R&D, Product Renewal and Clusters in Belgium

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Abstract*

Using the cluster definitions of the European Cluster Observatory, this paper investigates the link between cluster membership and firm-level product innovation and renewal; using data from the Community Innovation Survey for Belgium. Clustered firms account for 71 percent of total product renewal generated in 2004 and for 58 percent of all exports; compared to 29 and 42 percent for non-clustered firms, respectively. Furthermore, cluster membership is shown to be conducive to firm-level product innovation and renewal once firm size, export intensity and research inputs are taken into account. Foreign firms are not more prone to carry out product innovation, except for subsidiaries in clusters.

JEL classification: D21, F23, 031, O33
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1. Introduction

The liberalization of markets, more outward-looking development policies, and the attractiveness of regional economic integration initiatives have all contributed to push out the territorial boundaries of firms. The ease with which firms can transfer tangible and especially intangible assets across borders is being constrained by the fact that the location of the creative activities and use of these assets is becoming increasingly influenced by the presence of immobile clusters of complementary value-added activities. Thus, while globalization suggests that the location and ownership of production is becoming geographically more dispersed, other economic forces are stimulating a more pronounced geographical concentration of economic activity both within particular regions and countries (Dunning, 1998).

Silicon Valley (Saxenian, 1990) and Hollywood (Christopherson and Storper, 1986) may be the world's best-known clusters, but examples abound in every international, national, regional, state and even metropolitan economy, especially in the more advanced nations (Porter, 1998), although some developing countries, such as several countries in South America and the Caribbean, China and India, have also taken this to heart (see for instance De Beule et al., 2005).

Belgium, too, has a number of world-class and world-known clusters, such as the Flemish tufted-carpets cluster. Flanders was quick to adopt the clustering concept back in the early 1990s, soon after the regionalization of the main economic decision-making in Belgium. The idea caught on and a number of clusters or valleys were launched. But the difficulties in identification of promising technologies and the rather artificial localization of some proposed actors in geographically narrow valleys proved that a success model cannot be copied too mechanically. For instance, the Lernout and Hauspie Speech Products scandal and eventual bankruptcy meant the end of the Flanders Language Valley, and to some extent, the cluster policy.

Flanders has more recently renewed its interest in clusters, as the ministry has selected six technological clusters on which to focus its innovation policy. They are transport and logistical services, ICT and health services, food, new materials and nanotechnology, social economic innovation, and energy and the environment (De Backere, 2006).

At the Walloon level, the burden of the heavy industry and the structure of the economic fabric have not promoted the natural appearance of networks of companies. As such, the Walloon government was rather late in adopting clustering, but has followed through. In 2000, the Walloon Government set 'the support to the appearance of networks of companies' among the priority measures of its Contract for the Future for the Walloon Region, proving its willingness to promote co-operation and partnerships between Walloon enterprises, both SMEs and large enterprises.

After an evaluation period of specific policies and clusters, the Walloon government has recently voted a decree project related to the support and the development of the networks of enterprises in clusters, which called for a specific support for national and international cooperation. The number of clusters and firms has subsequently increased from 7 clusters with about 200 member firms in 2003 to 14 clusters with more than 1000 firms. Current clusters include aeronautics, automotive, solid waste, eco-building, space, nutrition, clinical research, micro-technologies for intelligent manufacturing and products, ICT, energy, environment and sustainable development technologies, image, sound and text technologies, and transport and logistics (DGEE, 2008).

While the observation that firms tend to cluster in particular regions is hardly novel (Marshall, 1890), it has recently been taken up to explain the stickiness of certain locations in an increasingly slippery world (Markusen, 1996). These theories suggest that firms may be drawn to the same locations because proximity generates positive externalities or agglomeration effects (Markusen, 1994). Economists have proposed agglomeration effects in the form of both static (pecuniary) and dynamic (technological) externalities to explain industry localization (Baptista, 1998). Increasingly, the analysis of geographically clustered firms has tended to shift towards the study of predominantly

untraded exchanges of knowledge and ideas (Storper, 1995, Maskell, 2001). Firms secure competitive advantages through gaining rapid access to knowledge concerning the innovations, techniques and strategies of competing firms (Henry and Pinch, 2006).

This paper intends to add to the latter research and analyzes the innovation propensity of firms in Belgium. It specifically distinguishes between clustered and non-clustered firms, while also taking account of foreign or domestic ownership. For policymakers, it is useful to know that clustered firms are better at innovation than firms in non-clustered sectors. Funding of research, for one, might be put to better use. For foreign firms, tapping into the local network of knowledge is becoming of paramount importance to improve their competitive advantage. Cluster membership is a positive conduit for foreign firm innovativeness.

Two measures of innovation are used, namely a binary variable whether firms have introduced product innovations or not, and the percentage of newly innovated products in turnover. The empirical analysis employs Belgian data of the European Community Innovation Survey (CIS), obtained from the Belgian Science Policy. Section 2 discusses the relevant literature and draws hypotheses, while section 3 deals with the data description and methodology. Finally the results are discussed and some recommendations are drawn.

