role of foreign direct investment and exporting in the relationships between innovation investment, innovation output and productivity.

Our econometric analysis suggests the following key findings. Foreign affiliates and domestic exporters were more likely to invest in innovation and furthermore, they were more likely to be more successful in terms of innovation output (product, process, and organisational innovations) and higher productivity than firms that served only the Irish market. Innovation output was positively associated with labour productivity over and above other determinants such as foreign linkages, firm size as well as unobserved industry, firm and time specific effects. With the exception of organisational innovation, innovation expenditure intensity was not significantly associated with innovation output over and

above other determinants such as international linkages, firm size and external knowledge flows, as well as unobserved industry, firm and time specific effects. For all types of innovations, knowledge flows from co-operations with suppliers, with consultants, commercial labs or private R&D institutes, and with universities or other higher education institutions were positively associated with innovation output over and above other determinants. Co-operation with customers was positively associated with product innovation. We find both similarities and differences in the relationships between innovation investment, innovation output and productivity for manufacturing and services, and for technological and non-technological innovation.

Our research results suggest a number of policy implications. First, enabling the internationalisation of firms via foreign direct investment and exporting could foster innovation and productivity. Second, fostering co-operation with other enterprises and institutions is an important way to source knowledge in order to generate innovation output. Third, innovation expenditure *per se* does not translate into innovation output. It appears that in the case of Ireland, access to international markets and to external knowledge played a bigger role in the innovation performance of firms in comparison to investment in innovation. However, there might be lagged effects of innovation investment on the innovation output which are not captured in this analysis due to data limitations. Furthermore, our results might reflect innovation failures and the lack of absorptive capacity. Fourth, our findings suggest that policy measures to foster innovation need to take account of the different innovation behaviour of firms in manufacturing and services. Fifth, given the increased internationalisation of production as well as of innovation and R&D activities, innovation policies need to be designed in an international context.

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Table 1. Distribution of Firms by Industry

NACE 2-digit Industry Description	NACE Code	CIS 2006 and 2008 Full Sample		CIS 2006 and 2008 Panel Sample	
		Number	Percent	Number	Percent
Manufacture of food products and beverages	15	268	6.62	58	8.02
Manufacture of tobacco products	16	4	0.10	2	0.28
Manufacture of textiles	17	37	0.91	7	0.97
Manufacture of wearing apparel; dressing and dyeing of fur	18	27	0.67	8	1.11
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	19	11	0.27	3	0.41
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20	90	2.22	20	2.77
Manufacture of pulp, paper and paper products	21	39	0.96	5	0.69
Publishing, printing and reproduction of recorded media	22	123	3.04	31	4.29
Manufacture of coke, refined petroleum products and nuclear fuel	23	4	0.10	1	0.14
Manufacture of chemicals and chemical products	24	139	3.43	34	4.70
Manufacture of rubber and plastic products	25	101	2.50	17	2.35
Manufacture of other non-metallic mineral products	26	100	2.47	18	2.49
Manufacture of basic metals	27	39	0.96	12	1.66
Manufacture of fabricated metal products, except machinery and equipment	28	206	5.09	31	4.29
Manufacture of machinery and equipment n.e.c.	29	136	3.36	27	3.73
Manufacture of office machinery and computers	30	33	0.82	6	0.83
Manufacture of electrical machinery and apparatus n.e.c.	31	62	1.53	16	2.21
Manufacture of radio, television and communication equipment and apparatus	32	40	0.99	12	1.66
Manufacture of medical, precision and optical instruments, watches and clocks	33	96	2.37	30	4.15
Manufacture of motor vehicles, trailers and semi-trailers	34	38	0.94	7	0.97
Manufacture of other transport equipment	35	22	0.54	7	0.97
Manufacture of furniture; manufacturing n.e.c.	36	141	3.48	10	1.38
Recycling	37	19	0.47	4	0.55
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	0	0.00	0	0.00
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	832	20.56	140	19.36
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52	6	0.15	0	0.00
Hotels and restaurants	55	3	0.07	0	0.00
Land transport; transport via pipelines	60	195	4.82	23	3.18
Water transport	61	15	0.37	5	0.69
Air transport	62	12	0.30	4	0.55
Supporting and auxiliary transport activities; activities of travel agencies	63	141	3.48	24	3.32
Post and telecommunications	64	75	1.85	11	1.52
Financial intermediation, except insurance and pension funding	65	140	3.46	26	3.60
Insurance and pension funding, except compulsory social security	66	56	1.38	22	3.04
Activities auxiliary to financial intermediation	67	133	3.29	33	4.56
Real estate activities	70	1	0.02	0	0.00
Renting of machinery and equipment without operator and of personal and household goods	71	0	0.00	0	0.00
Computer and related activities	72	365	9.02	36	4.98
Research and development	73	1	0.02	0	0.00
Other business activities	74	297	7.34	33	4.56
Sum		4,047	100.00	723	100.00

Table 2A. Summary Statistics of the Panel Sample: Manufacturing and Services

CIS 2006 and 2008

Types of firms	All firms	Innovators and non-innovators: Foreign-owned firms	Domestic exporters	Domestic non-exporters
	N=723	N=245	N=282	N=196
1. Innovation input				
Engagement in in-house R&D (per cent)	30.8	39.1	38.8	8.9
In-house R&D expenditure per employee (euro in 2004 price)	2,722.7	4,915.5	2,504.6	307.3
Engagement in innovation (per cent)	44.5	53.0	52.3	22.9
Innovation expenditure per employee (euro in 2004 price)	6,953.3	12,405.1	5,484.8	2,277.5
2. Innovation output				
Any type of innovation (per cent)	64.7	77.3	68.6	43.3
Product innovation (per cent)	41.6	53.0	47.3	19.3
Process innovation (per cent)	41.6	50.9	45.0	24.9
Organisational innovation (per cent)	47.0	57.3	51.2	28.2
All types of innovation (per cent)	22.8	29.4	27.1	8.4
Product and process innovation (per cent)	27.6	36.0	31.9	10.9
Product and organisational innovation (per cent)	29.3	37.8	34.4	11.5
Process and organisational innovation (per cent)	31.5	39.5	35.8	15.3
Innovative turnover share (per cent)	10.0	13.4	11.8	3.1
3. Knowledge flows				
Other enterprises within the same enterprise group (per cent)	11.6	24.7	6.0	3.3
Suppliers (per cent)	12.7	18.8	12.9	4.8
Clients or customers (per cent)	10.4	15.1	11.7	2.5
Competitors (per cent)	4.1	5.5	3.7	2.8
Consultants, commercial labs or private R&D institutes (per cent)	8.3	12.3	9.2	2.0
Universities or other higher education institutions (per cent)	8.2	13.9	8.0	1.5
Government or public research institutes (per cent)	4.6	5.7	6.4	0.8
4. Hampering factors				
Lack of internal funds	13.8	10.4	17.9	12.0
Lack of external funds	8.7	5.1	11.9	8.7
Costs too high	11.2	8.4	14.2	10.4
Lack of qualified personnel	7.1	6.1	9.0	5.6
Lack of technology information	2.8	1.6	3.9	2.8
Lack of market information	3.7	1.4	6.6	2.3

