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Conference Paper

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45th Congress of the European Regional Science Association: "Land Use and Water Management in a Sustainable Network Society", 23-27 August 2005, Amsterdam, The Netherlands

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Van Geenhuizen, Marina (2005) : Agglomeration Economies and Heterogeneity within Young Innovative Companies, 45th Congress of the European Regional Science Association: "Land Use and Water Management in a Sustainable Network Society", 23-27 August 2005, Amsterdam, The Netherlands, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

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Agglomeration Economies and Heterogeneity between Innovative Young Firms

Marina van Geenhuizen*

Abstract

This paper fits into a new trend in management studies in which a stronger attention is paid to heterogeneity between innovative companies, for example within sectors. This heterogeneity stems *inter alia* from different strategies, apparent in different business activity; different experiences of the companies at their start; and different networks through which external resources can be accessed. In this paper we adopt this focus on heterogeneity in a study of urban agglomeration economies. A central position is given to the nature and importance of urban agglomeration economies on the micro-level and the concomitant degree of location-boundness (or footlooseness). The following questions will be addressed: (1) Which factors determine the degree of location-boundness? To what extent is there heterogeneity within economic sectors? (2) What is the importance of local knowledge spillovers and to what extent is a low importance compensated by a high importance for access to global knowledge? (3) Which differentiation can be seen in the spatial coverage of agglomeration economies? To answer these questions, we utilized 21 in-depth case studies in a selected sample of innovative companies in large cities in the Netherlands. We made use of rough set analysis, a classification method that typically fits small samples and qualitative data. The structure of the paper is as follows. After the introduction and problem statement, we introduce key notions from agglomeration theory and resource-dependence theory. We then clarify the nature of the empirical research. The results of the empirical study and the evaluation of these results are presented next. The paper concludes with a summary and an indication of potential future research steps.

Key words: agglomeration economies; heterogeneity, innovative companies; rough set analysis; The Netherlands.

Acknowledgement: this study benefits from a grant of the Netherlands Organisation for Scientific Research (project number: 014-43-616-P).

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1. Diminishing Power of Agglomeration Economies?

In the past decades a considerable attention has been given to agglomeration economies. Introduced by Marshall in the 1880s, the concept has been “reinvented” by authors on the new industrial districts since the 1980s and was given a central position in the “new economic geography” in spatial economic models based on monopolistic competition (e.g. Krugman, 1991, in Parr, 2002). Furthermore, it plays a critical role in the field of urban and regional policy, particularly in those development strategies based on clusters of economic activity (e.g. Porter, 1998). In this paper, we will focus on the type of urban agglomeration economies that is of interest for innovative companies and lies at the heart of urban incubation hypotheses (e.g. Acs, 2002; Davelaar, 1990). The external economies of scale and scope concerned follow from the spatial concentration of similar and dissimilar industries and include pools of skilled labour, the possibility of knowledge spillovers, the possibility to share public utilities (infrastructures), and access to specialist services and a sufficiently large market to test the product.

The relevance of external economies is increasingly questioned to date, not at least due to the growing influence of modern information and communication technology (ICT). Modern ICT has attracted attention from many researchers and policymakers in urban geography and urban economics (e.g. Glaeser, 1998; Graham, 1998; Malecki, 2002) because of their potential distance ‘shrinking’ character. It is often argued that ICT (particularly, the Internet) is profoundly changing the space-economy while decreasing the benefits from agglomeration economies, particularly those of knowledge spillovers. The application of ICT in business transaction means a quicker and denser communication and a tighter co-ordination within and between companies and customers. ICT allows for outsourcing and relocation of more activities and over larger distances than in the past. In addition, ICT - and the Internet - enables a shortening of value chains by the elimination of wholesale and retail activities in particular places (e.g. van Geenhuizen, 2004a; Kenney and Curry, 2001). Also, the rise of new types of companies (virtual or network-based) has been a new phenomenon creating companies that have a minimum of tangible assets of their own and organise assets at other companies’ places (contractors, partners) in a flexible and

