

ET

47

05348

1986

SERIE RESEARCH MEMORANDA

THE INCUBATOR HYPOTHESIS:

RE-VITALIZATION OF METROPOLITAN AREAS?

Evert Jan Davelaar

Peter Nijkamp

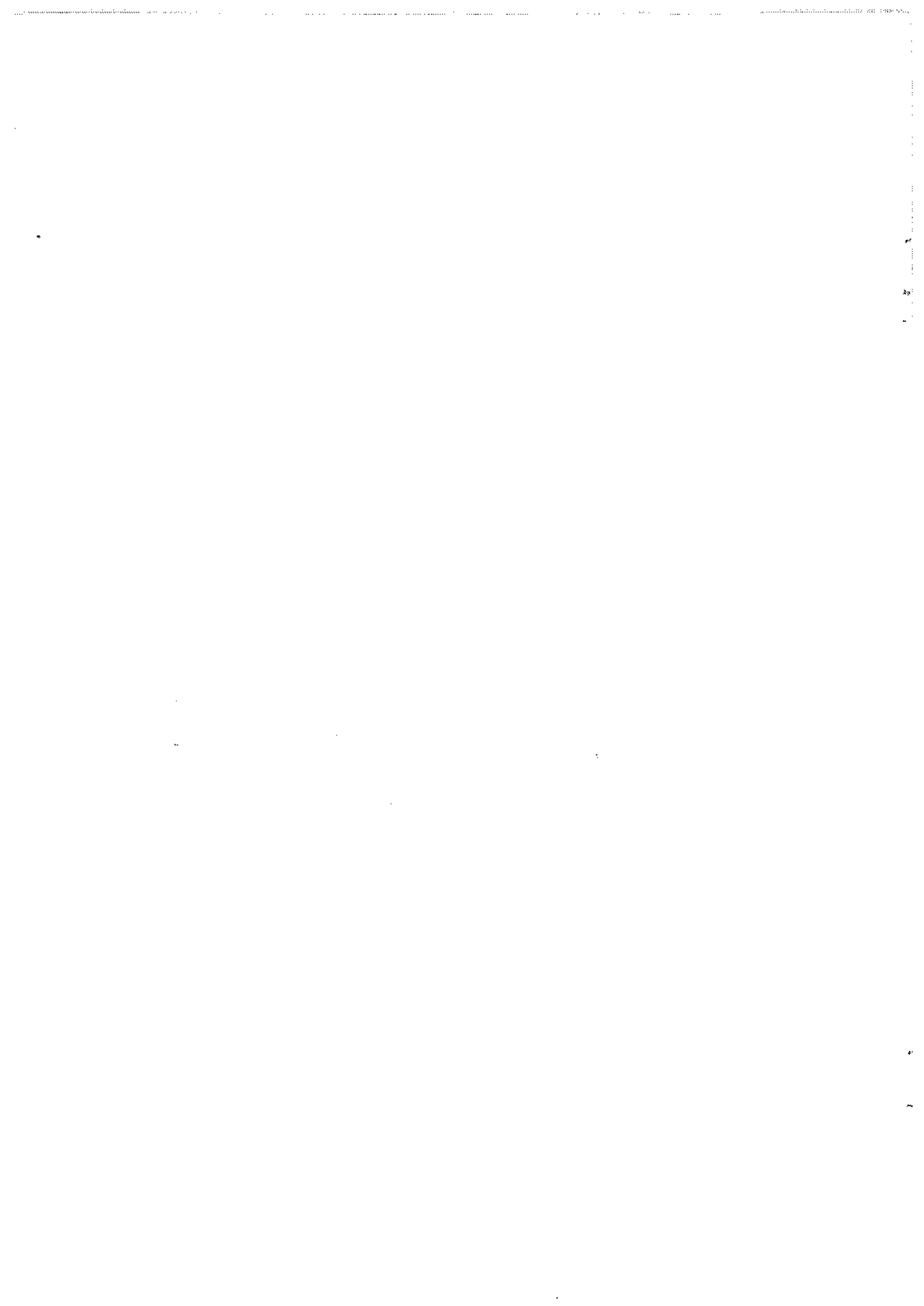
Researchmemorandum 1986-47

December 1986



**VRIJE UNIVERSITEIT
FACULTEIT DER ECONOMISCHE WETENSCHAPPEN
AMSTERDAM**

2-3



THE INCUBATOR HYPOTHESIS:
RE-VITALIZATION OF METROPOLITAN AREAS?

Evert Jan Davelaar
Peter Nijkamp

This study was supported by the Netherlands Organization for the Advancement of Pure Research (ZWO), projectnumber 46-155.

Paper Summer Institute, Umea, June 1986.

1. Introduction

Modern technology appears to lead to contrasting views on the social and economic value of its impacts. On the one hand, there is the view that automation, computerization and high tech operations will affect the creativity and craftsmanship of workers due to a separation of work into conception and execution à la Taylor (see e.g. Braverman, 1974, and Elger, 1982). The deskilling thesis inherent in a 'Bravermania' has increasingly been criticized, as it underestimates the potential flexibility and the degrees of freedom for creativity of new technology (see Sabal, 1982).

