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Journal:	*Regional Studies*
Manuscript ID:	CRES-2005-0143.R2
Manuscript Type:	Main Section
JEL codes:	L20 - General < L2 - Firm Objectives, Organization, and Behavior < L - Industrial Organization, O18 - Regional, Urban, and Rural Analyses < O1 - Economic Development < O - Economic Development, Technological Change, and Growth, O32 - Management of Technological Innovation and R&D < O3 - Technological Change|Research and Development < O - Economic Development, Technological Change, and Growth, R12 - Size and Spatial Distributions of Regional Economic Activity < R1 - General Regional Economics < R - Urban, Rural, and Regional Economics
Keywords:	external knowledge relations, open innovation, urban structure

The spatial organisation of innovation: open innovation, external knowledge relations and urban structure

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Abstract

The increased use of external knowledge relations, complementary to in-house R&D, influences the way firms are organised to manage innovation. The 'new' imperative of open innovation promotes the idea that firms organise innovation, to a greater extent, in interaction with outside parties. This paper argues that both the organisation of innovation as well as the use of external knowledge depends on the physical, socio-economic and cultural environment. The outcome of the analysis supports the idea that (open) innovation is spatially organised. Contrary to the expectations, innovative firms in less urbanised areas show a higher degree of openness.

JEL codes: L20, O18, O32, R12

Key words: Open innovation, external knowledge relations, urban structure

1. Introduction

Due to the increasing complexity of innovation, companies use external knowledge to complement their in-house innovative activities. The well-known linear model of innovation

was replaced by its successor, the non-linear feedback model (KLINE and ROSENBERG, 1986), incorporating the changed nature of technology and zooming in on the learning process within, and between, firms and other organisations. However, as innovation networks grew even more complex, the innovation strategies of firms changed accordingly. This development is captured by the 'new imperative' for creating and profiting from technology: open innovation. In the 'open innovation model' firms adapt their business model in favour of R&D activities and technical change that take place outside the firm. As such, innovation becomes increasingly distributed amongst various partners (VON HIPPEL, 1988).

Naturally, external knowledge is not to be found around every corner. It is crystallised in space and not in some random manner. The rise of spatial organisation in the innovation literature is being exemplified by many notions and concepts such as 'innovative environments' (AYDALOT, 1985), 'clusters' (PORTER, 1990), 'innovative milieux' (CAMAGNI, 1991), 'regional innovation systems' (COOKE, 1992), and 'learning regions' (FLORIDA, 1995).

The adoption by firms of the open innovation model has some potential implications for the spatial organisation of innovation networks (COOKE, 2005). Interactions become the focus of research and these interactions imply an adapted spatial setting to facilitate the establishment of innovation networks and external knowledge relations. This paper aims at the inclusion and empirical testing of the relation between (1) a physical, socio-economic and cultural environment, (2) the openness of the firm, and (3) the external knowledge relations it maintains. Therefore, the analytical difference between the internal open innovation business model and the external knowledge relations of firms is important. The next section briefly reviews the existing literature on this relation. The concepts and data are elaborated in section 3. Empirical testing for Belgium is dealt with in section 4. Tentative conclusions and guidelines for further research conclude the paper.

2. Theoretical framework: knitting the strands together

The spatial organisation of innovation couples two strands of research. The first one acknowledges innovation as a main driver for local and regional economic growth, and places the innovation strategies of firms at the centre of the arguments. The second one aims at explaining how the spatial organisation works as a catalyst for innovation activities by firms. A closer look at these research themes brings out their points of intersection and the lines along which the analysis is conducted.

2.1. Open innovation and external knowledge relations

The notion of open innovation is the result of the increasing complexity of innovation and how innovation management should cope with this complexity. It reflects an ever changing research environment (CHESBROUGH, 2001): the increasing mobility of knowledge workers; the applicability of research results of universities to enterprises; more widely distributed knowledge; erosion of oligopoly market positions; more deregulation and an increase in venture capital. This resulted in an open stage gate process with the following features: (1) the centralised in-house R&D lab is no longer the main source of ideas or knowledge and is being complemented by other enterprises, new technology based start-ups, universities, and public research centres; (2) commercialisation also occurs outside the traditional markets of the enterprise through licensing, spin offs, and research joint ventures; (3) the role of the first mover advantage becomes more important than the development of a defensively orientated system of knowledge and technology protection. Chesbrough sees the well established ‘closed’ innovation model (Figure 1a) for managing industrial R&D eroding and gradually being replaced by an ‘open’ innovation model (Figure 1b) (CHESBROUGH, 2003: xxii and xxv).

** INSERT FIGURE 1a AND 1b ABOUT HERE **

The most important implications of the open innovation model rest in the detection of interesting technological trends and which knowledge and R&D is to be acquired through the market. External knowledge relations are an indispensable element in the open innovation business model and complement internal research (COHEN AND LEVINTHAL, 1990; VEUGELERS, 1997; CHESBROUGH *et al.*, 2006). Many ideas Chesbrough formulated were already around (COHEN and LEVINTHAL, 1990; ARORA and GAMBARDELLA, 1994; HOWELLS, 1999; QUINN, 1999; CHIESA, 2001; VEUGELERS and CASSIMAN, 1999). The particular focus in this paper on external knowledge relations in the 'open innovation' model is closely related to the concept of 'distributed innovation', i.e. means and measures allowing companies to capture the distributed knowledge within a wide network of actors (users, manufacturers, suppliers, research centres, and others) to solve a technical problem (VON HIPPEL, 1988; COOMBS *et al.*, 2003; CHESBROUGH *et al.*, 2006).

Although the open innovation model further emphasises the importance of the 'knowledge landscape' for the organisation of internal R&D (CHESBROUGH, 2003: p.53), none of the abovementioned authors felt the necessity to look into possible spatial impacts these ideas brought in their wake. However, according to Cooke (2005), it is expected to find spatial implications accompanying this change in business organisation. This paper deals with this lacuna.

2.2. Bringing in the spatial dimension of innovation

The spatial organisation of innovation has attracted the attention of many (FELDMAN, 1994; BRESCHI, 1999). The concept is hardly new. It can be found in the works of Marshall ('industrial districts') where the spatial specialisation of economic activities leads to agglomeration economies. In terms of industrial policy, the cluster approach (PORTER, 1990)

has occupied a prominent position since the nineties. The attraction of the cluster concept remains very strong until today. Yet these 'clusters' mostly consist of several specialisations and are far less (if at all) rooted in space.

However, the concentration of knowledge resources providing a critical mass for innovation is mainly to be found in urban areas which give them a relative advantage over more non-urban locations (FELDMAN, 1994). The transfer of knowledge is enhanced in urban areas because of the concentration of innovative companies, universities and research centres (MALECKI, 1979), and on account of the provision of pools of technical knowledge and specialisations having the capacity to develop new technologies assisted by similar concentrations of business services. The latter provide the marketing and commercial knowledge required for the introduction of innovations on the market (FELDMAN, 1994).

The tendency of enterprises to open up their innovation process through directing their business models so as to incorporate and manage the external knowledge relations could transform the spatial organisation of innovation. It is hypothesised that open innovation entails an intensification of the external knowledge relations and thus depends to a greater extent on available knowledge resources. These resources are assumed to be predominantly concentrated in urban areas due to the presence of universities, public research organisations, etc. Moreover, localised interactions promoting technological innovation are thought to be a driving force behind the persistence of urbanisation and localisation because spatial proximity improves flows of information upon which innovators depend, creating technological 'spillovers'. In this respect there is fragmentary but fairly convincing evidence that urban areas are centres of innovation in the production of both ideas and knowledge, and in their commercialisation (FELDMAN and AUDRETSCH, 1999; JAFFE, TRAJTENBERG and HENDERSON, 1993).

Possessing different specialisations, urban areas have a main advantage in offering possibilities for 'picking and mixing' knowledge inputs as and when they are needed (SIMMIE, 2003). Moreover, urban areas facilitate learning and are particularly attractive for highly-talented young people who have large potential returns form learning. In addition, labour mobility among highly qualified professional and technical workers which contribute to the sharing and diffusion of knowledge is more likely to occur within urban labour markets (FLORIDA, 1995). The absorption of knowledge from contact with more skilled individuals in their own industry and the number of probable contacts an individual makes it an increasing function of city size (GLAESER, 1999). The economic and social diversity jam-packed into a limited space facilitates haphazard, serendipitous contact among people (JACOBS, 1969), and face-to-face contact (STORPER and VENABLES, 2003) creates an important advantage for urban areas.

