ICT, the Knowledge Society and Changes in Work
The Hague, 9-10 June 2005
Session 2: Globalisation: geographical and labour market approaches

ICT, Footlooseness and Agglomeration Advantages

Marina van Geenhuizen*

Abstract

The present study addresses the relevance of agglomeration and proximity for companies under the influence of advanced ICT. The background to this study are the many visions and speculations on an increased footlooseness of companies and a concomitant dispersal of urban economic activity. First, theory on advantages from knowledge spillovers is discussed and connected to more recent resource-dependence views on companies. Secondly, an empirical analysis of innovative companies in various city-regions in the Netherlands is presented. This exploratory analysis of various high-technology sectors deploys an artificial intelligence method, named rough set analysis, to increase understanding of the crucial factors influencing the relevance of physical proximity. Based on the results, we argue that agglomeration economies 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 and agglomeration economies that cover a larger metropolitan area. The only fundamental change in proximity needs among young, innovative companies originates from a small class of so-called network companies, which have a wide geographic coverage. Particular segments of high-technology companies can be seen as somewhat footloose, but these still have some proximity needs. In addition, the results of an in-depth analysis of ICT use reveals various important obstacles to the adoption of advanced ICT, contributing to a broad uncertainty about the speed of adoption and impacts on business locations.

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

*Associate Professor, System Innovation and Spatial Development, Faculty of Technology, Policy and Management; Delft University of Technology, Delft, The Netherlands (m.s.vangeenhuizen@tbm.tudelft.nl).

1. Setting the Scene

In our competitive global economy the growth and decline of business firms is increasingly seen as critically contingent on urban seedbed and incubator conditions, knowledge production and adoption, creativeness and learning attitudes and adoption of modern lifestyles (see also Acs, 2002). In recent years, we have witnessed an upsurge of entrepreneurial initiatives closely connected with the rapid growth of the information and communication technology (ICT) sector. It is generally recognized that modern dynamic sectors of the economy, in particular the ICT sector, have the promise 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 (e.g. Camagni, 1991).

It is now an important question whether access is best saved through physical proximity of firms or whether modern ICT systems create virtual connectivity without the need of geographic proximity. There have been many speculations on the 'death of distance' and on the space-opening character of the advanced ICT sector (see for a review e.g. Cohen et al., 2004). But what are the empirical facts on 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, and what are the urban entities that are involved? 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. What matters in interaction is in fact 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, 1995). Clearly, both concepts may be intertwined. Cities can be seen as agglomerations of economic activities based on advantages of both kinds of proximity.

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. The use of ICT in business transaction means a quicker and denser communication and a tighter co-ordination 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' 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 in order to avoid 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, while agglomeration of economic activities is not necessary, as this does not necessarily add to production growth and economic externalities anymore (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 far-reaching characteristics of the Internet self (Kenney and Curry, 2001). First, it offers an 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, such 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 utilise 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 moving 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 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 (van Geenhuizen, 2004a). This would mean that agglomeration economies remain a key attraction factor of cities for young and innovative entrepreneurs, mainly based on knowledge spillovers (see, e.g. Audretch, 1998). However, due to progress in the potentials of the communication technologies themselves (e.g. an increased codification of previously tacit knowledge and use of intelligent agents that undertake selection tasks) barriers may be moving and influence companies working with the technologies, based on an increased learning curve and cultural adjustment (Andriessen, 2003). 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 (2004a), Grentzer (1999), and Kalsaas (1996).

Given the above situation, we attempt to clarify the relevance of proximity 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 may be the implication of this situation for the future position of cities?

2) Which factors limit and which enhance the use of advanced ICT? What is the role of ICT in becoming more footloose?

In this study 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, including e.g. Electronic Data Interchange (EDI) and the Internet, and more complex systems of remote monitoring and computer-aided decision-making in virtual networks. Three basic roles can be distinguished for ICT in business activities: (1) as a product (services) like advanced facility sharing and call centre activity, (2) as a '*driver*' of new business models, like in network or virtual companies, and in electronic commerce companies (the latter class falls beyond the scope of this study), and (3) as support in business operations, like EDI, web ordering, and remote maintenance and services. Accordingly, the roles may include merely communication but also integration and coordination, and various combinations (van Geenhuizen, 2004b). Each of these roles may be connected to different needs for physical proximity, but the implications call for a thorough empirical analysis.