Especially in the 1980s a less deterministic and more optimistic view on modern technology has emanated, in which reskilling and work competence have been much stronger emphasized. Technological innovation has almost become a magical word for policies aiming at an economic recovery (see Freeman, 1984). Although there is as yet no consensus about the existence and explanation of long waves (of the Kondratiev or Schumpeter type), there is much evidence that economic fluctuations related to technological changes do exist in the long-term evolution of western economies (see also Kleinknecht, 1986). The latter debate has also evoked a profound interest in the mechanism of technological regimes and technological styles (see Nelson and Winter, 1984).

The more positive view on the role of technological change is confronting us with an intriguing question, viz. the geographical distribution of innovations and industrial changes, including innovation diffusion (see also Malecki and Varaiya, 1986). An unequal spatial distribution of innovations in the industrial and service sector will of course have an enormous impact on regional labour markets and, in a broader sense, on regional welfare profiles (see e.g. Nijkamp, 1986). The analysis and explanation of the geographical pattern of innovations requires a coherent framework, in which the innovative potential of specific places plays a dominant role. In this context, the urban incubation hypothesis may provide a useful explanatory paradigm, in as far as it is based on the impact of specific agglomeration economies on entrepreneurial behaviour. Consequently, in the present paper the spatial dimensions of the degree of innovativeness will play a central role.

This paper is organized as follows. Section 2 provides a general discussion of innovations from 3 different angles, viz. time, space and systems impacts, resulting in the notion of a so-called innovation cube. Next, in section 3 the attention will be focused on spatial and temporal aspects of production dynamics by using the concept of spatial product cycles. Next, section 4 will provide an explanatory framework for the geographical distribution of innovations, based on

an adjusted spatial incubation thesis. A preliminary test of the framework will be carried out in section 5 by using a contingency table analysis for innovation data from an industrial survey in the Netherlands. Section 6 is devoted to a more rigorous test of innovation-incubation hypotheses by means of various regression models. The paper will be concluded with some retrospective and prospective remarks.

2. Temporal, Spatial and Systems Aspects of Innovations

An innovation means a successful or commercially feasible introduction of an invention, a new technology or a whole technological regime by an agency or firm. In the literature we can observe a growing tendency to consider the metropolitan areas as breeding places of innovative activities (cf. Malecki 1979, Norton 1979 and Pred 1977). A topic related to this is the issue that the old industrial areas are tending to loose their innovation potential to attractive residential areas. Malecki (1979) and Norton (1979), for example, try to explain the rise of certain sunbelt states in the U.S. by means of an interregional shift of the incubation areas of innovative activities from the Northeast to these regions. Aydalot (1984) observes the same tendencies in France.

A question related to this is whether the large metropolitan areas are also loosing their innovation potential to smaller cities or rural areas due to this shifting of the regional innovation potential. Here the evidence seems to be contradictory. In a way this seems to be related to the type of study performed. In a rather rudimentary way we could distinguish between micro(firm) based innovation studies on the one hand and case studies of high quality innovations on the other hand.

Many studies which are concerned with special high quality innovations find that the time-space trajectory of these innovations is highly urban-based! Some examples are:

- Andersson and Johansson (1984) with regard to the consultancy sector in Sweden.
- Camagni (1984) with regard to robotics in Italy.
- Feller (1973) with regard to inventions in general.
- Oakey (1980) with regard to high quality product innovations.
- Koerhuis and Cnossen (1982) with regard to the computer service and software firms in the Netherlands.

Of course these studies are in line with the Hagerstrand (1967) central place diffusion process.

On the other hand, the micro(firm) based innovation studies which study R&D, innovation production and adoption at the individual firm level, especially in the Netherlands, do not find (any) or at

least weaker evidence concerning a very strong innovative position of firms in metropolitan regions. Some examples are Kok (1984), Klein-knecht and Mouwen (1985) and Thwaites (1982). As a matter of fact there is even a tendency (especially in the Netherlands) to speak of a shift of the regional innovation potential away from the central areas.

In order to integrate both types of studies, and on behalf of the analysis and explanation of the geographical pattern of innovations in general, a coherent framework is needed. Recent innovation research has however clearly pointed out the difficulties involved in developing or using an operational and unambiguous definition of innovations. Therefore, the major aim of the present section is to provide a clear conceptual framework for analysing innovations in space and time.

The generation, diffusion and adoption of an innovation presupposes the emergence of a new activity. The degree of novelty of this activity has 3 important dimensions, viz. time, space and systems.

The time dimension deals with the dynamic trajectory of an innovation (e.g., on the basis of a logistic growth curve). The space dimension concerns the geographical dispersion of innovations over different regions or places (e.g., on the basis of a distance decay curve). The systems dimension relates to impacts (or adoption) of innovations in different production systems or industrial sectors (e.g., on the basis of a classification of a variety of actors accepting the innovation concerned, ranging e.g. from individual firms, branches or industrial sectors to the economy as a whole). Thus, the degree of novelty of an innovation is time-specific, space-specific and systems-specific. These elements will now briefly be discussed.

(a) Time

The time trajectory of an innovation may exhibit a pattern of either fast dynamics (quick acceptance, e.g.) or slow dynamics. An example of fast dynamics can be found in the introduction and adoption of word processors in office automation, whilst an example of slow dynamics can be found in technological changes inherent in a long-term Kondratiev cycle (based e.g. on a clustering of basic innovations over time; see Mensch, 1979).

