VU VRIJE UNIVERSITEIT AMSTERDAM

VU Research Portal

A comparative study on innovation in European cities by means of multicriteria analysis

Nijkamp, Peter; Reggiani, Aura

2000

document version
Publisher's PDF, also known as Version of record

Link to publication in VU Research Portal

citation for published version (APA)
Nijkamp, P., & Reggiani, A. (2000). *A comparative study on innovation in European cities by means of multicriteria analysis*. (Research Memorandum; No. 2000-4). Faculty of Economics and Business Administration, Vrije Universiteit Amsterdam.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

E-mail address:
vuresearchportal.ub@vu.nl

Download date: 28. Mar. 2024

Faculteit der Economische Wetenschappen en Econometrie

SERIE RESEARCH MEMORANDA

A Comparative Study on Innovation in European Cities by Means of Multicriteria Analysis

Peter Nijkamp
Aura Reggianni

Research Memorandum 2000-4 **January 2000**

vrije Universiteit *amsterdam*

DRIVERS OF INNOVATION

A Comparative Study on Innovation in European Cities by Means of Multicriteria Analysis

Peter Nijkamp
Free University
Amsterdam

Aura Reggiani
University of Bologna
Bologna

Abstract

This paper addresses the issue of innovative behaviour of firms in an urban European context. It aims to identify key factors for innovation at the local level, based on micro survey information from firms. In seeking for prominent explanatory variables for entrepreneurial innovation in various classes of European cities, a particular multivariate method – i.e., Regime analysis – is employed. This special type of multicriteria method appears to be a fruitful tool for comparative analysis and generates a wide range of interesting empirical results on innovation factors in European cities.

Pn890ar

1. Setting the Scene

There is a growing recognition that economic development is not "manna from heaven", but the result of a transformation process induced and governed by economic actors who respond to competitive, institutional and political challenge. The currently popular endogenous growth theory argues that investments in innovation, education and infrastructure provision are critical success factors for economic progress (see for a review also Nijkamp and Poot, 1998). The present paper will focus in particular on innovative behaviour of firms in relation to their locational profile (including their needs for R&D facilities and accessibility).

Innovation has become a popular field of research in many disciplines, ranging from technology to economics or political science. Apart from macro studies on innovative competitiveness of countries and the related growth impacts, there have been numerous studies on individual entrepreneurial behaviour and attitudes vis-a-vis innovation. The spatial configuration of innovation has extensively been investigated in regional economics and geography. However, the linkage between individual innovation motives and their geographical location has less intensively been studied in the past decade (see among others, Nakicenovic and Grübler, 199 1; Karmeshu, 1992; Silverberg, 1992).

The innovation trajectory is essentially a chain activity starting from local incubation via generation of innovations and market acceptance into geographical spread of new products, services, processes, designs or ideas (see also Bertuglia et al., 1997). In this trajectory the nodal point of spatial industrial networks, in particular cities, play a strategic role. Not only does the "urban milieu" offer favourable seedbed conditions for innovative behaviour (such as R&D infrastructure, educational facilities, financial and venture capital mechanisms, socio-cultural networks and the like), but it also acts as a catalyst for transmitting new findings to other places in the network. As explained extensively in conventional space-time geography (see Hägerstrand, 1987), such transformation patterns have a clear geographical and time dimension. And cities are in this process prominent focal points of transactions favouring new ways of doing things (see also Davelaar and Nijkamp, 1997; Suarez-Villa and Hasnath, 1993).

This paper addresses the issue of identification of local innovation drivers in the light of the economic motives and objectives of firms. A systematic exploratory analysis based on individual entrepreneurial data in cities in three European countries (Italy, The Netherlands, U.K.) is offered. Its aim is to map out a series of driving forces which may potentially impact on the implementation or adoption of an innovation in a city of a certain class. Consequently, relevant local factors have to be identified and to be investigated in terms of their contribution to the firm's objectives. The identification of the most important alternative factors for a successful innovation will be undertaken here by using multicriteria analysis. Through this approach the most promising local factors can be pinpointed, while also their policy relevance can be judged.

This paper is organized as follows. We will offer a concise introduction to multivariate assessment analysis, in particular multicriteria analysis, in the next section (Section 2). Then in Section 3 we will give a concise description of the data base employed. Next, we will describe the results emerging from the micro survey data on the sample of European firms in various cities, followed by an interpretation of these results. Finally, in Section 5 we will offer some retrospective and prospective remarks.

