Does multinationality affect the propensity to innovate?
An analysis of the third UK Community Innovation Survey

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Abstract

The paper is developed at the interface between internationalisation and innovation studies. It utilises data on innovation from the UK CIS3 and 2 to assess whether multinationality affects the innovation propensity of surveyed enterprises. The indicators of innovation propensity – our dependent variables – are taken from the following CIS sets of variables: innovation outputs; innovation inputs; innovation outcomes (patent applications); innovation continuity/sustainability. The latter element of innovation propensity is considered to be the ability of the enterprise to sustain innovation over a long period of time. The relevant variables are derived from the responses of enterprises to both CIS3 and 2. This allows the paper to introduce dynamic elements into the analysis. Our main hypothesis states that multinationality per se (i.e. being part of a multinational company network) affects the propensity to innovate. We also test for three sub-hypotheses related to characteristics of multinationality. Specifically: belonging to a group versus being independent; degree of multinationality; being part of a foreign versus domestic multinational. Correspondingly to these hypotheses, we construct a relevant set of independent variables. The results show that all those CIS enterprises that belong to a multinational corporation are more likely to show innovation propensity; they are also more likely to engage in innovation activities on a continuous basis. The results support our expectations on the sub-hypotheses.

1. Introduction: the theoretical context

The last two decades have seen the publication of a number of works analysing the role of multinational companies (MNCs) in innovation. Various characteristics of MNCs have been the subject of such studies. For example Pearce and Papanastassiou (1999) analyse the location strategies of research and development (R&D) laboratories by foreign MNCs in the UK; Pavitt and Patel (1999) find that most
MNCs tend to locate their R&D activities at home and that therefore the national system of innovation of the home country affects their type and pattern of innovation. ‘Foreign’ ownership and its impact on innovation is the subject of several studies which use the Community Innovation Survey (CIS) databases in the UK or other European countries (Tether et al 1999; Tether 2000; Balcet and Evangelista, 2005; Sadowski and van Beers, 2003). Other databases have also been used to explore the issue of foreign versus UK multinationals in terms of their innovative behaviour: for example Tomlinson and Coombs (1988) use the Confederation of British Industry (CBI) 1998 survey to this effect.

Thus the multinationality characteristic is often identified with ‘foreignness’, and therefore with companies based in countries other than the one whose innovation activities are being studied. This approach is very useful and has led to interesting results. However, it does not allow us to distinguish between the innovation effects of being ‘foreign’ versus the innovation effects of operating at the multinational level independently of the country of origin of the company.

There are both theoretical and empirical grounds for conjecturing that multinationality per se may affect the innovation behaviour of companies. There is also empirical evidence that this is indeed the case. On the theoretical side the issue has been analysed by Cantwell (1989, 1999) in a detailed study of the innovative behaviour and outcomes of MNCs from six industrialised countries; USA, UK, Germany, France, Switzerland and Sweden. He begins with a critique of the then prevalent model of innovation development and diffusion in the context of internationalisation and MNCs’ activities: the International Product Life Cycle (IPLC) developed in Hirsch (1965) and Vernon (1966; 1974 and 1979).

The IPLC led – directly or indirectly – to a view of innovation activity and diffusion characterized by the following elements. Innovation is seen as related – and analysed with respect – to the product rather than the process or the firm as a whole or the industry. The innovation drive for the product is centred on the single firm

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2 Castellani and Zanfei (2003) analyse the innovation activities and performance of Italian manufacturing enterprises using various databases including CIS2. They test for the effects of both multinationality and foreign ownership.
operating in a specific country whose environment is congenial to innovation. Moreover, the theory led to a hierarchical view of innovation potential and activities: it envisaged – in terms of innovation – a hierarchy of countries (the US, Europe and developing countries) from which knowledge and innovation might be ‘transferred’ to less innovative countries. The theory also led to a hierarchy of firms (innovative and non innovative); a hierarchy of products (innovative and imitative) and a hierarchy of potential and actual innovation centres within the firm: the headquarters of American firms had the lead in the development of innovation and the foreign subsidiaries would follow and imitate. Rival firms would also imitate the product. The innovation potential of the home country is linked to various elements including macroeconomic and technological conditions: favourable income per capita, a large market, tastes of sophisticated consumers, and labour skills (engineering, production and marketing ones) create ideal conditions for the introduction of new products.

The IPLC theory does not give much scope for decentralization of innovative activities. In particular, there does not seem to be much interaction between subsidiaries and between subsidiary and headquarters; and between subsidiary and the local cultural and innovation environment of the host country. In terms of the internationalisation issue the model stresses the nationality of ownership rather than multinationality per se.

The 1980s and 1990s saw a variety of developments ranging from: the new information and communication technologies (ICTs) that facilitated the transmission of knowledge; to the increase in FDI in services; to the growth in inter-firm collaborative agreements (Contractor and Lorange, 1988; Hergert and Morris, 1988; Hagedoorn, 1996; Narula, 2000). These changed conditions in the micro and macro economy led to changed perspectives on innovation. The MNC has gradually come to be seen as an evolutionary institution with strong interactions with its economic environments in both the home and host countries. The evolutionary character is seen in terms of the way it organises its businesses and in terms of the development of its competitive strategies among which a prominent role is played by strategies on innovation.
Following a strong critique of the IPLC model, Cantwell (1989) developed his own theory which he tested against – and finds it supported by - data on patents from his sample of developed countries and their MNCs. His theory starts from the assumption that innovation and technological accumulation are used strategically by managers to enhance the firm’s competitive advantages.

The following are key elements in Cantwell’s theory. Ownership advantages – specifically in the innovation field – can be ‘created’; innovation is transmitted internally to the firm from country to country. There is also a strong interaction with the external environment: innovation activities within the companies generate spillover effects and therefore have external benefits on the local environment. This leads to the view of endogenous location advantages. Moreover, the subsidiary of a MNC learns from the local environment and thus the scope for further innovation in the subsidiary and, through it, in the other parts of the firm, increases. For example, Driffill and Love (2003) finds that foreign investors into the UK are – to a large extent – motivated, in their choice of location, by the desire to access the good innovation environment and capabilities in the host country (the UK).

Within this perspective on the development and diffusion of innovation, multinationality per se plays a very considerable role; so does the existence of internal networks and the integration of the various parts of the MNC’s group within the local environments in which they operate. It is a decentralized, network-centred view of innovation, its development and diffusion. Moreover, integration – within the group and between elements of the group and their external environment – rather than hierarchy, becomes relevant in this approach. These views are supported by a variety of works dealing with the organization of the firm (Hedlund, 1986; Bartlett and Goshal, 1989; Hedlund and Rolander, 1990; Gupta and Govindarajan, 1991 and 2000), as well as by Zanfei (2000) who explores further the dichotomy between centralised and decentralised organisational structures of the firm.

