The Novelty of Innovation and the Level of Development*

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Abstract

Innovation has its most important impact on the economy through the diffusion of new technical knowledge, from its first worldwide implementation in the production of goods and services to its adoption and adaptation by enterprises located in different places across the globe. One way to identify whether an enterprise creates new knowledge or uses already existing knowledge is to measure the novelty of the innovation in various markets, namely whether the innovation is new to the world, country and local market, or only to the enterprise. While innovation new to the enterprise may be only capturing the ability of an enterprise to use and adopt new knowledge, it is also a precondition for economic growth and development. Pooling information from the Third Community Innovation Survey carried out in thirteen European countries, including several countries significantly behind the European average per capita income, we estimate an ordered probit model that relates the novelty of product innovation to structure, strategy and capabilities of enterprises. The study shows that research and marketing capabilities boost the outcome most in the frontier countries, while process upgrading and foreign ownership make much more difference in catching-up countries. This illustrates how the nature of the innovation process changes with the increasing distance from the technology frontier.

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> "As a rule – and especially in the economic domain – we can … predict a great deal about the phenomena associated with development. … Prediction is impossible only in one case, even where such a norm is known with the utmost precision, namely with respect to the kind and intensity of the novelty itself that might be arriving."
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> –J. A. Schumpeter (2005:116)

1. Introduction

Innovation has its most important impact on the economy through the diffusion of new technical knowledge, from its first worldwide implementation in the production of goods and services to its adoption and adaptation by enterprises located in different places across the globe. Since all innovations contain a certain degree of novelty, measuring the degree of novelty helps us to identify whether an enterprise creates new knowledge or uses already existing knowledge. The focal point of the Oslo Manual (OECD, 2005), which forms the basis for the Community Innovation Survey (CIS), is on innovative activity at the enterprise level. The core questionnaire for CIS-3 defined product innovation as a new or significantly improved good or service introduced by the enterprise and process innovation as a new and significantly improved production technology, new and significantly improved methods of supplying services and of delivering products introduced by the enterprise. Considered on its own, this definition does not differentiate between radically new ideas from incremental change. But it is possible to infer the degree of novelty from the question on the enterprise's most significant market (OECD, 2005). Enterprises that are first to develop products that are new to the world are seen as the creators of new knowledge, whereas enterprises that introduce product innovations that are not new to any market are seen as users of the new knowledge. Products that are new to national and regional markets will generally be seen as innovations based on existing knowledge, but the enterprise in this market will likely be the innovation leader. Ultimately, the degree of novelty for the enterprise depends on the perceived newness of the innovation in a particular market (Downs and Mohr, 1976).

Schumpeter (1934; 1939) alluded to the idea that the degree of novelty is important. In a paper written in 1932, Schumpeter (2005) defined novelty as the 'transition from one norm of the economic system to another norm in such a way that this transition cannot be decomposed into infinitesimal steps'. For Schumpeter (1939) innovation takes place inside of an enterprise and is carried out by the entrepreneur. The entrepreneur is not a person, but the function of carrying out 'new combinations' of resources available to the enterprise. Technology appears as a production function for a particular commodity, which can also represent the enterprise assuming it only produces one commodity. In *Business Cycles*, Schumpeter (1939) then defined innovation as the 'setting up of a new production function', which includes the introduction of a new product, new process and new form of organization. This is not different from the earlier definition, as the most novel innovations appear as discontinuities through time, whereas the less novel innovations appear as imitations and gradual improvements on the original innovation. There is, however, a lack of clarity on the different degrees of novelty and at which degree of novelty that a firm can be seen to set up a new production function or adopt the existing production function.

Novelty also represents originality, and as such can distinguish between the creation of new knowledge and the adoption and use of existing knowledge. Originality often involves greater risk and uncertainty (Rosenberg, 1976), but it can also lead to greater diffusion as other enterprises try to replicate the innovation. The diffusion of innovation is an important issue for economic growth in general and for closing the technology gap in particular. Without diffusion, innovation has no economic impact (OECD, 2005). While diffusion does not play a central role in Schumpeter's theory, he does recognize the importance of copying, imitating and gradually improving on the original innovation. Some enterprises follow an offensive strategy and introduce highly novel products onto the market, whereas others follow a defensive and imitative strategy and introduce less novel innovations (Freeman and Soete, 1997). The commodity, enterprise and entrepreneur are the units of analysis that are important for Schumpeter, which makes it possible to discuss some of the issues important to the degree of novelty.

The perceived newness of a new product in a particular market adds to our understanding of the development process. Arguably the prevailing "new to the firm" definition of innovation largely blurs comparison between countries at different levels of economic development, mainly because most innovation in countries behind the technological frontier captures the diffusion of relatively more advanced technology from abroad. It is an example of 'innovation through imitation' as Kim (1997) puts it, rather than an innovation that is 'new to the world'. Fagerberg, et al. (forthcoming) observed that innovations that are only 'new to the firm' appear frequent in countries below the technology frontier. Innovative enterprises almost always follow a defensive or imitative strategy in these countries. What may be more important is whether enterprises in these countries follow a passive or active form of technology absorption (Viotti, 2002). Innovation is important for firms in countries that are trying to catch-up to the technology frontier, but the nature of the innovation will not be understood without considering the degree of novelty.

Our main focus in the paper is on the nature of novelty and diffusion in the European economy. The main novelty of this paper is that it compares thirteen European countries with very diverse levels of development. There are few papers that address the issue from both inside and outside Europe. Arundel and Hollanders (2005) and Bloch et al. (2007) are two of only a few examples of where the degree of novelty is analyzed in the European context.[1] Baldwin and Hanel (2003), Drachs et al. (2007) and Urem et al. (2008) focus on the issue in the context of foreign ownership for Canada, China and the Nordic Countries respectively. We organize the paper in the following way. In section two we develop Schumpeter's approach innovation and economic development to include the degree of novelty to help identify technological learning and the diffusion of knowledge. Section three summarizes the information available in CIS-3 and explains how the variables are used in the analysis. In section four we estimate an ordered probit model that relates the novelty of product innovation to structure, strategy and capabilities of enterprises. We conclude with some remarks on limitations of the analysis and policy implications.