Based on these insights the basic hypothesis of this article is that innovative firms in urban areas have a business model that favours open innovation and relies increasingly on external knowledge relations since the firms operate in an environment inducing them to act accordingly.

2.3. Additional factors: firm characteristics and the nature of innovation

Space related differences in the business model of open innovation and the use of external knowledge must not lead to neglect various other features that can influence this relation. The literature points to firm size, sector of activity, novelty of innovation and type of innovation.

Since Schumpeter firm size is coupled to innovative activities and enhances the ability to adapt to the environment, to create and to assimilate knowledge. It affects both knowledge and technology transfer because it involves identifying the appropriate sources, interacting with those sources, acquiring the knowledge and/or technology, and integrating them into

existing organisational systems and procedures (ZMUD 1982). Large firms are thought to embrace the model of open innovation to a greater degree than smaller ones. The latter sometimes lack a critical mass of absorptive capacity and – especially in the case of knowledge intensive firms – are less likely to be open to outside partners. These firms are often based on the exploitation of a new idea and, given the danger they face from leakage of their ideas, they limit the nature and scope of external interaction. They are also extremely resource constrained and may therefore lack the time and attention necessary to capture knowledge from external sources.

The second firm characteristic is the sector of activity of the firm. Pavitt (1984) established a taxonomy of four different sector types for manufacturing industry: science based, scale intensive, resource intensive and specialised suppliers. Tidd *et al.* (1997) added a fifth type (including services): the information intensive sector. From the perspective of differences in knowledge exchange – according to the taxonomy – geographical location matters because of differences in knowledge endowment opportunities. In this respect, it is supposed that science-based, specialised suppliers and information intensive enterprises prefer urban areas. On the other hand, scale intensive firms are assumed to locate outside urban areas because of the availability of physical space. For resource intensive firms the situation is ambiguous. On the one hand they seem to be less dependent on the urban environment and locate wherever the (natural) resources are available. On the other hand, they are attracted by the diversity of activities in urban areas hinted at by Jacobs (1969), Feldman and Audretsch (1999) and Simmie (2003).

As for the nature of innovation, a distinction should be made between the type of innovation (product versus process innovation) and the degree of novelty (incremental versus breakthrough innovation). Innovative firms in urban areas are found to be more involved in product innovation, whereas non-urban areas tend to have a bias towards process innovation.

Based on empirical evidence for Great Britain by Harris (1988), and by Kleinknecht and Poot (1999) for the Netherlands, innovative firms in urban areas are found to be more involved in product innovation, whereas non-urban areas tend to have a bias towards process innovation.

Breakthrough product innovations are supposed to be associated with a high degree of risk and uncertainty and, in the early stage of their life cycles, often undergo drastic changes due to unforeseen technical problems, consumer reactions, and actions by competitors. Thus firms are supposed to rely on specific 'new' insights that might be developed in collaboration with key players (universities, suppliers, customers, etc). Consequently, agglomeration advantages can be of considerable importance for the emergence of such innovations and for the probability of their success or failure. As such, urban areas are a better breeding place for this kind of innovation (KLEINKNECHT and POOT, 1992). In a later stage of a technology life cycle, agglomeration advantages may lose importance and production may be transferred to locations in more non-urban areas where factor prices are lower (MARKUSEN, 1985).

2.4. Research design

The preceding paragraphs hand down three dimensions to study the innovation strategies of firms: (1) its location in the urban structure; (2) the degree of openness of the innovator; and (3) its position vis-à-vis external knowledge relations. To understand the spatial organisation of innovation the urban structure is central. Hence the search for associations between urban structure and degree of openness; between urban structure and external knowledge relations; as well as the interaction effect between all these variables. This is reflected in the upper part of Figure 2. The lower part lists the control variables.

** INSERT FIGURE 2 ABOUT HERE **

All variables (printed in capitals) are categorical and have different levels. It is common to analyse these data through loglinear modelling. The number of enterprises is placed between brackets. The model in Figure 2 guides the analysis in the empirical section 4.

3. Data description: Community Innovation Survey and urban structure

3.1. Open innovation and external knowledge relations

The paper draws on data for Belgium gathered as part of the Third European Community Innovation Survey conducted in 2002 by the different member states of the European Union. The survey was organised by postal mailing and stratified according to firm size (measured in terms of employment), economic activity (following the International Standard for Industrial Classification), and geographical location (following the NUTS-classification and stratified at NUTS1 level). For the latter, the location of the economic activity rather than the location of the headquarters is the main criterion. The target population includes private enterprises with 10 or more employees, active in a broad range of sectors.

The survey provides information on the overall innovation activity by firms. Innovative firms have achieved at least one product and/or process innovation during the period 1998-2000. A representative sample of 1,274 innovating firms was retained. Their innovation activities include firm level data on the sources and acquisition of innovation, and collaboration in the field of innovation. A wide pallet of partner types are included both for collaboration and sources (including universities, public research organisations, competitors, clients, suppliers, etc.), painting the innovation networks of companies. The survey gathered information on the type (product and/or process) of innovations, and on the degree of novelty of innovations. The sector of activity and firm size are also known.

To capture ‘open innovation’ the respondents were divided into three types referring to the ‘degree of openness’, using the mutually exclusive answer on the question ‘who is *mainly*

responsible for the product and/or process innovation developed within the firm?' The possibilities are: mainly the enterprise (i.e. the 'closed' or 'in-house' innovator), the enterprise in collaboration with others (the 'co-developing' innovator), or mainly others (the 'outsourcing' innovator). A hierarchy in the degree of open innovation is imposed between these types in the sense that co-developing innovators are considered to be more 'open' than 'outsourcing' innovators. The reason is that the co-developing innovator maintains a deliberate two way interaction between the innovator and another party based on mutual trust and knowledge sharing. An innovator mainly outsourcing its innovation is, in turn, more 'open' than the firm mainly making its innovations in-house because there is an undeniable one way transfer of knowledge from outside the company. It is important to note that the degree of openness is only defined in terms of the realisation of the innovation.

In contrast with the division in terms of openness of innovation, the different forms of external knowledge relations are not mutually exclusive: each innovator can be involved in each of the three types of external knowledge relations. The sources of innovation are further divided into market sources, public sources and other sources. When it comes to acquisition, a distinction is made between buying external R&D, embodied technology, and intellectual property rights. Collaboration is divided into collaboration with market partners, public partners or partners operating in a technology market. Special attention is paid to these divisions further on. The mutual occurrence of these external knowledge relations implies that the research design will be tested for each of these relations separately.

3.2. Urban structure

Empirical research on the location of innovation evolves around the key notion of agglomeration. Based on the work of Lösch (AYDALOT, 1985 and FELDMAN and AUDRETSCH, 1999), urbanisation economies represent advantages gained by all firms,

regardless of sector, from being located together. The emphasis lies on the different assets of place for innovative effects stemming from the internal operating of geographic areas (FELDMAN and AUDRETSCH, 1999). Urbanisation economies can be regarded as a general form of localisation economies, which refer to advantages that firms in a single industry, or in a set of closely related industries, gain from being located in the same place. In the case of urbanisation economies, all firms benefit from a pooled market for knowledge workers in general, from more efficient suppliers to the industry in general, and from a more efficient provision of general research infrastructure. Reference can also be made to certain technological spillovers benefiting a whole range of sectors, as opposed to one particular sector.

The concept of 'urban structure' can be made useful to detect features of urbanisation economics. The hierarchical urban structure is the principal framework used to account for the extension and evolution of urbanisation processes in Belgium (VAN DER HAEGEN *et al.*, 1996, LEEMANS *et al.*, 1990). The urban structure consists of a classification of spaces defined by the combination of a variety of functional, morphological and dynamic criteria. The degree of urbanisation, together with socio economic and socio cultural data, determines a hierarchical pattern in the localisation of people within cities and villages. This hierarchical structure includes four areas: urban, suburban, commuter, and other.