loosely coupled way, thereby heavily using ICT. Such companies seem to be footloose to a certain extent and to have more flexibility in their location behaviour than traditional companies. Altogether, we tend to observe a trend of decreasing importance of agglomeration economies in production activities. At the same time, it needs to be recognized that the use of ICT is still limited due to various practical problems. There seems only substitution between physical and virtual activities, if the communication and connected economic activity are non-material and sufficiently standardised, and if there is sufficient trust between the interacting partners. If the interaction is concerned with negotiation and unique problem-solving issues, or with risk-taking activities, electronic communication is facing basic shortcomings and too high costs (e.g. van Geenhuizen, 2004b).

The above considerations may imply that agglomeration economies remain a key attraction factor of cities for young and innovative entrepreneurs, mainly based on knowledge spillovers (see, e.g. Audretsch, 1998) but that to a certain extent these attraction factors work differently for different types of companies and have a different spatial coverage, in the sense of different kinds of urban places. Given the previous somewhat contradictory assumptions, we attempt to clarify the current relevance of agglomeration economies for young, innovative companies located in urban areas, by addressing the following questions:

- (1) Which factors determine the importance of agglomeration economies? To what extent is there heterogeneity within economic sectors?
- (2) What is the importance of local knowledge spillovers and to what extent is a low importance compensated by a high importance of access to global knowledge?
- (3) Which differentiation can be seen in the spatial coverage of agglomeration economies?

The structure of the paper is as follows. After the introduction and problem statement in the present section, we introduce key notions from agglomeration theory and resource-dependence theory. We then clarify the nature of the empirical research, including the method of analysis: rough set analysis. The results of the empirical study and the evaluation of these results are presented next, including determinant factors of

agglomeration economies and heterogeneity concerned, the importance of local knowledge spillovers, and the spatial coverage of agglomeration economies. The final section concludes with a summary of the findings and addresses a few next steps in the research.

2. Theories on Agglomeration Economies

In this section we derive views on agglomeration economies from two theoretical lines of thinking: (1) agglomeration theory and related cluster perspectives dealing with the supply-side of cities, and (2) resource-based theory dealing with the needs of companies for specific business resources. In addition, we pay attention to the conceptualisation of “location-bounded and footloose” in a modern urban setting.

According to agglomeration theory, cities provide advantages of knowledge spillover effects and an abundant availability of knowledge workers in the labour market (Acs, 2002). The spatial concentration of economic activities, involving spatial and social proximity, increases the opportunities for interaction and knowledge transfer, and the resulting spillover effects reduce the cost of obtaining and processing new knowledge. In addition, knowledge workers preferably interact with each other in agglomerated environments to reduce interaction costs, and they are more productive in such environments (Florida, 2002). Following this argumentation, cities are the cradle of new and innovative industries. Companies in the early stages of the product and company lifecycle – when dealing with manifold uncertainty - prefer locations where new and specialized knowledge is abundantly available for free (see, e.g. Audretsch, 1998; Camagni, 1991). It is also widely recognized that the spatial extent of knowledge spillovers is limited due to various kinds of geographic borders, e.g. a daily activity system where people meet easily and where people change jobs in their careers, or smaller areas such as quarters in a central business district or university premises where people see each other by chance (e.g. Rosenthal and Strange, 2001). However, there is not much clarity about the precise spatial constraints of knowledge spillovers. In addition, the need for spatial proximity to enjoy knowledge spillovers, seems at odds with the impacts of the recent telecommunication revolution, i.e. the costs of electronic communication have drastically declined, while advanced ICT

allows for long-distance videoconferencing, data-mining, virtual design, computer-assisted decision-making, etc.