2. Literature review and hypotheses

There is a long tradition in industrial location theory and regional economics of theorizing about why new industries emerge in particular places and why, once these places have experienced take off, further expansion of the sector is likely to be drawn to the original or neighboring sites. It was by observing industry localization that Marshall (1890) derived the concept of external economies. In Marshall's seminal analysis of industrial organization, the three fundamental reasons for geographical concentration or spatial clustering of production were identified as:

(1) the existence of a pooled market for workers with specialized skills:

> "A localized industry gains a great advantage from the fact that it offers a constant market for skill. Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require; while men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market".;

(2) the provision of specialized inputs from suppliers and service providers:

> "Subsidiary trades grow up in the neighborhood, supplying it with implements and materials, organizing its traffic, and in many ways conducing to the economy of its material […]".; and

(3) the relatively rapid flow of business-related knowledge between firms, which result in what are now called technological spillovers:

> "The mysteries of the trade become no mystery; but are as it were in the air. […] Good work is rightly appreciated; inventions and improvements in machinery, processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas".

In short, the external effects of agglomeration consist of various types of benefits and cost savings, obtained outside the market that may lead to increased productivity of a firm. These effects may be based on the availability of skilled labor, the access to specialized suppliers of intermediary goods, but also on localized knowledge spillovers. All of these factors are covered by the notion of agglomeration, which suggests that the stickiness of a place resides not in the individual firms or workers, but in the external economies available to each firm from its spatial conjunction with other firms and suppliers of services at a particular location. These economic benefits allow to increase

the productivity of firms in a static perspective and to augment the capacity for innovation and sustained productivity growth in a more dynamic perspective.

Static agglomeration economies are said to occur when the unit costs of production of a business enterprise or establishment are lower in the context of relatively dense clusters of other firms or specialized resources, such as skilled labor or infrastructure, than would be the case if the typical business were located elsewhere. Krugman (1991) recapitulates earlier work in offering as sources of static agglomeration economies: a local concentration of customers (or downstream firms) sufficient to permit suppliers to achieve economies of scale in production or distribution, great enough for local firms to amass sufficient demand to warrant the provision (usually by or via local governments) of specialized infrastructure, and large enough to attract a deep and diversified pool of workers sufficient to realize a more specialized local division of labor.

Dynamic agglomeration economies, on the other hand, refer to the heightened prospect for technological learning to occur (not simply reductions in unit costs of production with a given technology) in relatively dense clusters compared with less dense locations. Studies on geographic location and economic performance have shown that economic and technological activities have a strong tendency to agglomerate at certain locations, giving rise to patterns of national and regional specialization; and, that the performance and the growth of firms depend to a large extent on the conditions of the environment in which they operate, and particularly on those in the immediate proximity (Malmberg, Sölvell and Zander, 1996). The common starting point is the assumption that firms rarely innovate in isolation and need a network of suppliers and users with complementary knowledge to innovate successfully. In this way the cluster concept provides another way of looking at the economy and innovation and offers an alternative to the traditional sectoral approach (OECD, 1999).

It has been argued that the transmission of technological knowledge works better within spatial boundaries (Jaffe, 1986; Jaffe, et al., 1993). To the extent that differences in innovative behavior among firms are in part attributable to properties of the local

economies of which they are a part, most contemporary urban economic and geographic theory treats such dynamic growth processes in terms of the local production and diffusion of information relevant to the firm's decision to adopt (take up) a technology, and of the organizational capacity of that firm to make use of such information.

Industries, in which knowledge spillovers are more prevalent, have a greater propensity for innovative activity to cluster than industries where knowledge externalities are less important (Audretsch and Feldman, 1996). Clusters provide a fertile ground for learning, experimentation, and innovation due to short distances, short information time lags, and relatively inexpensive communication (von Zedtwitz and Heimann, 2006). As such, firms have been found to be considerably more likely to innovate if sectors are clustered (Baptitsta and Swann, 1998). And, although firms in clusters densely populated by other innovative firms positively affect the likelihood of innovating, quite strong disadvantages seem to arise from the presence of non-innovative firms in a firm's own industrial sector (Beaudry and Breschi, 2003).

Hypothesis 1a. *Firms in clusters will have a higher tendency to carry out product innovation, ceteris paribus, than firms in non-clustered sectors.*

Hypothesis 1b. *Firms in clusters will have more product renewal, ceteris paribus, than firms in non-clustered sectors.*

MNCs are increasingly seeking complementary foreign assets and knowledge-facilitating capabilities, in order to add value to their core competitive advantages. This is particularly the case when their affiliates become more firmly rooted in host economies. Examples of this approach indicate that foreign-owned subsidiaries typically tap into local industry in order to keep their parent company informed about leading-edge thinking (Porter, 1990; Bartlett and Ghoshal, 1994), while studies by Frost (1998) and Almeida and Kogut (1997) show how subsidiaries draw from local sources in their innovation processes.

R&D internationalization can be driven either from the bottom up or from the top down. In the case of bottom-up internationalization, R&D emerges naturally by following up on successful customer product service or local technology adaptation. Multinational subsidiaries set up these market seeking units because the country or region represents an important and leading market for the multinational group's products. In the case of market-seeking investments, foreign subsidiaries often serve as the centre for a particular business segment of MNCs at a global or regional scale. MNCs may also benefit from advantages that a foreign cluster might have in developing and producing a particular product or service that can be transferred to the existing business units of the group through its subsidiaries in the cluster (Enright, 2000).