Difficult to find co-operation partners	3.7	2.5	5.0	3.6
Market dominated by incumbents	13.9	1.4	15.8	10.7
Uncertain demand	11.6	8.8	15.2	9.9
Need to meet government regulation	8.9	7.6	8.3	11.2
Excessive risk	6.8	5.3	8.5	6.4
5. Other firm characteristics				
Labour productivity (turnover per employee, 2004 prices)	738,219.0	1,430,688.0	459,804.0	276,155.2
Employees	153.3	238.9	130.9	79.1
Distance to the global technological frontier (2004 prices)	388,135.1	308,074.8	372,095.2	510,771.0

Notes: Innovators are firms that report having at least one of the following types of innovation among product, process or organisational innovation. Firms reporting no innovation are considered non-innovators. Types of firms include: foreign-owned firms (as indicated in the original survey), domestic exporters (non-foreign-owned firms that export to Northern Ireland, the UK, the EU or other countries in the world) and domestic non-exporters (non-foreign-owned firms that do not export).

Table 2B. Summary Statistics of the Panel Sample: Manufacturing

CIS 2006 and 2008

Types of firms	All firms	Innovators and non-innovators		
		Foreign-owned firms	Domestic exporters	Domestic non-exporters
	N=366	N=139	N=159	N=68
1. Innovation input				
Engagement in in-house R&D (per cent)	44.1	53.2	49.7	12.5
In-house R&D expenditure per employee (2004 prices)	3363.4	5354.9	2753.7	717.8
Engagement in innovation (per cent)	56.1	67.3	59.4	25.7
Innovation expenditure per employee (2004 prices)	9263.8	14445.9	6263.3	5640.1
2. Innovation output				
Any type of innovation (per cent)	69.3	81.3	71.1	40.4
Product innovation (per cent)	48.9	59.4	52.2	19.9
Process innovation (per cent)	49.2	58.3	50.3	27.9
Organisational innovation (per cent)	48.1	57.6	51.3	21.3
All types of innovation (per cent)	27.7	34.5	29.9	8.8
Product and process innovation (per cent)	34.3	41.7	36.8	13.2
Product and organisational innovation (per cent)	33.7	41.4	37.4	9.6
Process and organisational innovation (per cent)	36.6	45.3	38.4	14.7
Innovative turnover share (per cent)	12.5	15.4	13.6	3.8
3. Knowledge flows				
Other enterprises within the same enterprise group (per cent)	14.2	29.9	6.0	14.7
Suppliers (per cent)	15.8	24.5	13.5	3.7
Clients or customers (per cent)	13.5	19.8	12.9	2.2
Competitors (per cent)	11.9	17.3	11.0	2.9
Consultants, commercial labs or private R&D institutes (per cent)	3.8	5.0	3.8	1.5
Universities or other higher education institutions (per cent)	12.2	19.1	10.3	2.2
Government or public research institutes (per cent)	6.6	7.2	8.2	1.5
4. Hampering factors				
Lack of internal funds (per cent)	15.7	10.8	20.8	14.0
Lack of external funds (per cent)	9.6	5.8	12.6	10.3
Costs too high (per cent)	13.0	9.0	17.0	11.8
Lack of qualified personnel (per cent)	8.3	6.5	10.1	8.1
Lack of technology information (per cent)	3.0	1.8	4.1	2.9
Lack of market information (per cent)	4.5	1.4	7.2	4.4

Difficult to find co-operation partners (per cent)	4.2	2.5	6.3	2.9
Market dominated by incumbents (per cent)	16.3	16.9	17.3	12.5
Uncertain demand (per cent)	12.4	9.4	16.4	9.6
Need to meet government regulation (per cent)	6.7	5.8	7.9	5.9
Excessive risk (per cent)	7.2	5.0	10.7	3.7
5. Other firm characteristics				
Labour productivity (turnover per employee, 2004 prices)	451,116.4	831,292.2	211,196.6	235,250.5
Employees	166.0	287.9	110.8	46.2
Distance to the global technological frontier (2004 prices)	266,202.1	226,977.2	269,622.4	338,384.7

Notes: Innovators are firms that report having at least one of the following types of innovation among product, process or organisational innovation. Firms reporting no innovation are considered non-innovators. Types of firms include: foreign-owned firms (as indicated in the original survey), domestic exporters (non-foreign-owned firms that export to Northern Ireland, the UK, the EU or other countries in the world) and domestic non-exporters (non-foreign-owned firms that do not export).

Table 2C. Summary Statistics of the Panel Sample: Services

CIS 2006 and 2008

Types of firms	All firms	Innovators and non-innovators: Foreign-owned firms	Innovators and non-innovators: Domestic exporters	Innovators and non-innovators: Domestic non-exporters
	N=357	N=106	N=123	N=128
1. Innovation input				
Engagement in in-house R&D (per cent)	17.1	20.4	24.8	7.0
In-house R&D expenditure per employee (2004 prices)	2,065.8	4,336.5	2,182.4	90.1
Engagement in innovation (per cent)	32.6	34.1	43.1	21.4
Innovation expenditure per employee (2004 prices)	4,584.6	9,716.2	4,452.6	498.0
2. Innovation output				
Any type of innovation (per cent)	60.0	44.5	65.4	44.7
Product innovation (per cent)	34.2	41.2	41.1	19.1
Process innovation (per cent)	33.8	56.9	38.2	23.3
Organisational innovation (per cent)	45.9	72.0	51.2	31.9
All types of innovation (per cent)	17.8	22.7	23.6	8.2
Product and process innovation (per cent)	20.7	28.4	23.6	9.7
Product and organisational innovation (per cent)	24.8	33.2	25.60	12.5
Process and organisational innovation (per cent)	26.2	31.8	30.5	15.6
Innovative turnover share (per cent)	7.5	10.9	9.5	2.8
3. Knowledge flows				
Other enterprises within the same enterprise group (per cent)	9.0	18.0	6.1	4.3
Suppliers (per cent)	9.5	11.4	12.2	5.4
Clients or customers (per cent)	7.1	9.0	10.2	2.7
Competitors (per cent)	4.6	5.7	6.9	1.6
Consultants, commercial labs or private R&D institutes (per cent)	4.3	6.2	3.7	3.5
Universities or other higher education institutions (per cent)	4.2	7.1	4.9	1.2
Government or public research institutes (per cent)	2.7	3.8	4.1	0.4
4. Hampering factors				
Lack of internal funds (per cent)	11.8	10.0	14.2	10.9
Lack of external funds (per cent)	7.8	4.3	11.0	7.8
Costs too high (per cent)	9.4	7.6	10.6	9.7
Lack of qualified personnel (per cent)	5.9	5.7	7.7	4.3
Lack of technology information (per cent)	2.6	1.4	3.7	2.7
Lack of market information (per cent)	2.8	1.4	5.7	1.2
Difficult to find co-operation partners (per cent)	3.2	2.4	3..3	3.9