An illustration of the spread of innovations over time, for a given system and a given space, is given in Fig. 1, which exhibits fluctuating patterns ('waves') of generating (adopting) innovations. These 'waves' may be system and space specific.

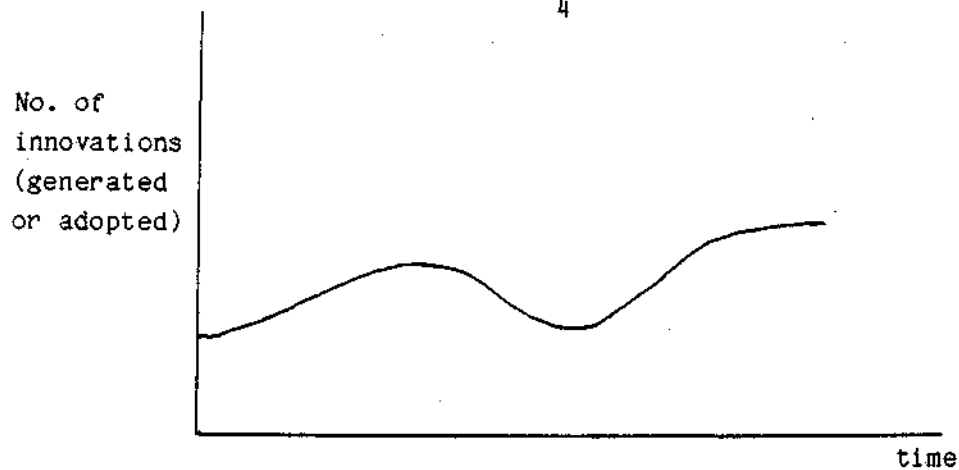


Fig. 1. Spread of innovations over time (for a given place and system)

(b) Space

It is evident that not all regions are equally productive or adoptive with regard to innovations (see, for example, Oakey, 1981, Thwaites, 1982, and Andersson and Johansson, 1984). Some regions or cities offer a more fertile climate for innovative behaviour than others. A good illustration of this point can be found in Jane Jacobs (1961). In this context the notions of agglomeration economies and of urban incubation phenomena play a major role. This may e.g. lead to a distance decay curve reflecting a centrifugal spatial pattern of innovations from a central place onward (see also Fig. 2).

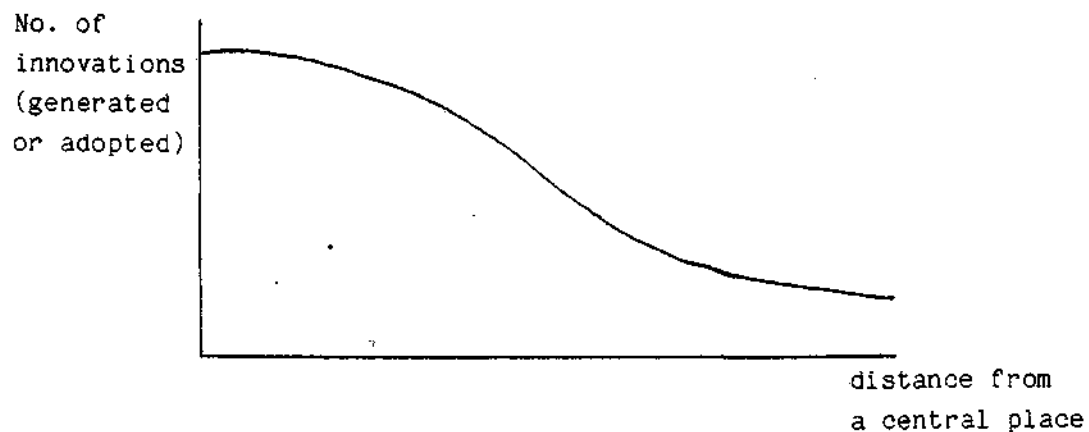


Fig. 2. Spatial dispersion of innovation (for a given time period and system)

(c) Systems impacts

The adoption of an innovation is not exhibiting a similar pattern in all firms, branches, sectors or the whole economy. For instance, in some sectors an innovation may be entirely new, while it may already have been accepted quite some time ago in another sector. Thus socio-economic, institutional or technological inertia leads to different adoption and implementation patterns in different sectors. For a given innovation, this leads to the notion of a so-called technology trajectory, which reflects the differential acceptance levels of technological changes across different sectors (see also Fig. 3). It is clear that each of the sectors of Fig. 3 may be further subdivided into constituent branches and even separate firms, as the degree of innovativeness may even vary within sectors or branches.



Fig. 3. Spread of innovations in different production systems
(for a given time and space)

By integrating now Figures 1-3, we may construct a so-called innovation cube (see Fig. 4). Each entry of this block represents the number and kind of innovations generated (or adopted) in a given sector (or firm, or branch), in a given place and in a given time period. By means of this cube we could define different types of innovations according to their degree of 'newness' in time, space and systems (see also the next section).