2. Multivariate Analysis for Comparative Case Study Research: the Regime Method

In the present paper the innovation attitude and behaviour of firms in various European cities is investigated by means of detailed empirical case study approaches, based on extensive interviews with individual firms. Case study research does not aim to extract peculiarities from seemingly unstructured real-world cases, but seeks for generality and transferability based on strict design principles for research (see Yin, 1994). Therefore, in our field work a systematic common analysis framework has been used for all individual cases.

Based on an extensive literature survey on innovation behaviour of firms at the local level, five key forces have been identified which are generally assumed as drivers of entrepreneurial innovation. These factors are: agglomeration advantages, population structure, information network infrastructure, physical network infrastructure, and institutional network infrastructure. These factors are however, not specified in a directly measurable way; they are latent variables. Hence, we need a set of manifest (observable and measurable) indicators for each of these latent variables in order to perform an empirical analysis. The data base concerned will be described in Section 3.

In the present section we will address the use of a multivariate analysis that is particularly suitable for our purposes. If we want to compare individual case study data, we have to deploy a multidimensional classification method which offers exploratory and explanatory power in identifying the urban success conditions for innovations of firms. Here we will resort to a particular multivariate technique, viz. multicriteria analysis, which has gained much popularity as a powerful method for classifying case study information and for identifying decision rules in case of both quantitative and qualitative data.

Multicriteria analysis (MCA) is essentially a multidimensional classification method (see for an extensive overview Nijkamp et al., 1992). It serves to disentangle the complexity of distinct real-world objects by creating an information table in which phenomena (objects, projects, actors or regions) are systematically described in terms of constituent attributes (features, characteristics, performance scores, etc). Given the multidimensional&y of these objects, two questions arise: which are prominent distinguishing features and which object is most in agreement with an ideal ranking in which the characteristic attributes have the best possible achievement?

MCA then aims to develop techniques for a proper classification of the objects concerned (including also a ranking), while taking into account the different measurement levels of attributes and the (possibility of) different weights or important scores attached to the underlying factors or criteria. In our case study the goal is to classify the innovation motives and factors of individual firms in terms of relative importance from the perspective of locational driving forces. In general, MCA aims to identify the best possible classification of objects (in particular, an optimal ranking of courses of actions) from a set of competing alternatives, while taking into account a variety of non-compatible or conflicting judgement criteria. The relative (policy, actor or subjective) importance of these judgement criteria can be incorporated by means of a weighting system.

There is a wide variety of different MCA's. In general, a distinction is made between methods that are able to include quantitative, qualitative and mixed information. In the light of the precision of the information from our survey among entrepreneurs, it seems plausible to seek for a method which is able to encapsulate qualitative information. In this context, the Regime method is a

promising MCA (see for a detailed description Hinloopen and Nijkamp, 1990; Nijkamp et al., 1992).

The Regime method is originally based on pairwise comparisons of the multidimensional outcomes of an impact assessment of competing objects. The main idea is to try to find a dominant alternative, by including also information on relative weights assigned to various criteria.

It seeks to derive dominance rules based on a consistent treatment of the information represented by relative qualitative differences in a multidimensional data set. At present standard software is available to carry out a Regime analysis (see Janssen, 1996).

The technicalities have been sufficiently described in the literature. The outcomes of a Regime method are fascinating, in the sense that out of a set of qualitative data finally a quantitative score in terms of the numerical performance of each individual alternative object can be calculated. These scores may be quantitatively interpreted (i.e., on a ratio scale) and reflect a performance measure of each individual alternative. This approach will be applied to the data base to be described in Section 3.

3. The Data Base on Urban Innovation

In the present section we will focus our attention on the identification of critical local factors in order to highlight the drivers in innovation by using the above mentioned MCA. We will consider in our case study innovation data of individual firms (at the plant level) in the manufacturing sector. Clearly, the local factors under analysis are manifold (as shown by the abundance of literature on this issue), but they can systematically be classified as follows (see Table 1). More detailed information on the backgrounds of this classification can be found in Kangasharju et al. (1999), Kangasharju and Nijkamp (1999), and Reggiani et al. (1998).