Market dominated by incumbents (per cent)	11.5	10.9	13.8	9.7
Uncertain demand (per cent)	10.8	8.1	13.8	10.1
Need to meet government regulation (per cent)	11.1	10.0	8.9	14.0
Excessive risk (per cent)	6.4	5.7	5.7	7.8
5. Other firm characteristics				
Labour productivity (turnover per employee, 2004 prices)	1,032,508.0	2,220,412.0	781,174.6	297,801.3
Employees	140.3	174.4	156.8	96.4
Distance to the global technological frontier (2004 prices)	513,142.0	414,923.8	504,560.0	601,994.9

Notes: Innovators are firms that report having at least one of the following types of innovation among product, process or organisational innovation. Firms reporting no innovation are considered non-innovators. Types of firms include: foreign-owned firms (as indicated in the original survey), domestic exporters (non-foreign-owned firms that export to Northern Ireland, the UK, the EU or other countries in the world) and domestic non-exporters (non-foreign-owned firms that do not export).

Table 3. Innovation Input: Manufacturing and Services

	Equation 1: Propensity of investing in innovation	Equation 2: Intensity of innovation input
Dependent variable	Innovation expenditure > 0	Log of innovation expenditure per employee
Estimator	Heckman first stage: probit	Heckman second stage: OLS
Foreign-owned firm	0.128***	0.790***
	(0.044)	(0.268)
Domestic exporter	0.230***	0.299
	(0.033)	(0.244)
Employment [20, 49]	0.089**	-0.545**
	(0.045)	(0.227)
Employment [50, 249]	0.212***	-0.321
	(0.043)	(0.260)
Employment [250, 499]	0.294***	-0.486*
	(0.066)	(0.284)
Employment [>=500]	0.470***	-0.523
	(0.054)	(0.344)
Distance to GTF	-0.006**	-0.075***
	(0.003)	(0.017)
Time fixed effect	-0.026	-0.173
	(0.024)	(0.136)
Lack of internal funds	0.101*	
	(0.061)	
Lack of external funds	0.041	
	(0.065)	
Costs too high	-0.138***	
	(0.045)	
Lack of qualified personnel	0.059	
	(0.059)	
Lack of technology information	0.079	
	(0.103)	
Lack of market information	0.073	
	(0.068)	
Difficult to find co-operation partners	0.122*	
	(0.068)	
Market dominated by incumbents	0.017	
	(0.033)	
Uncertain demand	0.053	
	(0.037)	
Need to meet government regulation	0.158***	
	(0.051)	
Excessive risk	-0.023	
	(0.054)	
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)	yes (0.000)
Constant	yes	yes
Log likelihood	-5,088.5	
λ	-1.464	
	(0.319)	
ρ	-0.787	
	(0.091)	

Wald test for H0: $\rho=0$ (χ^2)	19.9***
N	1,446

Note: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors shown in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. The dependent variable of the propensity to invest in innovation equation (Equation 1) is equal to 1 if a firm reports positive innovation expenditures and 0 otherwise. The dependent variable in the intensity of innovation equation (Equation 2) is the logarithm of innovation expenditures per employee. λ is the coefficient of the inverse mills ratio. ρ is the coefficient of the correlation of the error terms of the two equations measuring the interdependence of the two equations.

Table 4A. Innovation Output: Manufacturing and Services

	Equation 3: Innovation output			
Dependent variable	Any type of innovation	Product innovation	Process innovation	Organisational innovation
Estimator	RE Probit	RE Probit	RE Probit	RE Probit
Foreign-owned firm	0.284***	0.176***	0.105**	0.138***
	(0.046)	(0.050)	(0.044)	(0.040)
Domestic exporter	0.241***	0.167***	0.178***	0.243***
	(0.032)	(0.034)	(0.032)	(0.031)
Predicted innovation expenditure per employee	0.004	0.009	-0.000	0.057*
	(0.052)	(0.028)	(0.042)	(0.033)
Employment [20, 49]	0.095*	0.076**	0.075*	0.088**
	(0.052)	(0.038)	(0.045)	(0.039)
Employment [50, 249]	0.211***	0.153***	0.107**	0.143***
	(0.059)	(0.051)	(0.051)	(0.047)
Employment [250, 499]	0.238**	0.090	0.195**	0.224***
	(0.100)	(0.070)	(0.092)	(0.085)
Employment [>=500]	0.443***	0.359***	0.476***	0.414***
	(0.107)	(0.131)	(0.106)	(0.107)
Co-operation with other enterprises	0.318***	0.083*	0.306***	0.045
	(0.094)	(0.044)	(0.061)	(0.042)
Co-operation with suppliers	0.478***	0.155***	0.191***	0.222***
	(0.063)	(0.051)	(0.052)	(0.052)
Co-operation with customers	0.057	0.208***	0.080	-0.023
	(0.081)	(0.064)	(0.051)	(0.033)
Co-operation with competitors	-0.169**	-0.007	-0.023	0.093
	(0.068)	(0.033)	(0.051)	(0.062)
Co-operation with consultants	0.678***	0.152**	0.408***	0.323***
	(0.051)	(0.061)	(0.067)	(0.067)
Co-operation with universities	0.235**	0.173**	0.242***	0.260***
	(0.119)	(0.067)	(0.071)	(0.071)
Co-operation with government	0.678***	-0.007	-0.066	0.143
	(0.051)	(0.041)	(0.054)	(0.091)
Time fixed effect	-0.082***	-0.052***	0.043***	-0.076***
	(0.019)	(0.015)	(0.016)	(0.016)
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)	yes (0.000)	yes (0.000)	yes (0.000)
Constant	yes	yes	yes	yes
Log likelihood	-2179.1	-2017.0	-2157.5	-2301.2
χ^2	390.1	477.9	446.8	455.0
N	1,446	1,446	1,446	1,446

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. The dependent variables are binary variables indicating whether a firm reports various types of innovation. RE stands for random effects.