In the case of top-down R&D internationalization, strategy serves as a guideline for sourcing technology from abroad. Multinational subsidiaries sometimes serve as scanning units that tap selectively into sources of advantage in foreign national industrial clusters. From the MNC perspective, these subsidiaries in a foreign cluster may bring several benefits: the access to knowledge, which otherwise would have remained out of reach; the potential leveraging of this knowledge throughout the firm's internal network; the transfer of global best practices; the monitoring of rivals active in the foreign clusters, etc. In the case where foreign subsidiaries are set up as 'listening posts', they may be used to collect information and knowledge from the clusters and disseminate it to the parent companies and other subsidiaries. In an advanced stage, they can serve as a vehicle to transfer skills and capabilities from the cluster to the rest of the group. MNCs as such carry out 'asset-augmenting' investment abroad to gain access to specific capabilities present in a foreign cluster in order to enhance the assets that the corporation already possesses (Dunning, 1998; Dunning, 2000; Cantwell and Glac, 2005).

Agglomeration processes in innovative activities can therefore be accelerated by the increasing role played by multinational corporations as creators of innovation across national boundaries, as well as by the recent trend for multinational corporations (MNCs) to establish internal and external networks for innovation (De Beule, et al., 2005). Internationally integrated networks within the firm may lead to an improvement of

innovation capacity both of the MNC and of the host location. Inter-firm networks established between MNC subsidiaries and local firms may, in addition, amplify the advantages of geographical agglomeration in some particular lines of technological development, reinforcing the existing sectoral pattern of technological specialization of local systems (Cantwell and Iammarino, 1998).

MNCs tend to perform R&D in foreign locations with strong technological capabilities, and this leads to a further strengthening of indigenous R&D activities. There is an increase of knowledge seeking FDI by MNCs, because the intra-firm specialization and the related local embeddedness of know-how make it difficult to achieve international innovation processes within the MNC without participating in foreign clusters. The economics of industrial and technological localization are therefore likely to be increasingly shaped by the interaction between multinational corporations and local clusters. For instance, Birkinshaw and Hood (2000) showed that subsidiaries in clusters are more embedded, more autonomous, and more internationally-oriented than subsidiaries in other industry sectors.

MNCs have therefore increasingly invested in foreign clusters to augment their knowledge base through obtaining direct access to foreign pools of skilled human resources and knowledge (Dunning, 2000; Rugman and Verbeke, 2001). The positive impact of foreign industrial clusters on the asset creating nature and competitiveness of MNCs has become the focus of several studies (Birkinshaw and Hood, 1998; Birkinshaw, 2000; Birkinshaw and Hood, 2000; Enright, 2000; Peters and Hood, 2000), which provide a rich set of conceptual and practical insights into the contribution of foreign industrial clusters in general and foreign subsidiaries in particular to the competitive position of MNCs.

Yet, being in a foreign location does not necessarily create positive effects on the innovation process of MNCs for the following reasons. Different sub units within the MNC may have a specialized knowledge base and a specific technological trajectory, which may be inconsistent with the knowledge absorbed abroad. One of the main

obstructing factors with respect to international absorptive capacity of companies and regions is a phenomenon referred to as the liability of foreignness (Zaheer, 1995). Applied to foreign-owned R&D, gaining access to, understanding, and leveraging external foreign knowledge is more difficult than doing so in one's home country (von Zedtwitz and Heimann, 2006). In addition, the MNC unit involved in the knowledge absorption process may be faced with difficult choices between maximizing convergence of its own operations with the other parts of the MNC-network, and maximizing convergence with the localized knowledge (Cantwell and Santangelo, 1999).

However, foreign subsidiaries may use their cluster membership to reduce these disadvantages. Luo et al. (2002) illustrate how firms use local networking as a mechanism to overcome the liability of foreignness and thereby facilitate their embeddedness in the local business community. Given that clusters seem to facilitate knowledge creation, either for the external or internal network of MNCs, it is hypothesized that cluster membership of foreign subsidiaries is likely to be positively associated with the generation of product innovations (Castellani and Zanfei, 2006).

Hypothesis 2a. *Multinational subsidiaries in clustered industries will have more product innovation, ceteris paribus, than other firms.*

Hypothesis 2b. *Multinational subsidiaries in clustered industries will have more product renewal, ceteris paribus, than other firms.*

3. Data and methodology

Data on clusters in Europe are available from the European Cluster Observatory[1]. The cluster concepts used are based on the original definitions developed at the Institute for Strategy and Competitiveness of the Harvard Business School. Identification of clusters is achieved by looking at the geographic distribution of employment in the United States

[1] www.clusterobservatory.eu .

(Porter, 2003). Based on employment concentration patters, three types of industries are identified: (1) local industries, serving local markets and not exposed to direct competition across regions; (2) traded industries (clusters) which are concentrated geographically and that choose where to locate; and (3) natural resource-based industries, which are necessarily located close to their source. Traded or clustered industries account for about 32 percent of employment in the US (Porter, 2003), and about 37 percent of European employment (European Cluster Observatory).