The solution for this paradox on localization of knowledge spillovers seems to be lie in the type of knowledge concerned (Howells, 2002). On the one side, there is codified knowledge (partly just information) that can easily circulate electronically over large distances, like prices determined at a stock exchange and statistical data. On the other hand, there is tacit knowledge and its social context, and these are critical in innovation processes. The knowledge concerned is vague and difficult to codify and, accordingly, spreads mainly through face-to-face contact of the persons involved. Tacit knowledge is transferred through observation, interactive participation and practice and is understood through its social context. Contextual knowledge is achieved through longstanding and interactive learning, often in relatively open (unstructured) processes and seems influenced by the institutional setting of the economic activity concerned (Bolisani and Scarso, 2000; Gertler, 2003). Accordingly, tacit knowledge and its social context cannot be transferred and shared through telecommunication and, therefore, require proximity or for personal visits over a distance between people sharing the same social context. These observations call for alternative analytic perspectives, which we find in a combination with resource-dependence theory.

In general, high-technology small companies are facing strong needs for new knowledge, i.e. about the technology concerned, about dealing with the market, and about management and business strategy, but it needs to be stressed that these companies cannot generate all this knowledge by themselves (e.g. Locket and Thompson, 2001; Reid and Garnsey, 1998). In this context, Storper and Venables (2002) distinguish between various functions of tacit knowledge circulating in cities, like co-ordination, confirmation and check, and monitoring. In modern versions of resource-dependence theory it is acknowledged that companies make use of various bundles of resources on a temporary basis, including knowledge, capital, employees and networks, to generate profits. Success in generating profits depends both on the companies' own capabilities and the supply of resources in their environment (e.g. Barney, 1991), including the urban environment. The growth of companies is

constrained if there is a shortage or weakness in the available resources, or in the capability to mobilise or generate adequate resources. Reid and Garnsey (1998) distinguish between different stages in growth in this respect, running from achieving access to resources, to the mobilisation of resources and the own generation of resources. The use of the right combination of resources at the right time by young, innovative entrepreneurs enables them to undertake a jump in growth (next development stage). Failing to use the right combination at the right time may cause a delay in growth and even a fall back into previous stages (Vohora et al., 2004). In the early growth stages and after a fall back to such stages, companies may heavily rely on resources available in the environment, including the urban environment. In this paper we assume that young, innovative companies face larger needs for local resources (knowledge) if they undertake relatively risky activities and have a limited capability in mobilising external resources or generating resources by themselves; the latter may be due to e.g. an early growth stage (young age) or independent position without support. They also may face different needs, dependent upon diversity in opportunities seen and different available internal resources. A focus on such differentiation is increasingly acknowledged today in management studies (e.g. Druilhe and Garnsey, 2004) and calls for more appropriate applied work.

A thorough conceptualisation of the situation in which companies are free from location constraints is scarce (van Geenhuizen, 2004c). The term footlooseness is often used in this context but it is poorly conceptualised with regard to companies (see e.g., van Oort et al., 2003). An early use of the term footloose can be found in the work of Klaassen (1967). Accordingly, an industry is footloose, if its long run profitability is the same for any location in an economy. This is a quite rigorous definition that excludes different degrees of footlooseness. We may consider here footloose as the situation at one end of a spectrum with location- or place-bound at the other end. This allows for distinguishing various degrees of footlooseness and for emphasising the relative character of footlooseness. Thus, “being increasingly footloose” means in the discourse on agglomeration economies that particular constraining factors that were active in the past, like the need for proximity to knowledge institutes, specialised suppliers and specialised labour, decrease in importance, allowing companies to choose a location under higher degrees of freedom

within a certain spatial area. Note that footlooseness is often relative to a particular area or scale in consideration. For example, companies may be footloose with respect to their city-region, but not with respect to the national system or continent. In our study we will focus on footloose (and its counterpart location-bound) with respect to the city-region.