Cantwell’s results are supported by the work of Zanfei (2000), Frenz et al (2005) as well as Castellani and Zanfei (2003 and 2004). Zanfei (2000) sees the MNC as a network of innovators. He identifies two types of networks. Internal networks formed by the headquarters and subsidiaries of the company. The internal network may span
many countries. External networks emerge from the business links between parts of the company and other independent business units. Internal networks facilitate the transfer of knowledge and innovation internally to the company and within and across countries. These networks together with the use of ICTs facilitate the generalization and transfer of knowledge developed for a specific context and in a specific environment. Moreover, when local subsidiaries are given autonomy, they can engage in cooperative agreements with external businesses thus generating external networks. The latter facilitate the transfer of knowledge between the local environment and a specific part of the firm. The internal network can then help to transfer the acquired knowledge and innovation across the firm.

In Zanfei’s work the process of internal transfer is facilitated by a fairly centralized organization with strong centripetal forces. However, external transfers and spillover effects are facilitated by a more decentralized organizational structure. Here the author sees a source of conflict between decentralized organizations – that facilitate centrifugal forces and thus help the transfer of knowledge between the external environment and the local subsidiary – and centralized organization in which centripetal forces facilitate the internal transfer of knowledge and innovation. The conflict on the organizational structure of the firm is reflected in the possible dichotomy internal versus external transfer of knowledge. Zanfei’s analysis has therefore implications for the learning process and the spread of innovation. It has also relevant implications for the organization of companies.

The following points emerge from all these studies taken together. (1) Innovation activities can be used strategically to enhance the company’s competitive advantages. (2) Multinationality is an important element in these strategies because of the role it plays in the development and diffusion of knowledge and innovation. Through their subsidiaries, MNCs learn from the diverse local environments; conversely, the subsidiaries spillover innovation effects into the locations in which they operate. (3) The existence of internal networks facilitates the spread of knowledge within the company. (4) The organizational structure of the company and specifically the degree of autonomy enjoyed by the subsidiaries becomes relevant in the learning and diffusion process.
These points provide also the theoretical context of the present study which can thus be summarized. Innovation activities generate spillover effects of three types: (a) those from the innovating unit/enterprise to the other units which are part of the company; (b) those from the external environment to the unit spatially close to it and in turn from the unit to the rest of the company as in (a); and (c) those from the innovating enterprise/unit to the environment external to the company.

Points (a) and (b) are of specific relevance for the multinational companies because their networks extend over several countries with diverse innovation systems and environments. What we want to test is whether the diversity of environments in which the MNCs operate through their networks does indeed lead to a higher propensity to innovate for single enterprises of the companies.

In order to do so we have to isolate the effects of multinationality per se – that is the effects of belonging to a company that extends over many countries – from other effects specific to those companies such as: being part of a foreign or domestic MNC or being part of a network whose units are all located within a single country. In our case the country considered is the UK and the information derives from the UK CIS³.

The novelty of the paper can be found in the following. It tests the relevance, for innovation propensity, of multinationality per se in the context of the CIS database; it does so in juxtaposition to other characteristics of MNCs such as belonging to a group or being foreign-owned; it considers also the impact of the degree of multinationality of the company on the innovation propensity of its enterprises; it introduces a variable to indicate continuity/sustainance of innovation activity among the dependent variables. The latter element means considering the results of both CIS3 and 2.

The paper is thus structured. Section two develops the arguments and the hypotheses; section three considers the databases we use; sections four, five and six discuss the dependent, independent and control variables and section seven the

³ Networks with effects on innovation spillover may, of course, take various modalities such as those deriving from collaborative agreements. However, given our data source we are considering only those in which the enterprises are linked by ownership.
methodology. Sections eight and nine present the descriptive statistics and the regression results. Section 10 gives conclusions and implications.

2. Hypotheses

Multinationality is the general starting point for the development of our hypotheses and the construction of our dependent variables. However, multinationality is a fairly wide concept and it has a variety of connotation that need clarifying for a proper specification of our hypotheses. In particular, multinationality can be considered with respect to foreign MNCs operating the country, or to domestic MNCs; moreover, enterprises belonging to MNCs are part of internal networks formed by headquarters together with other parts of the company (affiliates/subsidiaries). It should also be noted that companies may have different degrees of multinationality; moreover, such degree is not a unique concept neither can it be captured by a single indicator but it differs according to the conceptual perspective and to the measurement frameworks considered.

In this paper we formulate a general hypothesis and a set of three sub-hypotheses. Our most general hypothesis derives from the analysis of the innovation propensity of all MNCs – whether their home country is foreign or the UK itself – versus the propensity of non-MNCs. Our sub-hypotheses aim to test different aspects of multinationality.

There may be two reasons – not necessarily mutually exclusive – why MNCs may exhibit a high propensity to innovate: (1) because all enterprises belonging to a MNC are part of a company that operates as a group. This characteristic of group belonging in itself may lead to a higher innovation potential because each part within the group learns from the environment in which it operates and transmits knowledge internally to the firm. Thus all the units of the MNC benefit from internal transfers (point a in section 1) as well as learning from their specific environments (point b in section 1).

The environments can be local (i.e. within the same nation-state) or related to different nation-states; this demarcation leads on to our second reason for the possible
association between multinationality and the propensity to innovate. Would operations across nation-states lead to higher potential for knowledge acquisition and spread? There may be good reasons why this might be the case: operating in different countries allows the company to learn from different innovation systems and cultures and this would have a higher impact on the innovation potential of the company as a whole. We must therefore try to capture the innovation effects of belonging to a group that is multinational versus belonging to a group that is uninational. This is what our first sub-hypothesis is designed to test: whether an enterprise that is part of a group operating in a multinational context shows a higher innovative propensity than an enterprise that is part of a group all operating within the single country, the UK. The latter case refers to a UNC with several subsidiaries all operating within the UK. In terms of our CIS dataset, enterprises that belong to a UK company can be: independent or part of a group. Moreover, they can be UK uninationals or they can be part of a UK company that operates in other countries as well as in the UK and is therefore a MNC.

In summary, an enterprise operating in the UK can be foreign (i.e. part of a foreign MNC) or domestic. In the former case, the enterprise is automatically part of a group and part of a MNC. In the latter case, the enterprise can be part of a UK MNC (that is a UK company that has foreign subsidiaries as well as, possibly, subsidiaries in the UK); it may also be uninational. UK uninational firms may be independent with no subsidiaries within or outside the UK, or they may be part of a uninational company group with their headquarters as well as all their subsidiaries located in the UK. Figure 1 illustrates the grouping of enterprises by type of ownership.