Table 4B. Innovation Output: Manufacturing and Services

	Equation 3: Innovation output				
Dependent variable	Product + process innovation	Product + org. innovation	Process + org. innovation	All types of innovation	Innovative turnover share
Estimator	RE Probit	RE Probit	RE Probit	RE Probit	RE
Foreign-owned firm	0.100**	0.061**	0.042	0.040*	0.941***
	(0.042)	(0.027)	(0.028)	(0.023)	(0.178)
Domestic exporter	0.087***	0.157***	0.177***	0.094***	0.845***
	(0.027)	(0.035)	(0.031)	(0.029)	(0.127)
Predicted inno. expend. per employee	-0.021	0.019	0.033	0.002	0.088
	(0.021)	(0.013)	(0.025)	(0.011)	(0.210)
Employment [20, 49]	0.028	0.044**	0.060*	0.022	0.219
	(0.025)	(0.022)	(0.032)	(0.017)	(0.200)
Employment [50, 249]	0.035	0.082**	0.096**	0.037	0.273
	(0.029)	(0.033)	(0.040)	(0.023)	(0.220)
Employment [250, 499]	0.020	0.090*	0.184**	0.044	-0.274
	(0.040)	(0.053)	(0.079)	(0.039)	(0.359)
Employment [>=500]	0.224*	0.297**	0.446***	0.209*	0.716*
	(0.122)	(0.116)	(0.115)	(0.113)	(0.433)
Co-operation with other enterprises	0.111**	0.035*	0.150***	0.059**	0.752***
	(0.045)	(0.021)	(0.047)	(0.029)	(0.199)
Co-operation with suppliers	0.091**	0.090***	0.143***	0.075**	0.887***
	(0.039)	(0.034)	(0.043)	(0.033)	(0.183)
Co-operation with customers	0.102**	0.043*	0.005	0.019	0.811***
	(0.044)	(0.024)	(0.024)	(0.016)	(0.202)
Co-operation with competitors	0.013	0.030	-0.004	0.003	-0.078
	(0.025)	(0.025)	(0.030)	(0.013)	(0.247)
Co-operation with consultants	0.154***	0.102**	0.290***	0.127**	0.522**
	(0.058)	(0.041)	(0.063)	(0.050)	(0.214)
Co-operation with universities	0.161***	0.170***	0.240***	0.143**	0.462**
	(0.061)	(0.058)	(0.064)	(0.056)	(0.227)
Co-operation with government	-0.004	-0.004	-0.018	-0.000	-0.519*
	(0.023)	(0.016)	(0.031)	(0.013)	(0.278)
Time fixed effect	-0.001	-0.017**	-0.018*	-0.007	-0.347***
	(0.007)	(0.007)	(0.010)	(0.005)	(0.071)
Industry fixed effects at NACE 2-digit level	yes	yes	yes	yes	yes
(P-value of joint significance)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	yes	yes	yes	yes	yes
Log likelihood	-1596.7	-1708.5	-1886.1	-1419.6	-9677.5
χ^2	386.6	424.1	430.8	340.3	758.0
N	1,446	1,446	1,446	1,446	1,446

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level, ** Significant at the 5 per cent level, * Significant at the 10 per cent level. The dependent variables in columns (1-4) are binary variables indicating whether a firm reports various types of innovation. The dependent variable in the last column is the logit transformed share of innovative turnover in total turnover in total sales. RE stands for random effects.

Table 5. Labour Productivity: Manufacturing and Services

Dependent variable	Equation 4: Labour productivity Log of turnover per employee								
	Any type of innovation	Product innovation	Process innovation	Organisational innovation	Product + process innovation	Product + org. innovation	Process + org. innovation	All types of innovation	Innovative turnover share
Estimator	RE	RE	RE	RE	RE	RE	RE	RE	RE
Foreign-owned firm	0.473***	0.504***	0.557***	0.470***	0.575***	0.546***	0.558***	0.581***	0.462***
	(0.063)	(0.060)	(0.058)	(0.060)	(0.057)	(0.057)	(0.057)	(0.057)	(0.062)
Domestic exporter	0.112**	0.150***	0.169***	0.082*	0.198***	0.158***	0.158***	0.196***	0.119***
	(0.046)	(0.042)	(0.041)	(0.044)	(0.040)	(0.041)	(0.041)	(0.040)	(0.043)
Predicted innovation output	0.479***	0.452***	0.334***	0.613***	0.271***	0.454***	0.436***	0.326***	0.114***
	(0.100)	(0.083)	(0.077)	(0.089)	(0.074)	(0.075)	(0.076)	(0.075)	(0.020)
Employment [20, 49]	0.038	0.053	0.066	0.057	0.074	0.074	0.075	0.080	0.070
	(0.053)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Employment [50, 249]	-0.067	-0.050	-0.014	-0.040	0.001	-0.018	-0.011	0.002	-0.009
	(0.061)	(0.059)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Employment [250, 499]	-0.118	-0.080	-0.090	-0.117	-0.051	-0.075	-0.094	-0.054	0.002
	(0.108)	(0.106)	(0.107)	(0.106)	(0.106)	(0.106)	(0.106)	(0.106)	(0.106)
Employment [>=500]	-0.095	-0.115	-0.099	-0.143	-0.060	-0.107	-0.125	-0.061	-0.055
	(0.130)	(0.130)	(0.131)	(0.129)	(0.130)	(0.129)	(0.130)	(0.129)	(0.128)
Time fixed effect	0.093***	0.093***	0.046**	0.120***	0.059***	0.080***	0.069***	0.063***	0.101***
	(0.019)	(0.019)	(0.018)	(0.020)	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)
Industry fixed effects at NACE 2-digit level	yes	yes	yes	yes	yes	yes	yes	yes	yes
(P-value of joint significance)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	yes	yes	yes	yes	yes	yes	yes	yes	Yes
Log likelihood	-5480.2	-5477.0	-5482.3	-5468.0	-5485.0	-5473.4	-5475.2	-5482.3	-5475.8
χ^2	810.7	817.1	806.5	835.2	801.2	824.2	820.6	806.5	819.5
N	1,446	1,446	1,446	1,446	1,446	1,446	1,446	1,446	1,446

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. RE stands for random effects.