[1] The degree of novelty often comes up as a secondary issue in the literature and as such can appear as an explanatory variable in the econometric analysis. In some cases the questionnaire does not contain clear questions defining the market. In the South African survey, for example, the distinction is made between radical and incremental innovations. But when the question does appear there appears to be a strong correlation between the extent of the market and the degree of novelty.

2. Schumpeter's theory of economic development and the degree of novelty

Novelty was central to Schumpeter's ideas on development, innovation and entrepreneurship. The *Theory of Economic Development* starts by adopting the set of data common to Walras (1873) and the marginalist (neoclassical) theory of value and distribution: (1) the initial endowments; (2) the preferences of consumers; and (3) the technical alternatives from which cost-minimizing producers can choose (Kurz and Salvadori, 1995).[2] Given the technology, endowments, preferences and the presumption of free competition, equilibrium prices of all factors of production and their distribution across different industries are determined simultaneously and symmetrically when marginal revenue equals marginal costs. Profits are maximized in equilibrium, since there would be no economic profits remaining in the economic system. Schumpeter (1934:62) was clear in his *Theory of Economic Development* that equilibrium prices, including uniform rates of remuneration for each particular kind of input (including labour and other material inputs) in the production process, results from the actions of competitive profit-seeking producers concerned with minimizing production costs. This process of search and selection by profit-seeking producers explains how capital and labour moves between enterprises in the absence of significant barriers to entry and exit. Novelty (Schumpeter, 1932) and innovation (Schumpeter, 1934) appears as spontaneous (or discontinuous) changes to the technical alternatives available to the enterprise, or what is more commonly called the production function in economic theory (Schumpeter, 1939).

Schumpeter essentially outlined the 'pure theory of production' from a Walrasian point of view, and then gave it dynamics by enhancing the function of the entrepreneur. Walras (and Pareto) envisioned the entrepreneur as the competitive profit-seeking agent, whose main function was to bring about dynamic market adjustments that would eventually result in the elimination of any excess profits above the interest rate. They may follow any number of different strategies, but they create the tendency toward equilibrium by choosing relatively more profitable investments over less profitable ones. While the entrepreneur provides some dynamics in the equilibrium analysis, Schumpeter argued that dynamic equilibrium conceals the process of economic change or evolution and masks the source of 'true profits'. In Schumpeter (1934; 1939), the main function of the manager would be to search for the most

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[2] In his preface to the Japanese edition of the *Theory of Economic Development* and in his *History of Economic Analysis* (Schumpeter, 1954), Schumpeter stated that Leon Walras was the most important influence on this economic thought. Schumpeter also mentions that Friedrich von Wieser was his most important teacher, who is known for developing the Austrian approach to the theory of value and distribution.

profitable opportunities and minimize the costs of production, whereas the main function of the entrepreneur was to carry out 'new combinations' of 'materials and forces within their reach'.[3] Like in Walras, Schumpeter envisaged the entrepreneur as an agent of change, but he differed from Walras in that this agent can also earn extra profits for bringing novelty to the market.

Throughout his work, Schumpeter (1939:30) focused on the theory of production, assuming that changes in the preferences of consumers and the quality and quantity of resource endowments are not directly relevant. A production function that links various inputs such as labour, capital, materials, and other intermediate inputs to the quantity of the product is used to express the technological process of production. But he described the production function as 'nothing but combining quantities of factors' that can only explain why firms produce or not.[4] Schumpeter was much more interested in changes in method of production that lead to changes in the production function, or in other words, innovation.

Schumpeter (1934:66) identified innovation as a distinct internal factor that is independent of other business behaviours, including invention. He defined it as carrying out 'New Combinations' of available materials and resources that appear discontinuously through time. Development is synonymous with innovation and novelty, and can occur in five ways: (1) the introduction of a new good or service or an improvement in the quality of a good or service; (2) the introduction of a new method of production, or way of handling a commodity commercially, that is new to the industry; (3) the opening of a new market; (4) success in obtaining new materials and other inputs in the production process; and (5) the introduction of new forms of market organization.[5] Schumpeter (1939:84-85) described innovation as 'the setting up of a new production function' and maintained that these factors offset Ricardo's

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[3] Schumpeter (1939:95-96) points out that he does not criticize the marginalist approach to value and distribution on its own ground, though he makes comments that are critical of the partial equilibrium approach of Marshall. He suggests that he is generalizing the marginalist approach when he argues that it 'still retains its place' when enterprises do not innovate. It should be noted that Dobb (1925) introduced the entrepreneur as innovator and risk-taker into Marshall's economics before Schumpeter published in English.

[4] Schumpeter does not specify the exact form of the production function. Rutton (1959) asserts that he uses a simple form of production function with labour only, but his description of the circular flow suggests that he is more likely thinking more in terms of Walras and Wiser and includes some kind of circulating capital. Many of the ideas of Schumpeter can be put into the classical theory of production.

[5] Schumpeter (1934; 1939:90-93) makes three assumptions about innovation: 1) they require a long time and a large investment; 2) they are embodied in new enterprises founded for that purpose; and 3) they are associated with the rise of new leadership (entrepreneurship). Schumpeter (1942) later argued that innovation could occur in larger, more established enterprises.

Law of Diminishing returns by 'jumping' to a new method of production. The consequence of the change in the method of production is that the marginal cost curve will also change immediately for the enterprise introducing the innovation and over time as the technology diffuses through the economy.