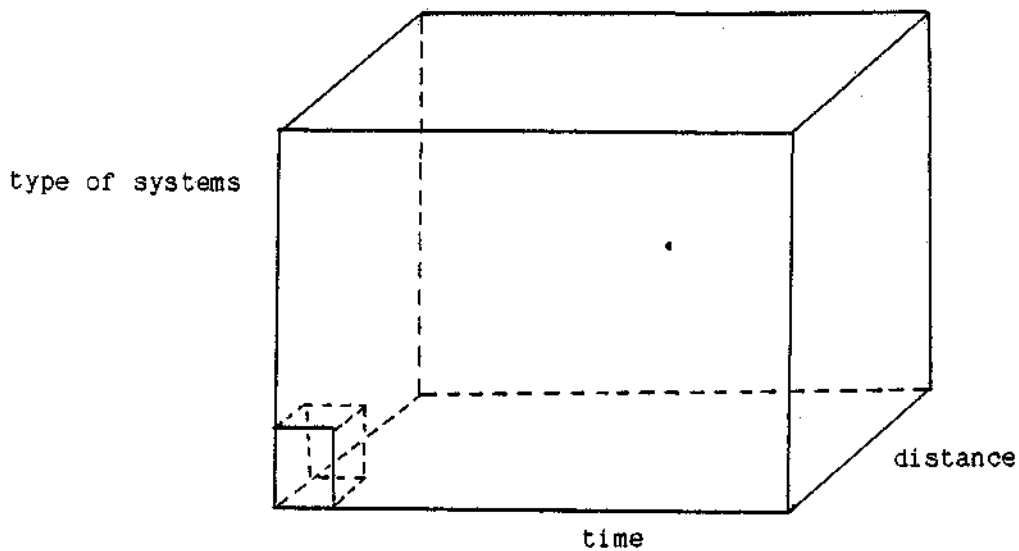


Fig. 4. The innovation cube.

Clearly, it is now also possible to make various cross-sections of the innovation cube leading to two-dimensional representations of innovation rates in time, space or production systems. So it may, for example, be possible to trace a certain innovation through space and time, or through space and production sectors. Consequently, it may be a useful endeavour to design a typology of innovations depending on their position in the innovation cube. In the next section, the three abovementioned dimensions will be incorporated in a discussion of spatial innovation and product life cycles.

3. Regional Development, Innovation Rates and Product Life Cycles

Innovation cannot be regarded as a footloose activity, but it clearly reflects spatial patterns. In this regard, the spatio-temporal distribution of innovative activities can be regarded from the viewpoint of a dynamic spatial innovation analysis. In our framework for such an analysis 3 focal points will be discussed, viz. a typology of innovations, the relevance of product life cycle theory, and the potential of a spatial product life cycle (or innovation-incubation) thesis.

(a) Typology of innovations

Innovations do not make up a homogeneous set, but are - as noticed before - marked by various attributes. In this framework, the following subdivision of innovations - based on the degree of novelty of the innovation concerned - may be made:

- product innovations which are new to the firm (we will call them secondary product innovations)
- product innovations which are not only new to the firm, but also to the whole branch (or sector) in the country concerned (we will call them primary product innovations)
- process innovations which are new to the firm (secondary process innovations)
- process innovations which are not only new to the firm, but also to the whole branch (or sector) in the country (primary process innovations)

Thus, the systems impact of innovations is studied here at the micro scale of the individual firm, at the meso scale of an industrial branch or sector, and at the macro scale of the country or region as a whole.

In terms of a regional subdivision of a country, it is usual to apply a spatial hierarchy concept by making a subdivision into central, intermediate (or half-way) and peripheral regions.

Thus the spatial notions (centre, intermediate area and periphery) and the systems notions (firm, and branch or sector as a whole) are the relevant items to be taken into consideration in the framework of our innovation cube (so we made a system (production sector) - space cross-section of our innovation cube).

(b) Relevance of product life cycle theory

The product life cycle theory has been extensively discussed in economic literature and there is no need to repeat the various arguments related to it. The general shape of a product life cycle is represented by Fig. 5.