Figure 1: Enterprises grouped by type of parent company

If multinationality turns out to be relevant for innovation propensity – as we expect it to be – we want to test whether enterprises that belong to companies with a high degree of multinationality are more likely to have higher innovation propensity than those belonging to MNCs with a low degree of multinationality. This issue forms the basis for our second sub-hypothesis on the impact of multinationality on innovation propensity. We expect this second hypothesis to be confirmed.
The *third sub-hypothesis* is designed to test whether – within the MNCs – the nationality of the company – domestic versus foreign – is relevant in terms of innovation propensity. The impact of domestic versus foreign MNCs on innovation propensity is unlikely to be a general effect applicable to all countries and sectors. It is more likely to be country and/or sector specific. The country specificity may be related to the stage of development of the country’s system of innovation. Those countries that have very advanced innovation systems and are, generally, at the forefront of innovation may find that foreign companies have relatively little to bring in terms of additional innovative capacity. Indeed, some countries may be chosen as host countries for foreign direct investment and other entry modes specifically because foreign firms want to take advantage of their innovative environment. The UK may indeed be one such example (Driffield and Love, 2003). In this context, we would expect foreign MNCs to exhibit higher propensity to innovate than domestic ones in cases in which the foreign MNCs originate from countries with more advanced systems of innovation. In our sample, some three quarters of foreign MNCs, of which our enterprises are part, originate from very advanced countries, at comparable levels of development in terms of their innovation systems. From this perspective we do not necessarily expect ‘foreignness’ to have an impact on the propensity to innovate. For other countries within the EU the situation may be different and foreign companies may indeed bring in knowledge and innovation from which the local enterprises can reap benefits.\(^4\)

Moreover, some authors have argued that multinational companies do not internationalise specific innovation activities. For example, Patel and Pavitt (1995, 1998) show that most MNCs locate the bulk of their R&D in the domestic market. This element might favour the hypothesis that enterprises which are part of domestic MNCs perform better in terms of innovation propensity because their R&D activities are located in the country of the enterprise.

However, there is a specific element that might support the hypothesis of higher propensity to innovate by enterprises that are part of foreign MNCs compared to those

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\(^4\) This might be the case of some Italian sectors though not others as preliminary research by Balcet and Evangelista (2005) seems to show. Sadowski and van Beers (2003) find that the affiliates of foreign MNCs in the Netherlands have a positive effect on product innovation. Both these studies use CIS2 data.
that are part of a domestic MNC. This has to do with elements of ex-ante self selection in the investment process. It may be that the very strong and innovative MNCs are the ones that invest particularly in a country like the UK.

The latter point is linked also to sector-specific elements. For any one country, specific industries may be more innovation advanced than others. Foreign companies may be able to make a considerable contribution to innovation in some sectors, and relatively little in others. Frenz et al (2005) results for financial services show that foreign vs. domestic ownership is not a relevant characteristic in a variety of innovation activities for the CIS2 in the UK. However, this result may be not only UK specific; it may be specific of a sector on which the UK is a leader in the development of products and processes. The same results may not hold for different countries within financial services or for different sectors within the UK itself.

For these reasons no general prediction can be made on the last hypothesis: the propensity to innovate could be higher or lower in enterprises belonging to domestic than to foreign MNCs according to the country and the sector(s) we are analysing. In our case (the UK and all sectors together) we would marginally expect enterprises that are part of foreign MNCs to exhibit a higher propensity to innovate on the ground that the UK is likely to attract very innovative companies.

Box 1: In summary our hypotheses are the following:

(1) **Main Hypothesis**

Multinationality has a positive impact on the propensity to innovate.

(2) **Sub-Hypotheses**

(a) MNCs are more likely to be innovators. This could be due to the fact that enterprises which belong to a MNC are automatically part of a group and group belonging affects the innovation propensity; or it could be due to the fact that being part of a MNCs allows the enterprise to rip the benefits of linkages with other countries and such linkages affect, positively, the propensity to innovate.
Our general aim is to test the impact of multinationality per se on innovation propensity. We are, nonetheless, aware that innovation can also be seen as an ownership advantage which may help the firm to become multinational. This means that multinationality could be seen to depend on innovation rather than the other way round as in our study. The following three points give support to our approach. (1) We examine subsidiary level innovation, rather than innovation capabilities of MNCs as a whole. The effects of the innovation activities of a single subsidiary may not necessarily lead to increased foreign direct investment decisions. Investment strategies are likely to be based on the accumulated knowledge and innovation within the entire MNC. (2) The enterprises we study are already part of multinational networks. Ours is not an ex-ante study of firms’ decisions to become multinationals by investing abroad and of the comparative advantages vis-à-vis other firms. (3) In our study the multinationality issue is not introduced in terms of foreign involvement – whether via FDI or through other modalities – but in juxtaposition to other specific characteristics of the company such as being foreign or UK-owned or being part of a UK only group.

3. The Community Innovation Survey and other databases

For our investigation we need variables related to two elements: innovation and multinationality. Information on innovation is taken from the Community Innovation Surveys. Innovation activities in EU countries have been the focus of a series of large surveys – currently in their third phase – in which the unit surveyed is the enterprise.5

5 According to the CIS an enterprise is defined as: “… the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain autonomy in decision making, especially for the allocation of its current resources. An enterprise carries out one or more
An enterprise may be an independent unit or part of a wider company. If an enterprise belongs to a wider group/company, then the CIS questions refer to the activities of the enterprise and not the activities of the company as a whole. Given the nature of the survey, the valuation of innovation activities generated by it is self-assessed by the participating enterprise.

In 2001 and 1997 the Office for National Statistics (ONS) conducted CIS3 and 2 on behalf of the Department of Trade and Industry (DTI). CIS3 has a population of 8,124 enterprises. For the purpose of this paper we consider a subset of all the CIS3 enterprises chosen for its characteristic of being a set that overlaps in both the CIS3 and 2. In other words we have chosen those enterprises which answered both CIS3 and CIS2. This choice is informed by the following main objective: to study the extent of continuity/sustainability of the innovation activities and thus to have a long term as well as a short term perspective on the propensity to innovate and, eventually, on the impact of multinationality on innovation propensity. Additionally to the questionnaire data, the ONS matched the CIS with information from the Inter-Departmental Business Register (IDBR). The latter gives information on structural features of the surveyed enterprises as well as on whether the respondent is part of a wider company/group or whether the enterprise is independent.

With respect to multinationality elements, the CIS/IDBR does not contain data on multinationality as such; information is available on the national origin of the ultimate company of which the enterprise is part. If an enterprise belongs to a foreign company, then it is automatically part of a MNC. However, this does not give us full information on multinationality for two reasons: (a) some companies that are UK-owned may also be MNCs and it is not possible – within the CIS information – to discriminate between those UK enterprises that are part of a MNC and those that are part of a uninational (UK) company; (b) we have no information on how relevant their activities abroad are in terms of the number of countries in which they operate and the extent of activities in such countries.

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activities at one or more locations. An enterprise may be a sole legal unit.” (see UK CIS2 questionnaire, p.1)

6 Compared to the whole of the CIS our sample contains a higher proportion of large enterprises. Details on this are in Frenz (2002).
In order to get these vital pieces of information on the multinationality characteristics we use Dun and Bradstreet’s *Who owns Whom (WoW)*, a large database that gives company tree data in the form of name, number and location of subsidiaries. The variable on foreign or UK ownership used in this paper also derives from WoW. We matched the CIS with the company tree data on WoW.

As illustrated in figure 1, the resulting data set contains 679 observations in total; 257 enterprises are part of a MNC out of which 137 are of foreign origin. Among the remaining 422 enterprises not part of a MNC – and therefore uninational firms – are 159 which belong to a UK uninational company group and 263 enterprises which are independent uninational enterprises.