In Schumpeter's (1939:88) theory, innovation gives rise to new production functions that 'incessantly shift existing cost curves', generates disequilibria and intensifies competitive behaviour. Competition in this context is not a state of the market, but a process that resembles the one advocated by the Austrian economists. At the same time he noted the importance of product differentiation, as described in Chamberlin's (1933) theory of monopolistic competition. Schumpeter (1939:99) stressed that 'disturbances of equilibrium arising from innovation' must be *large* enough to 'disrupt the existing system and enforce a distinct process of adaptation'.[6] Diffusion does not play a prominent role in Schumpeter's theory and only appears as a process by which firms copy, imitate and gradually improve on the original innovation, or what he described as 'induced innovations'.[7] They are innovations in the sense that it changed the production function of the follower firm. Large disturbances occur spontaneously, often in clusters, concentrating in a particular branch of industry, which makes it difficult for the economic system to absorb these changes quickly.[8]

An important implication of Schumpeter's idea that novelty is 'new combinations' of resources to the enterprise is that virtually all innovations depend on already existing knowledge, a point also emphasized by Lundvall (1992). Even enterprises that develop products that are new to the global economy depend on knowledge from other sources, including various collaborative agreements, many of which are with universities and other research laboratories. But it is these enterprises that establish the technology frontier that other enterprises will strive to attain if they are to stay competitive. They are the producers of new knowledge and set the pace of economic growth at the technology frontier. Other

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[6] Schumpeter (1939:84) maintained that 'it is entirely immaterial whether an innovation implies scientific novelty or not.'

[7] Products also tend to have a high degree of novelty at the beginning of their life-cycle whereas they tend to have a low degree of novelty when it is toward the end (Holt, 2002).

[8] Edquist and Lundvall (1992:268) preserve Schumpeter's line of thought by suggesting that everything other than breakthrough technology is diffusion, which includes assimilation, adaptations and incremental innovation. Freeman and Perez (1988) point out that some innovations are so radical that they change the technology system and techno-economic paradigm, and others may appear very subtle through user-producer interaction. Still others may involve a very significant product innovation and a very small process innovation and visa versa.

enterprises that are trying to maintain their competitiveness, or catch-up with the technological leader will depend on gaining access to the knowledge already created by the leading enterprises. The interesting question for economic development is whether enterprises below the technology frontier can search for and learn to combine available resources in new ways, which leads to new products, new processes and new forms of organization. Developing the ability 'to identify, assimilate and exploit knowledge from the environment' or what Cohen and Leventhal (1989) describe as the absorptive capacity of an enterprise becomes a central issue in the discussion.

Schumpeter's main contribution was to provide dynamics to the Walrasian theory of value and distribution by redefining the entrepreneur as innovator. Innovation is an endogenous process for Schumpeter (1939:82) 'because the turning of existing factors of production into new uses is a purely economic process.' He further adds that it 'is a distinct internal factor because it is not implied in, nor a mere consequence of, any other'. His empirical analysis, mainly provided through his book *Business Cycles*, was about countries on the technological frontier and how the clustering or bunching of innovative activity generated cycles over long-periods of time (50 years or more). Nelson and Rosenberg (1992) claim that Schumpeter only refers to the first firm that brings a new product to market and neglects those enterprises that most often capture the economic profit not associated with the original innovation.[9] There has also been considerable debate whether Schumpeter' ideas are applicable to countries that remain persistently below the technology frontier.[10] Abramovitz (1986) went beyond Schumpeter to explain why diffusion is much more important than generating technology new to the world in countries that are below the technology frontier. Viotti (2002) emphasized the difference between innovation in the strict sense as 'new combinations' available to the economy as a whole from innovation in the broad sense when an enterprise is learning how to integrate the new combination into its own organization. By contrast, Bell and Pavitt (1993) contend that making such a sharp distinction between

[9] Virtually all of the literature on national innovation systems view innovation to include induced innovations, or innovation that follow from the diffusion process.

[10] The applicability of Schumpeter's theory of economic development to the less developed and catching-up economies has been a topic of much discussion in the early 1960s. Laumas (1961) strongly advocated its applicability to the developing countries stressing the importance of finance, whereas authors such as Ruttan (1959) maintains that Schumpeter was describing the technology frontier and Wiles (1963) emphasized that the size of the innovation matters for economic development.

different degrees of novelty may not be useful in the context of countries below the technology frontier because innovation continues during diffusion.[11]

3. The Third Community Innovation Survey

This study relies on the Eurostat CIS-3 anonymised micro-database, which includes surveys from fifteen countries. Thirteen countries are included in the analysis: Belgium, Germany, Norway, Greece, Portugal, Spain, Czech Republic, Hungary, Estonia, Latvia, Lithuania, Bulgaria, and Romania. Slovakia and Iceland were excluded for missing information. Enterprises were asked about their activities aimed at generating new products and processes over a three-year period.[12] Data for each country was gathered through a national survey employing a harmonized methodology and a single base questionnaire developed by Eurostat.

According to the second edition of the Oslo Manual (OECD, 1997:31), on which this survey is based, innovation refers to a product or process that is at minimum 'new (or significantly improved) to the firm', but not necessarily in any market. According to OECD (1997:34):

> Worldwide [technological product and process] innovation occurs the very first time a new or improved product or process is implemented. Firm-only TPP innovation occurs when a firm implements a new or improved product or process which is technologically novel for the unit concerned but is already implemented in other firms and industries. …Between the two come degrees of diffusion of technologically new or improved products and processes.

The harmonized CIS-3 questionnaire, however, did not include a question about 'worldwide' innovation, so we had to find an indirect way to find out whether the innovation was new to the world. By combining information from the survey it was possible to approximate products that are new to the global market.

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[11] Evenson and Westphal (1995) also point out that conditions in developing countries are very different from those in which the technology was originally developed, which requires local enterprises to adapt the imported technology to differences in inputs, tastes, customs and cultures. Small innovations generally consist of context-specific improvements along the prevailing technological trajectories. While these innovations may be small in a technological sense, they can be of major economic significance for countries attempting to catch-up to the technological leaders.

[12] For most countries in the sample the reference period was 1998 to 2000, the exception being that Norway, the Czech Republic, Hungary, Latvia, and Lithuania covered the period from 1999 to 2001, Romania covered the period from 2000 to 2002, and Bulgaria covered the period from 2001 to 2003.

Enterprises were asked about goods or services that were not only new for the enterprise, but also new for the market, which provides valuable insight about the perceived degree of novelty. This perception depends on what the enterprise sees as its relevant market. Arguably, new to the national market still measures mainly diffusion of technology in the context of countries behind the technology frontier. Hence, information on the reach of the firms main market, whether local, national or foreign, can be important in this context. To distinguish the most likely degree of novelty of the product innovation, we therefore combine this information into a single overall *NOVELTY* variable, which can be used as a dependent variable in subsequent regression estimates.