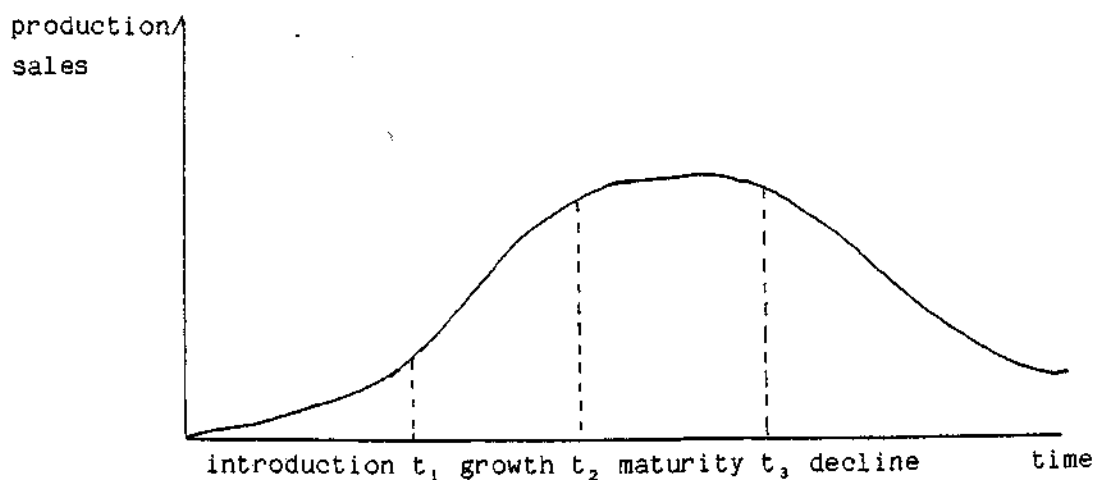


Fig. 5. A conventional product life cycle

Suppose a firm has introduced a completely new product on the market. During the introduction phase - and sometimes also during the growth phase - the product concerned may have to be revised several times because of technical reasons or adjusted to changing market tastes, while also the production process itself may have to be changed. In general these changes will have a high degree of novelty, that is to say, only very few firms will be engaged in developing this product and the related production process. As a consequence the (product and process) innovations might be primary in nature. During the maturity phase both the product itself and the production process will have been standardized to a high degree, so that radical changes are not likely to take place anymore. During this phase, however, the product (or production process) might be adopted by other firms (sectors). Consequently, this diffusion of innovations will be marked by a lower level of innovativeness (in terms of degree of newness in time, space and systems) than in previous phases, the innovation might be secondary in nature (see fig. 6).

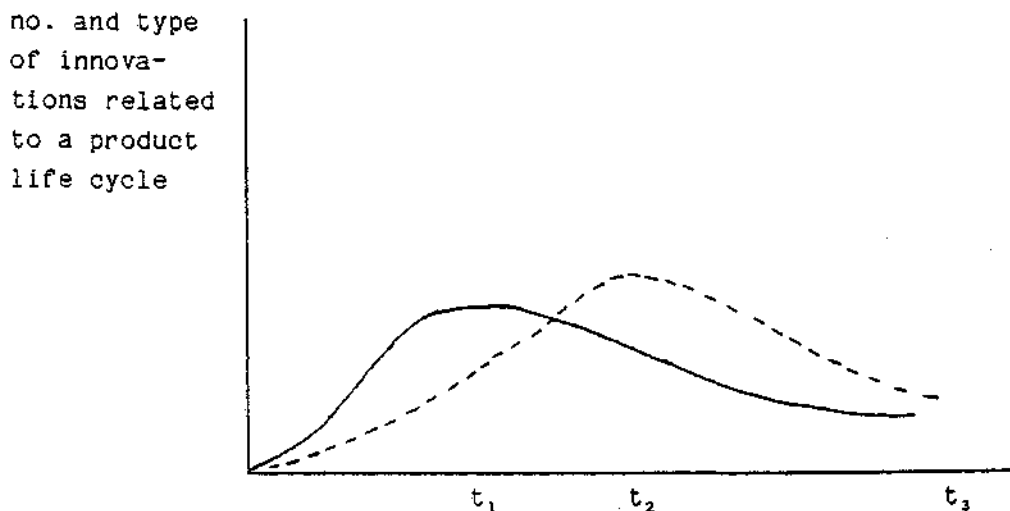


Fig. 6. Evolution of innovations

Legenda: — : primary product and process innovation
 - - - - - : secondary product and process innovation

Clearly, the scheme presented in Fig. 6 can be further elaborated by taking into account the systems impacts (via firms, branches, sectors or the economy as a whole). In a dynamic context, birth, expansion and death of firms may be analysed as well.

It is an interesting question now, whether also basic innovation cycles in the sense of Schumpeter do exist. Presupposing the validity of this thesis (without bothering about the length of these cycles and

the relationship between these innovation and Kondratiev cycles) means that basic innovations and the related product cycles will be clustered in time. This has implications for the testing of our theory as we will see in the next section.

(c) Potential of a spatial product life cycle theory

In this subsection, the spatial aspects of innovations will be included more thoroughly. A major paradigm in this context is the urban incubation hypothesis (see Hoover and Vernon, 1959, and Davelaar and Nijkamp, 1986). According to this concept new sectors based on certain basic innovations will start in metropolitan areas, conform the simple version of the incubation hypothesis, while later on, during the mature and decline phase, production may shift away from these metropolitan areas in order to be expanded in less densely populated areas. In this respect we also expect that innovations which do not result in new sectors will be first adopted and produced by firms in metropolitan areas.

In this way, the incubation hypothesis - based on concentration tendencies followed by centrifugal spillover effects - may be linked to the abovementioned product life cycle and the innovation cycle. This suggests a close correlation between specific types of innovations (as defined earlier) and their location in specific regions. This issue will be further discussed in section 4.

4. A Framework for Analysing Innovations by means of the Incubation Hypothesis

As mentioned above, there is a general tendency that during the initial stage of the product life cycle relatively many primary product and process innovations will be introduced, while their location (according to the urban incubation hypothesis) is usually to be found in large metropolitan areas, followed by a movement toward sub-urban and non-urban areas and accompanied by a shift from primary to secondary product and process innovations. Thus it is taken for granted that agglomeration advantages (scale economies, face-to-face contacts, information intensity, and so forth) are of decisive importance for primary innovations, while these agglomeration economies will be less relevant for secondary product and process innovations, so that a non-metropolitan location may also become feasible. Consequently, concentrated and deconcentrated patterns of innovations may co-exist. In this way, a dynamic framework for analysing innovations in a spatial setting can be achieved. The resulting pattern is presented in Fig. 7.