2. Theoretical Views on Needs for Proximity

In this section we address various theoretical views that shed light on advantages of proximity in urban areas. 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 conceptualisation of "footlooseness".

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 lifecycle – 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 of 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 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 often by chance (e.g. Rosenthal and Strange, 2001).

The need for spatial proximity to enjoy knowledge spillovers, however, 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. ICT offers an unlimited spectrum of virtual communication opportunities. The solution for this paradox on localization of knowledge spillovers seems to be 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 require proximity or face-to-face contacts by bridging distances between people sharing the same social context. These observations call for alternative analytic perspectives.

In general, young and innovative entrepreneurs face 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. Locket and Thompson, 2001; Reid and Garnsey, 1998). In this context, Storper and Venables (2002) distinguish between various functions of tacit knowledge transferred in cities, like for co-ordination, confirmation and check, and for 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). 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 enables young, innovative entrepreneurs 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., 2003). 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 a larger need 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 situation may be due to an early growth stage (young age) or independent position without support. Clearly, there is a need for more appropriate applied work to test various assumptions.

There is not much conceptualisation of the situation in which companies are free from location constraints (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 with respect to the city-region by using empirical interviews among young entrepreneurs in dynamic sectors of the economy.

3. Design of the Empirical Research

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. 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 over an eight-month period in 2003/2004. In the interviews, 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 case studies were particularly dealing 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 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 results from the interviews were systematically codified in a large case-study database as a matrix that constitutes a concise representation of the underlying field information (this matrix is also named information table). 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 Skowron, 1998). Rough set data analysis aims to perform a classification analysis on "soft" categorical data distinguished according to various groupings derived form 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. In our analysis we were particularly interested in the decision algorithms produced by a stepwise scanning of the data matrix. 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). A useful computer software programme to carry out a rough set analysis is Rough Set Data Explorer (ROSE).

The condition variables used in our empirical case study were selected based on the previously indicated resource-based approach to growth of companies (note 1):
1) position (corporate status); 2) age; 3) size; 4) main activity; 5) duration of innovation projects; and 6) spatial orientation.

We notice that the interpretation of the 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 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 1.0, 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 first, all six condition variables belong to the core meaning that all of them contribute to an explanation and no variable contains redundant information, and secondly, 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 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% (two companies) and 38.5% (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 footloose orientation of companies, we have to trace the conditional rough set statements. This will be done in the next section.

4. Footloose or Not?

We will now present the results of applying the rough set methodology to the degree of footlooseness of the 21 companies by viewing 12 rules (Table 1). More details on the rules can be found in Annex 1.

Table 1 Rules as outcomes of the rough set analysis

Companies	**Strength of rules**	**Number of companies**	**Generalization**
Conditions in rules on place-bound			
Rule 1) Regional orientation towards suppliers/ customers	38.5% a)	5	Biotechnology and advanced ICT services; the latter are tied to the highest level telecommunication nodes and the metropolitan labor 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 type 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 university of origin).
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 multinational (corporate origin).
Rule 8) Older age and long-lasting innovation projects	40.0% a)	2	More mature research companies in biotechnology and mechatronics that start 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.
Ambiguous results			
Rule 10-12) Spin-off 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 also Table 2):

- 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.
- Of the twelve rules five refer to the need for proximity and agglomeration advantages, whereas four 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 and long-lasting innovation projects (rule 8).
- 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 indifference of companies towards proximity and space.

It seems so far that, different from the death of distance scenarios, particular categories of companies seem not footloose at all. Despite a high appreciation of ICT-use, agglomeration economies tend to hold true for particular segments of innovative companies.