4. **Dependent variables: innovation propensity**

Our aim is to assess the relationship between multinationality and the propensity to innovate. For this we need two sets of variables: the first set, the *dependent variables*, relates to indicators of *innovation propensity*. The latter we see as a multidimensional concept related to innovation activity as well as innovation outcomes. It is represented by several indicators all taken from three sets of questions on innovation activities from the CIS3 as well as from the link between CIS3 and 2. The three sets of indicators relate to the following: (1) *Innovation output* in terms of (1a) *product innovation* and (1b) *process innovation*; (2) *innovation sustainability/continuity* of the innovation activity using information deriving from CIS3 and 2; (3) *innovation outcome* represented by the patenting activity. A fourth set of variables refers to

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7 WoW defines subsidiaries by a 50 per cent or more ownership. This constraint prevents us from including among the MNCs all those with associates abroad i.e. with ownership stakes of 10 to 50 per cent. Our sample of MNCs is, therefore, underestimated. Nonetheless the problem may be partly compensated by the fact that the data on WoW are biased towards reporting MNC rather than smaller UNCs.

8 Out of 786 firms in the CIS overlap 478 were included in the WoW dataset. The 478 firms are all firms belonging to either a multinational or uninational company group. Of the remaining 306 firms, which could not be matched with WoW, 201 were independent entities, according to the CIS information on group belonging. In 105 of the 786 observations common to CIS2 and CIS3 all the information available is that the enterprises belong to a company group. It is not known whether the relevant company group is uni- or multi-national; nor do we know anything about their degree of multinationality. For this reason those 105 observations have been dropped from the analysis. Thus, the data set used in this paper contains 679 observations.
innovation input in terms of R&D expenditure. The following sub-sections give a detailed overview of the different measures of innovation propensity.

4.1 Innovation output: product innovation

The variable used to assess product innovation activity derives from the following CIS question: Did your enterprise introduce new or significantly improved products which were new to the enterprise and new to the enterprise’s market between 1998 and 2000. This provides us with a variable on product innovation output which we call novel product innovation. Novel product innovation includes those enterprises which invented rather than enterprises which imitated. The resulting variable is called:

Novel product innovation: PROD_NOV

4.2 Innovation output: process innovation

Much innovation activity affects processes rather than – or in addition to – products. In the CIS questionnaires enterprises were asked if they introduced any new or improved processes for producing or supplying products (goods or services) which were new to the enterprise and new to the enterprise’s market. The process innovation variable is the following:

Novel process innovation: PROC_NOV

4.3 Continuous/sustained innovation activity

Continuous as opposed to sporadic innovation activity has been of interest to many researchers (Cefis, 2003, Cefis and Orsenigo, 2001, Geroski, Van Reenen and Walters, 1997). We also want to assess whether the possible effects of multinationality on innovation activities are one-off, and therefore short to medium term ones, or whether they are more sustained and long term. Thus the continuity and sustainability characteristic becomes one of our indicators of propensity. In order to obtain indicators and variables for the continuity element we consider the replies of
enterprises which reported to have engaged in novel product innovation in two consecutive survey periods; CIS2 (1994 to 1996) and CIS3 (1998 to 2000).

*Sustained novel product innovation: SUPROD_NOV*

### 4.4 Innovation outcome

From the CIS the variable representing outcome of innovation relates to data on patents. The variable is a numerical/discrete variable giving the number of patents an enterprise applied for between 1998 and 2000\(^9\).

*Number of patents applied for: PATENT*

### 4.5 Innovation input

A further variable contributing to our list of indicators of innovation propensity on the innovation input side is related to R&D activities\(^{10}\). We consider the amount an enterprise spent on R&D in £000s for the year 2000.

*Research and development related expenditure: R&D*

### 5. Independent variables: multinationality elements

The second set of variables refers to multinationality and related characteristics and these form our independent variables. Most of these variables derive from linking information from WoW to the CIS as highlighted in section 3. Variables related to multinationality are: (a) whether the enterprise belongs to a group/internal network or not; (b) whether the company to which the enterprise belongs is a multinational company or not; (c) the degree of multinationality on which we consider two types of

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9 Patents like R&D are a traditional measure of innovation activities. They tend to be geared towards manufacturing goods based on scientific and technological knowledge (Archibugi and Pianta, 1996) though software patenting is now thriving.

10 R&D is a variable often used in innovation studies and which has led to a stream of interesting results (Patel and Pavitt, 1995, Pearce and Papanastassiou, 1999).
indices; and (d) whether the company to which the enterprise belongs is foreign or UK-owned.

In order to test our first and main hypothesis, we create a dummy variable identifying all enterprises which belong to multinational companies (both foreign and UK). *The relevant variable is called: MNC.*

To test the first sub-hypothesis (a) we create a variable distinguishing whether an enterprise is part of a wider group as opposed to being an independent entity. The variable is extracted directly from the CIS/IDBR (as mentioned in section 3). *The relevant variable is labelled GP.*

To test the second sub-hypothesis (b) two indices of the degree of multinationality are calculated. They are developed in Ietto-Gillies (1998 and 2002: ch. 4) and are the Internationalisation Index (Ii) and the Network Spread Index (NSi). The internationalisation index (Ii) is designed to capture the *intensity* of internationalisation; that is the degree of foreign activities in relation to the total activities of the company. NSi aims to capture the degree of geographical (by nation-state) *extensity* of the MNC. We consider that both the extent of foreign involvement (intensity) and the number of countries in which direct foreign operations take place (extensity) may impact on the propensity to innovate of the specific enterprise considered. A description on the indices can be found in appendix A. A dichotomous variable is constructed selecting all enterprises which have an Ii and NSi which lie both above average in our sample, to express the fact that both elements of the degree of multinationality (*intensity* and *extensity*) may be relevant for assessing the impact of innovation propensity. *The relevant variable is called DGMNC.*

Lastly, to test our sub-hypothesis (c) we create a dummy variable distinguishing between foreign ownership on the one hand and domestic ownership on the other hand. There are 137 foreign-owned enterprises\(^{11}\) and 542 UK-owned enterprises. *The relevant variable on foreign versus domestic ownership is called FORMNC.*

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\(^{11}\) Of these 137 enterprises 43 originate from the US, 57 from the EU, 7 from other European countries, 26 from other developed countries, 8 from developing countries and 3 are registered in tax havens (Bermuda and the Cayman Islands).
6. Independent control variables

Two sets of control variables are used in the statistical analysis: firstly, enterprise size. Firm’s size whether measured in terms of employees, turnover or assets may be considered a “classic” explanatory variables in innovation studies, with a number of studies supporting an effect on the nature and patterns of innovation (Cohen, 1995 and Tether, 2001). We measure size with the natural log of the number of employees.

The second set of control variables measure the sectoral environment an enterprise operates in. A number of studies have shown that innovation patterns differ greatly across sectors. In particular service firms tend to be more active in process innovation and show a generally lower patent and R&D activity (Frenz, 2002, Tether, 2000). We distinguish between 11 industry sectors listed in table 1.

Table 1: Control variable: sectors

Details of all the variables used and their sources are in table 2.