The urban area is a morphological agglomeration defined by the continuity of residential dwellings (the threshold is 250 metres) around a central city characterised by a certain concentration of shops and services, a given density of population as well as the age and size of its dwellings. In the case of innovation, these surroundings provide a central feature of the knowledge base because most universities and public research infrastructure are located in this area.

The term 'suburban area' is used to define 'an area around the urban area'. Its definition is based on the population growth, the median income (relative to the district income), the importance of residential migration from the agglomeration, the travel to work and school flows, and finally the evolution of build-up surfaces. With regard to innovation, many of the knowledge workers with higher incomes reside in suburban areas because of the perceived higher quality of life (FLORIDA, 2002).

A ‘commuter area’ contains the municipalities where 15 % of the working population resides and migrates from, on a daily basis, towards the urban area. While suburban areas refer to the process of suburbanisation, the use of countryside areas refers to the residential commuter area. Again, in the light of innovation activities, the commuter areas are endowed with much more physical space to develop economic activities that require a large scale.

The final category consists of 'other' areas which are more or less of a rural nature. A good example of these type of areas can be found in the Southern part of Belgium (the Ardennes) which is far less populated and accessible due to the forests.

The urban structure capturing the overall attraction of municipalities in terms of a variety of socio-economic and cultural variables can be described through the classification of the 589 municipalities in Belgium in 17 city regions. Each of these city regions includes urban, suburban and commuter areas, and is to a high extent spatially independent from the other city regions. Of the 589 municipalities 98 are classified as urban areas; 117 as suburban areas; 160 as commuter areas; and the rest (214) as other areas. These categories make up the urban structure in Belgium as depicted in Figure 3. It shows that the urban structure classifies geographical areas all over the Belgian territory in four distinct categories. This results in a limited spatial dependency for the areas classified in the same category, and has important implications for the empirical analysis (see further). The Figure also illustrates that, although

distances are fairly small and there is an abundant supply of transport facilities, it is incorrect to refer to Belgium as a whole being an urban field.

** INSERT FIGURE 3 ABOUT HERE **

The innovation data provided by the Community Innovation Survey are linked to the urban structure by means of the postal code available for each innovative enterprise. Careful screening is done in order to take into account the location where the economic activity takes place rather than the location of the headquarters.

3.3. Control variables: firm characteristics and the nature of innovation

Control variables include, firm size, sector of activity, the degree of novelty of innovation and the type of innovation. Firm size is measured by the number of employees. Only enterprises of 10 or more employees are taken into account. Firms employing between 10 and 49 employees are classified as small. Large enterprises employ 50 or more employees.

The sector of activity is based on a conversion of the ISIC-classification used in the innovation survey in the adapted Pavitt taxonomy (see Annex 1). It differentiates between 'science based', 'specialised suppliers', 'resource intensive', 'scale intensive', and 'information intensive' firms.

Concerning the innovation characteristics (degree of novelty and type of innovation), the results of the Community Innovation Survey allowed a differentiation between enterprises realising only product innovations, those only involved in process innovation, and those specialised in both types of innovation. The degree of innovation (breakthrough versus incremental) was proxied by the fact whether the innovation was new to the enterprise only (incremental) or totally new for the market (breakthrough).

3.4. Data restrictions and robustness

The use of data provided by the Community Innovation Survey has its limitations. First, the survey captures an aggregate picture of firm innovation behaviour. Consequently, variations in innovation behaviour at the project level may be obscured. Secondly, due to the response burden it would generate, the analysis does not consider mutually exclusive activities for external knowledge relations (sources of innovation, acquisition of innovation or collaboration on innovation). The other variables considered (degree of openness of innovation, urban structure, firm size, sector of activity, degree of novelty and type of innovation) do not suffer from this problem. Furthermore, the interactions between the degree of openness of innovation and external knowledge relations on the one hand, and the type and degree of novelty of the innovation on the other hand can be troubled because of measuring both aspects within the same (two-year) time-span.

The analysis uses variables divided into discrete categories. It looks for possible associations and effects of interaction between the different variables in a multidimensional frequency table. The technique of loglinear modelling is well-suited for this and the number of observations (see Figure 2) allows doing so. The use of urban structure limits the problem of spatial dependency (in this case, the spatial reach of knowledge relations) and does not imply spatial econometrics.

4. Empirical analysis

4.1. Urban structure and open innovation

Table 1 links urban structure to degree of openness of innovation. There is a significant difference between urban and suburban areas on the one hand and commuter and other areas on the other. Innovators in the latter areas apparently are more open innovation minded. This difference is reflected in a higher preference for innovations together with third parties (co-developing) and, for 'other' areas, also in a higher propensity for relying on external parties

(outsourcing) for the development of innovations. The statistical dependency reveals that the degree of openness of innovation significantly differs for the four areas shaping the urban structure.

** INSERT TABLE 1 ABOUT HERE **

At a first glance, the results are not in line with those derived from the theoretical insights presented in the introduction. Innovating firms active in a more urbanised environment would be expected to have a business model for innovation that is more (and not less) open for interaction with the environment. All this because of the larger opportunities for positive spillovers from the presence of universities, public research centres, other enterprises, and services firms enhanced by a relatively better developed research infrastructure and knowledge networks. A closer look at the external knowledge relations (sources, acquisitions and collaborations) by urban structure could help explaining this finding.

4.2. Urban structure and external knowledge relations

4.2.1. Urban structure and the sources of innovation

Table 2 presents the external technology sources of innovation. For 1,256 out of the 1,274 firms information on their sources of innovation is available. Respondents could give multiple answers indicating more than one source. All taken together, no overall significant association is found between the type of external technology source used and the urban structure of the environment.

** INSERT TABLE 2 ABOUT HERE **

Market sources are very popular, except in the case of competitors. This might be caused by the need to protect innovation in order to benefit from it. Public information sources, which are mostly located in urban areas, are the least popular in all areas of the urban structure. The

other sources of innovation have an outspoken general character and are also a very popular channel.

4.2.2. Urban structure and acquisition of innovation

The innovation survey gathered information on three types of external technology offered on the market: external R&D, embodied technology and intellectual property rights. External R&D refers to the creative work to enlarge the stock of knowledge in the company needed to develop new products or processes. A company can also buy embodied technology offered on the market. In this case, advanced equipment, computer hardware, and specialised machinery is purchased in order to develop new products or processes. Finally, the firm can decide to buy intellectual property rights (patents, licences, trademarks, etc.) for the use of its innovation(s). These types are considered in Table 3.

** INSERT TABLE 3 ABOUT HERE **

According to the test of association, there is a difference in the dispersion of acquisition activities in relation to urban structure at a 10 % significance level. The acquisition of embodied technology is a common activity in all areas of the urban structure but occurs relatively less in the urban areas. Almost one third of all innovators have external R&D. Again, this is to a lesser extent the case in the urban areas. The reason might be that the knowledge base for enterprises in urban areas is larger than for enterprises operating in other areas.

4.2.3. Urban structure and collaboration on innovation

A limited number of innovating firms are involved in collaboration in the field of innovation. From the 1,274 firms in the sample, 380 collaborated on innovation. Firms restricting collaboration to the enterprise group were excluded, for it can be argued that in a lot of cases

this kind of collaboration is hardly external. Firms collaborating within the enterprise group in addition to other types of partners remained in the sample.

** INSERT TABLE 4 ABOUT HERE **

From the results in Table 4, no clear dispersion is noted according to the test of association. Overall, urban based universities are frequently solicited for collaboration (50.8% as compared to 36.9% when universities are considered as a source of innovation, Table 2). The opposite is the case for all market partners: suppliers, clients and competitors. This phenomenon could be explained by the idea that collaboration with these partners might lead to negative spillover effects and thus jeopardise profitability.

In sum, based on Tables 2, 3 and 4, no clear association between urban structure and the various external knowledge relations is found.