Table 1: Degrees of Novelty

NOVELTY	Description	Definition
0	Non-product innovator	INNPDT=0
1	New to the firm only product innovation	INNPDT=1 & INMAR=0
2	New to the market product innovation and the main market is local	INMAR =1 & SIGMAR = 1
3	New to the market product innovation and the main market is national	INMAR =1 & SIGMAR = 2
4	New to the market product innovation and the main market is international	INMAR =1 & SIGMAR = 3

More specifically, *NOVELTY* is a cross-product of three variables. First, *INNPDT* is the general dummy for product innovation, which has value 1 if the firm introduced any new or significantly improved products into the market that have been new to the enterprise. Other firms may have already introduced this product before the respondent. This is the minimum denominator of innovation most frequently used in the literature. If the answer was yes, the firm was also asked to assess whether the product was new to its market, which gives the *INMAR* dummy with value 1 if it is. The third variable, *SIGMAR*, provides information on the geographical scope of the firm's main market with value 1 if the firm's most significant market was within 50 km, value 2 if it was national and over than 50 km, and value 3 if it was international and more than 50 km. Table 1 outlines how we combine this information. *NOVELTY* has value 0 if the firm did not introduce product innovation (*INNPDT=0*), value 1 if the innovated product was only new to the firm, value 2 if the innovated product was new to the market and the firm's main market is local, value 3 if the innovated product was new to the market and the firm's main market is national and finally value 4 if the product was new to the market and the firm's main market is international.

Since innovation is usually a costly activity, we assume that enterprises focus on innovating products for their main markets and we use the information about the firm's main market to disentangle (infer on) the degree of novelty of the innovated product. A major drawback of this variable, that we fully acknowledge, is that this provides only a static insight on the degree of novelty in the sense that we assume that enterprises innovate for their main market only. In other words, we disregard the possibility that firms actually innovate to penetrate new (more distant) markets. While this simplification might appear heroic, other ways to measure the degree of novelty might be even more problematic.

An obvious alternative is to directly ask enterprises to provide more details about the novelty of their new product, that is, whether it is new locally, nationally or globally. But this suffers from serious problems of commensurability of the perceived degree of novelty, because firms are likely to be highly subjective in assessing the more fine-grained differences. Arguably, firms know best their main market, but their knowledge about other markets might be fairly limited, especially as far as the whole global market is concerned. If asked directly about the degree of novelty, firms may easily confuse 'new to the national market' innovations with 'worldwide' innovations, because they are simply not aware of other firms already on the market with a similar product in another market. Only the largest multinational enterprise may be able to evaluate the novelty of products on a global scale. This may be even more problematic in the dynamic context, if an enterprise is asked about novelty of a new product in a market that it plans to enter in the future. A direct measure of the worldwide degree of novelty might create more problems than our indirect composite indicator.

Table 2 provides a descriptive overview of the sample and the *NOVELTY* variable. Enterprises in countries on the technology frontier appear to be more likely to be market leaders in the sense that they operate predominantly on the foreign market and introduce product innovations that are both new to the firm and new to the market, though there does not appear to be a clear pattern when the main market is local or national. The share of firms with new to the firm only product innovations is higher in developed countries, because the local and national markets are at the technology frontier, and it is therefore more difficult for the firm to introduce innovations new to the market. Specialization patterns can underlie these data, which are corrected in the econometric results by including relevant dummies. The final two columns show the number of firms in the sample and the sum of their weights. Since coverage and response rate of the surveys differ between countries, we use weights that refer to the inverse of the so-called sampling fraction, corrected for non-response and for no longer existing enterprises to obtain unbiased results.

The independent variables include measures of structural characteristics, strategy and capabilities of firms. Size of the firm is difficult to measure since there are no data for the number of employees. The only relevant measure is the micro-aggregated value of turnover in Euros at the beginning of the period, which is the *SIZE* variable expressed in natural logarithms.[13] Foreign ownership is derived from the question whether the firm is part of an enterprise group and where the head office is located. Dummies are introduced for foreign ownership *FO* if the firm is affiliated to a group with the head office abroad; if the firm successfully introduced process innovation *INNPCS;* and if the firm had any valid patents to protect intramural innovations at the end of the reference period *PAVAL*. We obtain the industrial dummies *IND* by taking the NACE, rev. 1.1 industrial classification system at the alphabetical level, which allows us to distinguish between 16 sectors.[14] The country, where the firm operates, defines the *NAT* dummies. For the purposes of comparison, we estimate the model for five geographic groups of these countries that parallel differences in the levels of development: 1) Northern Europe: Belgium, Germany and Norway; 2) Southern Europe: Greece, Portugal and Spain; 3) Central Europe: Czech Republic and Hungary; 4) Baltics: Estonia, Latvia and Lithuania; and 5) Balkans: Bulgaria and Romania.

Only those enterprises engaged in innovative activities were asked to provide further details on the different types of innovation activities, including internal R&D, importance of external information sources for innovation or whether they engaged in innovation collaboration with other organizations (see Appendix 1 for a full overview of these variables). Since the variables on details on the innovation activity of firms tend to be highly correlated to each other, which raise serious problems of multicollinearity in regression estimates, we use factor analysis to construct composite indicators for various latent aspects of the

[13] Firms newly established during the reference period were excluded from the analysis, because a new firm must by principle introduce at least “new to the firm” product. If the new firm do not indicate this, it is a measurement error. And there is highly uneven share of new firms by country, which may bias the results.

[14] More detailed industrial classification was not possible to use due to limitations of the dataset. Definition of the industry dummies used in the analysis is available from the author upon request.

innovation process (for a technical description of factor analysis see Basilevsky, 1994).[15] Various methods of multivariate analysis were used to classify innovation behaviour of firms. Studies based on micro data from early vintages of the CIS questionnaire, for example Hollenstein (1996, 2003), de Jong and Marsili (2006) and Leiponen and Drejer (2007), showed that besides the traditional idea about 'science-based' innovation, many firms rely on 'market-oriented' and 'process, production, supplier-driven' strategies. Jensen et al. (2007), based on the Danish DISKO survey, highlighted two types of learning in firms labelled as 'science, technology and innovation' and 'doing, using and interacting' modes. Srholec and Verspagen (2008) indentified four dimensions in the same CIS-3 database used in this paper, which can be interpreted as research, user, external and production patterns of innovative behaviour of firms. Using evidence on organizational and marketing changes from the fourth round of CIS, Frenz and Lambert (2009) added what they call 'wider innovating' mode.