3. Nature of the Empirical Study

The research design of this study employs an inductive approach in which a selected set of representative case studies is carefully investigated by means of non-parametric methods. The case study design permits a logic in the sense of “replication”, allowing the case analysis to be treated as a series of independent experiments (Yin, 1994). “Carefully selected” means that the selected companies hold different positions on those factors that are assumed to influence needs for proximity, according to the previously indicated theoretical views, like age of the company and innovative level. For example, in the biotechnology sector we selected genuine research companies (a long development path of new medicines often in global alliances) and service companies (shorter development paths in innovation often on demand of customers). Different positions on such factors are assumed to reflect different resource needs and different capabilities to generate resources or achieve external resources. The variance enables us to investigate the possibility of “replication logic” across cases and across sectors.

We utilised a detailed field study of 21 companies to cover an array of different young and innovative companies in cities in the Netherlands. The criterion “young” led to a selection of companies younger than 10 years and the criterion “innovative” led to a selection of sectors from innovative manufacturing and producer services, i.e. mechatronics (optronics), biotechnology, and ICT-services and engineering services. Data were derived from in-depth face-to-face interviews with corporate managers. A semi-structured questionnaire was used to enable both measuring in a standardised way (scores) and capturing in-depth insights on motives, needs and performance of the companies.

The degree of footloose or place-bound was determined as stated preference using a set of seven variables representing various agglomeration advantages, i.e. proximity to knowledge institutes, suppliers, customers, labour, personal networks, ICT infrastructure, and an international airport. A high score assigned by the manager to proximity to these factors was used as an indicator for being strongly place-bound, whereas a relatively low score was seen an indicator for a certain degree of footlooseness. In reality there appeared also a class “undetermined” for those cases that gave no conclusive picture of scores. Accordingly, the companies were classified as “place-bound” and “somewhat footeloose”, aside from “undetermined”.

The interview results were systematically codified in a large case-study database as a matrix that constitutes a concise representation of the underlying field information. Conventional statistical analysis, such as multiple regression analysis or discrete choice modelling, could not be applied in our study because of the low level of measurement of some variables (categorical level) and the small sample. Therefore, we made use of another technique that has increased in attention in the recent past, i.e. rough set analysis (see e.g., Pawlak, 1991; for details, we refer to Polkowski and Stolron, 1998). Rough set data analysis aims to perform a classification analysis on “soft” categorical data distinguished according to various groupings derived from the previously mentioned data matrix (named information table). If in a causal investigation a distinction is made between stimuli (*condition or explanatory variables*) and a response (*decision or endogenous variable*), rough set analysis is able to identify causal linkages between classified conditions and decision variables. Rough set analysis may be interpreted as a qualitative exploratory correlation analysis for small samples. Accordingly, we could identify which conditions (combinations of attributes of the condition variables) lead – in a logic deterministic way - to a particular state of the decision variable, i.e. degree of footlooseness. Consequently, the results are represented in rules as ‘if... then...’ statements (so-called decision rules). The condition attributes used in our study were selected based on the previously indicated resource-based approach to company growth (note 1): (1) position (corporate status); 2) age; 3) size; 4) main activity; 5) duration of innovation projects; and 6) spatial orientation. A useful computer software programme to carry out a rough set analysis is Rough Set Data Explorer (ROSE).

Note that the interpretation of rough set analysis results is valid to the extent in which the case studies selected provide a fair representation of young and innovative entrepreneurs located in large city-regions in the Netherlands. Note also that there are some quality assessments based on the characteristics of the information table (note 2). Furthermore, each rough set estimation produces a set of decision rules and the concomitant coverage for each decision rule. The coverage is an indicator for the strength of the rule and gives the percentage of all cases sharing a similar score on the decision variables for which the rule is true. For example, the highest coverage rates gained in the rules of our analysis are 40% (for two companies) and 38.5% (for five companies). Aside from the presence of condition variables in such strong rules, the presence of them in all rules provides useful information about the importance of particular condition variables. Thus, if we want to ‘explain’ the footlooseness orientation of young and dynamic companies, we have to trace the conditional rough set statements. This will be done in the next section.

