DEATH OF DISTANCE AND AGGLOMERATION FORCES OF FIRMS IN THE URBAN E-ECONOMY
AN ARTIFICIAL INTELLIGENCE APPROACH USING ROUGH SET ANALYSIS

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Abstract

The present study addresses the relevance of geographic proximity for companies in our age of advanced ICT. Many visions of, and speculations on, an increased footlooseness of companies and a concomitant dispersal of urban economic activity have been published in recent years. To identify whether urban agglomeration economies (in particular, knowledge spillovers) are still a key force in preventing such dispersal, we investigate the degree of footlooseness of young, innovative companies. First, we briefly review the traditional theory of agglomeration economies, in particular knowledge spillovers. Next, we connect this theory with more recent resource-dependence views. We then present the results of an empirical analysis of young, innovative companies in various city regions in the Netherlands. The selected innovative sectors are medical biotechnology, ICT services, and mechatronics (optronics), and do not include consumer-oriented activities. The exploratory analysis based on interviews with 21 companies employs an artificial intelligence method, called 'rough set analysis', to increase our understanding of the crucial factors that influence the relevance of physical proximity. On the basis of these results, we argue that agglomeration economies still remain important for various categories of young, innovative firms, even those providing ICT services, but that we need to make a distinction between agglomeration economies that work exclusively in the largest city (i.e. Amsterdam) and agglomeration economies that cover a larger metropolitan area. The only fundamental change in proximity needs among these young, innovative companies originates from a small class of 'network companies', which are footloose even beyond the larger metropolitan area.

Key words: ICT, young and innovative companies, agglomeration economies, proximity, footlooseness, rough set analysis, artificial intelligence.

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1. Proximity Matters?

Innovation and entrepreneurship are key elements of a flourishing urban economy. The growth and decline of business firms is critically contingent on urban seedbed and incubator conditions, knowledge production and adoption, creativeness and business potential, and adoption of a modern business lifestyle and culture (see, also, Acs, 2002; Bögenhold et al., 2001; Romein and Albu, 2002; Sexton and Smilor, 1986). In recent years, we have witnessed an upsurge of entrepreneurial initiatives closely connected with the rapid growth of the ICT sector (see, e.g., Cairncross, 1997; Cooke and Wills, 1999; Ohmae, 1999). In the industrial organization and management literature, much attention has been given to participation in, and access to, formal and informal networks as strategic mechanisms for creating increasing returns in an uncertain dynamic business environment (see, e.g., Borgatti and Foster, 2003; Hoang and Antoncic, 2002; Malecki, 1997; Schiller, 1999). It is generally recognized that modern dynamic sectors of the economy, in particular the ICT sector, have the potential to generate high returns, though often in a risky businesses environment. Access to knowledge and information is usually seen as a key factor for success in a risky entrepreneurial context.

It is now an important question whether, in our age of advanced telecommunication, access is best served through physical proximity of firms, or whether modern ICT systems create virtual connectivity without the need for geographic proximity. There have been many speculations on the death of distance and on the space-opening character of the advanced ICT sector (for a review, see, e.g., Cohen et al., 2004). But what are the empirical facts concerning the needs of business firms for geographic juxtaposition in the urban economy? Does ICT favour footloose behaviour of firms, or will it reinforce urban agglomeration forces? These questions will be addressed in the present paper.

'Proximity' is a frequently used concept in geography, but it has different connotations. First, there is physical proximity in terms of a short straight-line distance or a short distance based on using a transport network. In fact, what matters in interaction is the time in bridging such distance. Geographic proximity is either a physical or a time concept, or both. However, in a social space there is also social proximity, i.e. a perceived small distance as a result of impacts from social

relationships, common habits and interests, etc. (see, e.g., Gertler, 2003). Clearly, both concepts may be intertwined. Cities can be seen as agglomerations of economic activities based on advantages of both kinds of proximity.

In recent years, modern ICT has attracted much attention from many researchers and policy makers in urban geography and urban economics (e.g. Glaeser, 1998; Graham, 1998; Malecki, 2001), because of their potential distance- "shrinking" character. It is often argued that ICT (particularly, the Internet) is profoundly changing the space-economy. The use of ICT in business transactions means a quicker and denser communication and a tighter coordination within and between companies, 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. Also, the rise of new types of companies (virtual or network-based) has been a new phenomenon, creating firms that have a minimum of tangible assets of their own and organise assets at other companies' establishments (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 in order to avoid the costs of congestion in large cities. Altogether, we tend to observe a trend of decreasing importance of physical proximity in production activities. Economic value is transmitted across physical space at zero marginal costs, and therefore agglomeration of economic activities is not necessary as it no longer necessarily adds to production growth and economic externalities (see, e.g., Borja and Castells, 1997; Tabuchi, 1998). In this scenario, companies tend to become increasingly "footloose" leading to spatial dispersal, thus confirming the 'death of distance' hypothesis .