Table 2: Overview of variable names, their description and the source of the information

7. Methodology

To test the main and subsidiary hypotheses descriptive statistics and regression methods are used; in the latter we examine the association between our indicators of innovation propensity and a variety of multinationality elements of the enterprise and the company to which it belongs. Probit, negative binomial and tobit models are used as appropriate and as will be explained in the discussion of the results. The results,

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12 We calculated the same regressions using the log of turnover and found that the results were not significantly different from the result generated when using employment figures as a measure of enterprise size.
where statistically significant, support an association not causality between elements of multinationality and innovation variables. They may be interpreted as the probability of an enterprise being innovation active or showing a high innovation propensity when certain elements of multinationality are present (e.g. foreign ownership).

The main hypothesis states that multinationality has a positive impact on innovation. To find support we compare the innovation activities of enterprises belonging to MNCs with the innovation activities of uninational enterprises. The sample of 679 enterprises is divided into 257 enterprises which are part of a MNC and 422 which are not. A dummy variable selecting the MNCs (i.e. value of 1) and deselecting the UNC (i.e. value of 0) is our independent variable, which is called MNC. The following equation is estimated to test the main hypothesis:

\[
Y_i = \alpha + \beta \text{MNC}_i + \gamma_1 \text{Size}_i + \gamma_{2-12} \text{Sector}_i + \varepsilon_i \tag{1}
\]

where \(Y_i\) is a measure of innovation propensity as introduced in section 4; \(\beta\) is the difference in innovation activity predicted by the model depending on whether an enterprise is part of a MNC or not; \(\gamma_1\) represent the impact on performance of enterprise size and \(\gamma_{2-12}\) capture the industry effects.

Some variables are derived from yes/no questions, i.e. whether an enterprise engaged in novel product or process innovation. The related regression models have dichotomous dependent variables assigning a value of 1 to all enterprises declaring to have been innovation active. Probit models are used in the case of dichotomous dependent variables. When the dependent variable is count data – number of patent applications – a negative binomial model is used. Where the dependent variable is continuous – the amount spent on R&D – tobit analyses are applied. The tobit estimation is left censored at zero, because a large number of enterprises – 344 – had no R&D expenditure. Marginal effects, the change in absolute probability of the outcome induced by the regressors dy/dx, are reported. The following equation is estimated in order to test the three sub- hypotheses:

\[
Y_i = \alpha + \beta_1 \text{GP}_i + \beta_2 \text{MNC}_i + \beta_3 \text{DGMNC}_i + \beta_4 \text{FORMNC}_i + \gamma_1 \text{Size}_i + \gamma_{2-12} \text{Sector}_i + \varepsilon_i \tag{2}
\]
where \( Y_1 \) is a measure of innovation propensity. \( \beta_1 \) represents the difference in innovation activity predicted by the model between enterprises that are part of a wider company group operating in a single country – uninational company groups – and independent enterprises not integrated in a network of firms through ownership linkages. \( \beta_2 \) measures the gap between enterprises that belong to a MNC – that has a below average degree of multinationality and that is not foreign-owned (i.e. DGMNC = 0 and FORMNC = 0) – and enterprises that belong to a uninational company group. \( \beta_3 \) denotes the additional differential of a high degree of multinationality. \( \beta_4 \) measures benefits of belonging to a foreign-owned as opposed to domestic-owned MNC. The sum of \( \beta_2, \beta_3 \) and \( \beta_4 \) is the difference in innovation performance of being part of a MNC per se – independent of the degree of multinationality and country of ownership – compared to uninational company groups. The impact of enterprise size on performance is represented by \( \gamma_1 \) while \( \gamma_{2.12} \) captures the industry effects.

8. Results: descriptive statistics

This section and table 3 give a brief overview of the number and proportion of innovators among enterprises belonging to a wider group (GP); those that belong to a multinational group (MNC); those that are part of a MNC with above average degree of multinationality (DGMNC) and enterprises that are part of a foreign-owned multinational (FORMNC).

Table 3: Innovation activity across groups

The first column of table 3 gives the number of enterprises in each group, e.g. there are 257 enterprises that are part of a MNC. The second and third columns give the number and per cent of novel product innovators in each group, followed by novel process innovators and sustained innovators. Column 8 gives the average number of patent applications in each group and column 9 the average amount spent on R&D measured in £000s.
On the whole enterprises that belong to a company group (GP), independently of whether or not the group operates in one or in more than one country, appear to have a higher innovation propensity than enterprises that are independent units. Enterprises belonging to a multinational company (MNC) show a higher innovation performance than enterprises belonging to a UNC. In particular enterprises that belong to a MNC with a high degree of multinationality (DGMNC) exhibit a high innovation propensity. Enterprises that belong to a foreign-owned company (FORMNC) do not appear to have a higher propensity to innovate than enterprises belonging to MNCs per se.

9. Results: regression analysis

Table 4 gives the findings of the regression model testing the main hypothesis [Eq. 1]. We report the marginal effects and the t-statistics of the underlying coefficients in parentheses. The results as a whole show that multinationality per se has a positive and significant impact on innovation performance. In terms of novel product innovation and novel process innovation we find that multinationality is positively and significantly related to innovation (1 per cent level and 5 per cent level). The strongest relationship between MNC and innovation activities is found when examining R&D expenditure. There appears to be no relationship between the number of patent applications and multinationality per se\(^{13}\).

Table 4: Regression results for the main hypothesis

Table 5 gives the results of tests for the three sub-hypotheses [Equ. 2]. We remind the reader that the aim of the sub-hypotheses is to find out how the results for the main hypothesis (table 4) are connected to the following:

(a) The fact that such enterprises are part of a group whose internal networks span across a number of countries rather than being all located in a single country ($\beta_2 + \beta_3 + \beta_4$);

\(^{13}\)Furthermore, we tested for relationships between multinationality and (i) product innovation (not necessarily new to the enterprise’s market) and (ii) continuous R&D and found some indication of a relationship (10 per cent level significance). Results for process innovation and continuous patent activity were statistically insignificant.
(b) The relevance of the degree of multinationality: do enterprises belonging to MNCs whose networks pass a certain threshold – in terms of intensity and extensity of their multinationality – have a higher propensity to innovate ($\beta_3$)?

(c) Are foreign MNCs more likely to be innovators than UK owned ones ($\beta_4$)?

Table 5: Regression results for the sub-hypotheses

Belonging to a wider uninational group as opposed to being an independent enterprise has a positive and significant effect on the number of patent applications ($\beta_1$). Enterprises that are part of a MNC per se compared to enterprises that are part of a wider company group operating in a single country ($\beta_2 + \beta_3 + \beta_4$) show a higher innovation performance across all measures of innovation activity.

Being part of a MNC has a positive impact on innovation propensity largely due to enterprises that are part of a MNC with a high degree of multinationality ($\beta_3$). This effect is highest in the case of novel product innovation and patents. Belonging to a foreign multinational appears to have no significant impact on innovation propensity ($\beta_4$).