4.3. Urban structure, open innovation and external knowledge relations

Combining the pieces of the open innovation business model and the reliance on external knowledge relations in one model while bringing in the urban structure, allows looking for associations between the three components of the basic model as presented in the research design. Because external knowledge relations are not mutually exclusive each type of relation is modelled separately. The screening of the best loglinear model is done using a simple backward strategy. Starting from a saturated model where the frequency table is completely replicated ($L^2=0$), the Brown's screening method based on Akaike's and/or Bayesian information criterion (AIC and BIC) checks, in a hierarchical way, for non significant effects. This approach penalises for complexity and sample size and thus results in the most parsimonious model (that with the lowest L^2). The p-value indicates how well the model fits the data. A balance needs to be found between this goodness of fit (p-value) and the simplicity (AIC and BIC based on the L^2-statistic) of the model (HAGENAARS, J.A., 1990).

For the sake of brevity, this paper only reports the best model in terms of AIC and BIC which in all models did not contradict each other.

4.3.1. External sources of innovation

Figure 4 presents the three models depicting the relations between urban structure, degree of openness of innovation, and external sources of innovation (market or public or other – see section 4.2.1).

** INSERT FIGURE 4 ABOUT HERE **

The model including market sources shows a significant association between market sources and degree of openness of innovation, and between openness of innovation and urban structure. Apparently, firms mainly co-developing their innovations are significantly less involved in market sources. The opposite is true for innovators mainly outsourcing to complete their innovations.

A similar model appears when concentrating on the public sources of innovation. The association between degree of open innovation and public sources of innovation is also significant. Firms outsourcing their innovation use significantly less public sources. The opposite is true for firms co-developing their innovations and to a lesser extent (at 10% significance level) also for in-house innovators. These results are in line with the findings in Table 1.

Other sources, although often used as external technology source (Table 2), are not related to urban structure, nor to the degree of open innovation. This is an indication that these sources are equally present in all areas and for all degrees of open innovation. This should not come as a surprise since meetings and magazines and fairs and exhibitions are presumably the easiest sources to access.

4.3.2. Acquisition of innovation

Figure 5 presents the results of three separate loglinear models for each type of acquisition (external R&D, embodied technology, intellectual property rights), urban structure and the degree of openness of innovation.

** INSERT FIGURE 5 ABOUT HERE **

Firms mainly co-developing their innovation with third parties, rely significantly more on acquisition of external R&D and of intellectual property rights. In the case of external R&D, the opposite is true for 'outsourcing' innovators. In-house innovators, on the other hand, are significantly less involved in the acquisition of embodied technology. Furthermore, the latter form of acquisition occurs significantly less in urban areas. These differences offer a partial explanation for the rather odd finding in Table 1 i.e. innovators tend to have a more 'closed' innovation strategy in urban areas. A larger part of the innovating firms in other areas tend to rely on embodied technology which is rather easy commercialised, whereas firms in urban areas tend to be more oriented towards the acquisition of external R&D and intellectual property rights referring to innovation requiring more in-house absorptive capacity before it can be translated into potential commercial success. However, these results can not explain as to why there are more firms co-developing their innovations with third parties in the less urbanised areas.

4.3.3. Collaboration on innovation

Figure 6 presents the results of the loglinear models for collaboration (collaboration with market partners, public partners and partners active on the technology market), urban structure, and degree of open innovation.

** INSERT FIGURE 6 ABOUT HERE **

Firms mainly co-developing their innovations tend to rely more on collaboration with market partners in comparison to firms mainly outsourcing their innovations. The finding in Table 4 that collaboration with competitors (and more generally market partners) is more preferred in urban areas in comparison to other areas, possibly refers to larger opportunities for economies of agglomeration in urban areas than in non-urban areas. As such, it corroborates the ideas mentioned in the theoretical framework.

In the case of collaboration with public partners or with partners operating in the technology market there is a significant association between urban structure and openness of innovation. When it comes to the subset of collaborating firms – from the 1,274 innovative firms, only 380 firms are involved in collaboration – this association seems to hold.

The lack of differences in public and technology market collaboration for each area could be an indication that in an economy with dense infrastructure and good telecommunication networks, accessibility of this kind of knowledge is homogeneously distributed.

In sum, testing the association 'urban structure – open innovation – external knowledge relations' reveals significant associations between the business model in terms of openness to innovation and the use of external knowledge sources, and between openness of innovation and urban structure. With the exception of the acquisition of embodied technology, no links are found supporting a direct association between external knowledge relations and urban structure (see Table 2, 3 and 4). Therefore, differences in the business model in terms of open innovation are associated with differences in urban structure rather than with differences in external knowledge relations (confirming the results obtained in section 4.1 and 4.2).

4.4. Taking into account firm characteristics and the nature of innovation

In extension of the basic model, firm size, sector of activity, degree of novelty of innovation and type of innovation are included to verify whether these characteristics change the associations between urban structure (U) – openness of innovation (O) – and external knowledge relations (E = I, A or C). Only changes in the associations as they appear in section 4.3 are reported. The distinction between (the sublevels of the) sources, acquisition and collaboration on innovation is maintained.

4.4.1. Sources of innovation

Section 4.3.1 revealed an association between urban structure and openness of innovation for all types of innovation sources. For market and public sources, a significant association is detected between open innovation and the innovation source itself (this is referred to as the basic model in Table 5).

** INSERT TABLE 5 ABOUT HERE **

The inclusion of size exerts no influence on the basic model for each of the three types of sources. The same can be said for the breakdown between breakthrough and incremental innovations (degree of novelty of innovation).

The inclusion of the sector of activity through the enlarged Pavitt taxonomy confirms the associations detected in the basic model between open innovation and innovation source (OI). On the other hand, the association between urban structure and open innovation (UO) seems to run indirectly via the sector of activity: open innovation is significantly associated with the sector of activity which is in turn associated with urban structure. As it appears, it is the transitivity of this association which results in the association between urban structure and open innovation (UO) in the basic model. This transitivity phenomenon is also present in the relation between urban structure and openness (OU) when adding the type of innovation (T).

Regarding the latter, however, it should be noted that the direct relation between urban structure and openness (UO) seems to hold in the case of market sources.

4.4.2. Acquisition of innovation

Looking at the acquisition of innovation, associations mainly exist between urban structure and openness of innovation (see section 4.3.2.): the degree of openness differs according to the urban structure the firms are located in (UO). Inclusion of firm (S and P) and innovation characteristics (D and T) reveals that the association between urban structure and open innovation (UO) is indirect and runs via the sector of activity and via the type of innovation. These results are summarised in Table 6.

** INSERT TABLE 6 ABOUT HERE **

The association between open innovation and type of acquisition holds for external R&D with the inclusion of the additional characteristics. For IPR, however, the association (OA) vanished by the introduction of firm size (with which it presented a significant association) and degree of novelty of innovation, and became transitory for the type of innovation. In the case of embodied technology, the inclusion of the degree of novelty of innovation and the type of innovation rendered the models insignificant.

4.4.3. Collaboration on innovation

The basic model showed significant associations between urban structure and openness of innovation (UO), and between openness of innovation and collaboration with market partners (OC). The absence of association between urban structure and public collaboration also deserves attention. Inclusion of firm and innovation characteristics has no significant impact on the association between open innovation and collaboration (OC) in the case of collaboration with market partners (Table 7). With the exception of the inclusion of the type

of innovation, the same can be said for the association between urban structure and open innovation (UO).

** INSERT TABLE 7 ABOUT HERE **

For innovation partners operating in the technology market, the association between urban structure and open innovation holds when including firm size, sector of activity and degree of novelty of innovation. Only the type of innovation renders this association insignificant.

Finally, for collaboration with public partners, the expected – albeit absent – association in the basic model between urban structure and collaboration with public partners did not appear when including the additional characteristics. The relation only indirectly pops up when including the sector of activity and the type of innovation.

The results presented in Tables 5 to 7 indicate that the associations between urban structure and open innovation are indirectly related. They are both influenced by the sector of activity and by the type of innovation. Regarding the former, these influences depend on the type of external knowledge relation and lacked significance in case of collaboration.

5. Conclusions and directions for future research

The aim of this paper was to establish differences between innovative firms (in terms of external knowledge relations and in terms of the business model for open innovation) related to urban structure.

A significant association was found between the business model for open innovation (differentiating between the ‘in-house’, ‘outsourcing’, and ‘co-developing’ innovator) and urban structure. Contrary to the literature, it turned out that firms in less urbanised areas have a more open business model for innovation which was reflected in a higher presence of both outsourcing, and co-developing innovators.