4. Importance of Agglomeration Economies?

We will now present the results of applying the rough set methodology to the degree of footlooseness or location-boundness of the 21 companies by viewing 12 rules, subdivided into rules on place-bound and rules on somewhat footloose (Table 1). We will discuss the frequency of occurrence of condition variables in the rules, particularly the strong rules, and the number of rules that support importance of agglomeration economies and rules that support footlooseness (see, also Table 2). In addition, we pay attention to heterogeneity within the rules with regard to the economic sectors involved.

We may understand the rules and given conditions as follows:

- One condition variable is prominently influencing the degree of footlooseness, i.e. position (corporate status). It occurs in seven rules out of twelve. Size of the company is in second place (five rules). The following trends become clear: independent companies and young academic spin-offs tend to be place-bound, whereas corporate spin-offs and subsidiaries of foreign companies tend to be somewhat footloose.

Table 1 Rules as outcomes of rough set analysis

Conditions in rules	Strength of rules and nr of companies	Sector heterogeneity (a)	Generalization (types of companies)
<i>Rules on place-bound</i>			
Rule 1) Regional customer orientation (b)	38.5% (5)	66.6%	Biotechnology services and advanced ICT services
Rule 2) Long-lasting innovation projects	30.0% (4)	66.6%	Research in biotechnology and development in optronics
Rule 3) Independent position and short innovation projects (b)	38.5% (5)	66.6%	Biotechnology services and advanced ICT services (partial overlap with type 1).
Rule 4) Very young academic spin-offs	15.4% (2)	100%	Research in biotechnology and development in ICT services (close interaction with university)
Rule 5) Large corporate spin-offs	7.7% (1)	n.a.	Development in optronics (close interaction with company of origin)
<i>Rules on somewhat footlooseness</i>			
Rule 6) Small and employing a network model	20.0% (1)	n.a.	Development and manufacturing in optronics (risk market) employing a model of comprehensive outsourcing.
Rule 7) Corporate spin-offs engaged in services	20.0% (1)	n.a.	Specialized biotechnology services (inserted into global networks by company of origin).
Rule 8) Older age and long-lasting innovation projects (b)	40.0% (2)	100%	More mature companies in biotechnology and optronics entering global networks (R&D or outsourcing)
Rule 9) Subsidiary (foreign) and medium-sized	33.3% (1)	n.a.	More mature engineering service-companies with clients over the country.
<i>Ambiguous results</i>			
Rule 10-12) Spin-off and partly a mix of local and global orientation	33.3% (1) (c)	n.a.	Miscellaneous, but all speculate on (partial) relocation in the near future.

a. Actual number of different sectors divided by potential number of different sectors (percentage).

b. Relatively strong rules.

c. Each of the three rules has a coverage of 33.3% and is supported by one company.

Source: Adapted from van Geenhuizen, 2004b.

- Five of the twelve rules refer to the need for agglomeration economies, whereas four rules refer to some degrees of freedom in location choice (footlooseness).
- Conditions included in relatively strong rules concerning place-bound are: a regional orientation (customers or suppliers) (rule 1), an independent position and short innovation projects (rule 3). By contrast, conditions included in strong rules concerning somewhat footloose are: a relatively old age and long-lasting innovation projects (rule 8).
- All rules covered by more than one company (5 in total) are heterogeneous in terms of sectors; this means that non-sector characteristics tend to overrule sector characteristics.
- A small minority of companies is difficult to classify (three out of twenty-one). This outcome may be caused by a less accurate measuring of footlooseness in our study, but also by a genuine indifference of companies towards proximity and space.