Table 1. A systematic list or urban success factors for business performance, product innovation, market innovation, process innovation, and management innovation of individual firms
Source: Kangasharju and Nijkamp **(1999)**

LOCAL INNOVATION DRIVERS				
Agglomeration	**Population Structure**	**Information Network Infrastructure**	**Physical Network Infrastructure**	**Institutional Network Infrastructure**
Al Local suppliers A2 Local subcontractors Quality of local business services: A3 Supporting technology A4 Supporting marketing **A5** Supporting management	**B1** Skills in **labour** market B2 Skills in training support B3 Local customers	Cl Science **&** technology links with local university or college C2 Management links with local university or college C3 Chambers of commerce and industry C4 Trade association **C5** Clubs and societies C6 Conference services	**D1** Quality of telecommunications services D2 Quality of local transport facilities D3 Quality of international transport links	**El** Local investment subsidies E2 Local financial institutions E3 Favourable attitude of local politicians E4 Available land and building

In our empirical case study research, the importance of the local factors under investigation – perceived by each firm – is evaluated for the following five criteria:
(1) *commercial success of the company* in the recent past and in the next decade;
(2) *product innovation* in the recent past and in the next decade;
(3) *market innovation* in the recent past and in the next decade;
(4) *production process innovation* in the recent past and in the next decade;
(5) *management structure* in the recent past and in the next decade.

The data set used in our empirical application contains detailed information on entrepreneurial innovation based on controlled interviews, held in the framework of the so-called URBINNO' study (see, for details, also Damman, 1994), among different manufacturing industries (273) in various cities in three European countries: The Netherlands (33), Italy (32) and the United Kingdom (208) (see Table 2). The list of cities comprises both large and medium-size towns.

Table 2. Geographical location of the firms under investigation

Country	The Netherlands (NL)	Italy (IT)	United Kingdom (UK)
City	Rotterdam, Eindhoven and Tilburg	Milan and Como	Sheffield, Bristol, Coventry, Newcastle Nottingham, Blackbum, Peterborough and Reading
Number of firms	33	32	208

The questionnaire used for the personal interviews with qualified managers refers to retrospective (past) and prospective (future) information on 21 local key factors (see Table 1) for the 5 main objectives listed above.

The next section will illustrate the results of the MCA (see Section 2) by considering the above main criteria as single classifiers for implicit multidimensional decision-making. In other words, for each criterion, an MCA is carried out in order to offer an hierarchical classification of the above mentioned local factors for innovative behaviour.

4. Research Findings on the Relevance of Local Factors

In this section the results of a multicriteria experiment will be described, which aims to generate a hierarchical classification of distinct local innovation factors for each country considered, as well as for the joint level of all three countries, on the basis of the

[1] The URBINNO (Urban Innovation) study was a project originally financed by Volkswagen Foundation (between 1987 and 1989) for studying innovations in several urban areas from different perspectives, such as population, urban economy, institutions and infrastructure, and urban form (see, for details, also Davelaar, 199 1). Later on the study was financed by the European Commission.

relative importance of these factors for innovation in the recent past and future. The main idea behind this approach is that the alternatives – in the context of the MCA – are the 2 1 local innovation factors listed above, while the criteria are assumed to be made up by the structured views of the firms examined. In our case study, the number of criteria used in the MCA is *six:* three related to the importance of each alternative (ranked on a 3-point scale) for the recent past, and analogously, three criteria, ranked on a scale [1-3] for the future. Consequently, in our MCA, each importance score may be defined – in a quantitative way – by the number of the firms (frequency) that considered the local factor concerned as important for a given criterion. The results of the corresponding Regime method are presented in Tables 3 to 6.

By applying the multivariate Regime method to the data presented in Table 2 it is possible to derive the performance scores – in quantitative terms – for each of the 21 alternative attributes A1-A5, B 1-B3, C 1-C6, D 1-D3 and E 1-E4. We have assumed here an unweighted case, for all criteria (a)-(e), but a sensitivity analysis with varying importance indicators or weights did not lead to significant differences in results, so that the outcomes are rather robust. The final ordinal rankings of the 21 attributes (alternative drivers) responsible for local innovative behaviour can be found in Table 3. This table shows the results of the Regime analysis for four cases, viz. for both the three countries taken together (Table 3a) and for each of the individual countries, viz. The Netherlands, Italy and the UK, respectively (Tables 3b-3d). Thus, each entry in Tables 3a-3d represents – in a vertical sense – the (qualitative) rank order of the importance attached by the firms in the area at hand to each of the 21 alternative innovation factors. As explained above, a distinction is made in all four countries between the main criteria (a)-(e). We will now concisely discuss the results in Table 3.