The association between urban structure and the use of external knowledge relations (including sources, collaboration and acquisition) proved insignificant. External knowledge relations, though, seemed to be highly associated with open innovation. In this respect, 'co-developing' innovators rely significantly more on the acquisition of external R&D and intellectual property rights. 'Outsourcing innovators' were found to be significantly more oriented towards the acquisition of embodied technology and to rely less on external R&D to perform their innovations. For 'in-house' innovators the opposite is true. Taking into account that different forms of acquisition have different requirements in terms of absorptive capacity, this indicates a different innovation strategy according to the business model for open innovation.

The addition of firm characteristics and a refinement of the nature of innovation revealed that firm size and the degree of novelty of innovation (breakthrough versus incremental innovation) did not significantly influence the association between the business model for open innovation, external knowledge relations and urban structure. The type of innovation (product versus process innovation) and the sector of activity (in terms of Pavitt taxonomy) did have an impact on this relation but did not make the urban structure redundant.

There are several limitations to this study which deserve attention in future research. First, further work should appreciate the innovation project itself as a tendency exists towards more openness in simple or discrete technologies that are relatively easy to master (NELSON and WINTER, 1982). A project rather than a firm based approach (here proxied by means of differentiation between incremental and breakthrough innovators) could clarify this.

Secondly, extra attention should be paid to the relation between openness of innovation and strategic efforts in order to capture the returns on innovation bearing in mind the tensions between openness and appropriability of the results of the innovation.

A third challenge is to include the dynamics over time in the networking behaviour of innovative firms, as argued by Chesbrough. These dynamics are needed to search for causal relations.

Bearing in mind the limitations of the analysis and the suggestions for further research, an important conclusion for policy makers that could be drawn from this paper is the significant relation between urban structure and business attitude towards open innovation. For (regional) policy makers, it is an indication that the facilitation of the – transitory – process towards more open innovation minded business models depends, at least partly, on the socio-economic and cultural environment as measured by the urban structure approach.

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Table 1. Relation between urban structure and the degree of openness of innovation – in column percentages

Degree of openness	Urban structure				All respondents
	Urban areas	Suburban areas	Commuter areas	Other areas	
In-house innovator	58.1	58.0	48.3	46.8	53.5
Outsourcing innovator	13.3	12.0	13.3	18.2	14.4
Co-developing innovator	28.6	30.0	38.4	35.0	32.1
Number of observations	573	150	211	340	1274

Note: Chi-square = 17.401 and p = 0.008

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.

Table 2. External technology sources by type of source of innovation and by urban structure – in %

External technology sources		Urban structure				National total
		Urban areas	Suburban areas	Commuter areas	Other areas	
Market	Suppliers	72.9	76.0	72.9	78.2	74.7
	Clients	68.8	67.8	66.2	68.4	68.2
	Competitors	55.3	53.4	51.2	51.9	53.5
Public	Universities	36.1	37.7	39.6	36.1	36.9
	Government	25.5	21.2	21.7	21.8	23.4
Other	Meetings and magazines	66.7	70.5	61.8	62.7	65.3
	Fairs and exhibitions	66.7	69.9	72.9	71.6	69.4
Number of observations		568	146	207	335	1256

Note: Chi-square = 6.875 and p = 0.991

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.

Table 3. Acquisition of innovation by type of activity in relation to the urban structure – in %

Type of acquisition	Urban structure				National total
	Urban areas	Suburban areas	Commuter areas	Other areas	
External R&D	29.2	32.4	33.6	37.7	32.6
Embodied technology	62.2	70.3	71.1	68.0	66.2
Intellectual property rights	26.6	20.3	24.6	21.1	24.0
Number of observations	561	148	211	337	1257

Note: Chi-square =10.960 and p=0.090

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.

Table 4. Type of partner in collaborating on innovation by urban structure – in %

Type of partner		Urban structure				National total
		Urban areas	Suburban areas	Commuter areas	Other areas	
Market	Suppliers	65.1	68.8	68.3	70.9	67.4
	Clients	54.3	58.3	46.7	50.0	52.6
	Competitors	34.9	20.8	28.3	24.4	29.7
Public	Universities	50.0	56.3	51.7	48.8	50.8
	Government	29.0	14.6	28.3	29.1	27.1
Technology market	Consultants	45.2	29.2	30.0	41.9	40.0
	R&D labs	25.8	20.8	35.0	34.9	28.7
Number of observations		186	48	60	86	380

Note: Chi-square =16.422 and p=0.563

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.

Table 5. Urban structure, degree of openness of innovation, external source (market - public - other) and firm characteristics and features relating to the nature of innovation – Loglinear models, results.

	Source of innovation (I) - N = 1,256		
	Market	Public	Other
Basic model*	UO, OI (L^2=14.61; p=0.10)	UO, OI (L^2=6.56; p=0.68)	UO, I (L^2=11.81; p=0.38)
Firm size (S)	UO, OI, OS (L^2=36.92; p=0.18)	UO, OI, IS (L^2=25.76; p=0.73)	UO, OS, IS (L^2=23.46; p=0.83)
Economic activity (P)	OI, OP, UP (L^2=95.12; p=0.26)	OI, OP, UP, IP (L^2= 85.68; p=0.40)	OP, UP, I (L^2=86.97; p=0.57)
Degree of novelty (D)	UO, OID (L^2=30.29; p=0.30)	UO, OI, OD, ID (L^2=21.22; p=0.85)	UO, OD, ID (L^2=20.57; p=0,92)
Type of innovation (T)	UO, OI, OT, IT, UT (L^2=56.87; p=0.08)	OI, OT, UT, IT (L^2= 49.18; p=0.47)	OT, UT, IT (L^2=66.58; p=0.07)

* Basic model = urban structure (U) – openness of innovation (O) – external knowledge relation (source, I), section 4.3.1

Table 6. Urban structure, degree of openness of innovation, acquisition (external R&D - embodied technology - IPR) and firm characteristics and features relating to the nature of innovation – Loglinear models, results.

	Acquisition of innovation (A) - N = 1,257		
	External R&D	Embodied technology	IPR
Basic model*	UO, OA (L^2=7.56; p=0.58)	UO, OA, UA (L^2=5.31; p=0.50)	UO, OA (L^2=11.69; p=0.23)
Firm size (S)	UO, OA, AS (L^2=28.92; p=0.57)	UO, OA, AS (L^2=36.98; p=0.21)	UO, AS (L^2=42.88; p=0.12)
Economic activity (P)	OAP, UP (L^2=74.07; p=0.51)	OA, OP, UP, AP (L^2=81.88; p=0.51)	OA, OP, UP, AP (L^2=91.79; p=0.24)
Degree of novelty (D)	UO, OA, OD, AD (L^2=21.74; p=0.83)	-	UO, OD, A (L^2=26.38; p=0.75)
Type of innovation (T)	OA, OT, UT, AT (L^2=48.72; p=0.48)	-	OT, UT, AT (L^2=55.72; p=0.30)

* Basic model = urban structure (U) – openness of innovation (O) – external knowledge relation (acquisition, A), section 4.3.2

Table 7. Urban structure, degree of openness of innovation, type of collaboration on innovation (market – public – technology market) and firm characteristics and features relating to the nature of innovation – Loglinear models, results.