The influence of ICT and of the Internet on business operations and location choice is based on various specific and far-reaching characteristics of the Internet itself (Kenney and Curry, 2001). First, it offers increased access to many places around the globe. Addresses connected via the Internet are almost unlimited and almost equally accessible. Accordingly, producers and consumers are able to search for the best price/quality of inputs and consumer products in the world, and producers can make themselves – or their products or services - known to a global market. The

second important feature is interactivity, as in information feedback loops between producers and consumers in the composition of a product, or in monitoring by suppliers of product use (remote diagnostics). A third and probably the most powerful feature is information intelligence. Intelligence is the ability to collect information across the network, to store and process the information, and utilize the results in one node or redistribute the results across the network. These activities include search functions, selection functions (decision support), functions to connect selectively, and data analysis including data-mining and monitoring, etc. These functions have already led to new services between producers and customers (customer services), as the former are able to monitor customers' shopping behaviour and changing preferences. They have also led to new relations between producers and suppliers by sharing knowledge management systems. Logistics in the physical distribution sector offers the same potential.

At the same time, it ought to be recognized that the use of ICT is still limited due to various practical problems. There only seems to be substitution between physical and virtual activities, if the communication and connected economic activity are non-material and sufficiently standardized, 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 then faces basic shortcomings and too high costs (van Geenhuizen, 2004). This would mean that agglomeration economies that are mainly based on knowledge spillovers, remain a key attraction factor of cities for young and innovative entrepreneurs (see, e.g., Audretch, 1998). Nevertheless, because of progress in the potential of the communication technologies themselves (e.g. an increased codification of previously tacit knowledge and use of intelligent agents who undertake selection tasks) and because of an increased learning curve and cultural adjustment of organizations working with the technologies, barriers may be moving (Andriessen, 2003). However, our knowledge to date is not sufficient to assess the implications of such moving barriers. There is a shortage of data about the emerging processes in business operations and implications for location needs on the micro-level of companies. Exceptions are, for example, studies undertaken by van Geenhuizen (2004), Grentzer (1999), and Kalsaas (1996).

Given the above situation, we attempt to clarify the relevance of proximity nowadays for young, innovative companies located in urban areas, by addressing the following questions:

1) To what extent are companies "footloose"? Which factors influence differences in footlooseness? What is the role of ICT in companies becoming more "footloose"?
2) What may be the implications of the above situations for the future position of cities?

At this point, it is necessary to clarify the use of concepts and definitions surrounding ICT. ICT is conceived of as a set of heterogeneous technologies (hardware and software) that allow for electronic (data) communication and data collecting and processing in distributed networks, such as Electronic Data Interchange (EDI) and the Internet, and more complex systems of remote monitoring and computer-aided decision making in virtual networks (see Cohen et al., 2004). Three basic roles can be distinguished for ICT in business activities: (1) as a product, as in services, advanced facility sharing, and call centre activity; (2) as a '*driver'* of new business models, as in network or virtual companies, including remote control, and in electronic commerce companies (the latter class falls beyond the scope of this study); and (3) as support in business operations, such as EDI, web ordering, and remote maintenance and services. Each of these roles may lead to different needs for physical proximity. In conclusion, the urban economic scene is changing, but the implications of this change call for a thorough empirical analysis.

2. Theoretical Perspectives on Urban Agglomeration

The urban future is clearly subjected to the unprecedented forces of ICT. In this section we address various theoretical views that shed light on the advantages of proximity in urban agglomerations. These are derived from: (1) agglomeration theory and related cluster thinking dealing with the supply-side of cities as places of location; and (2) resource-based theory dealing with the needs of companies for specific business resources. In addition, we pay attention to the conceptualization of 'footlooseness' 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). Spatial concentration of 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 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 life cycle - when dealing with manifold uncertainty - prefer locations where new and specialized knowledge is abundantly available for free (see, e.g., Audretch, 1998; Camagni, 1991). Cities offer an enormously rich potential for business opportunities.

It is also widely recognized that the spatial extent of knowledge spillovers is limited due to various kinds of geographic borders, e.g. a wide daily activity system where people can meet easily and where people change jobs in the course of their careers, or smaller areas such as quarters in a central business district or university premises where people see each other often by chance (e.g. Rosenthal and Strange, 2001). The need for spatial proximity to enjoy knowledge spillovers seems, however, 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. ICT offers an unlimited spectrum of virtual communication opportunities.