Table 6. Innovation Input: Manufacturing

	Equation 1: Propensity of investing in innovation		Equation 2: Intensity of innovation input
Dependent variable	Innovation expenditure > 0		Log of innovation expenditure per employee
Estimator	Heckman first stage: probit		Heckman second stage: OLS
Foreign-owned firm	0.240***		0.159
	(0.074)		(0.258)
Domestic exporter	0.281***		0.124
	(0.065)		(0.219)
Employment [20, 49]	0.209**		-0.534**
	(0.083)		(0.267)
Employment [50, 249]	0.295***		-0.380
	(0.069)		(0.300)
Employment [250, 499]	0.388***		-0.658*
	(0.046)		(0.343)
Employment [>=500]	0.537***		-0.631
	(0.022)		(0.384)
Distance to GTF	-0.003		-0.102***
	(0.005)		(0.020)
Time fixed effect	-0.020		-0.166
	(0.048)		(0.174)
Lack of internal funds	0.200*		
	(0.103)		
Lack of external funds	0.054		
	(0.114)		
Costs too high	-0.244***		
	(0.088)		
Lack of qualified personnel	0.161		
	(0.157)		
Lack of technology information	-0.137		
	(0.126)		
Lack of market information	0.075		
	(0.125)		
Difficult to find co-operation partners	0.217		
	(0.132)		
Market dominated by incumbents	0.107		
	(0.129)		
Uncertain demand	0.090		
	(0.091)		
Need to meet government regulation	0.288***		
	(0.108)		
Excessive risk	-0.170*		
	(0.091)		
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)		yes (0.000)
Constant	yes		yes
Log likelihood		-2694.1	
λ		-0.269	
		(1.859)	
ρ		-0.190	

	(1.290)
Wald test for H0: $\rho=0$ (χ^2)	0.02
N	732

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors shown in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. The dependent variable of the propensity to invest in innovation equation (Equation 1) is equal to 1 if a firm reports positive innovation expenditures and 0 otherwise. The dependent variable in the intensity of innovation equation (Equation 2) is the logarithm of innovation expenditures per employee. λ is the coefficient of the inverse mills ratio. ρ is the coefficient of the correlation of the error terms of the two equations measuring the interdependence of the two equations.

Table 7A. Innovation Output: Manufacturing

	Equation 3: Innovation Output			
Dependent variable	Any type of innovation	Product innovation	Process innovation	Organisational innovation
Estimator	RE Probit	RE Probit	RE Probit	RE Probit
Foreign-owned firm	0.384***	0.211***	0.163***	0.247***
	(0.064)	(0.061)	(0.059)	(0.053)
Domestic exporter	0.350***	0.206***	0.153***	0.266***
	(0.050)	(0.049)	(0.045)	(0.042)
Predicted innovation expenditure per employee	0.045	-0.004	-0.000	0.040
	(0.050)	(0.021)	(0.039)	(0.031)
Employment [20, 49]	0.249***	0.082**	0.143***	0.100**
	(0.063)	(0.040)	(0.054)	(0.043)
Employment [50, 249]	0.258***	0.128***	0.107**	0.102**
	(0.062)	(0.045)	(0.050)	(0.041)
Employment [250, 499]	0.208*	0.021	0.211**	0.048
	(0.113)	(0.045)	(0.097)	(0.064)
Employment [>=500]	0.652***	0.260**	0.610***	0.214**
	(0.112)	(0.126)	(0.100)	(0.102)
Co-operation with other enterprises	0.758***	0.026	0.017	0.013
	(0.059)	(0.046)	(0.073)	(0.057)
Co-operation with suppliers	0.394**	0.050	0.185**	0.118*
	(0.162)	(0.049)	(0.083)	(0.067)
Co-operation with customers	0.248	0.232**	0.271***	-0.057
	(0.151)	(0.095)	(0.095)	(0.038)
Co-operation with competitors	-0.242***	-0.035	-0.037	0.017
	(0.059)	(0.032)	(0.084)	(0.084)
Co-operation with consultants	0.758***	0.056	0.446***	0.430***
	(0.059)	(0.056)	(0.099)	(0.090)
Co-operation with universities	0.758***	0.460***	0.377***	0.353***
	(0.059)	(0.119)	(0.099)	(0.090)
Co-operation with government	0.758***	0.002	-0.099*	0.264*
	(0.059)	(0.050)	(0.059)	(0.136)
Time fixed effect	-0.027	-0.038**	0.083***	-0.063***
	(0.027)	(0.016)	(0.025)	(0.020)
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)	yes (0.000)	yes (0.001)	yes (0.000)
Constant	yes	yes	yes	yes
Log likelihood	-893.9	-969.6	-1017.6	-1003.3
χ^2	158.8	214.9	199.7	242.7
N	732	732	732	732

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. The dependent variables are binary variables indicating whether a firm reports various types of innovation. RE stands for random effects.

Table 7B. Innovation Output: Manufacturing

	Equation 3: Innovation Output				
Dependent variable	Product + process innovation	Product + org. innovation	Process + org. innovation	All types of innovation	Innovative turnover share
Estimator	RE Probit	RE Probit	RE Probit	RE Probit	RE
Foreign-owned firm	0.098**	0.159***	0.144***	0.135**	0.765***
	(0.049)	(0.054)	(0.050)	(0.058)	(0.236)
Domestic exporter	0.092**	0.188***	0.162***	0.129***	1.170***
	(0.039)	(0.050)	(0.041)	(0.048)	(0.185)
Predicted innovation expenditure per employee	-0.011	0.003	0.013	0.001	0.121
	(0.018)	(0.011)	(0.027)	(0.013)	(0.198)
Employment [20, 49]	0.053	0.017	0.037	0.004	0.336
	(0.036)	(0.017)	(0.035)	(0.016)	(0.225)
Employment [50, 249]	0.039	0.035*	0.039	0.007	0.681***
	(0.030)	(0.021)	(0.034)	(0.017)	(0.223)
Employment [250, 499]	0.007	0.004	0.080	0.002	-0.170
	(0.034)	(0.020)	(0.065)	(0.024)	(0.370)
Employment [>=500]	0.307**	0.088	0.270**	0.098	1.151***
	(0.146)	(0.063)	(0.109)	(0.078)	(0.431)
Co-operation with other enterprises	0.054	0.007	0.056	0.039	0.709**
	(0.050)	(0.019)	(0.057)	(0.037)	(0.308)
Co-operation with suppliers	0.025	0.046	0.140**	0.046	0.415
	(0.033)	(0.034)	(0.064)	(0.037)	(0.283)
Co-operation with customers	0.255**	0.020	0.005	0.046	0.927***
	(0.105)	(0.023)	(0.040)	(0.038)	(0.296)
Co-operation with competitors	0.005	0.005	-0.000	-0.003	-0.292
	(0.037)	(0.024)	(0.057)	(0.022)	(0.376)
Co-operation with consultants	0.070	0.081*	0.349***	0.084	-0.217
	(0.055)	(0.047)	(0.088)	(0.053)	(0.290)
Co-operation with universities	0.409***	0.304***	0.313***	0.323***	1.467***
	(0.124)	(0.100)	(0.087)	(0.112)	(0.293)
Co-operation with government	-0.023	0.019	-0.006	-0.006	-0.495
	(0.021)	(0.031)	(0.052)	(0.018)	(0.359)
Time fixed effect	0.004	-0.026**	0.003	-0.013	-0.379***
	(0.009)	(0.012)	(0.016)	(0.009)	(0.106)
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)	yes (0.000)	yes (0.007)	yes (0.001)	yes (0.000)
Constant	yes	yes	yes	yes	yes
Log likelihood	-821.5	-816.3	-915.3	-723.9	-4535.4
χ^2	180.9	203.6	219.2	169.5	345.7
N	732	732	732	732	732