	Collaboration on innovation (C) - N = 380		
	Market	Public	Technology market
Basic model*	UO, OC (L^2=5.87; p=0.75)	UO, C (L^2=3.78; p=0.97)	UO, C (L^2=8.90; p=0.63)
Firm size (S)	UO, OC, S (L^2=29.83; p=0.58)	UO, CS (L^2=38.28; p=0.24)	UO, C, S (L^2=30.33; p=0.65)
Economic activity (P)	UOP, OC (L^2=57.45; p=0.22)	UO, UP, CP (L^2=91.68; p=0.35)	UO, OP (L^2=109.64; p=0.10)
Degree of novelty (D)	UO, OC, OD (L^2=19.45; p=0.93)	OCD, U (L^2=42.42; p=0.13)	UO, OD, CD (L^2=34.33; p=0.31)
Type of innovation (T)	OC, UT, CT, OT (L^2=47.57; p=0.53)	CT, UT, OT (L^2=48.32; p=0.58)	UT, OT, CT (L^2=54.50; p=0.34)

* Basic model = urban structure (U) – openness of innovation (O) – external knowledge relation (collaboration, C), section 4.3.3

Annex 1. Classification of sector of activity: adapted Pavitt taxonomy

SCIENCE BASED	SPECIALISED SUPPLIERS	RESOURCE INTENSIVE
Aerospace	Non-electrical machinery	Food, beverages and tobacco
Primary sector (biotech)	Electronics-communications	Textile and clothing
Computers, office machinery	Electrical machinery	Wood and furniture
Scientific instruments	Financial intermediation	Petroleum refining
Pharmaceuticals	Postes	Non-ferrous metals
	Transport	Non-metallic mineral products
SCALE INTENSIVE	Business services	Fabricated metal products
Paper printing	Wholesale	Recycling
Rubber and plastic products		Construction
Chemicals	INFORMATION INTENSIVE	Gas, water, electricity
Motor vehicles	Computer and related activities	Other manufacturing
Ferrous metals	Telecommunications	
Shipbuilding	Research and development	
Other transport equipment	Technical engeneering	

Sources: Pavitt, 1984; Tidd *et al.*, 1997; Kristensen, 1999.

Figure 1a: The closed innovation model

Source: CHESBROUGH, 2003: xxii and xxv.

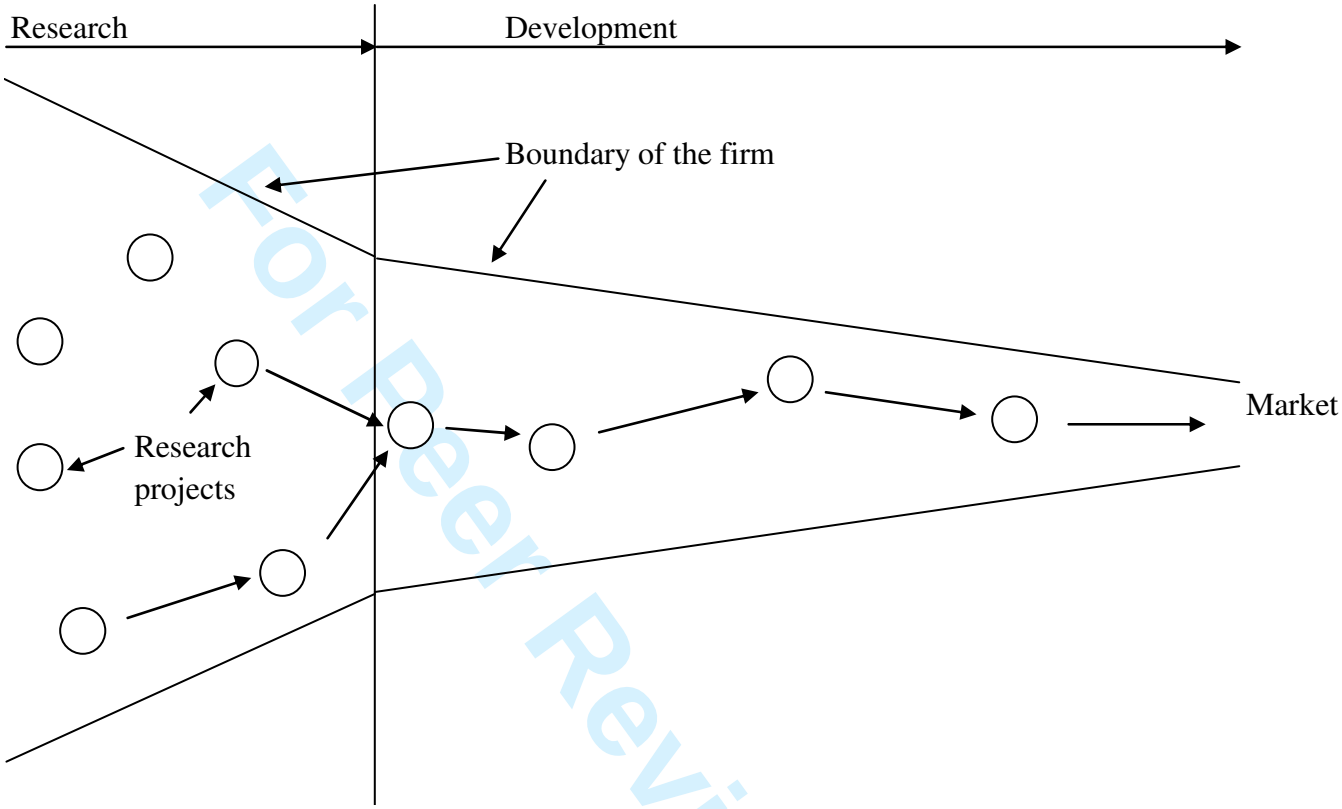


Figure 1b: The open innovation model

Source: CHESBROUGH, 2003: xxii and xxv.