The solution for this paradox concerning the localization of knowledge spillovers seems to lie in the type of knowledge concerned (Howells, 2002). On the one hand, there is codified knowledge (partly just information) that can easily circulate electronically over large distances, e.g. prices determined at a stock exchange and statistical data. On the other hand, there is tacit knowledge and its 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. Contextual knowledge is achieved through long-term and interactive learning, often in relatively open (unstructured) processes (Bolisani and Scarso,

2000). These observations raise the question of whether alternative analytical perspectives exist.

According to modern resource-dependence views, young and innovative entrepreneurs have strong needs for new knowledge, i.e. knowledge about the technology concerned and knowledge to deal with the market, but they cannot generate this knowledge by themselves (e.g. Lockett and Thompson, 2001; Reid and Garnsey, 1998). In this context, Storper and Venables (2002) distinguish between various functions of tacit knowledge transferred in cities, e.g. for coordination, confirmation and checking, and for monitoring. In modern versions of resource-dependence theory it is taken for granted 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 their own capabilities and the supply of resources in their environment (e.g. Barney, 1991). The growth of companies is constrained if there is a shortage or weakness in the available resources, or in the capability to mobilize or generate adequate resources. Reid and Garnsey (1998) distinguish between different stages in growth, ranging from achieving access to resources to the mobilization of resources, and companies' 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 (i.e. the 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 rely heavily on resources available in the environment, including the urban environment. Clearly, there is a need for more appropriate applied work in order to test various assumptions.

In this paper, we assume that young, innovative companies face a greater need for local resources (knowledge) if they undertake relatively risky activities and have a limited capability in mobilizing external resources or generating resources by themselves; the latter may be due to an early growth stage (young age) or an independent position. This assumption is partly reflected in the research design for our empirical case study, particularly in the selection of influencing factors (Section 3).

There is not much conceptualization of the situation in which companies are free from location constraints. The term 'footlooseness' is often used in this context, but it is poorly conceptualized 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. However, this is quite a rigorous definition that excludes different degrees of footlooseness. Here, we may consider footloose as the situation at one end of a spectrum, with location- or place-bound at the other end. This makes it possible to distinguish various degrees of footlooseness and to emphasize 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, such as the need for proximity to knowledge institutes, specialized suppliers and specialized labour, decrease in importance, thus 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 with respect to the city region by using information obtained from interviews with young entrepreneurs in dynamic sectors of the economy.

3. Description of the Empirical Study

Applied field work is expensive and time-consuming. In modern artificial intelligence techniques researchers often resort to low sample methods, in which a selected set of representative objects is carefully investigated by means of non-parametric methods.

The research design of this study employs an inductive approach, using a limited number of carefully selected case studies. 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). This approach allows for close correspondence between theory and data, a process in which the emergent theory is grounded in the data (Eisenhardt, 1989). 'Carefully selected' means that the selected companies hold different positions on those factors that are supposed to influence the various needs for proximity, according to theoretical views. 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 based on the demand of customers). The factors taken into account are: position (corporate status), age, size, main activity (manufacturing or services), level of innovativeness (duration of innovation projects), and the general spatial orientation of the company. Different positions on these factors are assumed to reflect different resource needs and different capabilities to generate resources or gain external resources, as outlined in Section 2.

In our study, we address young and innovative entrepreneurs. The specific selection procedure required information about the companies in advance, and this information was drawn from branch journals, such as *Link* in the mechatronics (optronics) sector, and from annual reports of branch societies, such as Biopartner in the biotechnology sector (Biopartner, 2002). We utilized a detailed field study of 21 young and innovative companies in various 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 over the period August 2003 to March 2004. In the interviews, a semi-structured questionnaire was used to enable both measuring in a standardized way (scores) and capturing in-depth insights on motives, needs and performance of the companies.

The case studies particularly dealt with footloose features of the companies concerned. The degree of footlooseness 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 given by the company 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 also appeared to be an 'undetermined' class for those cases where the scores provided no conclusive picture. Accordingly, the companies were classified as: 'place-bound', or 'somewhat footloose', or 'undetermined'.

The results from the semi-structured interviews were systematically codified in a large case-study database as a matrix that constitutes a concise representation of the underlying field information. This multi-attribute table served as a basis for a systematic comparison of the degree of footlooseness and factors influencing this characteristic. The actual analytical artificial intelligence method employed in our study, rough set analysis, will be described in the next section.

4. Rough Set Analysis

Conventional statistical analysis, such as multiple regression analysis or discrete choice modelling, could not be applied in our study because of the qualitative nature of some variables and the small sample. The information was gathered in terms of the assignment of relevant attributes of our explanatory model to distinct categorical classes. Therefore, we made use of another technique that has received increased attention in the recent past, i.e. rough set analysis (see, e.g., Pawlak, 1991; for details, we refer to Polkowski and Skowron, 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 (called an '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. In our analysis, we were particularly interested in the decision algorithms produced by a stepwise scanning of the data matrix. Accordingly, we may identify which conditions (combinations of attributes of the condition variables) lead - in a logical deterministic way - to a particular state of the decision variable, i.e. degree of footlooseness.