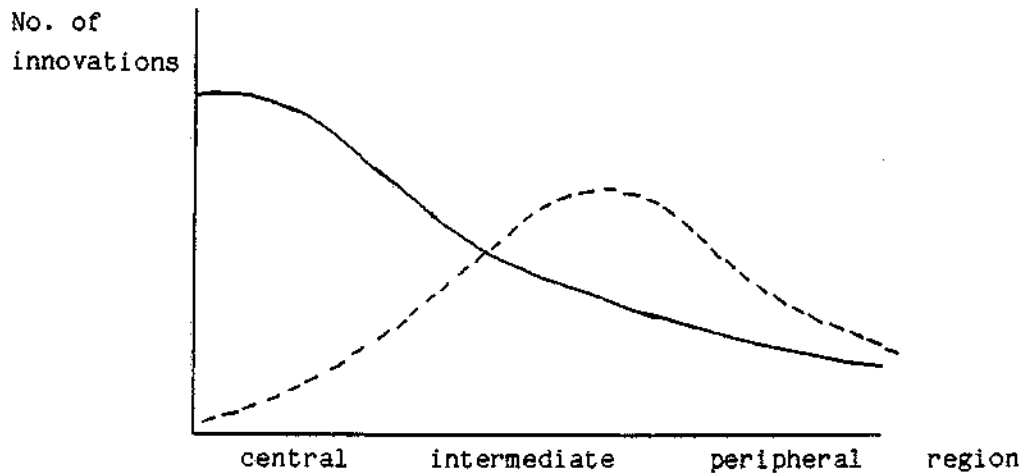


Fig. 7. Innovations and location

Legenda: ————— primary innovations
 - - - - - secondary innovations

This figure also illustrates that the difference between regions is not so much in terms of the number of innovations, but more in terms of the types of innovations. In this context, it is useful to make a distinction between 2 groups of industries, viz. new line industries (composed of relatively young firms) and old line industries (composed of firms in later phases in the product cycle).

Having designed now the formal framework of a spatially-oriented innovation theory, we will formulate the following hypotheses:

- (1) Firms in 'new line industries' are more oriented towards primary (product) innovations than firms in 'old line industries', the difference between the two groups being larger for primary product than for primary process innovations (because during the maturity and decline phase we expect the firms to improve their production process by means of (primary) process innovations).
- (2) Metropolitan areas will provide more fertile conditions for firms to implement primary (product) innovations than other areas.
- (3) Non-metropolitan areas are more appropriate seedbeds for firms to implement secondary (process) innovations.

Clearly, these hypotheses are difficult to test in a cross-sectional way, as economic upswing reflected in an innovation cycle will first be observed in a centrally located area (the 'simple' innovation-incubation hypothesis) and later on in more outbound areas. This time element, viz. the delay in reaction speed of less central areas (the 'complex' innovation-incubation hypothesis), should be taken into account while testing the abovementioned hypotheses (hypotheses 2 and 3 indirectly reflect this time element). A description of available

data for testing these hypotheses as well as some preliminary results will be given in section 5.

5. Empirical Test of Innovation-Incubation Hypotheses

The above-mentioned three hypotheses will now be tested by means of industrial survey data from the year 1983, a period exhibiting the first signs of a recovery after the economic recession. The data used here have been derived from Hoogteijling (1984); see also Hoogteijling et al. (1986), based on a sample of 295 positive responses on a postal survey on innovative behaviour and employment in Dutch firms (at the establishment level). The firms were grouped according to a two-digit standard classification, while the spatial scale of the information related to the geographical subdivision into Chambers of Commerce areas. The firms were also classified into (I) old line industries (textile, food, etc.) and (II) new line industries (metal, chemistry, electronics, etc.).

Thus the first question to be answered in relation to hypothesis (1) is whether firms in group I are more innovative (especially concerning primary innovations) than those in group II. Table 1 presents a cross-tabulation of the empirical results, based on a χ^2 -test of a contingency table analysis.

Table 1. Primary product innovations by group:

type of firms	number of firms <u>without</u> primary product innovation	number of firms <u>with</u> primary product innovation	total number of firms
GROUP I	99	15	114
GROUP II	131	50	181
	230	65	295

$$\chi^2 = 8.53, \text{ with 1 d.o.f. ; significance} = 0.004.$$

Our conclusion from Table 1 is, that there is a significant difference between the two groups of firms with regard to primary (i.e., new to the whole branch in the Netherlands) product innovations. In the 'old line industries' approximately 13 % of the firms has introduced primary product innovations in the years 1982 and 1983, while in the 'new line industries' this percentage equals 38 %!

Next, with regard to primary process innovations the following results are obtained (see Table 2):

Table 2. Primary process innovations:

type of firms	number of firms <u>without</u> primary process innovation	number of firms <u>with</u> primary process innovation	total number of firms
GROUP I	107	7	114
GROUP II	157	24	181
	264	31	295

$\chi^2 = 3.76$, with 1 d.o.f. ; significance = 0.05.

So it is clear that both groups of firms differ also significantly for primary process innovations.

Now we will consider the secondary product and process innovations. In relation to secondary product innovations the following contingency table is used (see Table 3).