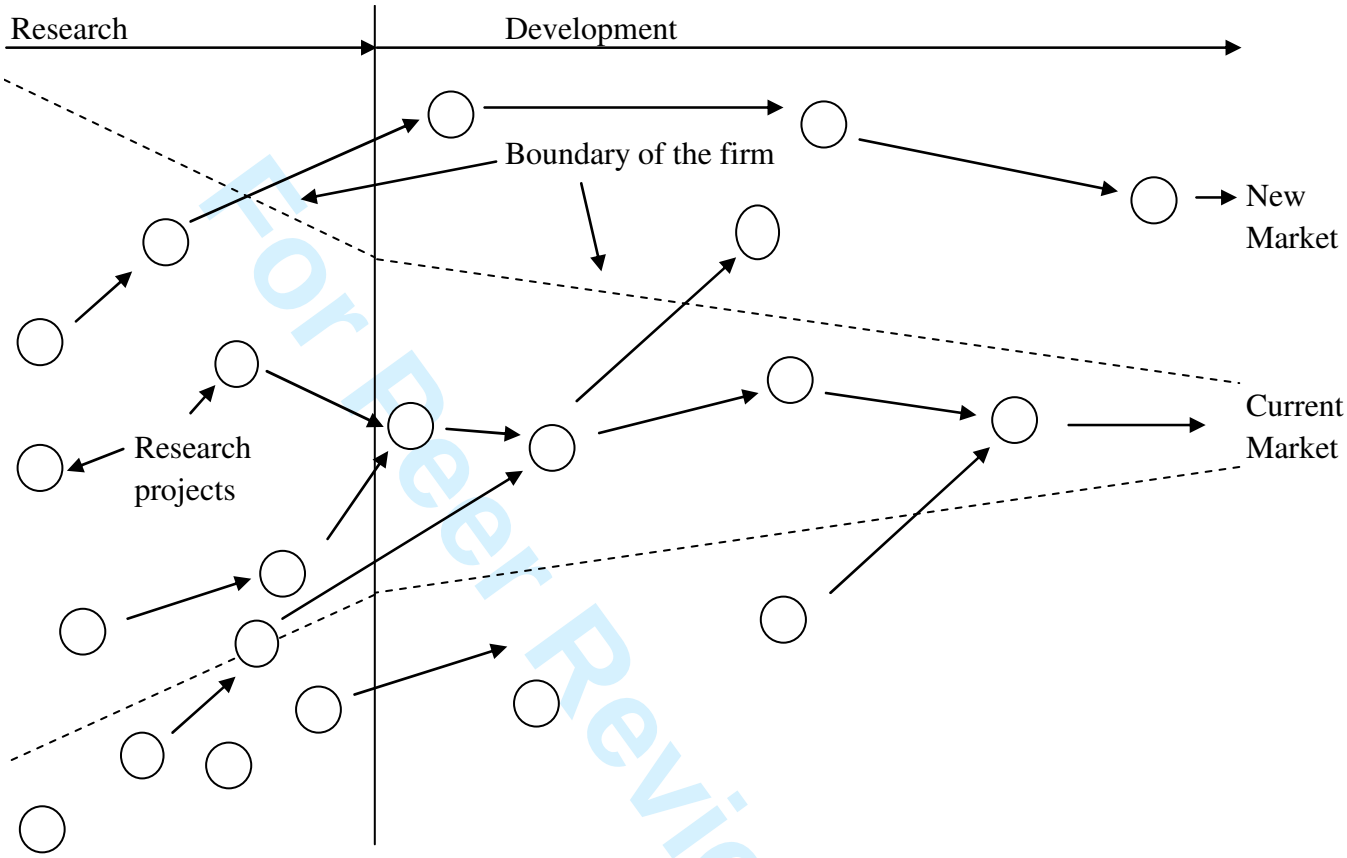


Figure 2: Conceptual framework of this study

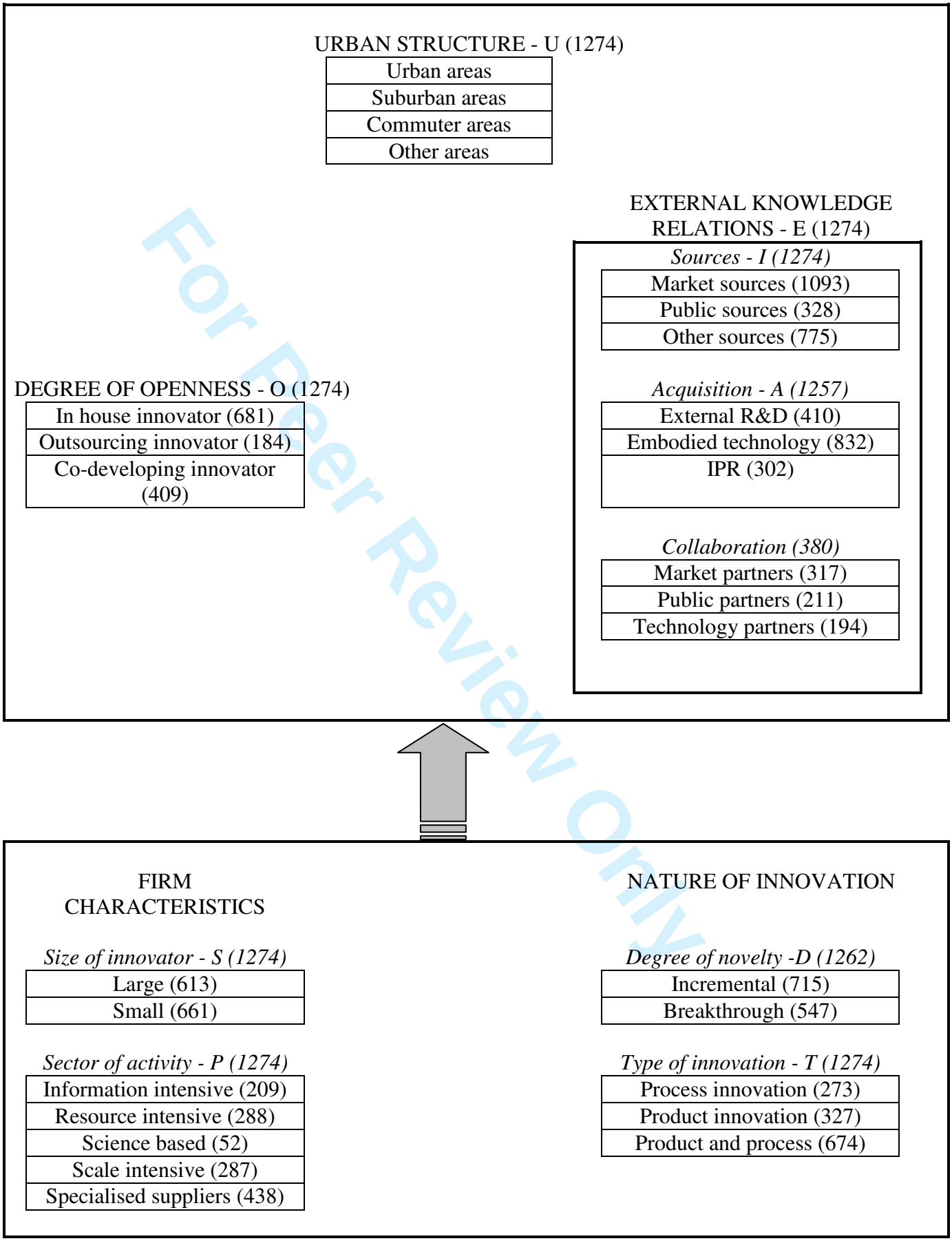


Figure 3: The urban structure of Belgium

Source: Van der Haegen *et al.* (1996)

Figure 4: Urban structure, degree of openness of innovation and external source (market - public - other) – Loglinear models, results.

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.

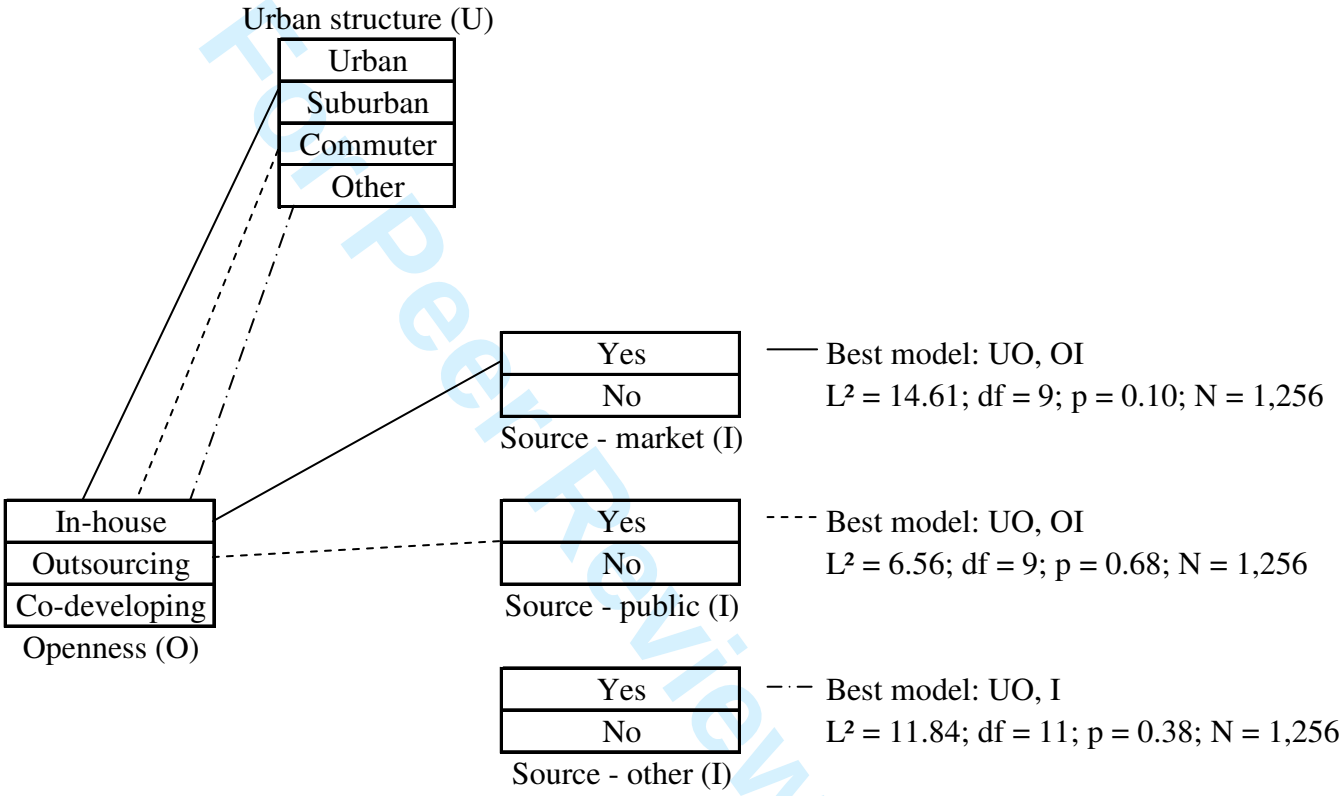


Figure 5: Urban structure, degree of openness of innovation and acquisition (external R&D - embodied technology - intellectual property rights) – Loglinear models, results.

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.