Table 2. Summary of rough set results

Strength of information matrix	
Number of core variables	6 out of 6 (quality of core: 1.0)
Condition variables (frequency in rules)	
Position	7 out of 12
Age	4 out of 12
Size	5 out of 12
Activity	2 out of 12
Duration of innovation projects	3 out of 12
Spatial orientation	4 out of 12
Strength of rules	
Highest coverage	Rule 1 (38.5%): 5 companies Rule 3 (38.5%): 5 companies Rule 8 (40.0%): 2 companies
Direction of decision variable	
Match with agglomeration theory	5 out of 12 decision rules
Match with idea of footlooseness	4 out of 12 decision rules

Source: Adapted from van Geenhuizen 2004b.

It seems so far that particular categories of companies are not footloose at all. Despite a high appreciation of ICT-use, agglomeration economies tend to hold true for

particular segments of innovative companies, and these segments tend to be heterogeneous in terms of economic sectors.

5. A Closer Look at Knowledge Spillovers

In this section we consider the importance of knowledge spillovers for different classes of young, innovative companies. We approached the importance of knowledge spillovers as stated preference referring to three particular knowledge sources (Table 3). It appears that the highest importance is assigned by companies covered by rule 4, i.e. very young academic spin-offs in biotechnology and ICT-services. Accordingly, knowledge institutes, like universities and research institutes, and personal networks of the CEO have a maximum score or almost a maximum score. In second place are companies covered by rule 1, i.e. service companies with a regional customer orientation in biotechnology and ICT-services. A pool of skilled knowledge workers and personal networks are the most important sources here. In third place are companies covered by rule 2, including biotechnology research companies and development companies in optronics, both employing long-lasting innovation projects. Knowledge institutes are the most important sources of knowledge for this class of companies.

Table 3 Valuation of local knowledge sources (a)

Company classes	Knowledge institutes	Pool knowledge workers	Personal networks
<i>Place-bound</i>			
Rule 1	72	80	80
Rule 2	95	70	65
Rule 3	60	80	72
Rule 4	100	80	90
Rule 5	80	80	60
<i>Somewhat footloose</i>			
Rule 6	80	20	100
Rule 7	60	40	40
Rule 8	60	70	50
Rule 9	40	40	40

(a) Actual score per class divided by maximum score (as percentage).

Not surprisingly, for somewhat footloose companies local knowledge spillovers tend to be less important. The lowest valuation is given by companies covered by rule 9, i.e. mature, foreign subsidiaries that serve the national market of the Netherlands. A contradictory pattern is observed among companies represented by rule 6: young (small) network companies. At a young age they still depend on local knowledge institutes and personal networks of the CEO. However, due to a comprehensive outsourcing they are not dependent on knowledge in the local labour market. Furthermore, it is foreseen that as they mature they will widen the area within they can produce profitably based on a European scale of outsourcing.

We now take a look at the importance of access points to knowledge interaction in a wider geographic area, mainly referring to global knowledge, as we may expect that innovative companies with small benefits from local knowledge spillovers compensate this pattern with global knowledge. It appears that the overall pattern of valuation of proximity to ICT nodes and international airports do not support this idea of compensation (Table 4). With one exception, somewhat footloose firms do not compensate a low importance of local knowledge spillovers with a relatively high importance of access to global knowledge sources. This situation may be caused by a higher knowledge production of the companies by themselves, particularly if they are relatively mature as a company.

Table 4 Valuation of Access to Global Knowledge

Company classes	ICT node	International airport
<i>Place-bound</i>		
Rule 1	56	64
Rule 2	70	75
Rule 3	68	72
Rule 4	100	80
Rule 5	80	40
<i>Somewhat footloose</i>		
Rule 6	60	40
Rule 7	40	100
Rule 8	40	70
Rule 9	40	20

(a) Actual score per class ICT by maximum score (as percentage).

By contrast, the relatively high relevance of local knowledge spillovers among place-bound companies tends to be coupled with a relatively high relevance of access to global sources. This is particularly true for companies under rule 4: very young academic spin-offs in biotechnology and ICT-services. Apparently, these companies tend to interact intensively with both local and global knowledge sources.