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level, ** Significant at the 5 per cent level, * Significant at the 10 per cent level. The dependent variables in columns (1-4) are binary variables indicating whether a firm reports various types of innovation. The dependent variable in the last column is the logit transformed share of innovative turnover in total turnover in total sales. RE stands for random effects.

Table 8. Labour Productivity: Manufacturing

Dependent variable	Equation 4: Labour Productivity Log of turnover per employee								
	Any type of innovation	Product innovation	Process innovation	Organisational innovation	Product + process innovation	Product + org. innovation	Process + org. innovation	All types of innovation	Innovative turnover share
Estimator	RE	RE	RE	RE	RE	RE	RE	RE	RE
Foreign-owned firm	0.401***	0.506***	0.532***	0.471***	0.554***	0.546***	0.534***	0.554***	0.470***
	(0.085)	(0.077)	(0.073)	(0.076)	(0.072)	(0.072)	(0.072)	(0.071)	(0.076)
Domestic exporter	-0.008	0.084	0.107**	0.042	0.125**	0.112**	0.104**	0.125**	0.019
	(0.064)	(0.056)	(0.053)	(0.057)	(0.051)	(0.052)	(0.052)	(0.051)	(0.060)
Predicted innovation output	0.459***	0.257**	0.213**	0.373***	0.163**	0.191**	0.236***	0.186**	0.093***
	(0.120)	(0.100)	(0.088)	(0.095)	(0.077)	(0.084)	(0.083)	(0.081)	(0.024)
Employment [20, 49]	0.008	0.062	0.068	0.071	0.083	0.089	0.090	0.095	0.069
	(0.067)	(0.065)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)
Employment [50, 249]	-0.002	0.039	0.065	0.055	0.076	0.071	0.075	0.081	0.019
	(0.073)	(0.072)	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)	(0.072)
Employment [250, 499]	0.122	0.175	0.156	0.187*	0.190*	0.194*	0.176	0.194*	0.199*
	(0.111)	(0.110)	(0.111)	(0.109)	(0.110)	(0.109)	(0.110)	(0.109)	(0.109)
Employment [>=500]	0.222	0.265*	0.260*	0.263*	0.289**	0.302**	0.274*	0.303**	0.213
	(0.145)	(0.146)	(0.147)	(0.142)	(0.145)	(0.143)	(0.144)	(0.143)	(0.145)
Time fixed effect	0.040*	0.040*	0.006	0.053**	0.021	0.036	0.022	0.026	0.057**
	(0.022)	(0.022)	(0.022)	(0.023)	(0.021)	(0.022)	(0.021)	(0.021)	(0.023)
Industry fixed effects at NACE 2-digit level	yes	yes	yes	yes	yes	yes	yes	yes	yes
(P-value of joint significance)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	yes	yes	yes	yes	yes	yes	yes	yes	yes
Log likelihood	-2109.3	-2113.3	-2113.6	-2108.9	-2114.3	-2114.0	-2112.5	-2113.9	-2108.9
Chi^2	308.1	300.2	299.5	308.9	298.1	298.8	301.7	298.9	308.9
N	732	732	732	732	732	732	732	732	732

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. RE stands for random effects.

Table 9. Innovation Input: Services

	Equation 1: Propensity of investing in innovation		Equation 2: Intensity of innovation input
Dependent variable	Innovation expenditure > 0		Log of innovation expenditure per employee
Estimator	Heckman first stage: probit		Heckman second stage: OLS
Foreign-owned firm	0.028		1.347***
	(0.048)		(0.254)
Domestic exporter	0.197***		0.357
	(0.031)		(0.401)
Employment [20, 49]	0.040		-0.435
	(0.036)		(0.389)
Employment [50, 249]	0.146***		-0.436
	(0.054)		(0.542)
Employment [250, 499]	0.070		-1.136*
	(0.124)		(0.684)
Employment [>=500]	0.285***		-0.884
	(0.105)		(0.759)
Distance to GTF	-0.012***		-0.029
	(0.004)		(0.043)
Time fixed effect	-0.031		-0.218
	(0.026)		(0.207)
Lack of internal funds	0.167*		
	(0.094)		
Lack of external funds	-0.020		
	(0.086)		
Costs too high	0.063		
	(0.169)		
Lack of qualified personnel	0.027		
	(0.081)		
Lack of technology information	0.217		
	(0.182)		
Lack of market information	0.153***		
	(0.056)		
Difficult to find co-operation partners	-0.054		
	(0.068)		
Dominated by incumbents	-0.076		
	(0.059)		
Uncertain demand	0.079		
	(0.104)		
Need to meet government regulation	0.100		
	(0.106)		
Excessive risk	-0.004		
	(0.080)		
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)		yes (0.000)
Constant	yes		yes
Log likelihood		-2264.6	
λ		0.741	
		(1.606)	

ρ	0.455
	(0.865)
Wald test for H0: ρ=0 (χ^2)	0.20
N	714

Note: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors shown in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. The dependent variable of the propensity to invest in innovation equation (Equation 1) is equal to 1 if a firm reports positive innovation expenditures and 0 otherwise. The dependent variable in the intensity of innovation equation (Equation 2) is the logarithm of innovation expenditures per employee. λ is the coefficient of the inverse mills ratio. ρ is the coefficient of the correlation of the error terms of the two equations measuring the interdependence of the two equations.