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	- 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

5. A Closer Look at Footlooseness

Based on in-depth information, we could identify changes in footlooseness in the near future as foreseen by managers and the background to these changes. The following trends appear:

- Place-bound companies tend to reinforce their overall need for proximity, and this is primarily connected to knowledge workers; customers, knowledge institutes, and private social networks are in second place. This pattern refers to small research and service companies in biotechnology, aside from customer- and labour market-oriented ICT service companies.
- In particular circumstances place-bound companies tend to become more footloose and that is when they develop a global orientation in their next growth stage as a research company (high level of specialization in innovation and knowledge needs).
- Among somewhat footloose companies, footlooseness tend to increase based on a further globalization through supplier networks (network model), customer markets and research and development alliances.
- By contrast, somewhat footloose companies tend to develop more needs for proximity if they originate from abroad and establish a market in the Netherlands; this is also true for companies displaying an ambiguous behaviour (e.g. in ICT services, after a reorganization).

The above trends point to a differentiated situation, in which place-boundness and footlooseness increase and decrease in the near future. So far we may conclude that the empirical material does not support a large scale increase of footlooseness. Only particular segments of young, innovative companies tend to become more footloose, i.e. those that enter global knowledge relations, employ and extend a network model (high levels of outsourcing) and enter global markets. These segments may increase in size and kind because there is a move to global knowledge relations (e.g. Simmie, 2003) and the most determining factor of footlooseness (position) is influenced by an increased globalization of corporate ownership relations.

Our empirical results also indicate that a certain degree of footlooseness may still be coupled with some specific spatial needs within 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 may arrive at three “candidate” agglomerations based upon sheer size of their population, a certain level of centrality, an easy access to Amsterdam Schiphol Airport (within approximately 1 to 1.5 hour travel time by public transport), and access to global knowledge through a university and a first-tier node in the science and education grid SURFnet (Gigaport, 2004). These cities are Leiden, Eindhoven, and Tilburg (Table 3), of which the first is the most centrally located towards the four large cities and Amsterdam Schiphol Airport. In addition, there are three agglomerations without a university, but with higher educational institutes and connections to the SURFnet grid, i.e. Dordrecht, Haarlem and Breda.

Table 3 Agglomerations as nodes 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 of the urban agglomeration in January 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 a second reound.

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

Dependent on how strictly defined, the above cities indicate a larger metropolitan area in which a set of more general agglomeration advantages may be satisfied. Note that the empirical results also indicate that particular agglomeration advantages can only be enjoyed in the largest city (Amsterdam), e.g. internationally oriented (multilingual) knowledge workers; direct access to the highest capacity telecommunication node and grids; and proximity to particular customers and suppliers to participate in joint projects facilitating learning on a daily basis.

6. The Role of ICT

In some studies it is argued that ICT opens up new worlds and, accordingly, profoundly changes the structure and geographic location of business operations. In this section, therefore, we explore remaining obstacles to the adoption of ICT in business operations and identify how such obstacles may contribute to uncertainty concerning the growth of numbers of footloose companies.

In exploring obstacles to adoption of ICT we distinguish between different categories of obstacles: between users and systems, between systems, between users, between users and third parties, and between users' needs and ICT infrastructure capacity (Table 4). Our empirical material indicates a dominance of obstacles in the match between users and systems, based on an overestimation of ICT's potentials (including a wrong use) and lack of skills to adequately deal with the technology. The fear that the company becomes dependent upon a certain system is also a serious obstacle in this category. Other categories of obstacles seem less important, but are still relevant, i.e. the match between systems and the match between users. The latter includes issues that are not technical but social, cultural and legal.

Table 4 Obstacles in the adoption of advanced ICT

Category of obstacles	Number of opinions
Match between user and systems - wrong use and expectations of ICT potentials - shortage in skills to handle systems - fear of dependence of interaction on systems	23
Match between systems - insufficient match between software	6
Match between users - lack of trust - difference in corporate culture - lack of transparency in legal responsibility and liability issues - different cultures and dynamics within a company active in different supply chains	5
Users and third parties - easy spread (abuse) of secret information	2
Match between users' needs and ICT infrastructure - insufficient bandwidth	1
Totals	37

In the remaining part of this section, we focus on the relevance of the previous obstacles among other factors of uncertainty surrounding the increase of footloose companies. We consider two main models among young, innovative companies leading to footlooseness, i.e. the network model and remote control of processes in other companies (current application of the latter is still very limited).