Table 3 provides results of the factor analysis. We have detected four principal factors. The first factor labelled 'Science-based' loads highly on both internal R&D and acquisition of R&D from external sources, which confirms their complementary role in the innovation process rather than 'make or buy' decisions of firms along these lines (see Veugelers and Cassiman, 1999). Also extensive sourcing of information from universities and research institutes seems to complement these R&D inputs. For firms on this path to innovation protection of intellectual property rights is a great concern, because they frequently protect their technology by patents, and they have a tendency to participate in joint innovation projects with other organizations. The factor score generated for this dimension in the data shall be called *SCI* in the following.

Another principal factor that has been detected correlates with training, but even more with market introduction of innovations and resources devoted to design and other preparations, so that this aspect has been labelled 'Marketing-oriented', and indentifies the *MKT* factor score. The third principal factor indentifies firms that give high weight on harnessing external information for their innovation activity, particularly from clients, competitors and various kinds of professional events (fairs, exhibitions, conferences and journals). This reflects quite 'soft' approach to innovation not based on indigenous capabilities of firms. We call this aspect as 'External information-driven' innovation and use

[15] We use tetrachoric and polychoric correlations in the factoring procedure, which are better suited for binary and Likert scale variables (Kolenikov and Angeles 2004), and which have become preferred in the recent studies based on the CIS data (Leiponen and Drejer, 2007; Srholec and Verspagen, 2008 and Frenz and Lambert, 2009).

the *INFO* shortcut for the factor score. Finally, the fourth dimension in the data integrates acquisition of technology embodied in capital goods, the purchase of other external knowledge and high importance attached to information from suppliers. Hence, this is the 'Supplier-dominated' way in which enterprises innovate, or *SUPP*.

The main outcome of the factor analysis is that there is a straightforward distinction between Science-centred *SCI* and other innovation activities, and a difference between innovations based on internal capabilities (*SCI* and *MKT*), and dominated by external inputs (*INFO* and *SUPP*). Overall these results confirm the above literature using multivariate methods on micro data with some differences that are likely to be related to differences in the variables we use, composition of the sample, etc.

4. An ordered probit model of the novelty of innovation

A qualitative response model is ideal for capturing information contained in innovation surveys as it asks whether the enterprise introduced a product that is new to the firm or new to the market. Many questions in the survey only require a binary response, for example, whether or not an enterprise introduced a new product innovation over a certain period of time. The question y has two possible answers, $y=1$ if the firm is innovative and $y=0$ if it is not. Assuming a normal probability distribution, the probit response probability would appear as:

$$P(y=1|x) = \Phi(x\beta), \tag{1}$$

where Φ is the standard cumulative normal probability distribution and ß are unknown parameters (Wooldridge, 2001). In this example, the variable x might contain various individual characteristics of the enterprise, such as size, location, ownership, whether it carries out R&D activity, etc. A latent variable model is used to estimate the model.

Some survey questions require a multinomial response, that is, there can be more than one response to the same question. For example, the survey question y can ask not only whether the enterprise introduced a new product innovation or not, but also whether the product innovation was new to some particular market or only new to the enterprise. Even if the question itself does not ask about certain details about a particular market, it is possible to add information so long as the firm only provides one and only one response to the hypothetical survey question. This is what is called an ordered response model, where according to our *NOVELTY* dependent variable $y=0$ represents the non-innovative enterprise and $y=j$ represents the various degrees of novelty. Assuming a normal probability distribution, and that responses to the question y can be ordered from $\{0,1,2,\ldots,j\}$, the ordered probit response probability would appear as:

$$P(y=j|x) = \Phi(x\beta). \tag{2}$$

In our model we define four ordered degrees of innovation novelty based on geography ($j=4$), plus the possibility that the enterprise did not introduce a new product over a three-year period ($y=0$). CIS-3 also included information about whether the new product was also new to the market of the enterprise, which allowed us to define the innovative enterprise with more precision and to order the degree of product innovation. This allowed us to redefine $y=1$ to include firms with product innovations that were only new to the firm and not new to any market. Enterprises were asked about their most significant market in the CIS-3. In general, a local market was defined as being within about 50 km of the enterprise and within the national boundary, the national market was defined as being greater than 50 km from the enterprise and within the national boundary, and the global market was beyond the national boundary. In our model, $y=2$ if the main market of the enterprise was local and the firm introduced a product new to the market, $y=3$ if the main market was national and the firm introduced a product new to the market; and $y=4$ if the main market was global and the firm introduced a product new to the market.

We use an ordered probit model since the dependent variable *NOVELTY* is ordinal multinomial. It should be noted that the ordered probit model requires the proportional odds assumption, which means that the odds ratio for being in a chosen category or higher compared to being in a lower category is the same regardless of which category is chosen. In other words, the estimates assume that the difference between being in $j=0$ versus $j=1$ categories is the same as compared to the distance between $j=1$ and $j=2$, etc. This means that if the ordinal variable were collapsed into two categories, the odds ratios would be the same regardless of the cut-off chosen for the collapsing. As a consequence, the estimated coefficients of the independent variables do not differ by the response.

First, the following ordered probit model is estimated:

$$NOVELTY = a_1 + a_2SIZE + a_3FO + a_3INNPCS + a_4PAVAL + a_5IND + a_6NAT \tag{3}$$

This model is estimated on a full sample, meaning that we include all firms, whether they have innovated or not. The base category is 0, that is, the firm is a non-innovator. We only include size *SIZE*, foreign ownership *FO*, process innovation *INNPCS* and patents *PAVAL* as explanatory variables, because these are available for all firms. We also include industry *IND* and country *NAT* dummies.