Table 10A. Innovation Output: Services

	Equation 3: Innovation Output			
Dependent variable	Any type of innovation	Product innovation	Process innovation	Organisational innovation
Estimator	RE Probit	RE Probit	RE Probit	RE Probit
Foreign-owned firm	0.219	0.147	0.100	-0.003
	(26.089)	(0.119)	(0.106)	(0.119)
Domestic exporter	0.153	0.107*	0.192***	0.139
	(16.423)	(0.061)	(0.058)	(0.957)
Predicted innovation expenditure per employee	-0.026	0.037	-0.015	0.122
	(2.469)	(0.064)	(0.061)	(1.039)
Employment [20, 49]	-0.025	0.078*	0.024	0.061
	(2.344)	(0.045)	(0.039)	(0.463)
Employment [50, 249]	0.137	0.172***	0.116***	0.123
	(15.529)	(0.045)	(0.038)	(0.769)
Employment [250, 499]	0.157	0.273*	0.140	0.491
	(21.386)	(0.161)	(0.128)	(3.396)
Employment [>=500]	0.207	0.498***	0.355***	0.447
	(31.320)	(0.115)	(0.104)	(2.415)
Co-operation with other enterprises	0.209	0.197***	0.466***	0.100
	(29.934)	(0.075)	(0.067)	(0.577)
Co-operation with suppliers	0.286	0.320***	0.234***	0.336
	(45.899)	(0.071)	(0.064)	(0.217)
Co-operation with customers	-0.023	0.243***	-0.015	0.056
	(2.112)	(0.088)	(0.058)	(0.393)
Co-operation with competitors	-0.019	-0.033	-0.027	0.118
	(1.743)	(0.066)	(0.067)	(0.594)
Co-operation with consultants	0.369	0.318***	0.355***	0.313
	(24.280)	(0.103)	(0.092)	(0.245)
Co-operation with universities	-0.313	-0.070	0.113	0.143
	(11.313)	(0.065)	(0.099)	(0.608)
Co-operation with government	0.317	0.092	0.003	0.142
	(48.336)	(0.134)	(0.106)	(0.603)
Time fixed effect	-0.102	-0.085***	0.008	-0.094
	(9.756)	(0.027)	(0.027)	(0.796)
Industry fixed effects at NACE 2-digit level (P-value of joint significance)	yes (0.000)	yes (0.000)	yes (0.000)	yes (0.000)
Constant	yes	yes	yes	yes
Log likelihood	-1239.9	-1025.7	-1117.0	-1280.2
χ^2	215.4	258.9	236.1	216.0
N	714	714	714	714

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. The dependent variables are binary variables indicating whether a firm reports various types of innovation. RE stands for random effects.

Table 10B. Innovation Output: Services

	Equation 3: Innovation Output				
Dependent variable	Product + process innovation	Product + org. innovation	Process + org. innovation	All types of innovation	Innovative turnover share
Estimator	RE Probit	RE Probit	RE Probit	RE Probit	RE
Foreign-owned firm	0.164*	-0.037	-0.061	0.020	1.483***
	(0.095)	(1.298)	(2.767)	(1.754)	(0.471)
Domestic exporter	0.120***	0.075	0.113	0.078	0.564**
	(0.043)	(2.370)	(4.346)	(6.398)	(0.250)
Predicted innovation expenditure per employee	-0.039	0.078	0.066	-0.001	-0.199
	(0.033)	(2.617)	(2.800)	(0.053)	(0.295)
Employment [20, 49]	0.029	0.078	0.067	0.042	0.011
	(0.025)	(2.397)	(2.652)	(3.573)	(0.183)
Employment [50, 249]	0.071***	0.103	0.099	0.062	-0.194
	(0.027)	(3.025)	(3.740)	(5.094)	(0.169)
Employment [250, 499]	0.070	0.447	0.369	0.157	-0.508
	(0.092)	(6.092)	(7.302)	(10.195)	(0.523)
Employment [>=500]	0.320***	0.492	0.478	0.333	0.436
	(0.118)	(5.954)	(6.875)	(15.648)	(0.422)
Co-operation with other enterprises	0.168***	0.126	0.260	0.110	0.714***
	(0.055)	(3.386)	(6.905)	(7.911)	(0.263)
Co-operation with suppliers	0.188***	0.220	0.183	0.145	1.332***
	(0.054)	(5.026)	(5.649)	(9.787)	(0.238)
Co-operation with customers	0.036	0.138	0.018	0.018	0.736***
	(0.037)	(3.604)	(0.740)	(1.612)	(0.276)
Co-operation with competitors	0.001	0.039	-0.024	-0.009	-0.175
	(0.033)	(1.209)	(1.068)	(0.878)	(0.332)
Co-operation with consultants	0.319***	0.225	0.262	0.283	1.876***
	(0.089)	(4.978)	(6.760)	(14.700)	(0.321)
Co-operation with universities	-0.001	0.094	0.218	0.037	-1.301***
	(0.037)	(2.631)	(6.099)	(3.069)	(0.367)
Co-operation with government	0.089	-0.018	-0.018	0.046	-0.084
	(0.086)	(0.617)	(0.777)	(3.773)	(0.469)
Time fixed effect	-0.020	-0.001	-0.030	-0.006	-0.425***
	(0.015)	(0.028)	(1.276)	(0.574)	(0.120)
Industry fixed effects at NACE 2-digit level	yes	yes	yes	yes	yes
(P-value of joint significance)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Constant	yes	yes	yes	yes	yes
Log likelihood	-753.1	-871.2	-958.3	-675.4	-5087.7
χ^2	191.9	217.6	214.6	171.9	438.6
N	714	714	714	714	714

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level, ** Significant at the 5 per cent level, * Significant at the 10 per cent level. The dependent variables in columns (1-4) are binary variables indicating whether a firm reports various types of innovation. The dependent variable in the last column is the logit transformed share of innovative turnover in total turnover in total sales. RE stands for random effects.