Rough set analysis has recently found several applications in economics and geography (see, e.g., van den Bergh et al., 1997; van Delft et al., 2000; Goh and Law, 2003; Nijkamp, 2000; Masurel et al., 2001). These applications concern, *inter alia*, land use, environmental evaluation, transportation, tourism and ethnic entrepreneurship.

A rough set is a set for which the classification of a group of certain objects is not entirely certain. The reason is that the classification of specific categorical data is dependent on the measurement scale (the degree of 'granularity'). Of course, we have to assume that there is a finite set of objects to be classified. Information on these objects is collected by assigning features of these objects to distinct relevant classes. Any feature (or a coded value of this feature) can express the relevant properties of the object concerned. These features (or attributes) can be used to define various relationships between the set of condition variables and the response variable. In this way, one may also identify equivalence classes. Objects that belong to the same equivalence classes, based on the relevant features considered, are called 'indiscernible'. In addition, one may eliminate redundant information for a classification experiment, so that one may achieve the same quality of classification as the original set of features. The corresponding minimum set of features is called a 'reduct'. Adding more features to a 'reduct' does not result in a more precise classification. Next, we may identify a 'core', which consists of the class of all indiscernible equivalence relationships. Attributes in a core may be seen as the critical variables in an exploratory sense.

Rough set analysis is thus essentially a classification experiment. It aims to identify under which conditions certain features (or attributes) are necessary to 'explain' the existence of a feature of a response variable. Consequently, the results are usually represented in rules in the form of 'if… then…' statements (known as 'decision rules'). A useful computer software programme to carry out a rough set analysis is Rough Set Data Explorer (ROSE). This algorithm constructs the best possible decision rules to explain the frequency of occurrence of features. Further details can be found in the aforementioned references.

The condition attributes used in our empirical case study were selected on the basis of the previously indicated resource-based approach to the growth of companies (Note 1), viz:

A1) position (corporate status)

A2) age

A3) size

A4) main activity

A5) duration of innovation projects

A6) spatial orientation.

The relevant information on each of these items was collected for all interviewees. It should be noted that the interpretation of the rough set analysis results is valid to the extent to which the case studies selected provide a fair representation of young and innovative entrepreneurs located in Dutch city regions. Note also that there are some quality assessments based on the characteristics of the information table. 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.

Each rough set estimation produces a set of decision rules and the concomitant coverage for each decision rule. The coverage is an indicator of 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). Apart 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.

5. Lessons from the Survey Experiment

We will now present the results of applying the rough set methodology to the degree of footlooseness of the 21 companies. There are 12 rules and these are concerned with the categories: (1) place-bound, (2) somewhat footloose, and (3)

undetermined (Table 1, and see also Annex 1 for the detailed rules). Note that each rule can be seen as a relevant hypothesis to be tested for our small sample.

Table 1 Rules as outcomes of the rough set analysis

Conditions	Strength of rules	Number of companies	Generalization
Conditions in rules on 'place-bound'			
Rule 1. Regional orientation	38.5% a)	5	Biotechnology and advanced ICT services; the latter are tied to the highest telecommunication nodes and the metropolitan labour market.
Rule 2. Long-lasting innovation projects	30.0%	4	Advanced research companies in biotechnology and mechatronics.
Rule 3. Independent position and short innovation projects	38.5% a)	5	Particular ICT service-companies and biotechnology service-companies (overlap with Rule 1).
Rule 4. Very young academic spin-offs	15.4%	2	Research companies in ICT and biotechnology in the first life stage (close ties with the university).
Rule 5. Large corporate spin-offs	7.7%	1	Research company located at short distance from company of origin while continuing close interaction.
Conditions in rules on 'somewhat footlooseness'			
Rule 6. Small and employing a network model	20.0%	1	Research companies in risk markets employing a model of comprehensive outsourcing.
Rule 7. Corporate spin-offs engaged in services	20.0%	1	Highly specialized service companies inserted into global networks by a multinational company (corporate origin).
Rule 8. Older age and long-lasting innovation projects	40.0% a)	2	More mature research companies in biotechnology and mechatronics that are starting to enter global networks (R&D alliances or outsourcing relations).
Rule 9. Subsidiary (foreign) and medium-sized	33.3%	1	More mature producer service-companies with clients all over the country.
'Undetermined' results			
Rules 10-12. Spin-offs and partly a mix of local and global orientation	33.3%	1 b)	Miscellaneous, but all speculate on (partial) relocation in the near future.