Translation of the US cluster definitions is achieved in three steps. First, the Cluster Observatory translated the US SIC classification into the European Nace classification. Since there is no one-to-one correspondence between the two systems, some choices in translation had to be made, resulting in 38 clusters for Europe, or three less than the original 41 clusters defined for the US. Second, to identify clusters in Europe, regions were identified using the NUTS classification. For most countries, NUTS 2 regions were used (usually the provincial level). However, for a number of smaller countries, including Belgium, NUTS 1 regions were used in order to make the size of the regions comparable across Europe. Finally, the Cluster Observatory obtained employment data at the highest level of detail available (usually Nace four-digit level). Collection of these data was performed during the period December 2006 – June 2007. The data for Belgium pertain to the year 2004.

In addition to identification of clusters in Europe, which was achieved using employment concentration patterns, the Cluster Observatory classifies these clusters according to their strength, based on three criteria: size, specialization and focus. If a cluster is in the top ten percent of all clusters in Europe in terms of employment (*size*), it receives one star. If employment concentration in a particular region and industry is larger than overall employment concentration of that industry in Europe (*specialization*), it receives a second star. Finally, if the cluster is in the top ten percent of industries in the region in terms of employment, it receives a third star.

Translation of the clusters identified by the Cluster Observatory is not straightforward since complete concordance tables (giving detailed Nace codes corresponding to each of the clusters) are as of yet not available[2]. Hence, cluster definitions applied here and listed in Appendix A, are necessarily crude. As can be seen in Appendix A, whether a firm is part of a cluster depends on two criteria: (1) the industry the firm belongs to; (2) the region of activity for the firm. Industries are defined using the Nace[3] classification commonly used in European statistics. Regions are defined at the NUTS-1 level for Belgium; this implies that there are three regions: Brussels, the Flemish region and the Walloon region.

Firm-level data on innovation are taken from the Community Innovation Survey for Belgium (CIS4) and were obtained from the Belgian Science Policy[4]. The Community Innovation Survey (CIS4) collects information on innovations at the firm level for the period 2002 – 2004. Although the survey is organized by the EU, data are collected by national authorities. For Belgium the Belgian Science Policy is responsible for the data collection. Apart from innovation-related information, the survey also records detailed information on employment, turnover, ownership and exports of the firm. Although the CIS4-questionnaire pertains to the years 2002-2004, quantitative data are only available for 2004. Hence, the data are cross-sectional in nature.

The CIS data are available for 3,322 firms and are representative for the full population of Belgian firms employing at least 10 people[5]. Firms with missing identification number (1 firm) and firms with exports amounting to more than 100 percent of sales in 2004 (1 firm) are omitted. Similarly, firms reporting unrealistically high R&D to sales ratios are omitted (14 firms). Hence, the final sample consists of 3,306 firms. The questionnaire contains detailed information on firms' innovation activities. Apart from R&D

[2] According to the Cluster Observatory, complete concordance tables will be provided in the near future.

[3]The Nace classification can be downloaded from the Eurostat ramon server at http://ec.europa.eu/eurostat/ramon.

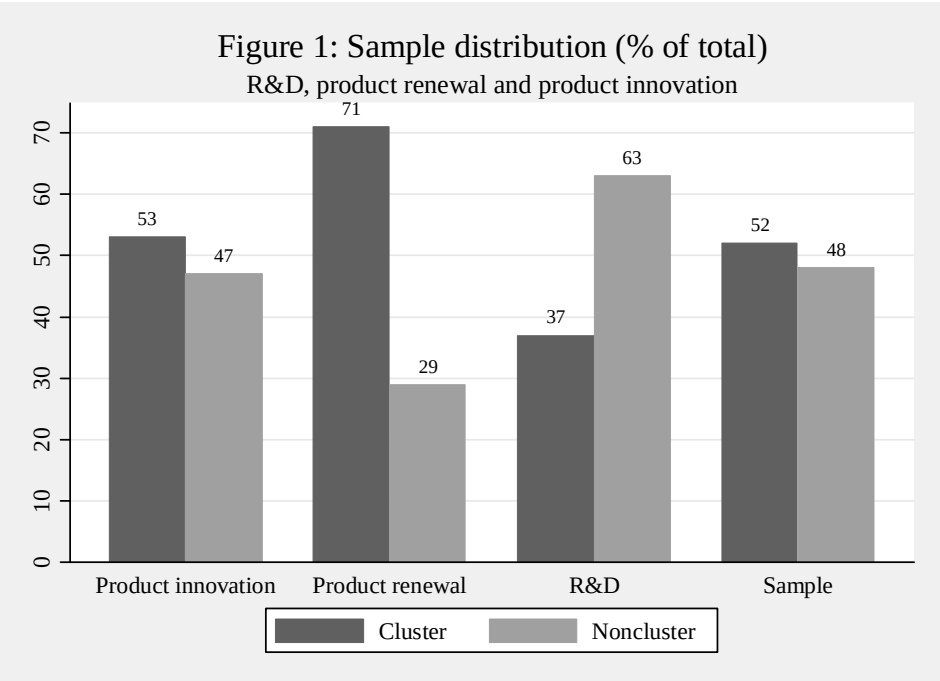
[4] We would like to thank Manu Monard, Peter Teirlinck and the CFS-STAT Commission of the Belgian Science Policy for granting access to the data at the offices of the Belgian Science Policy in Brussels.