Table 11. Labour Productivity: Services

Dependent variable	Equation 4: Labour Productivity Log of turnover per employee								
	Any type of innovation	Product innovation	Process innovation	Organisational innovation	Product + process innovation	Product + org. innovation	Process + org. innovation	All types of innovation	Innovative turnover share
Estimator	RE	RE	RE	RE	RE	RE	RE	RE	RE
Foreign-owned firm	0.490***	0.461***	0.533***	0.385***	0.542***	0.505***	0.536***	0.560***	0.448***
	(0.093)	(0.089)	(0.087)	(0.089)	(0.087)	(0.086)	(0.085)	(0.086)	(0.094)
Domestic exporter	0.218***	0.213***	0.207***	0.063	0.245***	0.184***	0.162***	0.234***	0.230***
	(0.063)	(0.059)	(0.061)	(0.065)	(0.059)	(0.059)	(0.061)	(0.059)	(0.060)
Predicted innovation output	0.383***	0.609***	0.450***	1.058***	0.419***	0.749***	0.754***	0.536***	0.098***
	(0.144)	(0.124)	(0.118)	(0.148)	(0.122)	(0.116)	(0.127)	(0.126)	(0.027)
Employment [20, 49]	0.085	0.075	0.089	0.062	0.086	0.080	0.076	0.079	0.091
	(0.079)	(0.079)	(0.079)	(0.078)	(0.079)	(0.078)	(0.079)	(0.079)	(0.079)
Employment [50, 249]	-0.065	-0.075	-0.043	-0.101	-0.027	-0.051	-0.052	-0.031	0.012
	(0.093)	(0.090)	(0.090)	(0.089)	(0.090)	(0.089)	(0.089)	(0.089)	(0.089)
Employment [250, 499]	-0.451**	-0.471**	-0.445**	-0.695***	-0.431**	-0.526**	-0.534**	-0.452**	-0.331
	(0.214)	(0.211)	(0.212)	(0.214)	(0.212)	(0.211)	(0.211)	(0.211)	(0.211)
Employment [>=500]	-0.406*	-0.526**	-0.467**	-0.662***	-0.451**	-0.567***	-0.594***	-0.474**	-0.352*
	(0.217)	(0.217)	(0.217)	(0.216)	(0.217)	(0.215)	(0.217)	(0.216)	(0.214)
Time fixed effect	0.122***	0.137***	0.083***	0.206***	0.093***	0.110***	0.121***	0.093***	0.126***
	(0.031)	(0.029)	(0.028)	(0.032)	(0.028)	(0.028)	(0.028)	(0.028)	(0.030)
Industry fixed effects at NACE 2-digit level	yes	yes	yes	yes	yes	yes	yes	yes	yes
(P-value of joint significance)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	yes	yes	yes	yes	yes	yes	yes	yes	yes
Log likelihood	-3238.5	-3229.9	-3234.8	-3216.4	-3236.1	-3221.3	-3224.4	-3232.9	-3235.4
χ^2	456.7	473.9	464.1	500.8	461.4	491.0	484.8	467.8	462.8
N	714	714	714	714	714	714	714	714	714

Notes: Figures reported in the table are marginal effects. Estimates are obtained from weighted regressions. Standard errors in parentheses are clustered at industry level (NACE rev. 1.1, 2-digit). *** Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level. RE stands for random effects.

Appendix

Table A1. List of Variables

Variable	Definition	Source
1. Foreign linkages		
Foreign-owned firm	Dummy variable indicating whether a firm is foreign owned (1) or not (0).	CIS
Domestic exporter	Dummy variable indicating whether a non-foreign-owned firm exports to Northern Ireland, the UK or other countries (1) or not (0)	CIS
2. Innovation input		
Engagement in in-house R&D	Dummy variable indicating whether a firm reported a positive value of in-house R&D expenditure (1) or not (0)	CIS
In-house R&D expenditure per employee	The ration of in-house R&D expenditure in constant prices over the number of employees	CIS
Engagement in innovation	Dummy variable indicating whether a firm reported a positive value of total innovation expenditure (1) or not (0)	CIS
Innovation expenditure per employee	The ratio of innovation expenditure in constant prices over the number of employees	CIS
3. Innovation output		
Any type of innovation	Dummy variable indicating whether a firm reports having any type of innovation, namely product, process or organisational innovation (1) or not (0).	CIS
Product innovation	Dummy variable indicating whether a firm reports having product innovation (1) or not (0)	CIS
Process innovation	Dummy variable indicating whether a firm reports having process innovation (1) or not (0).	CIS
Organisational innovation	Dummy variable indicating whether a firm reports having organisational innovation (1) or not (0).	CIS
Product and process innovation	Dummy variable indicating whether a firm reports having both product and process innovation (1) or not (0).	CIS
Product and organisational innovation	Dummy variable indicating whether a firm reports having both product and organisational innovation (1) or not (0).	CIS
Process and organisational innovation	Dummy variable indicating whether a firm reports having both process and organisational innovation (1) or not (0).	CIS
All three types of innovation	Dummy variable indicating whether a firm reports having all three types of innovation, namely product, process and organisational innovation (1) or not (0).	CIS
Innovative turnover share	Percentage of turnover of innovative products in total turnover.	CIS
4. Knowledge flows		
Co-operation with other enterprises	Dummy variable indicating whether a firm co-operated with other enterprises within the same enterprise group (1) or not (0)	CIS
Co-operation with suppliers	Dummy variable indicating whether a firm co-operated with suppliers of equipment, material, components or software (1) or not (0)	CIS
Co-operation with customers	Dummy variable indicating whether a firm co-operated with clients or customers (1) or not (0)	CIS
Co-operation with competitors	Dummy variable indicating whether a firm co-operated with competitors or other	CIS

	enterprises in the same sector (1) or not (0)	
Co-operation with consultants	Dummy variable indicating whether a firm co-operated with consultants, commercial labs or private R&D institutes (1) or not (0)	CIS
Co-operation with universities	Dummy variable indicating whether a firm co-operated with universities or other higher education institutions (1) or not (0)	CIS
Co-operation with government	Dummy variable indicating whether a firm co-operated with government or public research institutes (1) or not (0)	CIS
5. Other firm and industry characteristics		
Labour productivity	Turnover per employee in constant prices.	CSO
Employees	Number of employees	CSO
Distance to Global technological frontier	Absolute difference between the turnover per employee of a firm in the CIS and the global technology frontier (GTF). GTF is obtained from the OECD. It is computed by pooling firms from 17 OECD countries. It is the turnover in constant prices per employee of the 90 percentile of firms in the 17 OECD countries sample. It is available at NACE 2 or 3-digit level.	OECD
6. Hampering factors to innovation		
Dummy variable indicating whether a firm perceived the following factors as having a high degree of importance in relation to innovation (1) or not (0):		
Cost Factors		
Lack of internal funds		
Lack of external funds		
Costs too high		
Knowledge Factors		
Lack of qualified personnel		
Lack of technology information		CIS
Lack of market information		
Difficult to find co-operation partners		
Market Factors		
Market is dominated by incumbents		
Uncertain demand		
Need to meet government regulation		
Excessive risk		

Year	Number	Title/Author(s) ESRI Authors/Co-authors *Italicised*
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Richard S.J. Tol

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