We may conclude with the following remarks. Local knowledge spillovers tend to be highly important for different classes of innovative companies, like very young academic research spin-offs, service companies with a local customer orientation, and highly innovative research and development companies. All three classes of companies are heterogeneous in terms of sectors. For somewhat footloose companies, local knowledge spillovers tend to be less important but this is not compensated by importance of proximity to nodes of global knowledge; rather, our results tend to support the idea of a mutual reinforcing of local knowledge spillovers and global knowledge interaction.

6. Spatial Coverage of Agglomeration Economies

In this section we consider the spatial reach of different agglomeration economies. Our in-depth results indicate that a certain degree of footlooseness may still be coupled with some specific spatial needs that can be satisfied outside the large city-regions in a larger part of the Netherlands:

- a certain level of agglomeration
- a certain level of centrality
- proximity to knowledge and a good knowledge culture
- accessibility by car
- proximity to a well-connected international airport.

In an attempt to identify cities outside the large ones in the Netherlands which broadly satisfy the above needs, we considered sheer size of the population (agglomeration level), a certain amount of centrality, an easy access to Amsterdam Schiphol Airport (within approximately 1 hour travel time by public transport), as well as access to knowledge through a university and a first-tier node in the global science and education telecommunication grid SURFnet (Gigaport, 2004). Three cities satisfy the

above needs to a large extent, i.e. Leiden, Eindhoven, and Tilburg (Table 5), of which Leiden is the most centrally located towards the four large cities in the Randstad and Amsterdam Schiphol Airport. In addition, there are four agglomerations without a university, but with higher educational institutes and connections to the SURFnet grid, i.e. Dordrecht, Haarlem, Amersfoort, and Breda.

Table 5 Agglomerations in a potentially larger metropolitan area (a)

Large cities	Medium-sized (central)	Medium-sized at a distance (South)
Amsterdam (1017.050)	Leiden (254.130)	Eindhoven (319.670)
Rotterdam (1001.450)	Dordrecht (246.490) (b)	Tilburg (221.350)
The Hague (616.090)	Haarlem (189.930) (b)	Breda (166.035) (b)
Utrecht (405.470)	Amersfoort (161.960) (c)	

a. Within brackets: number of inhabitants (agglomeration) in 2004. Only agglomerations larger than 150.000 inhabitants.

b. No university; linked to SURFnet in a second round.

c. No university; not connected to SURFnet in later rounds.

Source: Netherlands Central Bureau of Statistics (2004) and Gigaport (2004).

Dependent on how strictly the agglomeration economies are perceived by somewhat footloose companies, the above cities indicate two larger metropolitan areas, one in which centrality is important merely with respect to the large cities in the Randstad and one in which the larger metropolitan area also includes the agglomerations in the South. Note that not all places within such larger areas seem attractive, only the ones that offer a certain level of agglomeration (see also Sohn, 2004).

The empirical results of our study also indicate that particular agglomeration economies can only be enjoyed in the city-region of Amsterdam (van Geenhuizen, 2004b). This finding suggests a two-level structure in agglomeration economies. The agglomeration economies forwarded as strong and exclusively available in Amsterdam are the following:

- An internationally oriented (multilingual and flexible) pool of knowledge workers.
- Direct access to the highest capacity telecommunication node and grid, and connected advanced services.
- Proximity to selected customers to participate in joint projects facilitated by knowledge interaction on a daily basis.

We may conclude with a summary of a trend in agglomeration economies based on the above results: more general urban agglomeration economies have spread over a larger metropolitan area, whereas a set of selected agglomeration economies remains exclusively available in the largest city-region (Amsterdam).

7. Conclusion

This study supports the idea that there is a considerable heterogeneity between young, innovative companies in terms of needs for urban agglomeration economies. Within one and the same economic (sub)sector, companies may be location-bound, footloose to some degree, or their behaviour does not show a clear pattern. Various company characteristics tend to overrule sector influences, like regional customer orientation, duration of innovation projects, and position (status) of the company. This is also true for knowledge spillovers: all three classes for which knowledge spillovers are important are heterogeneous in terms of the sector.