[5] For a detailed overview of the CIS population selection process and the sampling issues involved, we refer to Teirlinck (2005).

expenditures, which are reported for 2004; the data set contains information on whether firms have introduced product and/or process innovations during 2002-2004 as well as on the share of turnover that is accounted for by the introduction of new products in 2004 (either new to the market or new to the firm). Appendix B provides an overview of the specific questions asked to firms in the questionnaire concerning their innovation activities.

By combining the information on clusters in Belgium with the CIS-data, the firms are classified into two groups: (1) firms that are part of a cluster, i.e. active in a sector and region identified as a cluster; (2) firms that are not part of a cluster. According to this definition; 1,599 firms in the sample are not part of a cluster, compared to 1,707 firms that are.

Figure 1: Sample distribution (% of total)



To gain some preliminary insights into the performance of firms that are part of a cluster in Belgium, figure 1 shows the contribution of cluster and non-cluster firms to total R&D spending, product innovation and product renewal in the sample. The figure also shows, for comparison purposes, the distribution of the number of firms in the sample.

As can be seen in figure 1; 52 percent of all firms are active in sectors and regions part of a cluster, compared to 48 percent in non-clustered industries. The number of firms that report to have introduced a product innovation during the years 2002-2004 shows is proportional to the firm distribution: 53 percent of all firms that introduced a new product are active in clusters, compared to 47 percent for the firms not part of a cluster. For product renewal (percentage of new products in turnover); the distribution is clearly in favor of firms part of a cluster. These firms account for 71 percent of total innovative sales generated in 2004; compared to 29 percent for non-cluster firms. The distribution of R&D spending in the sample is somewhat surprising. Firms that are not part of a cluster together account for 63 percent of total innovative effort, compared to 37 for their non-clustered counterparts.

Table 1: Firm performance according to cluster membership

Variable	*Firms not part of a cluster*	*Firms part of a cluster*
Number of observations	1,596	1,707
Share of new products in sales	0.07	0.07
Product innovation (d)	0.29	0.31
R&D intensity	0.02***	0.01
Funding (d)	0.15***	0.11
Employment	118.22	187.86***
Export intensity	0.25**	0.22
Foreign ownership (d)	0.29***	0.24

Notes: Reported values are means (except for the first row).
Significance levels (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$) refer to one-tailed test on the difference between the means for the two types of firms (part of a cluster or not).
(d) refers to dummy variable. Variables are defined in Appendix B.

Table 1 summarizes a number of firm-level characteristics for both types of firms. Apart from the number of observations in each group, the table summarizes average innovative output (measured as the number of firms introducing a product innovation or as the share of new products in turnover) as well as average innovative effort for both types of firms.

In addition, firm-level employment, export intensity and foreign ownership, which will serve as additional control variables in the empirical analysis below, are compared across types in the table. A number of interesting findings emerge from the table.

First, although firms in clusters account for the majority of total innovative sales generated in the sample (figure 1), they are on average larger than non-cluster enterprises (table 1). As a consequence, their innovative output expressed in relative terms (as a share of innovative sales) is not found to be significantly different from the innovative sales intensity reported by non-cluster firms. Second, firms located in clusters are found to spend significantly less (on average) than their non-cluster counterparts, both in absolute terms (figure 1) and in relative terms (table 1). Similarly, firms not located in clusters exhibit a higher propensity of acquiring R&D funding from regional, national or EU authorities. They are also more export-intensive, i.e. the share of turnover that is being exported is higher for non-cluster firms; and they have a higher percentage of foreign ownership than clustered firms.

Comparing the results of table 1 and figure 1 on innovative inputs (R&D, funding) and outputs, these findings suggest that firms that are part of a cluster are able to reap higher returns on their R&D, given that they spend less than non-clustered firms (half as much in absolute terms), while they have much higher innovative sales (in absolute terms). In order to determine whether this higher rate of return is attributable to agglomeration economies resulting from cluster membership, we proceed to the full empirical model.

In order to obtain further insights into the importance of cluster membership for firm-level innovative behavior, the following empirical model is estimated:

$$\begin{aligned} Inn_i = {} & \alpha_0 + \alpha_1 RD_i + \alpha_2 Funding_i + \alpha_3 Exp_i + \alpha_4 \ln(Emp_i) \\ & + \alpha_5 Foreign_i + \alpha_6 Cluster_i \\ & + \alpha_7 Foreign_i * Cluster_i \\ & + \alpha_7 RD_i * Cluster_i \\ & + \sum_j \beta_j Region_i + \sum_k \beta_k Ind_i \end{aligned} \qquad (1)$$

where

Inn_i	Firm-level innovation measure, defined as product innovation (dummy), or the share of new products in turnover (censored variable).
RD_i	R&D-intensity of the firm, measured as total internal R&D expenditures relative to firm turnover.
$Funding_i$	Funding dummy, equal to one if the firm has acquired funding from regional, national or EU authorities.
Emp_i	Employment of the firm, measured in full-time equivalents.
Exp_i	Firm-level export intensity, defined as the share of exports in total turnover.
$Foreign_i$	Foreign ownership dummy, equal to one if the head office of the group is located outside of Belgium.
$Cluster_i$	Dummy, equal to one if the firm is part of a cluster.
$Region_i$	Region dummy, defined using NUTS1-regions.
Ind_i	Industry dummies (two-digit Nace level).