Table 3a demonstrates clearly that on average a few innovation drivers stand out in the overall ranking in the first five columns (a)-(e), viz. skills in the local labour market (B1), skills in training support (B2) and quality of telecommunications services (D1). Based on a cross-section of the three countries considered, we may thus conclude that high skills and access to ICT services are regarded as critical success factors for local innovative behaviour of firms. The results also point out a set of losers, viz. the quality of local business services supporting marketing (A5), the presence of clubs and societies (C5) and the availability of conference services (C6). It is thus noteworthy that the firms interviewed tend to attach, in general, a higher importance – for their innovation success - to human capital factors such as skills in the labour market and in training support or access to high quality telecommunications services than to 'softer' types of network benefits such as clubs, societies and conferences.

Table 3a. Results of firms for three countries

	(a)	(b)	(c)	(d)	(e)	Σ
A1	8	5	6	6	13	6
A2	7	8	9	7	14	8
A3	13	6	10	5	8	7
A4	19	17	18	21	20	19
A5	18	18	20	17	7	18
B1	3	1	3	1	1	1
B2	1	2	4	2	2	2
B3	10	7	5	12	18	11
C1	11	4	11	4	5	5
C2	15	12	16	10	4	12
C3	16	16	13	18	6	15
C4	17	19	15	16	9	17
C5	21	20	21	20	21	21
C6	20	21	19	19	19	20
D1	5	3	1	3	3	3
D2	4	13	7	13	12	9
D3	2	9	2	8	10	4
E1	12	10	8	9	11	10
E2	14	11	17	14	15	16
E3	9	15	14	11	17	14
E4	6	14	12	15	16	13

Table 3b. Results of firms from The Netherlands

	(a)	(b)	(c)	(d)	(e)	Σ
A1	8	9	6	3	5	5
A2	6	4	8	5	6	4
A3	10	6	9	4	9	7
A4	14	11	10	13	13	13
A5	19	19	16	17	4	20
B1	5	1	4	2	2	2
B2	2	2	3	1	1	1
B3	12	7	7	12	11	10
C1	11	8	14	9	10	11
c2	17	13	15	15	7	15
C3	16	15	13	19	18	16
c4	21	21	19	20	19	21
C5	18	17	20	21	20	17
C6	20	18	21	14	21	18
D1	4	3	2	8	3	3
D2	7	12	5	16	8	9
D3	1	5	1	6	12	6
E1	13	16	18	11	15	14
E2	15	20	17	18	14	19
E3	3	10	12	7	16	8
E4	9	14	11	10	17	12

Table 3c. Results of firms from Italy

	(a)	(b)	(c)	(d)	(e)	Σ
A1	17	9	14	7	18	15
A2	20	19	18	13	17	18
A3	7	6	3	4	10	5
A4	19	20	16	19	19	19
A5	18	17	15	14	12	16
B1	12	2	10	1	4	4
B2	10	4	8	2	2	2
B3	21	21	19	20	21	21
C1	3	3	7	3	5	1
c2	16	13	13	10	3	11
c3	4	8	5	15	1	6
c4	13	11	4	16	6	9
C5	14	18	9	17	7	13
C6	8	15	6	18	8	12
D1	6	1	1	6	9	3
D2	2	10	11	9	15	10
D3	5	7	2	12	11	8
E1	1	5	12	5	13	7
E2	11	12	20	8	14	14
E3	15	14	17	11	16	17
E4	9	16	21	21	20	20

Table 3d. Results of firms from the UK

	(a)	(b)	(c)	(d)	(e)	Σ
A1	4	4	6	5	8	4
A2	5	6	7	10	11	6
A3	13	7	14	6	7	8
A4	19	15	18	18	18	19
A5	18	18	19	16	6	17
B1	2	1	2	1	1	1
B2	1	2	4	2	2	2
B3	9	8	5	9	10	7
C1	14	5	15	4	5	9
c2	15	13	13	7	4	13
c3	17	19	16	19	16	18
c4	16	17	17	17	19	16
C5	21	20	21	20	21	21
C6	20	21	20	21	20	20
D1	8	3	1	3	3	3
D2	6	14	8	13	14	12
D3	3	10	3	8	12	5
E1	12	11	10	11	9	11
E2	11	9	12	15	15	14
E3	10	16	11	12	17	15
E4	7	12	9	14	13	10

Table 3. Rank order results (positions) of the Regime analysis for firms in cities in various European countries

Legend: 1 = highest position, 21 = lowest position

Clearly, it is also interesting now to analyze the results for each individual country, in order to identify nation-specific drivers among the attitudinal preferences of the firms considered. These results can be found in Tables 3b-3d.