Table 3. Secondary product innovations:

type of firms	number of firms <u>without</u> secondary product innovation	number of firms <u>with</u> secondary product innovation	total number of firms
GROUP I	77	37	114
GROUP II	91	89	180
	168	126	294

$\chi^2 = 7.546$, with 1 d.o.f. ; significance = 0.006.

Thus, also concerning secondary product innovations our hypothesis is confirmed by the data.

Finally, the results for secondary process innovations are presented in Table 4.

Table 4. Secondary process innovations by group:

type of firms	number of firms without secondary process innovation	number of firms with secondary process innovation	total number of firms
GROUP I	69	45	114
GROUP II	117	64	181
	186	109	295

$$\chi^2 = 0.347, \text{ with 1 d.o.f. ; significance} = 0.558.$$

So, in contrast with the foregoing results, the secondary process innovations do not show a significant difference between the two groups. As a matter of fact, this conclusion is not a total surprise, because - according to the product life cycle concept - (secondary) process innovations will also be introduced after the introduction and growth phase of a new product because of rationalization and standardization of production (for example, by means of diffusion of standardized production techniques).

Our general conclusion is that hypothesis 1 is not rejected by the data. Both groups differ especially concerning primary (product and process) innovations. This is in accordance with our prior expectations.

Now we have to test hypothesis 2 according to which metropolitan areas will be especially fertile for primary innovations. To this end, we subdivided the Netherlands into three zones: central, intermediate and peripheral. Our assumption is that the central zone is metropolitan in nature. This is a fairly realistic assumption, because this zone consists of the Randstad (including Amsterdam, Rotterdam, The Hague and Utrecht.)

Although this spatial subdivision is rather rudimentary, it will suffice as a first approximation. Is it true that the central zone is the most productive zone concerning primary innovations? By means of Table 5 we will try to answer this question.

Table 5. Primary innovation and region:

type of innovation	metropolitan	non-metropolitan	
	region 1 central	region 2 intermediate	region 3 peripheral
PRIMARY PRODUCT	17	32	16
PRIMARY PROCESS	7	18	6

From this table we can conclude that in region 2 many primary product and process innovations are generated. However, we still have to compensate for the sectoral composition and the total number of firms in each region. Our expectation is that the favourable position of region 2 will be especially due to group I (which might perhaps already have been decentralized from the central zone or which may exhibit a delayed reaction time in adopting certain innovations) and a relative large number of firms. This will be checked in the following tables.

Table 6. Primary product innovations and region.

type of firm		central	intermediate	peripheral
group I	number of firms with primary product innovations	3	11	1
	%	3/36=± 8%	11/50=±22%	1/28=± 3.5%
group II	number of firms with primary product innovations	14	21	15
	%	14/59=±24%	21/69=±30%	15/53=±28%

From Table 6 it can indeed be concluded that the favourable position of region 2, besides a relatively large number of firms in the sample located here, is especially caused by group I! This is in accordance with our theoretical framework sketched above. The differences between the regions concerning group II, however, are not very large. This is not according to our expectations because we expected region 1 to be the more productive concerning this group.

Primary process innovations exhibit the following pattern (see Table 7).

Table 7. Primary process innovations and region.

type of firm		central	intermediate	peripheral
group I	number of firms with primary process innovations	2	5	0
	%	2/36=±5.5%	5/50= 10%	0/28= 0 %
group II	number of firms with primary process innovations	5	13	6
	%	5/59=±8.5%	13/69=±19%	6/53=±11%

Both concerning groups I and II region 2 is in a favourable position (because of the low number of observations one should be careful in drawing conclusions, however). These results do not contradict our theory. The favourable position of region 2 with regard to group 2 could, for example, be due to the production of certain goods marked by a maturity phase in the central zone, by means of new production processes in the intermediate zone (cf. the 'complex' version of the innovation-incubation hypothesis). So these results are not very discriminatory concerning the acceptance or rejection of hypothesis 2.

Hypothesis 3 states that region 2 and/or 3 will be strongly oriented towards secondary innovations, especially in relation to the secondary (process) innovations.

Table 8. Secondary innovations by region and group.

region		product innovations		process innovations	
		group I	group II	group I	group II
central	number of firms	9	29	12	16
	with secondary innovations (%)	9/36 = 25%	29/59 = 49%	12/36 = 33%	16/59 = 27%
intermediate	number of firms	22	34	24	31
	with secondary innovations (%)	22/50 = 44%	34/69 = 49%	24/50 = 48%	31/69 = 45%
peripheral	number of firms	6	26	9	17
	with secondary innovations (%)	6/28 = 21%	26/53 = 49%	9/28 = 32%	17/53 = 32%

Our expectation that region 2 (or 3) will be in a strong position concerning secondary (process) innovations is indeed confirmed by the data. So, in general, hypothesis 3 is indeed validated by our data.

In conclusion, we may state that the above (preliminary) results are indeed promising, the only exception being primary product innovations in group II which show no relative concentration in region 1.

So far, we have mainly studied how the concepts of 'phase in product life cycle' and 'location' influence the type of innovativeness of both groups of firms. It is however unrealistic to expect that there are only 2 elements which determine the innovation potential of a firm. In the next section some of these determinants will also be considered and tested.