Table 4 gives the results. We look at the results by groups of countries, which broadly follow differences in level of development. Foreign ownership becomes more important in countries further behind the frontier in terms of both statistically significance and magnitude of the coefficient). Process innovation is significantly complementary to novelty of product innovation in all countries, but the magnitude is strongly increasing with decreasing level of development. Size and patents come out also statistically significant in all countries, but the magnitude is decreasing with the level of development. In sum, these estimates suggest that the role of indigenous research capabilities, for which the *PAVAL* variables is the proxy in this specification, is much lower in countries behind the technology frontier, where the novelty of product innovations tends to be more intimately related to process improvements and driven by technology transfer from abroad through foreign ownership.

To gain more preciseness on the role of capabilities of firms, we replace the *PAVAL* variable with more detailed information about the innovation activities in the firm derived from the factor analysis. Since this detailed information is only available for innovators, the sample becomes reduced to product innovating firms, which gives us the second specification of the model as follows:

$$NOVELTY = a_1 + a_2SIZE + a_3FO + a_3INNPCS + a_4SCI + a_5MKT + a_6INFO + a_7SUPP + a_8IND + a_9NAT \qquad (4)$$

Estimates on the reduced sample are presented in Table 5. The base category is *NOVELTY = 1*, i.e. the new to the firm only product. Here we do not treat the potential selection bias by reducing the sample to product innovators, which we attempt to deal with below. The first result to notice is that foreign ownership broadly follows the same trend of increasing importance down the technology ladder, though it is no longer significant in central Europe. Again, process innovation is significantly complementary in all countries, but the magnitude is increasing with decreasing level of development.

The results also show that the internal technological capabilities of firms (*SCI* and *MKT*) are essential for novel innovators, while using external sources (*INFO* and *SUPP*) is insignificant. Internal research capabilities are relatively more important that internal activities directed to introduction of the innovations on the market. However, the effect of the internal capabilities strongly decreases with decreasing level of development of the country where the firm is located. *SCI* and *MKT* turn out to be highly relevant in Northern Europe, but irrelevant in Balkans. *INFO* and *SUPP* even come out with a negative coefficient, but not statistically significant in many of the estimates.

As already anticipated, estimation of the model on the restricted sample can be influenced by a sample selection bias. We therefore estimate the following Heckman ordered probit model:

$$INNPDT = a_1 + a_2SIZE + a_3FO + a_3INNPCS + a_4PAVAL + a_5IND + a_6NAT \qquad (6a)$$

$$NOVELTY = b_1 + b_2SIZE + b_3FO + b_3INNPCS + b_4SCI + b_5MKT$$

$$+ b_6INFO + b_7SUPP + b_8IND + b_9NAT + \lambda_{INNPDTheck} \qquad (6b)$$

First, we predict the probability of the firm to be included in the restricted sample, in other words to be innovative, in Equation *(6a)*. *SIZE, FO, INNPCS, PAVAL* and the *IND* and *NAT* dummies, which is information available for the full sample, are the predictors of *INNPDT*. In the second stage we use the so-called inverse Mills' ratio ($\lambda_{INNPDTheck}$) derived from the previous estimate to control for the potential selection bias in Equation *(6b)*, which predicts the *NOVELTY* variable with the identical set of predictors as in the previous specification. Unfortunately, due to lack of relevant instruments, the model is essential identified by the functional form only. [16]

Table 6 gives results of the second equation *(6b)*. The results of the sample selection equation *(6a)* are reported in Appendix 2. The main difference that should be noted is that *INNPCS* ceases to be statistically significant in most of the estimates and even become significantly negative in the Northern Europe. Otherwise, the results remain very similar to the previous specification. It should be mentioned, furthermore, that we tested merging the local and national market definition of the dependent variable, but with little effect on the results; signs of the estimated coefficients have never changed and only the coefficient of *SIZE* in Balkans has changed its significance level.

5. Concluding remarks

Innovation that takes place within the enterprise can have varying degrees of novelty. One way to identify whether an enterprise creates new knowledge or uses already existing knowledge is to measure the novelty of the innovation in various markets, based on

[16] *PAVAL* appears in Equation *(6a)* but not in Equation *(6b)*. However, this variable highly overlaps with the *SCI* factor score.

geographical and/or national proximity. Pooling information from the Third Community Innovation Survey carried out in thirteen European countries with very diverse levels of development, we estimate an ordered probit model that relates the novelty of product innovation to structure, strategy and capabilities of enterprises.

The study shows that research and marketing capabilities boost the outcome most in the frontier countries, suggesting that following a strategy of building capabilities within the enterprise is more important than relying on information external to the enterprise. Process upgrading and foreign ownership make much more important difference in countries with a relatively lower per capita income. This may have something to do with the industrial structure of these countries, and that in some industries, particularly chemicals and plastics, product innovation depends on process innovations (which are product innovations in another industry; see Freeman and Soete, 1997). Foreign ownership also tends to be more important in countries further behind the technology frontier, which highlights the potential for knowledge diffusion and spillovers. Finally, enterprises in countries below the frontier tend to bring novelty in their products through process innovation instead of focusing on the product itself. Similarly patents become less important in countries below the technology frontier, which plays down the importance of intellectual property rights. This illustrates how the nature of the innovation process changes with the increasing distance from the technology frontier.

An alternative way to estimate the equations would be to include GDP per capita and study the interaction effect between this variable and the enterprise predictors. Preliminary results suggest that the interaction effects are significant, but we need further time to improve the specification of the model. Nevertheless, there still remains the issue of potential endogeneity of the estimated coefficients because a lack of valid instruments in the dataset. Any interpretation in terms of causality between the explanatory and dependent variables should be therefore put forward with caution. Another related limitation given by the dataset in hand is the cross-sectional nature of the analysis. It remains an important challenge for future research to address these caveats if better sources of data become available.