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

We may understand the outcomes of the rules and given conditions as follows (see Table 2):

- One condition variable prominently influences the degree of footlooseness, i.e. 'position (corporate status) of the company'. It occurs in 7 rules out of 12. 'Size of the company' is in second place (5 rules). The dominant influence of position is also true for rules merely concerning place-bound and those merely concerning somewhat footloose, but not for rules concerning undetermined.
- With respect to position, the following trends become clear: independent companies and academic spin-offs tend to be place-bound, whereas corporate spin-offs and subsidiaries of foreign companies tend to be somewhat footloose.
- Of the 12 rules, 5 refer to the need for proximity and agglomeration advantages, whereas 4 rules refer to some degrees of freedom in location choice.
- 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 of companies and long-lasting innovation projects (Rule 8).
- 'Somewhat footloose' has different connotations in terms of the geographic areas involved, i.e. a larger part of the South-East of the Netherlands (optimal locations in relation to the network of subcontractors), various larger university cities (not in a particular one), and a centrally-located part from which the country can be covered by services). 'Somewhat footloose' excludes a location in remote areas of the North of the Netherlands, except for the university town of Groningen.
- A small minority of companies are difficult to classify (3 out of 21). 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.

It can be concluded so far that, in contradiction to the death of distance scenarios, particular categories of companies seem to be not footloose at all. Despite the high utilization of ICT by young, innovative companies, agglomeration economies still tend to hold true for particular segments of these companies. Of all rules, 5 clearly support the relevance of agglomeration advantages in terms of proximity to various

resources. On the other hand, 4 rules clearly support the idea of degrees of freedom in location choices, but within limited areas.

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 of all 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%), including 5 companies Rule 3 (38.5%), including 5 companies Rule 8 (40.0%), including 2 companies
Direction of decision variable	**Number of decision rules**
Match with agglomeration theory	5 out of 12
Match with idea of footlooseness	4 out of 12

6. ICT and Implications for the Future of Cities

As already addressed in Section 1, ICT may have different roles in business models of companies: the main service activity (e.g. in facility sharing and call-centre activity); a 'driver' of new business models (e.g. in network companies); and support in all kind of business operations (e.g. in use of Internet, EDI, web ordering, remote design and remote services, the latter two are emerging new developments). Given the limits of our selected segments of innovative companies, we expect only network companies to have little need for proximity and agglomeration economies of cities. These companies employ a few activities of their own (mainly coordination) and contract other activities out to a network of companies (e.g. research companies, suppliers of manufactured goods, logistic companies), thereby heavily using ICT. This model is ICT-driven because it is the technology that allows for its development.

With regard to the near future, we foresee that agglomeration economies will remain relevant among particular segments of ICT services, on the basis of their needs in the labour market, needs for proximity to highly advanced (physical) ICT links and nodes, and needs for proximity to customers in order to facilitate mutual

learning on a daily basis (Table 3). Part of the agglomeration economies involved are only available in the largest city (in this case the city of Amsterdam), e.g. a young and internationally-oriented (multilingual) workforce and direct access to the highest level telecommunication node and networks. The remaining agglomeration economies are also available in a larger metropolitan area, e.g. in the suburban zone, or in medium-sized towns at a somewhat greater distance from the largest city.

Our results also seem to support the idea that, in the near future, the number of network companies will increase. Their business model is an important strategy to reduce risk of large investments in research laboratories and production facilities in an increasingly competitive and risky global market, as in mechatronics (chip machine industry). This would mean a higher degree of footlooseness of new companies, also linked to an extension of the networks within Europe and North-America (and maybe the Far East). But the question remains whether this business model also matches with other types of high-technology manufacturing sectors (e.g. process-based). In addition, we may expect an increase of footloose companies due to a growth in global corporate ownership relations.

Table 3. ICT and proximity (selected segments of companies)

Function of ICT	**Location factors**	**Relevance of proximity (agglomeration economies)**
ICT as advanced services	- Specialized workers (multilingual) - Connectivity to high capacity grid and nodes (AIE, global access points) (a) - Proximity of customers (joint projects)	- A remaining high relevance of proximity, mainly based on economies that are *exclusively* available in the largest city
ICT as a 'driver' of a new business model (network company)	- Need for a strategic location towards the network of suppliers and otherwise related companies	- Decreasing relevance of proximity, but relevance of a central location in expanding networks (national/European)
ICT as support in business operations	- No changes (because ICT is a limited substitute for face-to-face contact) - Access to international airport	- Relevance of proximity remains, but maybe on a somewhat larger scale

(a) AIE: Amsterdam Internet Exchange.