The outcomes of rough set analysis indicate that particular types of companies tend to be somewhat footloose. Nevertheless, a particular need for agglomeration economies seems remaining and can be satisfied in larger metropolitan areas. Our rough set results also indicate the presence of particular types of companies that tend to be location-bound. These companies include academic spin-offs and fully independent ones, companies that utilize strong linkages with local suppliers or customers, and companies that are “fixed” to the highest level of ICT nodes and to the urban labour market. Further, location-bound companies tend to couple a high importance of local knowledge spillovers with a high importance of access to global knowledge. Our results also indicate that many location-bound companies tend to enjoy agglomeration economies in the largest city that are exclusively available here. The findings thus support the idea of a two-level spatial structure in agglomeration economies: more general urban agglomeration economies in a larger metropolitan area and selected agglomeration economies exclusively in the largest city-region (Amsterdam).

The focus of this study has been on young, innovative companies active in producer markets. This implies that many questions are still unanswered, e.g. concerning older companies and concerning changes in business relations with consumers. More importantly, this study has revealed some trends in location-bound and footloose which may serve as hypotheses to be tested in a larger study based on statistical generalization. Clearly, our analysis has brought to light interesting findings on the location-bound and footloose character of urban companies, and the role of knowledge spillovers, but at the same time, it ought to be recognized that there is a need for more profound empirical work using e.g. a meta-analytical approach.

Annex 1 Rules produced by rough set analysis (selection)

Rules concerning being 'place-bound'

- *Rule 1.* If companies have a regional orientation towards suppliers or customers, then they are place-bound (38.5%). This hypothesis has a relatively strong support, i.e. from five companies. These represent companies in services both in biotechnology and the ICT sector, with strong customer ties in the city-region; ICT services are also tied to the city-region by an advanced ICT infrastructure and the (metropolitan) labour market. It appears that all these companies employ knowledge networks that are predominantly regional (local).
- *Rule 2.* If companies innovate through very long development trajectories, then they are place-bound (30.0%). This hypothesis is also strongly supported, i.e. by four companies. These represent research companies both in biotechnology and mechatronics (optronics), with – different from the previous category – predominantly global knowledge networks. Accordingly, this rule suggests that companies can be place-bound even if their knowledge networks are global.
- *Rule 3.* If companies are independent and innovate through short development projects, then they are place-bound (38.5%). This hypothesis is also relatively strong, as it is supported by five companies. They represent partly a particular (less innovative) segment of ICT-services and services in biotechnology (overlap with rule 1).
- *Rule 4.* If companies are young and academic spin-off, then they are place-bound (15.4%). This hypothesis is supported by two companies, representing research companies in biotechnology and ICT-services that find themselves in an early stage of their lifecycle in which the relationships with the mother-university are still strong.
- *Rule 5.* If companies are corporate spin-off and very large, then they are place-bound (7.7%). This rule is supported by only one company, and requires some additional information for a correct interpretation. Additional information confirms that this company was separated from the mother-company as a relatively large business unit and remained located close to the mother-company while employing strong linkages with this company.

Note 1

It needs to be mentioned that in all but one of the case studies a high value was assigned to ICT use; thus, this attribute could not contribute to a clarification of the degree of footlooseness.

Note 2

Fortunately, in all cases analysed, the accuracy and the quality of the rough set approximation appeared to be equal to 1, meaning that the reliability of the classification for the dependent variable and the overall quality are at their maximum. The 21 cases are apparently totally distinguishable. With regard to the division of the condition variables into 'core variables' and other variables it appeared that all six condition variables belong to the core, meaning that all of them contribute to an explanation and no variable contains redundant information, and that the core has the maximum quality of 1.0.

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