Estimation of (1) is achieved by using a different methodology that depends on the innovation measure used. Product innovation is an indicator variable, hence a logit model is estimated. The share of new products in turnover is limited below by zero and above by one, which is why a tobit model is used.

Since innovative output at the firm level is essentially a function of innovative effort and other control variables (see Mairesse and Mohnen, 2002), equation (1) includes firm-level R&D intensity, measured as total internal R&D over sales in 2004. Moreover, as argued by Tallman et al. (2004), investment in R&D activities additionally acts as a firm-level measure of absorptive capacity, since it (indirectly) facilitates knowledge transfers from other firms. Hence, we expect to find a positive effect of innovative effort, measured by internal R&D intensity, on firms' innovative output.

Similarly, access to finance, particularly in the context of uncertain innovation outcomes, may also affect firms' ability to innovate, and particularly the commercialization of their innovations as measured by their innovative sales intensity (see for instance Aharonson,

Baum and Plunket, 2008). We therefore include a funding dummy in (1), indicating whether the firm had acquired funding from regional, national or EU agencies during 2002-2004. Funding is expected to have a positive impact both on firms' propensity to innovate and its innovative sales intensity.

In addition to these "input" measures, firm size, export intensity[6] and sector dummies are included as control variables in all the regressions reported below. Additionally, we include region dummies in (1) to control for the demand structure in the different regions and hence to ensure that the effect captured by the cluster membership dummy is not attributable to differences in regional demand patterns (Baptista and Swann, 1998).

Moreover, we control for firms' global engagement status by including a variable measuring the export intensity of firms as well as a foreign ownership dummy. For both variables, effects on innovative output are ambiguous. This stems from the fact that innovation can be linked to exposure on international markets in two ways[7]. Firms can innovate prior to entry on international markets, enabling them to gain the productivity advantage needed to overcome the sunk cost associated with global engagement. On the other hand, firms' international experiences may induce further innovative activities (for instance stimulated by contacts with foreign buyers), hence reinforcing their productivity advantages. Given the cross-sectional nature of the data, we are not able to infer causality from estimating (1). However, to the extent that learning effects are important, a positive effect of firm-level export intensity and foreign ownership on innovative output is expected.

As was indicated in Hypothesis 1, firms located in clusters are expected to benefit from agglomeration economies, allowing them to be more innovative than their non-cluster

[6] The relationship between exports and innovation can go both ways. Either firms innovate prior to their entry on export markets, enabling them to gain the necessary

[7] For a theoretical model allowing for these features, we refer to Costantini and Melitz (2007). Aw et al. (2007) provides empirical evidence showing that firms make their internationalization (export) and innovation decisions jointly

counterparts. Hence, a positive effect of the cluster dummy is expected on both innovative output measures.

Finally, two interaction effects are included in (1). The first interaction effect ($Foreign_i$*$Cluster_i$) is a dummy variable equal to one for affiliates of foreign multinational firms that are located in a cluster; is included to test hypothesis 2 as outlined in section 2, i.e. multinational firms in clusters are more innovative than domestic firms which are not part of a cluster.

As was noted above, the preliminary evidence presented in figure 1 and table 1 suggests that firms located in clusters are able to reap higher returns on their R&D investments compared to non-cluster firms, since they spend less on R&D but produce more innovative output. To test for this effect empirically, a second interaction effect is included in (1), RD_i*$Cluster_i$.

4. Results

The results of estimating (1) for the full sample of firms are given in tables 2 and 3. Table 2 summarizes results for product renewal defined as the share of new products in turnover of the firm in 2004; while table 3 presents results for the product innovation variable, indicating whether or not the firm has carried out a product innovation during 2002-2004. Both regressions include two-digit industry dummies, which are unreported for brevity. Reported values are marginal effects, t-values are given between brackets.

The following stepwise approach is followed in both tables, i.e. start out from a very basic model in column (I), including only the firm-level control variables R&D-intensity, export intensity and firm size in addition to sector and region dummies. Column (II) displays results of the baseline model (I), including the cluster membership dummy and foreign ownership. Columns (III), (IV) and (V) additionally add the interaction effect between cluster membership and foreign ownership, the funding variable and the interaction term between the cluster dummy and R&D-intensity respectively.