Statistically significant industry effects were found when examining patent and R&D data. The industry groups showed little impact in the case of novel product and process innovation and continuous novel product innovation. Enterprises in the chemical and pharmaceutical sector are more likely to have a high patent application count, so have machinery and equipment manufactures. Financial, insurance, post and telecommunication enterprises are less likely to have a high patent count. The chemical and pharmaceutical enterprises have a significantly higher R&D expenditure than other sectors, whereas transport services had a significantly lower one$^{14}$.

10. Summary, conclusions and implications

$^{14}$The regression results on the sectors are available from the authors on request. They are not included here for the sake of brevity and clarity in the presentation of the results in tables 4 and 5.
The main aim of the paper is to test the relationship between multinationality and the propensity to innovate using information from the CIS3 and 2 for the UK. The propensity to innovate is identified by a variety of indicators related to output, input and outcome of innovation as well as by continuity of innovation activities. It is in relation to the last indicator of innovation propensity that we utilise information from two consecutive CISs. To this end, our choice of subset from the CIS surveys falls on those enterprises that replied to both surveys. The information in the CISs refers to the surveyed enterprise and not to the company as a whole.

The paper starts by setting up the theoretical context of the study and argues the reasons why multinationality and innovation may be related. Many studies that utilise CIS in various European countries, tackle the issue of multinationality. However, they largely identify multinational enterprises as those that belong to a foreign company. The CISs lend themselves to this structure because they provide information on whether the enterprise belongs to a foreign company, but not on whether it belongs to a (UK) MNC. Now, while all enterprises belonging to foreign companies are, indeed, part of a MNC, they are not the only ones. Some enterprises are part of UK companies with affiliates abroad and therefore they are part of a UK MNC.

Our study aims to capture the impact of multinationality per se, whether the ultimate company is UK or foreign based. One of our three sub-hypothesis (c in section 2) tests the relevance to foreign versus UK multinationality. Another sub-hypothesis (a) tests the impact of multinationality versus belonging to a group. All enterprises belonging to MNCs are automatically part of a group; however, they are not the only ones. Some UK uninational companies may have a network of affiliates all operating in the UK. Group belonging may favour acquisition and diffusion of knowledge and innovation. Our question in this respect is whether such acquisition and diffusion is higher when the network spreads across several countries rather than a single one (in our case the UK). A third sub-hypothesis (b) tests the impact on innovation of the degree of multinationality measured by intensity and extensity indicators.
The results support the main hypothesis as well as the three sub-hypotheses: multinationality seems to be related to innovation. This is true over and above any effect due to group belonging. An enterprise’s propensity to innovate increases with their degree of multinationality. Moreover, the impact seems to be due to multinationality \emph{per se} and not to ‘foreignness’.

What the overall results seem to show is that enterprises learn from being part of a network. The learning and knowledge diffusion seems to be higher whenever they belong to a network that spreads over different countries and therefore over diverse knowledge and innovation systems. Moreover, the higher the degree of multinationality the stronger the impact on innovation propensity.

There is scope for some wider reflections and clarifications here. Some reflections are inferred directly from our results. Others can be derived more indirectly and are, at this stage, in the nature of speculations, thus calling for further research in the field. Some have policy implications, some have research implications.

Our results show that the impact on innovation derives from characteristics of the company as a whole over and above any impact related to characteristics of the single enterprise. In our case the main characteristic analysed is multinationality in its various connotations. However, there are likely to be other relevant characteristics of the company such as size, or organizational structure or performance or overall input into research. Yet the CISs structure and underlying theoretical framework centres on the enterprise. There may be a case for rethinking the framework of future CISs. There may also be a case for providing more information on the companies as a whole, whatever the framework.

Our model implies a strong interaction between the enterprise and the rest of the company as well as the enterprise and company and the environment(s) in which they operate. The interaction reflects spillover effects from the various parts of the company to the industry, and, conversely, learning opportunities by the companies.
from their environment (points a, b and c in section 1). In either case the national systems of innovation and the industry-specific innovation elements may be crucial\textsuperscript{15}.

In this context we must note the following. Our results refer to a specific country, the UK. This is a country characterised among others by the following: (a) it has a fairly advanced system of innovation in many sectors; (b) its corporate sector exhibits a high degree of multinationality (Ietto-Gillies, 2002: chs 4 and 5). The latter characteristic puts the enterprises belonging to domestic MNCs to, more or less, the same level as the enterprises belonging to foreign MNCs. The innovation ‘ability’ we see here refers to the ability to absorb, spread within the organisation and outside it as well as the ability to originate and develop innovation. In fact, most of the foreign MNCs whose enterprises enter into our study come from advanced countries\textsuperscript{16} with comparable systems of innovation and degree of multinationality. An advanced national system of innovation means that (i) the enterprises operating in it can absorb new knowledge and innovation – whether originating from foreign or domestic owned companies – more easily and quickly; and (ii) foreign companies may be interested in investing in it to exploit innovation spillovers (Driffield and Love, 2003); (iii) moreover, as large companies involve smaller ones in their supply and/or distribution chain there is potential for the involvement of smaller companies into the innovation system. In these cases, the development stage of the national system of innovation may be crucial in the country’ – and its enterprises’ – ability to absorb and spread innovation. This may be true of both large and smaller companies.

Might we expect different results for countries with different national systems of innovations and/or different degrees of multinationality of their MNCs or different modalities of foreign investment? Our speculative answer is that this is very likely. However, we cannot be sure. We need further research comparing results for a variety of EU countries – all involved in CISs – with: (a) different systems of innovation; and (b) different degrees of multinationality for the MNCs of which our enterprises are part.

\textsuperscript{15} John Cantwell pointed out to us that the specificity of the country may also manifest in terms of the industries it is involved in.

\textsuperscript{16} The US account for 31 per cent, European countries account for a further 42 per cent, Japan for 7 per cent and other developed countries for 12 per cent. Developing countries account for less than 6 per cent.
We also suspect that there are strong industry differences regarding the degree to which multinationality may impact on innovation. Our data did not allow us to disaggregate, though a study for a specific sector, financial services (Frenz et al 2005), shows that multinationality is indeed a very important characteristic in innovation activity.

There are important policy implications from these results and discussions. If multinationality is relevant for the origin, absorption and spread of innovation under specific conditions of the national system of innovation, then policies should (a) concentrate on improving such systems; and (b) attract the type of investment that contributes to such improvement.
References


Appendix A

Indices of the degree of multinationality (re: sec. 5)

In sections four and five we explained the meaning of individual variables – dependent and independent - and how they were arrived at. We would like here to give further explanation of the two indices designed to measure the degree of multinationality which we introduced in section 5.

The internationalisation index (Ii) is designed to capture the intensity of internationalisation, that is the degree of international activities in relation to the total activities of the company. Ii is calculated as the ratio of foreign to total companies’ subsidiaries and it thus gives the degree of ‘foreign projection’ of the company. NSi aims to capture the degree of geographical (by nation-state) extensity of the MNC. It is the number of foreign countries in which the company has subsidiaries in relation to the total number of foreign countries in which it could potentially have operated. The latter is identified as the number of countries in receipt of inward stock of FDI: an indication that the country is potentially willing to accept foreign investment. The number of countries in receipt of FDI is used only as a normaliser; its actual value does not affect the comparability of our estimates across companies and countries. Both indices are based on the number of subsidiaries rather than value of their assets or activities. This is due to paucity of data on such values by subsidiaries. Both indices have value 0 for those enterprises which are part of UK uninationals, whether these are independent or part of a group. The average Ii for all 257 MNCs in our sample is 51 per cent; the highest value is 100 per cent. The average NSi is 6 per cent; the highest value is 32 per cent. On average the MNCs in our data set have subsidiaries in 10 foreign countries.