If we accept that technical shortages can be overcome, like bandwidth shortage and a poor quality of telecommunication (e.g. videoconferencing), various other uncertainties remain. These uncertainties are concerned with economic motives to adopt the network business model and with legal issues. The former includes uncertainty about increasing investment risks and global competition in high-technology sectors, and uncertainty about the match of the network model with needs in particular high-technology business. For example, the network model including high levels of outsourcing may match with the chip-related industry but may not match with particular segments of biotechnology (new drugs) because of the non-component character of the product and lack of potentials to reduce costs in this way. The latter type of uncertainty (legal issues) includes new arrangements (laws) between the partners involved, in terms of protection of secret information, the definition of responsibilities of each of the partners and liability issues between them. The previous economic and legal factors are at the base of growth of applications of advanced ICT, because these factors determine whether adoption of such applications increases profitability and whether it causes too many risks. Thus, we may conclude that a quick increase in the application of advanced ICT seems not realistic for all segments of high-technology sectors included in this study. The applications may not be cost-competitive and the risks may be too large due to unsettled responsibility and liability issues.

Table 5 Trends in footlooseness, including the role of ICT and uncertainty

Trends in footlooseness	Function of ICT	Nature of uncertainty
Network model	-*Crucial* in business model	-Development of investment risks and global competition -Match between network model and type of product and business culture in high-tech sector
Remote control	-Trend towards remote control of processes at supplier by customer (*crucial*)	-Problems of insufficient bandwidth -Lack of transparency in issues of protection of secret information and responsibility and liability between partners

8. Conclusion

A major result of this study is that there is quite some differentiation between young, innovative companies in proximity needs and footlooseness under the influence of ICT. Within one and the same sector, companies may be place-bound, footloose to some degree, or their behaviour does not show a clear pattern. The outcomes of the study based on rough set analysis 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 completely free to locate anywhere. We foresee that these companies will increase in number due to a growing globalization of ownership relations of companies and of knowledge networks for highly advanced technologies. Although the degrees of freedom in location choice have increased for certain segments of innovative companies, a particular need for agglomeration advantages seems remaining that can be satisfied in larger metropolitan areas, most probably in somewhat agglomerated places (see also the results of Sohn, 2004). The role of ICT is only profound (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 of which a fundamental decrease in proximity needs can be expected. 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. 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 tend to be place-bound. Despite a high appreciation of ICT use, a strong relevance of agglomeration economies holds true for particular segments of companies. These economies can be partly satisfied in a larger metropolitan area and partly merely in the largest city.

In addition, the results of an in-depth analysis of ICT use has revealed various important obstacles to the adoption of advanced ICT, contributing to a broad uncertainty about the speed of adoption and implications for business locations. These obstacles are mainly connected to an insufficient match between users and the systems, like an overestimation of the potentials of ICT and fear for dependence of the company upon a certain system. Other factors that still hamper a quick and broad adoption of advanced ICT are concerned with economic issues (cost) and with legal factors that need to be settled between the partners involved.

The focus of this study has been on young and innovative companies active in producer markets. This means that many questions are still unanswered, e.g. concerning older companies, and concerning changes in business relations with consumers driven by ICT-use. Also, questions concerning major progress in ICT, were beyond the scope of this study, but point to interesting next research steps. Particularly the way legal obstacles concerning responsibilities and liabilities of partners, need to be solved before various models of remote control can be implemented, calls for attention.

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 profound empirical work, both on a city-by-city basis and in the form of a meta-analytical comparative study.

Annex 1 Rules produced by rough set analysis (selected by the author)

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 form 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 lifecyle 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 addition 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.