Table 2: Share of new products in sales: tobit regression results

Variable	*(I)*	*(II)*	*(III)*	*(IV)*	*(V)*
R&D-intensity	0.247***	0.245***	0.246***	0.170***	0.141***
	[9.10]	[9.08]	[9.08]	[6.57]	[3.98]
Funding (d)	-	-	-	0.098***	0.099***
				[9.20]	[9.23]
log(Employment)	0.012***	0.012***	0.012***	0.008***	0.008***
	[7.24]	[6.75]	[6.78]	[4.88]	[4.85]
Export intensity	0.040***	0.040***	0.040***	0.028***	0.028***
	[6.15]	[6.08]	[6.05]	[4.36]	[4.33]
Foreign ownership (d)	-	0.002	-0.006	0.002	0.002
		[0.40]	[-0.95]	[0.26]	[0.28]
Cluster membership (d)	-	0.028***	0.022***	0.021**	0.020**
		[3.50]	[2.56]	[2.53]	[2.45]
*Cluster * Foreign (d)*	-	-	0.018	0.015	0.014
			[1.63]	[1.43]	[1.42]
*Cluster * R&D intensity*	-	-	-	-	0.175***
					[4.85]
Brussels region	-0.009*	0.005	0.005	0.006	0.006
	[-1.69]	[0.63]	[0.63]	[0.88]	[0.87]
Walloon region	-0.023***	-0.012**	-0.012**	-0.013**	-0.013**
	[-5.34]	[-2.20]	[-2.19]	[-2.43]	[-2.44]
N	3,303	3,303	3,303	3,303	3,303
Censored observations	2,370	2,370	2,370	2,370	2,370
Pseudo R-square	0.209	0.212	0.213	0.259	0.26

Notes: All regressions include two-digit industry dummies, in addition to region dummies. The dependent variable is the share of new products in total sales, where new products are new to the market or new to the firm. Values are marginal effects [t-values], evaluated at the mean of the independent variables and referring to the impact on innovative sales intensity, conditional on positive innovative sales. For dummy variables (d), marginal effects refer to discrete change from 0 to 1. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

Table 3: Product innovation: logit regression results

Variable	*(I)*	*(II)*	*(III)*	*(IV)*	*(V)*
R&D-intensity	2.059***	2.080***	2.052***	1.223***	0.668***
	[6.20]	[6.23]	[6.19]	[4.71]	[2.60]
Funding (d)	-	-	-	0.441***	0.443***
				[13.75]	[13.82]
log(Employment)	0.068***	0.065***	0.066***	0.055***	0.055***
	[9.30]	[8.59]	[8.62]	[6.98]	[6.89]
Export intensity	0.194***	0.192***	0.192***	0.165***	0.166***
	[7.15]	[6.97]	[6.97]	[5.77]	[5.70]
Foreign ownership (d)	-	0.021	-0.016	0.012	0.010
		[0.97]	[-0.55]	[0.39]	[0.34]
Cluster membership (d)	-	0.095***	0.073**	0.068*	0.051
		[2.86]	[1.70]	[1.83]	[1.34]
*Cluster * Foreign (d)*	-	-	0.073*	0.073*	0.079*
			[1.70]	[1.67]	[1.77]
*Cluster * R&D intensity*	-	-	-	-	2.784***
					[3.08]
Brussels Region	-0.070***	-0.029	-0.029	-0.027	-0.031
	[-3.32]	[-1.06]	[-1.05]	[-0.95]	[-1.07]
Walloon Region	-0.108***	-0.070***	-0.070***	-0.087***	-0.088
	[-5.90]	[-2.99]	[-2.98]	[-3.65]	[-3.61]
N	3,303	3,303	3,303	3,303	3,303
Pseudo R-square	0.200	0.202	0.204	0.252	0.254

Notes: All regressions include two-digit industry dummies, in addition to the region dummies. The dependent variable is a dummy, indicating whether the firm has introduced a product innovation (new to the firm or the market) between 2002 and 2004. Values are marginal effects [t-values], evaluated at the mean of the independent variables and referring to the impact on the probability to innovate. For dummy variables (d), marginal effects refer to discrete change from 0 to 1. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

As expected, employment and exports are both positively related to the innovation measures (in all columns). This confirms our hypothesis that larger firms with exposure to global markets are more likely to introduce product innovations and renew their products. However, foreign ownership does not contribute in any significant way to firm-level innovation. In accordance with expectations, investment in R&D is positively and significantly related to both innovation measures.

In both tables, explanatory power of the regressions increases as more variables are included and particularly so when the funding variable is added to the model (column IV). This suggests that external funding opportunities are a particularly important driver of innovative output at the firm level. Turning to the magnitude of the marginal effects, the result on the funding dummy for innovative sales intensity implies that the acquisition of funding for a firm is associated with an increase in the innovative sales intensity of 11.2 percent (column IV), the highest effect reported in the table. For the product innovation variable in table 3, the marginal effect amounts to 0.44, implying that securing funding increases the firm's propensity to innovate by 44 percentage points. Since the overall probability to innovate in the sample amounts to 27.26 percent, an increase of 44 percentage points implies a rise in the probability to innovate of more than 250 percent, which is very high.