Table A.1: Number of MNCs and indicators of the degree of multinationality

<table>
<thead>
<tr>
<th>Origin</th>
<th>MNCs</th>
<th>Ii</th>
<th>NSi</th>
<th>No. of foreign countries</th>
<th>No. of foreign subsidiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Per cent</td>
<td>Per cent</td>
<td>Count</td>
<td>Count</td>
</tr>
<tr>
<td>Foreign</td>
<td>137</td>
<td>68</td>
<td>7</td>
<td>13</td>
<td>70</td>
</tr>
<tr>
<td>UK</td>
<td>120</td>
<td>31</td>
<td>4</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>257</td>
<td>51</td>
<td>6</td>
<td>10</td>
<td>52</td>
</tr>
</tbody>
</table>

Source: WoW own calculations.

Table 2 breaks the 257 MNCs in our sample into two groups; foreign owned and UK owned MNCs. It gives values for the two indices of the degree of multinationality (Ii and NSi) as well as data on the number of foreign countries in which the MNCs operate and the number of total and foreign subsidiaries they have. The UK MNCs appear to be less internationalised than the foreign ones on both indicators of intensity (Ii) and extensity (NSi, number of foreign countries and of foreign subsidiaries).
Appendix B

Table B.1: Collinearity statistics of the predictor variables used.

<table>
<thead>
<tr>
<th>Indep.Var.</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>GP</td>
<td>0.506</td>
<td>1.975</td>
</tr>
<tr>
<td>MNC</td>
<td>0.404</td>
<td>2.478</td>
</tr>
<tr>
<td>DGMNC</td>
<td>0.724</td>
<td>1.382</td>
</tr>
<tr>
<td>FO</td>
<td>0.497</td>
<td>2.013</td>
</tr>
<tr>
<td>Size</td>
<td>0.629</td>
<td>1.590</td>
</tr>
</tbody>
</table>

Source: Own calculations CIS and WoW

A tolerance below 0.1 indicates a serious problem and a tolerance below 0.2 a potential problem (Field 2000). If the largest VIF is greater than 10 then there is cause for concern and if the average VIF is substantially greater than 1 the regression may be biased (Bowerman and O’Connell). For our model the VIF values are all well below 10 and the tolerance statistics is above 0.2. Therefore we can assume that there is no problem arising from collinearity in our data.
137 enterprises are foreign owned. Therefore they are part of an MNC.

542 enterprises are domestic owned enterprises.

137 enterprises are part of a foreign MNC. Therefore, they are also part of a wider group.

120 enterprises are domestic firms owned by a UK MNC. They are also part of a group.

The remaining 422 domestic enterprises are not part of a UK MNC. They are uninationals.

137 enterprises which are part of a foreign MNC.

120 enterprises which are part of a domestic MNC.

159 enterprises which are part of a domestic company group.

263 enterprises which are stand alone entities. They are independent.

In total there are 679 enterprises included in our sample.

In total 257 enterprises are part of a MNC.

In total 416 enterprises are part of a wider group. This includes the 257 enterprises part of a MNC.
Table 1: Control variable: sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery and equipment incl. transport equipment</td>
<td>108</td>
<td>15.9</td>
</tr>
<tr>
<td>Non-metallic and metal products</td>
<td>106</td>
<td>15.6</td>
</tr>
<tr>
<td>Textiles, Leather, Publishing, Printing</td>
<td>86</td>
<td>12.7</td>
</tr>
<tr>
<td>Manufacturing n.e.c. incl. utilities, construction and mining</td>
<td>74</td>
<td>10.9</td>
</tr>
<tr>
<td>Other business activities incl. real estate</td>
<td>60</td>
<td>8.8</td>
</tr>
<tr>
<td>Communication equipment and scientific instruments</td>
<td>56</td>
<td>8.2</td>
</tr>
<tr>
<td>Financial, insurance, post and telecommunications</td>
<td>47</td>
<td>6.9</td>
</tr>
<tr>
<td>Wholesale, retail and trade</td>
<td>46</td>
<td>6.8</td>
</tr>
<tr>
<td>Transport services</td>
<td>41</td>
<td>6.0</td>
</tr>
<tr>
<td>Food, beverages and tobacco</td>
<td>31</td>
<td>4.6</td>
</tr>
<tr>
<td>Chemicals and pharmaceuticals</td>
<td>24</td>
<td>3.5</td>
</tr>
<tr>
<td>All enterprises</td>
<td>679</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Source: own calculations CIS.*

Table 2: Overview of variable names, their description and the source of the information

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variables</strong></td>
<td><strong>Dependent variables</strong></td>
<td><strong>Dependent variables</strong></td>
</tr>
<tr>
<td>PROD_NOV</td>
<td>Any product innovation output new to the market: yes or no</td>
<td>CIS3</td>
</tr>
<tr>
<td>PROC_NOV</td>
<td>Any process innovation new to the market: yes or no</td>
<td>CIS3</td>
</tr>
<tr>
<td>SUPROD_NOV</td>
<td>Enterprise was novel product innovator in CIS2 and 3</td>
<td>CIS3 and 2</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Total R&amp;D expenditure in 2000 measured in £000s</td>
<td>CIS3</td>
</tr>
<tr>
<td>PATENT</td>
<td>The number of patents an enterprise applied for</td>
<td>CIS3</td>
</tr>
<tr>
<td><strong>Independent variables</strong></td>
<td><strong>Independent variables</strong></td>
<td><strong>Independent variables</strong></td>
</tr>
<tr>
<td>MNC</td>
<td>Selects all enterprises which are part of an MNC</td>
<td>WoW</td>
</tr>
<tr>
<td>GP</td>
<td>Selects all enterprises which are part of a wider company group</td>
<td>WoW and CIS3</td>
</tr>
<tr>
<td>DGMNC</td>
<td>Selects all enterprises with a degree of multinationality that is above average</td>
<td>WoW</td>
</tr>
<tr>
<td>FORMNC</td>
<td>Selects all UK owned (domestic) enterprises</td>
<td>WoW</td>
</tr>
<tr>
<td><strong>Control variables</strong></td>
<td><strong>Control variables</strong></td>
<td><strong>Control variables</strong></td>
</tr>
<tr>
<td>Size</td>
<td>Natural log of the number of employees in 2001</td>
<td>IDBR/CIS3</td>
</tr>
<tr>
<td>Sector</td>
<td>11 UK industry dummies (see Table 2)</td>
<td>CIS3</td>
</tr>
</tbody>
</table>
### Table 3: Innovation activity across groups