Economic development involves much more than Schumpeter's discussion about how 'new combinations' of known resources affects the production function of the enterprise. It also involves more than the diffusion of knowledge and technology through the global economy. Development also requires building the absorptive capacity or capability to assimilate and apply new ideas and technology created through innovation processes located outside of the enterprise. Viotti (1997) reinforces this view when he suggests that learning (education as well as learning-by-doing, learning-by-using, etc.) always accompanies diffusion and incremental innovation. Depending on the degree of novelty, there might also be a lack of complementary technologies or even of the infrastructure needed for diffusion.

This paper shows that the innovation survey can provide valuable insights into the development process by distinguishing between innovation that is only new to the enterprise or new to a particular geographic market. Countries on the technology frontier are more likely to introduce new products that are also new to the global market and those that are below the frontier are learning how to produce products that may already be in the global market. There is a difference in the strategies followed by enterprises at the technology frontier and those aspiring to be on the frontier. Measuring the perceived novelty of innovation in local and global markets is one way to capture the process of catching-up and falling behind.

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Table 2: Overview of the dataset

	NOVELTY					N	Sum of weights
	0	1	2	3	4		
Country:							
Belgium	59.9	22.2	3.4	6.3	8.1	1,229	12,904
Bulgaria	89.6	3.8	2.3	3.2	1.1	9,496	9,496
Czech Republic	75.3	12.4	0.5	4.3	7.5	3,119	16,850
Germany	58.3	23.5	3.4	7.0	7.8	2,781	111,150
Estonia	73.2	12.9	2.9	6.4	4.5	2,340	3,148
Spain	79.3	9.5	4.1	5.9	1.2	7,532	65,029
Greece	81.1	7.8	2.0	6.9	2.2	1,478	8,315
Hungary	82.5	8.4	0.8	5.9	2.4	891	11,724
Lithuania	78.5	7.9	5.4	5.3	2.9	1,700	3,689
Latvia	86.4	4.6	3.8	2.9	2.3	1,900	3,709
Norway	70.7	15.2	4.0	6.9	3.3	3,034	7,904
Portugal	73.5	6.9	4.8	10.7	4.2	1,749	22,126
Romania	84.8	1.4	3.1	7.2	3.5	7,318	21,596
Regional group:							
Northern Europe	59.2	22.9	3.4	7.0	7.5	7,044	131,957
Southern Europe	78.1	8.7	4.1	7.1	2.0	10,759	95,470
Central Europe	78.2	10.8	0.6	5.0	5.4	4,010	28,575
Baltics	79.7	8.2	4.1	4.8	3.2	5,940	10,546
Balkans	86.3	2.2	2.8	6.0	2.7	16,814	31,092
All countries	70.6	14.5	3.3	6.6	4.9	44,567	297,640

Note: Own computations based on Eurostat (2007); average weighted by the sampling fraction, corrected for non-response and for no longer existing enterprises; only firms with non-missing information for the base model.

Table 3: Factor analysis on characteristics of the innovation process

	(1)	(2)	(3)	(4)
	Science-based	Marketing-oriented	External information-driven	Supplier-dominated
	SCI	MKT	INFO	SUPP
R&DIN	0.71	0.17	-0.07	-0.17
R&DEX	0.72	0.13	-0.21	0.18
MACHINE	-0.10	0.18	0.06	0.68
LICENSE	0.20	0.07	-0.09	0.69
TRAIN	0.03	0.70	0.06	0.36
MKTINT	0.06	0.89	0.05	-0.04
DESIGN	-0.03	0.90	0.04	-0.02
SUPPLIER	-0.06	-0.18	0.46	0.47
CLIENT	0.12	0.17	0.61	-0.25
COMPET	-0.05	0.14	0.74	-0.14
UNI	0.67	-0.09	0.38	0.02
LAB	0.64	-0.20	0.39	0.03
PROF	0.16	0.09	0.61	0.20
FAIR	-0.07	0.05	0.73	0.16
PAVAL	0.67	0.12	-0.04	-0.14
COOP	0.69	-0.03	-0.11	0.16

Note: Estimation weighted by the inverse of the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 10,893 (sum of weights is 80,763); four factors with eigenvalue > 1 were detected, which explain 59.5% of total variance; extraction method: principal components factors; rotation: oblimin oblique.

Table 4: Results of the ordered probit model on the full sample

	All countries	Northern Europe	Southern Europe	Central Europe	Baltics	Balkans
SIZE	0.10 (8.86)***	0.11 (5.74)***	0.10 (6.88)***	0.10 (5.04)***	0.05 (3.65)***	0.05 (3.56)***
FO	0.03 (0.46)	-0.14 (1.34)	0.20 (2.17)**	0.16 (1.73)*	0.16 (2.08)**	0.35 (3.42)***
INNPCS	0.94 (23.42)***	0.76 (11.28)***	0.91 (19.90)***	1.19 (14.90)***	1.39 (30.51)***	2.46 (47.39)***
PAVAL	0.72 (12.43)***	0.75 (8.45)***	0.71 (11.27)***	0.76 (6.40)***	0.64 (8.27)***	0.50 (4.65)***
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
/cut1	2.13	1.81	2.93	1.81	1.53	2.18
/cut2	2.77	2.65	3.35	2.40	2.01	2.41
/cut3	2.97	2.83	3.62	2.44	2.33	2.75
/cut4	3.55	3.30	4.52	2.88	2.92	3.74
Wald χ^2	3,376.34	621.56	1,162.44	727.34	1,761.74	3,697.83
Pseudo R^2	0.15	0.13	0.13	0.17	0.20	0.36
Number of observations	44,567	7,044	10,759	4,010	5,940	16,814

Note: Estimation weighted by the inverse of the sampling fraction, corrected for non-response and for no longer existing enterprises. Absolute value of robust z-statistics in brackets and ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table 5: Results of the ordered probit model on the sub-sample of product innovators