For The Netherlands (see Table 3b) the results are largely in agreement with the European average; innovation factors like local skills (Bl) and skills in training activities (B2) appear to score also relatively high here. Interestingly enough, the third highest scoring factor in the European cross-section analysis, i.e., access to high quality telecommunications services (Dl), receives a slightly less prominent position, which is most likely caused by the already existing, generally good quality of Dutch telecommunications services. Instead, the quality of international transport links (D3) is given a high importance, which is clearly a result of the Dutch policy focussed on The Netherlands as a transport and distribution country. Furthermore, also the presence of local subcontractors (A2) is regarded as fairly important. The least important innovation drivers in the Dutch context are – in addition to the above mentioned factors of presence of clubs or societies (C5) and conference services (C6) – trade association (C4), supporting management (A5) and local financial institutions (E2).

If we now turn to the Italian results (Table 3c), we find more variation in the rankings of the innovation attributes. Clearly, B1 and B2 appear to obtain also an important position among Italian firms, while also D1 is given quite some importance. But – besides this confirmation of previous results – Italian firms attach also a high value to science and technology links with local universities or colleges (Cl), the presence of Chambers of Commerce and Industry (C3) and local investment subsidies (El). Losing alternative drivers appear to be A2, A4 (supporting marketing), B3 (local customers) and E4 (available land and building). Thus, the Italian situation offers an interesting contrast compared to The Netherlands and the 'European average'.

Finally, we will pay some attention to the British outcomes (Table 3d). It is clear that the British firms more or less confirm the findings from the 'average European' Table 3a. Drivers like B1, B2 and D1 are highly regarded, while A4, A5 and C6 are given a low value. The same applies also to C3, C4 and C5.

The findings discussed above show – of course – some variation among the criteria (a)-(e), and therefore the question is legitimate whether a more robust pattern of results can be obtained by performing an aggregate Regime method. This experiment can be done in a stepwise way, which means that the MCA performance scores underlying the rankings of Tables 3a-3d can be used as the input for a new application of the Regime method. This leads then to an overall – unweigted – rank order of all 21 innovation drivers, for both the 'European average' and for the individual countries. This new ranking is indicated by the C-sign at the top of the 6th column in each of the Tables 3a-3d.

The last column of Tables 3a-3d appear to confirm our previous results. The innovation factors B 1, B2 and Dl appear to be the winning alternatives, except for Italy where Cl (R&D links with local higher educational institutes) turns out to be of outstanding importance. The 'losing' drivers are - in general - again A4, C5 and C6, with some exceptions for E2 and C4 in The Netherlands, and B3 and E4 in Italy. So, the overall results seem to be fairly robust, but show some variation for the individual countries involved. Clearly, the same experiment might also be carried out at the individual urban level in order to identify site-specific innovation drivers, but this experiment is beyond the scope of this paper.

In conclusion, the above described investigation into the driving forces of innovative behaviour of firms in various European cities has brought to light interesting features. Local skills of various kind appear to be of critical importance in all cases, while in the Italian case also the access to (formal and informal) local information and communication networks appears to be an important driver. Both The Netherlands and the UK appear to be closer to the 'European average', while Italy has some notable exceptions.

5. Concluding Remarks

The previous results - offering interesting 'lessons' on the behavioural attitude of innovative firms in three European countries - are meaningful in the context of spatial forecasting and spatial policy analysis.

In the first place, in the light of the spatial dynamics of firm (re)location in an integrating European market, it is important to identify the local success factors for innovative activities in order to map out the spatial opportunities of cities all over Europe. In this context, the previous experiments are extremely revealing, as they are able to generate conditional forecasting statements of a 'what.. .if' nature.

Secondly, the previous information is also of high relevance for local policy-makers, as these findings point at various driving forces for innovative behaviour of firms at the local level, which may be supported by a (pro-)active and dedicated urban policy for attracting new firms.