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

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
Bolisani, E. en E. Scarso (2000), Electronic communication and knowledge transfer. *Int. Journal of Technology Management*, 20 (1/2), 116-133.
Borja, R. and 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 Camagni, R. (ed), *Innovation Networks: Spatial Perspectives*, Belhaven, London.
Cohen, G., P. Nijkamp and K. van Montfort (2004), Modeling ICT perceptions and views of urban front liners, *Urban Studies* 41(13): 2647-2667.
Florida, R. (2002), *The rise of the creative class, and how it is transforming work, leisure, community and everyday life*. New York, Basic Books.
Geenhuizen, M. van (2004a), Cities and Cyberspace: New Entrepreneurial Strategies. *Entrepreneurship and Regional Development*, January 2004: 5-19.
Geenhuizen, M. van (2004b), *ICT-use, location dynamics and the future of cities* (in Dutch). Delft: Faculty of Technology, Policy and Management, Section System Innovation and Spatial Development.
Geenhuizen, M. van (2004c) Footloose or Not? A Rough Set Approach to Relevance of Proximity in the Urban Economy. In: Johansson, I. (ed) *Udevalla Symposium 2004 "Regions in Competition and Co-operation"*, Udevalla (Sweden): University of Trollhättan/Udevalla, pp. 389-401.
Geenhuizen, M. and P. Nijkamp (2001), Electronic Banking and the City System in the Netherlands, in: Leinbach, T. and S.D. Brunn (eds) *Worlds of E-commerce: Economic, Geographic and Social Dimensions*, John Wiley, New York, pp.181-201.
Geenhuizen, M. van and P. Nijkamp (2004), In Search of Urban Futures in the E-economy, in: Beuthe, M., V. Himanen, A. Reggiani, and L. Zamparini (eds) *Transport Developments and Innovations in an Evolving World*, Springer, Berlin, pp. 69-83.
Gertler, M.S. (1995), 'Being there': proximity, organization and culture in the development and adoption of advanced manufacturing technologies, *Economic Geography*, 71: 1-26.
Gertler, M. (2003) "Tacit knowledge and the economic geography of context, or The undefinable tacitness of being (there)" *Journal of Economic Geography* 3 (1): 75-99.
Gigaport (2004) www.gigaport.nl

Glaeser, E. L. (1998), Are cities dying? *Journal of Economic Perspectives*, 12 (2): 139-160.

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.

Howells, J.R.L. (2002), Tacit knowledge, innovation and economic geography. *Urban Studies*, 39 (5): 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. and Curry, J. (2001), Beyond Transaction Costs: E-Commerce and the Power of the Internet Dataspace. In: Leinbach, T.R. and S.D. Brunn (eds.) *Worlds of E-Commerce: Economic, Geographic and Social Dimensions*. Wiley, Chichester, pp. 45-65.

Klaassen, L. (1967), *Methods of Selecting Industries for Depressed Areas: An Introduction to Feasibility Studies*, OECD, Paris.

Lockett, A. and Thompson, S. (2001), Resource-based view and economics. *Journal of Management* 27 (6): 723-755.

Malecki, E. (1997), Entrepreneurs, networks, and economic development, *Advances in Entrepreneurship, Firm Emergence and Growth* 3: 57-118.

Malecki, E. (2002), The Internet Age: Not the End of Geography, In Felsenstein, D. and Taylor, M.J. (eds) *Promoting Local Growth: Process, Practice and Policy*, Ashgate, Aldershot.

Oort, F. van, Raspe, O. and Snellen, D. (2003), *Spatial Impacts of ICT (in Dutch),* National Spatial Planning Bureau (The Hague), NAi Uitgevers, Rotterdam.

Oort, F.G. and Stam, E. (2004) '*Entrepreneurship and Agglomeration Economies in the Dutch ICT Industry*' Udevalla Symposium Anthology Book, Udevalla 2004.

Pawlak, Z. (1991), *Rough Sets*, Kluwer, Dordrecht.

Polkowski, L., Skowron, A. (1998) (eds) *Rough Set in Knowledge Discovery*, Springer, Physica Verlag, Berlin.

Rosenthal, S.S. and Strange, W.C. (2001), The determinants of agglomeration. *Journal of Urban Economics*, 50: 191-229.

Reid, S. and Garnsey, E. (1998), Incubation Policy and Resource Provision: Meeting the Needs of Young Innovative Firms. In Oakey, R. and Dunning, W. (eds) New Technology Based Firms in the 1990s, Volume V, Paul Chapman, London, pp. 67-80.

Sexton, D.L. and R.W. Smilor (eds.) (1986), *The Art and Science of Entrepreneurship*, MIT Press, Cambridge, UK.

Simmie, J. and Sennet, J. (1999) Innovative clusters: global or local linkages? *National Institute Economic Review* 170: 87-98.

Sohn, J. 'Information technology in the 1990s: More footloose or more location-bound?'. *Papers in Regional Science*, 2004 (83): 467-485.

Storper, M. and 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. and 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).