Finally, we expect that ICT-use in supporting business operations will not lead to basic changes in the relevance of proximity in cities. ICT provides only a limited substitution for face-to-face contacts. In our case-studies electronic modes like videoconferencing and teleconferencing seem inadequate to create trust, to solve non-routine problems, to decide on taking risks, etc. Thus, existing needs for face-to-face

contacts remain, but most probably these are satisfied over a somewhat larger area, though maybe somewhat less frequently. In addition, with regard to companies employing global knowledge networks (R&D alliances), the transfer of tacit and contextual knowledge takes place over large distances, using travelling by air. This implies a relevance of proximity or good connections to an international airport.

Given the selected category of young and innovative companies mainly active in producer markets, our observations in relation to the future of cities are partial, and may be different for other categories of companies (see, e.g., van Geenhuizen and Nijkamp, 2004). However, we take the stance that young and innovative entrepreneurs deserve particular attention, as they play a vital role in the permanent restructuring of urban economies in the force-field of dynamic markets, emerging technologies and competing city-systems.

Our first observation on the future of cities is the following. Though not on a large scale, there will be an increasing trend for companies to become footloose to some degree. This means that the strength of cities needs to be reinforced by creating conditions that enhance the establishment of those companies that are place-bound, at least for a part of their life, i.e. local academic spin-offs and independent companies. Secondly, two categories of companies are, by definition, place-bound, i.e. companies that serve a strong regional customer base, as in biotechnology services (e.g. specialists in standard measurement and determination techniques) and in ICT-services (e.g. advanced facility providers), including those ICT companies that need close access to the highest level of ICT nodes (Internet exchange, highest capacity connections). The strength of cities in this respect can be reinforced by improving conditions for cluster-like developments and for increasing the quality of high-level ICT-nodes and networks.

7. Conclusion

In this paper, we have addressed the relevance of proximity in the urban e-economy. The focus has been on young, innovative companies, as the primary source of innovation and growth of the urban economy. In the empirical part of the paper, we compared 21 companies that were selected on the basis of factors that may influence the relevance of proximity and agglomeration economies. The methodology used was rough set analysis, which is appropriate for our qualitative data and small sample.

Following our analysis, we may conclude that there is quite some differentiation between young, innovative companies in terms of proximity needs and footlooseness. Within one and the same sector, e.g. biotechnology and mechatronics, companies may be place-bound, footloose to some degree, or their behaviour shows no clear pattern. This differentiated pattern calls for further research to consider more differentiating factors than just sectors or sub-sectors in large-scale surveys, and a need to connect large-scale surveys with detailed case studies based on an industrial organization and management approach (an interesting recent example is van Oort and Stam, 2004).

The rough set outcomes indicate that particular types of companies tend to be somewhat footloose; these are mainly corporate spin-offs, subsidiaries (foreign), and small companies in the sense of a network company. 'Somewhat footloose' means to be free to locate in a larger part of the Netherlands or in a particular category of cities (like university towns), it never means free to locate *anywhere.* We foresee that these companies will increase in number as a result of the growing globalization of companies' ownership relations and of knowledge networks for highly advanced technologies. Although the degrees of freedom in location choice have increased for certain segments of innovative companies, it would appear that there still remains a particular need for agglomeration advantages that can be satisfied in larger metropolitan areas, probably still in agglomerated places (for results on a sector level, see, e.g., Sohn, 2004). The role of ICT is only really strong (a 'driver') in the growth of network companies, as ICT allows for the maintenance and deepening of the vital relationships within the network. It is precisely this type of company for which we expect a fundamental decrease in proximity needs. By contrast, companies that tend to be place-bound are academic spin-offs and independent companies, companies that have strong linkages with local suppliers or customers, and companies that are 'fixed' to the highest level ICT nodes. Hence, an increased use of ICT as support in various business activities of these companies does not cause a shift to footlooseness. Thus, contrary to the death of distance scenarios, various categories of companies still tend to be place-bound. Despite the high utilization of ICT by young, innovative companies, agglomeration economies continue to be very relevant for particular segments of these companies.

In this study, the focus has been on young and innovative companies active in producer markets. This means that many questions still remain unanswered, e.g.

concerning older companies, and concerning changes in business relations with consumers that are driven by ICT use. Moreover, questions concerning major progress in ICT were beyond the scope of this study, but point to interesting future research directions. Most importantly, this study has revealed some trends in location-bound and footlooseness 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 importance of ICT for the modern urban e-economy. But at the same time, it ought to be recognized that there is a need for more in-depth empirical work, both on a city-by-city basis and in the form of a meta-analytical comparative study.

Annex 1

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 relatively strong support, i.e. from five companies. These represent companies in services in both biotechnology and the ICT sector, with strong customer ties in the city; ICT services are also tied to the city by an advanced ICT infrastructure and the 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 in both 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 partly represent 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-offs, 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 life cyle in which the relationships with the mother-university are still strong.
- *Rule 5*. If companies are corporate spin-offs 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, still maintaining strong linkages with this company.