<table>
<thead>
<tr>
<th>Enterprise group</th>
<th>Number of enterprises</th>
<th>PROD_NOV</th>
<th>PROC_NOV</th>
<th>SUPROD_NOV</th>
<th>PATENT</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1) Count</td>
<td>(2) Count Per cent</td>
<td>(3) Count</td>
<td>(4) Count Per cent</td>
<td>(5) Count</td>
</tr>
<tr>
<td>GP</td>
<td></td>
<td>416</td>
<td>72</td>
<td>17.3</td>
<td>56</td>
<td>13.5</td>
</tr>
<tr>
<td>MNC</td>
<td></td>
<td>257</td>
<td>56</td>
<td>21.8</td>
<td>44</td>
<td>17.1</td>
</tr>
<tr>
<td>DGMNC</td>
<td></td>
<td>59</td>
<td>21</td>
<td>35.6</td>
<td>16</td>
<td>27.1</td>
</tr>
<tr>
<td>FORMNC</td>
<td></td>
<td>137</td>
<td>32</td>
<td>23.4</td>
<td>22</td>
<td>16.1</td>
</tr>
<tr>
<td><strong>All enterprises</strong></td>
<td></td>
<td>679</td>
<td>97</td>
<td>14.3</td>
<td>74</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Source: own calculations CIS.

### Table 4: Regression results for the main hypothesis

<table>
<thead>
<tr>
<th>Dep. Var.</th>
<th>PROD_NOV</th>
<th>PROC_NOV</th>
<th>SUPROD_NOV</th>
<th>PATENT</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Est. Model</td>
<td>PROBIT</td>
<td>PROBIT</td>
<td>PROBIT</td>
<td>NEG BINOMIAL</td>
<td>TOBIT</td>
</tr>
<tr>
<td>MNC</td>
<td>0.082***</td>
<td>0.070**</td>
<td>0.035*</td>
<td>0.016</td>
<td>0.129***</td>
</tr>
<tr>
<td>Size</td>
<td>0.019**</td>
<td>0.015*</td>
<td>0.010</td>
<td>0.025***</td>
<td>0.059***</td>
</tr>
<tr>
<td>Pr(Y = 1</td>
<td>X = x)</td>
<td>0.121</td>
<td>0.093</td>
<td>0.056</td>
<td>0.047</td>
</tr>
<tr>
<td>P(Y</td>
<td>a&lt;X&lt;b)</td>
<td>0.357</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>679</td>
<td>678</td>
<td>679</td>
<td>679</td>
<td>679</td>
</tr>
<tr>
<td>Model χ² (d.f.)</td>
<td>47.12(12)**</td>
<td>35.62(12)**</td>
<td>38.17(12)**</td>
<td>61.78(13)**</td>
<td>90.08(12)***</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.085</td>
<td>0.076</td>
<td>0.104</td>
<td>0.067</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Source: own calculations CIS and WoW.

Estimated equation: \( Y_i = \alpha + \beta \text{ MNC}_i + \gamma_1 \text{ Size}_i + \gamma_2 \text{ Sector}_i + \varepsilon_i \)

All regressions are estimated with a constant. Marginal effects (M.E.) are given with the t statistics of the underlying coefficients in parentheses. *, **, *** indicate significance at 10%, 5% and 1% level. M.E. are calculated at the means of the regressors in the case of continuous data and for discrete change from 0 to 1 in the case of dichotomous variables.
Table 5: Regression Results for the sub-hypotheses

<table>
<thead>
<tr>
<th>Dep. Var.</th>
<th>PROD_NOV</th>
<th>PROC_NOV</th>
<th>SUPROD_NOV</th>
<th>PATENT</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Est. Model</td>
<td>PROBIT</td>
<td>PROBIT</td>
<td>PROBIT</td>
<td>NEG BINOMIAL</td>
<td>TOBIT</td>
</tr>
<tr>
<td>GP</td>
<td>0.001</td>
<td>0.002</td>
<td>-0.033</td>
<td>0.072**</td>
<td>-0.009</td>
</tr>
<tr>
<td>(0.00)</td>
<td>(0.06)</td>
<td>(-1.12)</td>
<td>(1.97)</td>
<td>(-0.19)</td>
<td></td>
</tr>
<tr>
<td>MNC</td>
<td>0.060</td>
<td>0.069*</td>
<td>0.046</td>
<td>0.003</td>
<td>0.117**</td>
</tr>
<tr>
<td>(1.45)</td>
<td>(1.88)</td>
<td>(1.53)</td>
<td>(0.07)</td>
<td>(2.21)</td>
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<tr>
<td>DGMNC</td>
<td>0.149***</td>
<td>0.100**</td>
<td>0.089**</td>
<td>0.148*</td>
<td>0.125*</td>
</tr>
<tr>
<td>(2.55)</td>
<td>(1.97)</td>
<td>(2.15)</td>
<td>(1.70)</td>
<td>(1.79)</td>
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<tr>
<td>FORMNC</td>
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<td>-0.032</td>
<td>-0.018</td>
<td>-0.041</td>
<td>-0.016</td>
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<tr>
<td>(-0.33)</td>
<td>(-0.99)</td>
<td>(-0.72)</td>
<td>(-1.32)</td>
<td>(-0.28)</td>
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<tr>
<td>Size</td>
<td>0.0168</td>
<td>0.013</td>
<td>0.011</td>
<td>0.014</td>
<td>0.058***</td>
</tr>
<tr>
<td>(1.56)</td>
<td>(1.34)</td>
<td>(1.54)</td>
<td>(1.09)</td>
<td>(4.13)</td>
<td></td>
</tr>
<tr>
<td>Pr(Y = 1</td>
<td>X = x)</td>
<td>0.120</td>
<td>0.092</td>
<td>0.054</td>
<td>0.059</td>
</tr>
<tr>
<td>P(Y</td>
<td>a&lt;X&lt;b)</td>
<td>0.358</td>
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<tr>
<td>N</td>
<td>679</td>
<td>678</td>
<td>679</td>
<td>679</td>
<td>679</td>
</tr>
<tr>
<td>Model χ² (d.f.)</td>
<td>54.21(15)***</td>
<td>39.52(15)***</td>
<td>44.29(15)***</td>
<td>68.47(15)***</td>
<td>93.68(15)***</td>
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<tr>
<td>Pseudo R²</td>
<td>0.097</td>
<td>0.085</td>
<td>0.121</td>
<td>0.075</td>
<td>0.014</td>
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<tr>
<td>No of left censored obs.</td>
<td>344</td>
<td></td>
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Source: Own calculations CIS and WoW.

Estimated equation:

\[ Y_i = \alpha + \beta_1 \text{GP}_i + \beta_2 \text{MNC}_i + \beta_3 \text{DGMNC}_i + \beta_4 \text{FORMNC}_i + \gamma_1 \text{Size}_i + \gamma_{2.12} \text{Sector}_i + \varepsilon_i \]

All regressions are estimated with a constant. Marginal effects (M.E.) are given with the t statistics of the underlying coefficients in parentheses. *, **, *** indicate significance at 10%, 5% and 1% level. M.E. are calculated at the means of the regressors in the case of continuous data and for discrete change from 0 to 1 in the case of dichotomous variables.