From tables 2 and 3, it is clear that cluster membership is conducive both to product innovation and product renewal. The cluster dummy has a positive and significant sign in both regressions (column II). Hence, these results lend support to hypothesis 1, i.e. firms in clusters are able to benefit from agglomeration economies, allowing them to innovate more, ceteris paribus. Column III additionally includes the interaction effect between foreign ownership and clusters. While this interaction effect is insignificant for the share of innovative sales (table 2), it has a positive and significant effect on the propensity of firms to introduce a product innovation (table 3). Hence, results lend support to hypothesis 2a, i.e. foreign firms that are located in clusters are more likely to introduce product innovations. On the other hand, no support is found for hypothesis 2b, i.e. that foreign firms in clusters will also have a higher intensity of innovative sales.

As was noted in section 3, firms in clusters tend to spend less on R&D than their non-cluster counterparts; while they generate more innovative sales (on average). These findings suggest that firms in clusters are able to reap a higher return on investment for their R&D efforts. To investigate whether this is indeed the case, the final column in both tables (column V) includes an interaction effect between the cluster dummy and firm-level R&D-intensity. In both tables, this interaction effect is highly significant, suggesting that firms in clusters are indeed able to enjoy higher returns on their research efforts, ceteris paribus.

5. Discussion and recommendation

The current analysis has clearly shown that cluster membership can indeed be an important factor in the innovation process of firms. Firms in clusters enjoy a substantial and significant benefit from their presence. Controlling for research and development intensity, industries, export intensity, size, and regional differences; clusters are shown to be a serious catalyst in the renewal process of membership firms' product portfolio.

For firms in clusters, this means that their research and development is put to better use. The return on investment in innovation -that is expenditure on research and development- is more productive in clustered sectors. For policymakers, this means that clusters are an important aspect of the promotion of innovation. Funding, however, is currently more awarded to firms in non-clustered sectors.

With regard to the second hypothesis, foreign firms in clustered sectors are more likely to innovate than firms in non-clustered sectors. This implies that multinational firms should rather take notice, as they do not demonstrate a significantly better product innovation track-record in non-cluster locations. Cluster embeddedness seems to be one way of overcoming the liability of foreignness.

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Appendix A: Cluster definitions				
Cluster	*Nace*	*Description*	*Region*	*Stars*
Agricultural	1	Agriculture	Flemish region	*
Forest	2	Forestry	Flemish region	*
Food	15	Food and Beverages	Flemish region	**
Tobacco	16	Tobacco	Flemish region	**
Textiles	17	Textiles	Flemish region	*
Publishing	221	Publishing	Flemish region	*
Chemical	24	Chemicals	Flemish region	**
Biopharma	244	Pharmaceutical products	Flemish region Walloon region	* **
Plastics	252 2416	Plastic products Plastics in primary forms	Flemish region	*
Heavy machinery	29	Machinery and equipment	Flemish region Walloon region	* *
Lighting	315	Lighting equipment / electric lamps	Flemish region	*
Automotive	34	Motor vehicles	Flemish region	*
Furniture	361	Furniture	Flemish region	*
Construction	45	Construction	Flemish region Walloon region	** *
Building fixtures	4534	Building installation	Flemish region	*
Metal	27 28 29	Basic metals Fabricated metal products Machinery and equipment	Flemish region	*
Distribution	51 52	Wholesale trade Retail trade	Flemish region	*
Transportation	60 61 62 63	Land transport Water transport Air transport Ancilliary transport activities	Brussels Flemish region Walloon region	* ** *
Aerospace	623 353	Space transport Aircraft and spacecraft	Walloon region	*
Finance	65 66 67	Financial intermediation Insurance and pension funding Ancilliary financial activities	Brussels Flemish region Walloon region	*** * *
Business Services	74	Business activities	Brussels Flemish region Walloon region	** ** *
Education	80	Education	Brussels Flemish region	* *
Entertainment	92	Recreational, cultural, sporting act.	Flemish region	*
Source: European Cluster Observatory (www.clusterobservatory.eu)				

Appendix B: Definitions of variables

The Community Innovation Survey (CIS4) collects information on innovations at the firm level for the period 2002 – 2004. Although the survey is organized by the EU, data are collected by national authorities. For Belgium the Belgian Science Policy is responsible for the data collection. Apart from innovation-related information, the survey also records general information on the firm's activities, such as the level of employment, turnover, export intensity etc.

Innovation indicators

Product innovation

During the years 2002-2004, did your enterprise introduce new or significantly improved goods (services)?

Share of new products in turnover

Please give percentage of your total turnover in 2004 from: goods and service innovations introduced during 2002-2004 that were new to your market, or only new to the firm[1].

Process innovation

During the years 2002-2004, did your enterprise introduce new or significantly improved methods of manufacturing or producing goods or services; new or significantly improved logistics, delivery or distribution systems or new or significantly improved supporting activities for your processes (eg. maintenance systems).

Expenditures on R&D

Please estimate the amount of expenditure for each of your intramural R&D activities in 2004 only.

[1] The share of new products in turnover is recorded separately for product innovations new to the market and new to the firm. To obtain the total share of new products in total sales, we have summed both categories.

Basic economic information on the enterprise

Employment

What was your enterprise's total number of employees in 2002 and 2004?

Turnover

What was your enterprise's total turnover in 2002 and 2004?

Foreign ownership

Is your enterprise part of an enterprise group? In which country is the head office of your group located?