Rules concerning being 'somewhat footlooseness'

- *Rule 6*. If companies are small and corporate spin-offs, then they are somewhat footloose (20%). This idea is supported by one company. "Small" in this rule refers to the network character of the company involved, meaning only a small amount of activity in the company and a large amount of activity subcontracted to others. 'Somewhat footloose' here means footloose in a large area of the Netherlands (the Southeast-East), in fact bound by the current network of subcontractors. In the near future, this area will be extended to Northwest Europe.

- *Rule 7*. If companies are corporate spin-offs and their activities are in services, then they are somewhat footloose (20%). This hypothesis is supported by one company, i.e. a company in highly specialised biotechnology services, employing the global networks of the company of origin.
- *Rule 8*. If companies are older and innovate through long-lasting projects, then they are somewhat footloose (40%). This hypothesis is supported by two companies. They represent research companies in two different sectors, i.e. biotechnology and mechatronics (optronics). Here, 'somewhat footloose' means the entire configuration of city regions in the Western part of the Netherlands, in one case also including the city region of Eindhoven in the South-East.
- *Rule 9*. If companies are a subsidiary and medium-sized, then they are somewhat footloose (33.3%). This idea is supported by one company. Additional information says that the subsidiary belongs to a mother company abroad and produces advanced engineering services over the entire Netherlands. Here, 'somewhat footloose' means footloose within a larger, central area of the Netherlands.

Rules concerning 'undetermined'

- *Rules 10-11-12*. Each of these rules indicates an ambiguous pattern of appreciation of agglomeration advantages and is supported by only one company (33.3% coverage). The combination of conditions stated in the rules appears difficult to understand, except for an existing mixed regional and global orientation of companies towards suppliers or customers.

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.

References

Acs Z J, 2002, *Innovation and the growth of cities* (Edward Elgar, London).

Andriessen J H E, 2003, *Working together with Collaboration Technology: Understanding and Evaluating Computer Supported Interaction* (Springer Verlag, Heidelberg).

Audretch, D B, 1998, "Agglomeration and the location of innovative activity", *Oxford Review of Economic Policy,* **14** (2) 18-29.

Barney J, 1991, "Firm resources and sustained competitive advantage", *Journal of Management* **17** 99-120

Bergh J C J M, Button K J, Nijkamp P, Pepping G, 1997, *Meta-Analysis in Environmental Economics* (Kluwer, Dordrecht).

Biopartner, 2002, *Annual Report.* (The Hague).

Bögenhold D, Fachinger U, and Leicht R, 2001, "Self-employment and wealth creation", *International Journal of Entrepreneurship and Innovation* **2** 81-91.