	All countries	Northern Europe	Southern Europe	Central Europe	Baltics	Balkans
SIZE	0.05 (3.22)***	0.05 (1.94)*	0.10 (4.55)***	0.02 (0.47)	0.03 (1.31)	0.08 (4.22)***
FO	0.13 (1.79)*	0.06 (0.50)	0.29 (2.86)***	0.14 (0.89)	0.25 (2.58)***	0.28 (2.64)***
INNPCS	0.17 (2.66)***	0.16 (1.63)	0.19 (2.77)***	0.23 (1.99)**	0.30 (4.19)***	0.29 (3.41)***
SCI	0.37 (8.16)***	0.44 (7.01)***	0.24 (4.97)***	0.25 (2.95)***	0.18 (3.90)***	0.04 (0.80)
MKT	0.15 (3.83)***	0.16 (2.98)***	0.18 (4.13)***	0.10 (1.31)	0.12 (2.94)***	0.03 (0.77)
INFO	-0.05 (1.63)	-0.08 (1.57)	0.04 (1.07)	-0.10 (1.58)	-0.01 (0.38)	0.03 (0.88)
SUPP	-0.03 (0.94)	-0.03 (0.64)	-0.06 (1.59)	0.01 (0.10)	-0.01 (0.31)	-0.00 (0.05)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
/cut1	0.18	0.78	0.59	0.95	-0.85	1.19
/cut2	0.50	1.05	1.09	1.03	-0.31	1.93
/cut3	1.30	1.67	2.39	1.68	0.48	3.27
Wald χ^2	680.01	200.24	299.47	54.10	138.84	463.70
Pseudo R^2	0.07	0.09	0.07	0.05	0.04	0.08
Number of observations	10,893	2,897	2,849	1,202	1,403	2,542

Note: Estimation weighted by the inverse of the sampling fraction, corrected for non-response and for no longer existing enterprises. Absolute value of robust z-statistics in brackets and ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table 6: Results of the 2nd equation of the Heckman procedure for ordered probit model (see Appendix 2 for results of the selection equation)

	All countries	Northern Europe	Southern Europe	Central Europe	Baltics	Balkans
SIZE	0.03 (1.37)	0.00 (0.05)	0.08 (3.27)***	-0.01 (0.25)	0.02 (0.83)	0.08 (4.10)***
FO	0.11 (1.58)	0.10 (0.79)	0.26 (2.56)**	0.07 (0.43)	0.23 (2.30)**	0.27 (2.49)**
INNPCS	-0.16 (1.09)	-0.34 (1.69)*	0.03 (0.22)	-0.19 (0.70)	0.01 (0.03)	0.05 (0.15)
SCI	0.32 (6.86)***	0.35 (5.16)***	0.22 (4.26)***	0.19 (2.13)**	0.16 (3.32)***	0.03 (0.59)
MKT	0.15 (3.83)***	0.16 (2.97)***	0.18 (4.12)***	0.10 (1.33)	0.12 (3.03)***	0.03 (0.81)
INFO	-0.05 (1.47)	-0.08 (1.52)	0.04 (1.24)	-0.09 (1.49)	-0.01 (0.21)	0.03 (0.94)
SUPP	-0.04 (1.10)	-0.04 (0.83)	-0.06 (1.70)*	0.01 (0.21)	-0.02 (0.42)	-0.01 (0.13)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Inverse Mills ratio	-0.48 (2.61)***	-0.89 (2.83)***	-0.24 (1.31)	-0.46 (1.63)	-0.29 (1.29)	-0.13 (0.67)
/cut1	-0.29	-0.34	0.03	-0.47	-1.37	1.39
/cut2	0.04	-0.08	0.53	-0.39	-0.83	2.13
/cut3	0.84	0.55	1.84	0.26	-0.04	3.47
Wald χ^2	695.84	218.39	300.09	57.01	145.85	462.73
Pseudo R^2	0.08	0.09	0.07	0.05	0.04	0.08
Number of observations	10,893	2,897	2,849	1,202	1,403	2,542

Note: Estimation weighted by the inverse of the sampling fraction, corrected for non-response and for no longer existing enterprises. Absolute value of robust z-statistics in brackets and ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Appendix 1: List of the variables

<u>Available for the full sample:</u>

SIZE	Log of turnover at the beginning of the period (micro-aggregated)
FO	Dummy for being part of a group with headquarters abroad (foreign affiliate)
INNPCS	Dummy for process innovation
PAVAL	Dummy for a valid patent at the beginning of the period

<u>Available for the innovating firms only:</u>

R&DIN	Dummy for internal R&D
R&DEX	Dummy for acquisition of extramural R&D
MACHINE	Dummy for acquisition of machinery and equipment
LICENSE	Dummy for acquisition of other external knowledge
TRAIN	Dummy for training
MKTINT	Dummy for market introduction of innovations
DESIGN	Dummy for design and other
SUPPLIER	Importance of information from suppliers
CLIENT	Importance of information from clients or customers
COMPET	Importance of information from competitors or firms in the same industry
UNI	Importance of information from universities and other higher education
LAB	Importance of information from government or non-profit research institutes
PROF	Importance of information from professional conferences, journals, etc.
FAIR	Importance of information from fairs and exhibitions
COOP	Dummy for a cooperation arrangement on innovation

Appendix 2: 1st equation of the Heckman's sample selection model

	All countries	Northern Europe	Southern Europe	Central Europe	Baltics	Balkans
Constant	-2.46 (14.73)***	-2.10 (6.20)***	-2.42 (9.21)***	-1.71 (4.40)***	-1.40 (4.99)***	-1.80 (9.17)***
SIZE	0.09 (8.24)***	0.10 (5.11)***	0.10 (6.21)***	0.12 (5.32)***	0.05 (2.96)***	0.02 (1.70)*
FO	-0.00 (0.01)	-0.15 (1.33)	0.15 (1.45)	0.16 (1.75)*	0.10 (1.24)	0.35 (2.77)***
INNPCS	1.10 (24.73)***	0.93 (12.66)***	0.99 (19.63)***	1.38 (15.15)***	1.55 (29.88)***	2.87 (46.78)***
PAVAL	0.75 (10.95)***	0.71 (7.04)***	0.83 (12.00)***	1.02 (7.80)***	0.79 (9.29)***	1.10 (7.06)***
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	44,137	6,903	10,501	3,982	5,940	16,811

Note: Estimation weighted by the inverse of the sampling fraction, corrected for non-response and for no longer existing enterprises. Absolute value of robust z-statistics in brackets and ***, **, and * indicate significance at the 1, 5, and 10 percent level.