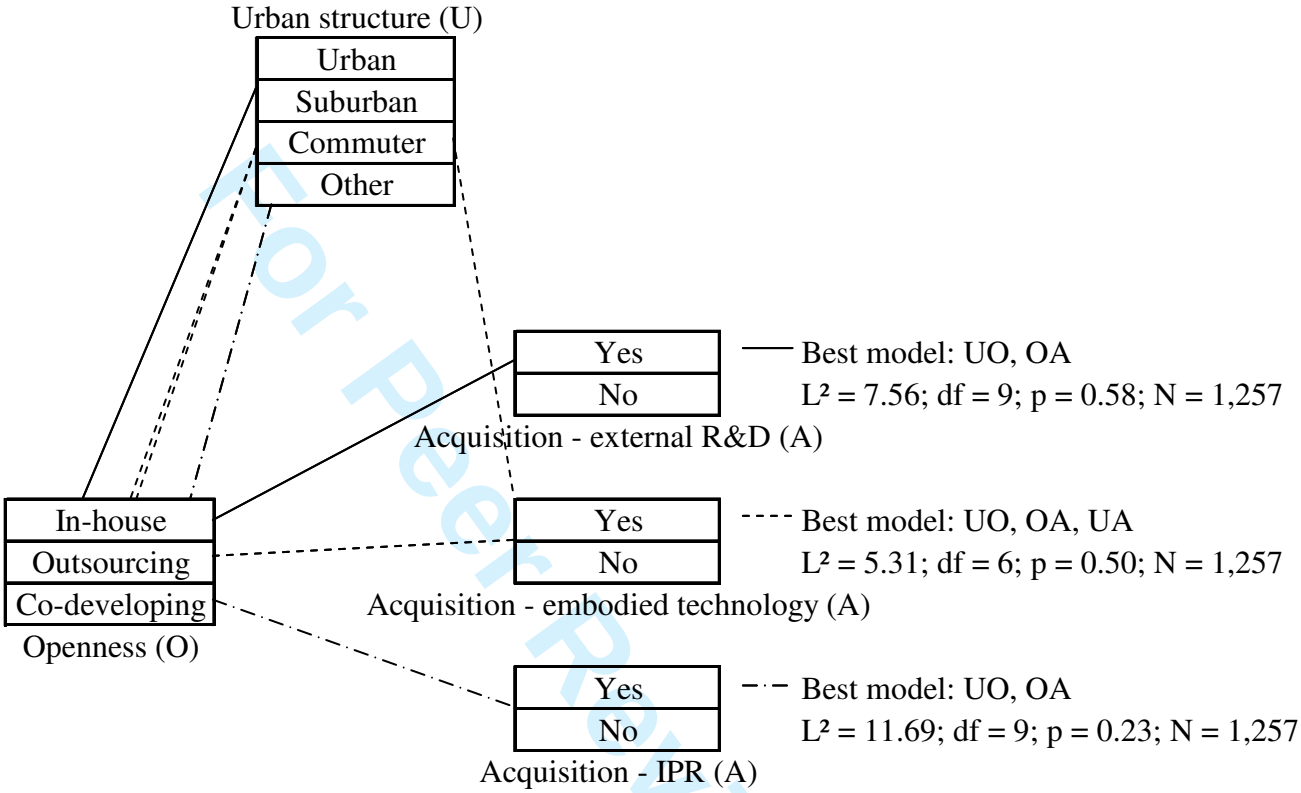
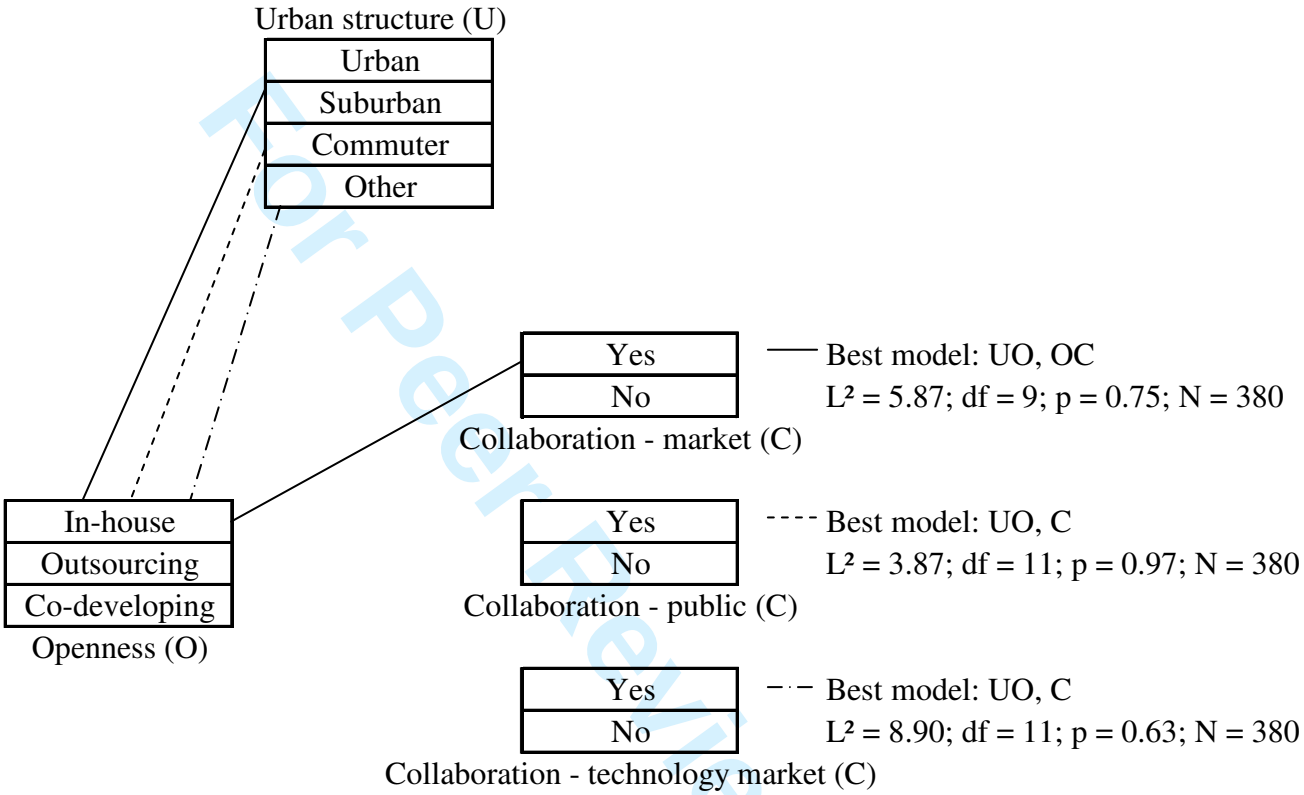
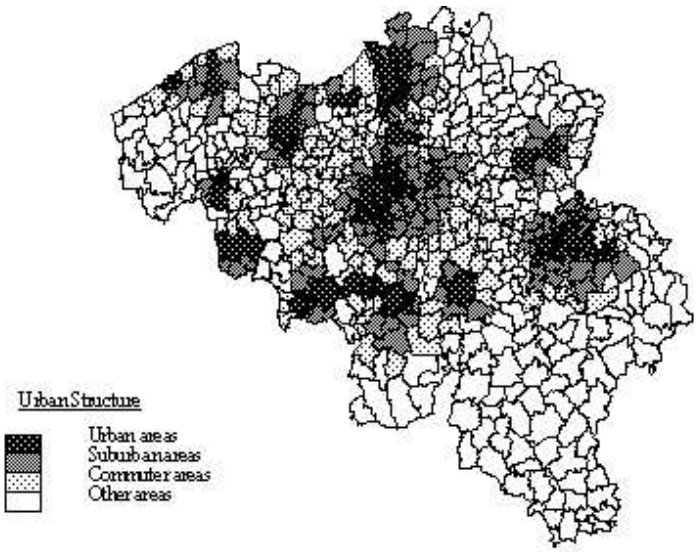


Figure 6: Urban structure, degree of openness of innovation and collaboration (market - public – technology market) – Loglinear models, results.

Source: Third Community Innovation Survey, Belgium, 2002. Own calculations.




Urban Structure
Urban areas
Suburban areas
Commuter areas
Other areas