Bolisani E, Scarso E, 2000, "Electronic communication and knowledge transfer". *Int. Journal of Technology Management* **20** 116-133.
Borgatti S P, Foster P, 2003, "The network paradigm in organizational research. A review and typology", *Journal of Management* **29** 991-1013.
Borja R, Castells M, 1997, *Local and global. The management of cities in the information age* (Habitat, London).
Cairncross F, 1997, *The Death of Distance* (Harvard Business School Press, Cambridge UK)
Camagni R, 1991, "Local "milieu", uncertainty and innovation networks: towards a new dynamic theory of economic space", in *Innovation Networks: Spatial Perspectives*, Ed R Camagni (Belhaven, London) pp 121-144.
Cohen G, Nijkamp P, Montfort K van, 2004, "Modeling ICT perceptions and views of urban front liners", *Urban Studies* **41** 2647-2667.
Cooke P, Wills D, 1999, "Small firms, social capital and the enhancement of business performance", *Small Business Economics* **13** 219-234
Delft H van, Gorter C, Nijkamp P, 2000, "In Search of Ethnic Entrepreneurship Opportunities in the City: a Comparative Policy Study", *Environment & Planning C*, **18** 429-451.
Eisenhardt K M, 1989, "Building theories from case study research". *Academy of Management Review* **14** 488-511.
Florida R, 2002, *The rise of the creative class, and how it is transforming work, leisure, community and everyday life* (Basic Books, New York).
Geenhuizen M. van, 2004, "Cities and Cyberspace: New Entrepreneurial Strategies". *Entrepreneurship and Regional Development* **16** 5-19.
Geenhuizen M. van, Nijkamp P, 2004, "In Search of Urban Futures in the E-economy" in *Transport Developments and Innovations in an Evolving World*, Eds M Beuthe, V Himanen, A Reggiani and L. Zamparini, (Springer, Berlin) pp. 69-83.
Gertler M, 2003 "Tacit knowledge and the economic geography of context, or The undefinable tacitness of being (there)" *Journal of Economic Geography* **3** 75-99.
Glaeser E L, 1998, "Are cities dying?" *Journal of Economic Perspectives* **12** 139-160.
Goh C, Law R, 2003, "Incorporating the Rough Sets Theory Into Travel Demand Analysis", *Tourism Management* **24** 511-517.
Graham S, 1998, "The end of geography or the explosion of place? Conceptualising space, place, and information technology" *Progess in Human Geography* **22** 165-185.
Grentzer M, 1999, Raumlich-strukturellen Auswirkungen von IuK-Technologien in transnationalen Unternehmen. Geographie der Kommunikation, 2 (LIT, Munster).
Hoang H, Antoncic B, 2002, "Network-based research in entrepreneurship: a critical review", *Journal of Business Venturing* **17** 1-23.
Howells J R L, 2002, "Tacit knowledge, innovation and economic geography", *Urban Studies* **39** 871-884.
Kalsaas B T, 1996, Spatial Impacts of Just-in-Time Production. Paper presented to NECTAR Euroconference no. 3, Université Catholique Mons, Belgium, September 24-28, 1996.
Kenney M, Curry J, 2001, "Beyond Transaction Costs: E-Commerce and the Power of the Internet Dataspace", in *Worlds of E-Commerce: Economic, Geographic and Social Dimensions* Eds T R Leinbach and S D Brunn, (Wiley, Chichester) pp. 45-65.
Klaassen L, 1967, *Methods of Selecting Industries for Depressed Areas: An Introduction to Feasibility Studies* (OECD, Paris).
Lockett A, Thompson S, 2001, "Resource-based view and economics". *Journal of Management Studies* **27** 723-755.
Malecki E, 1997, "Entrepreneurs, networks, and economic development" *Advances in Entrepreneurship, Firm Emergence and Growth* **3** 57-118.
Malecki E, 2001, "The Internet Age: Not the End of Geography", in: *Promoting Local Growth: Process, Practice and Policy*, Eds D Felsenstein and M J Taylor (Ashgate, Aldershot), pp. 227-253.
Masurel E, Nijkamp P, Tastan M, Vindigni G, 2002, "Motivations and Performance Conditions for Ethnic Entrepreneurship", *Growth and Change* **33** 238-260.

Nijkamp P, 2000, "Critical Success Factors for Soil Remediation Policy", *A Meta-Analytic Comparison, Journal for Environmental Policy and Law* **1** 81-98.
Ohmae K, 1999, *The Borderless World* (Harper Business, New York).
Oort F van, Raspe O, Snellen D, 2003, *Spatial Impacts of ICT (in Dutch)* (National Spatial Planning Bureau and NAi Uitgevers, The Hague and Rotterdam).
Oort F G, Stam E, 2004, "*Entrepreneurship and Agglomeration Economies in the Dutch ICT Industry*, in: *Udevalla Symposium 2004 Regions in Competition and Co-operation*, " Ed I Johansson, (University of Trollhattan/Udevalla, Udevalla) pp. 689-717.
Pawlak Z, 1991, *Rough Sets*, (Kluwer, Dordrecht).
Polkowski L, Skowron A, 1998, *Rough Set in Knowledge Discovery*, (Springer, Physica Verlag, Berlin).
Porter M, 2001, "Strategy and the Internet", *Harvard Business Review*, March, pp. 63-78.
Romein H, Albu M, 2002, "Innovation, networking and proximity", *Regional Studies* **36** 81-86.
Rosenthal S S, Strange W C, 2001, "The determinants of agglomeration", *Journal of Urban Economics* **50** 191-229.
Reid S, Garnsey E, 1998, "Incubation Policy and Resource Provision: Meeting the Needs of Young Innovative Firms", in: *New Technology Based Firms in the 1990s, Volume V*, Eds R Oakey and W During (Paul Chapman, London), pp. 67-80.
Schiller D, 1990, *Digital Capitalism*, (MIT Press, Cambridge, UK).
Sexton D L, Smilor R W (eds.), 1986, *The Art and Science of Entrepreneurship*, (MIT Press, Cambridge, UK).
Sohn J, 2004, "Information technology in the 1990s: More footloose or more location-bound?", *Papers in Regional Science* **83** 467-485.
Storper M, Venables A J, 2002, Buzz, the economic force of the city. Paper at the Druid conference Copenhagen.
Tabuchi T, 1998, "Urban agglomeration and dispersion: a synthesis of Alonso and Krugman" *Journal of Urban Economics* **44** 333-351.
Vohora A, Wright M, A Lockett, 2003, "Critical junctures in the development of university high-tech spinout companies", *Research Policy* **33** 147-175.
Yin R K, 1994, *Case Study Research* (Sage, Thousands Oaks , CA).