And finally, the same type of analysis could be also 'monitored' in a longitudinal way by asking regularly the same firms on the emergence (and relative importance) of new local factors (e.g., electronic information, etc.). Given the fast dynamics of innovation (see also Nijkamp and Reggiani, 1998), it is evident that in this sector also 'dynamic' and flexible tools of analysis are necessary.

One lesson is clear: innovation is a complex process whose success is dependent on entrepreneurial factors and on local determinants. It is also evident that these local factors are multidimensional in nature. They contribute individually and in combination to the success and failure of innovation behaviour. Policy can at best facilitate the emergence of

innovations; it is a flanking strategy which may have an important impact, but it is not a substitute for the 'animal spirit' which forms the backbone of innovation.

Acknowledgements

This paper has been carried out in the framework of the SOEIS (the Self-Organization of the European Information Society) project.

References

BERTUGLIA, C.S., S. **LOMBARDO** and P. NIJKAMP (eds.) (1997). *Innovative Behaviour in Space and Time,* Springer-Verlag, Berlin.

DAMMAN, M. *(1994). Individual and Spatial Success Factors of Innovative Firms,* M.A. Thesis, Department of Economics, Free University, Amsterdam.

DAVELAAR, E.J. *(1991). Regional Economic Analysis of Innovation and Incubation,* Avebury, Aldershot, UK.

DAVELAAR, E.J., and P. **NIJKAMP** (1997). Spatial Dispersion of Technological Innovation: A Review, *Innovative Behaviour in Space and Time* (C.S. Bertuglia, S. Lombardo and P. Nijkamp, eds.), Springer-Verlag, Berlin, pp. 17-40.

HÄGERSTRAND, T. (1987). Human Interaction and Spatial Mobility, *Transportation Planning in a Changing World* (P. Nijkamp and S. Reichman, eds.), Avebury, Aldershot, UK, pp. 1 l-28.

HINLOOPEN, E., and P. **NIJKAMP** (1990). Qualitative Multiple Criteria Choice Analysis: the Dominant Regime Method, *Quality and Quantity,* vol. 24, pp.37056.

JANSSEN, R. *(I 996). Multiobjective Decision Support for Environmental Management,* Kluwer, Dordrecht.

KANGASHARJU, A., and P. NIJKAMP (1999). Innovation Dynamics in Space, *Socio-Economic Planning Sciences,* (forthcoming).

KANGASHARJU, A., P. **NIJKAMP** and M. **VAN GEENHUIZEN** (1999). Local Opportunities and Innovative Behaviour, *Regional Development in an Age of Structural Economic Change* (P. Rietveld and D. Shefer, eds.), Avebury, Aldershot, UK, (forthcoming).

KARMESHU (ed.) (1992). Special Issue on Mathematical Modelling of Innovation diffusion and Technological Change, *Journal of Scientific and Industrial Research,* vol. 5 1, no. 3.

NAIUCENOVIC, N. and A. GÜBLER (eds.) (1991). *Diffusion of Technologies and Social Behaviour,* Springer-Verlag, Berlin.

NIJKAMP, P., and J. **POOT** (1998). Spatial Perspectives on New Theories of Economic Growth, *Annals of Regional Science, vol. 32,* no. 1, pp. 7-28.

NIJKAMP, P., and A. **REGGIANI** (1998). *The Economics of Complex Spatial Systems,* Elsevier, Amsterdam.

NIJKAMP, P., P. RIETVELD and **VOOGD** (1992). *Multiple Criteria Analysis in Physical Planning,* Elsevier, Amsterdam.

REGGIANI, A., P. NIJKAMP and E. **SABELLA** (1998). New Explanatory Models for Analysing Spatial Innovation, Discussion Paper, TI 98-13 1/3, Tinbergen Institute, Amsterdam.

SILVERBERG, G. (1992). On the Complex Dynamics of Technical Change and Economic Evolution, *Journal of Scientific and Industrial Research,* vol. 51, pp. 151-156.

SUAREZ-VILLA, L., and S.A. **HASNATH** (1993). The Effect of Infrastructure on Innovation, *Technological Forecasting and Social Change,* vol. 44, no. 3, pp. 333-358.

YIN, R. (1994). *Case Study Research,* Sage Publications, New York, 1994.