6. Some Determinants of the Innovation Potential of Firms

The following variables/factors are often expected to be related to the innovativeness of a firm (although the direction of causality is not always unambiguous):

- | | | |
|--|---|---|
| - Location of a firm | } | This has been the subject of the foregoing section. |
| - Phase in the product life cycle | | |
| - Growth of sales (+) | | |
| - Percentage of sales exported (+) | | |
| - Size of the firm/number of employees (+) | | |
| - Existence of R&D division (+) | | |
| - Number of employees in R&D division (+) | | |
| - Dependency structure | | |

In the present section we will try, in a preliminary way, to analyse the innovativeness of a firm by means of the above-mentioned variables. For this purpose we have estimated some multiple regression equations. To this end we have introduced the following dummy variables (because our data were often nominal or ordinal in character):

- $D_1 = 1$: the firm is located in the central zone
 $D_1 = 0$: otherwise
 $D_2 = 1$: the firm is located in the intermediate zone
 $D_2 = 0$: otherwise
 $D_3 = 1$: the sales of the firm have risen during 1981-1983
 $D_3 = 0$: otherwise
 $D_4 = 1$: the sales of the firm remained stable during 1981-1983
 $D_4 = 0$: otherwise
 $D_5 = 1$: the firm is (nearly) wholly independent
 $D_5 = 0$: otherwise
 $D_6 = 1$: the firm belongs to group II
 $D_6 = 0$: otherwise
 $D_7 = 1$: the firm exports more than 25 % of her sales
 $D_7 = 0$: otherwise

Other variables which have been introduced are:

- Number of employees per firm
- Number of R&D employees.

In the questionnaire firms were asked how many innovations they had introduced during the years 1982 and 1983. In the data set the following categories for the size of innovations were distinguished: 0, 1, 2, 3, 4, 5, 6-10, 11-20 and > 20 innovations. For the purpose of the regression analyses we have averaged the categories 6-10, 11-20 and > 20 as follows: 8, 15, 20. In the same data set the number of R&D employees were classified as follows: 0, 1, 2, 3, 4, 5, 6-10, 11-30,

31-100 and > 100; we have averaged the classes 11-30, 31-100 and > 100 as follows: 8, 21, 66 and 100. Now we will present some of the regression results.

We will try to explain the number of innovations per firms and not whether a firm will innovate or not (in contrast with the foregoing section). Consequently, one should be careful in comparing the results of the present and the foregoing section.

First, the number of secondary product innovations per firm has been taken as the variable to be explained. The results of estimates of our first regression equation are (t-value in parentheses):

$$(1) \text{ NPI}_B = 2.934 + 0.0514 \text{ RD}_B - 1.725 \text{ D}_7 \quad R^2 = 0.05$$

$$(3.12) \quad (1.779) \quad (1.667)$$

with:

NPI_B = number of secondary product innovations of firm B

RD_B = number of R&D employees within firm B

D_7 = dummy 7 with regard to firm B

So our conclusion is that the positive influence of the number of R&D employees on the number of secondary product innovations is statistically significant. This result is in accordance with our prior expectation that there is a positive relationship between R&D input and output. The negative influence of dummy 7 (export orientation) is however not in accordance with our expectations. No other variable could be included in this equation. As can be seen, the explanatory power of this equation is rather poor.

Now we will concentrate on the number of secondary process innovations per firm (we will again use the same criterion as before). Our estimated equation is as follows:

$$(2) \text{ NPRI}_B = 0.986 + 0.788 \text{ D}_{2B} + 0.0049 \text{ NE}_B \quad R^2 = 0.04$$

$$(2.685) \quad (1.5) \quad (2.259)$$

with:

NPRI_B = number of secondary process innovations in firm B.

D_{2B} = dummy 2 with regard to firm B.

NE_B = number of employees in firm B.

Again, the explanatory power is rather poor. It is striking, however, that also in this analysis (which is concerned with number of innovations per firm) the intermediate zone appears to be in a strong position for secondary process innovations per firm. Also the size of the firm appears to be relevant.

In the foregoing analysis we studied the number of secondary innovations per firm. Now we will concentrate on primary innovations. With regard to primary product innovations per firm, no variables appeared to provide a significant explanation. In relation to primary process innovations the following equation has been estimated:

$$\text{NPRI}^*_B = 2.096 + 1.358 D_1 - 1.735 D_2 + 0.00075 \text{NE}_B + 12.878 D_4$$

$$(2.498) \quad (1.514) \quad (-1.920) \quad (4.44) \quad (7.072)$$

$$R^2 = 0.84$$

with:

NPRI^*_B = number of primary process innovations in firm B.

A first characteristics to be noticed is that the explanatory power of this equation is relatively high. We can also conclude that region 1 is in a strong position concerning the number of primary process innovations per firm. Growth of sales during the foregoing years is negatively related to the number of primary process innovations per firm, while the total number of employees is (significantly) positively related to these innovations. The most significant variable, however, appears to be dummy 4. One explanation for this result could be that firms which experience a stable pattern of sales will be strongly motivated to introduce primary process innovation in order to enter again the growth phase of sales.

7. Conclusion

We have tried to demonstrate in this paper that innovations are time-specific, space-specific and systems-specific. In this framework, we have developed our innovation cube in which for each dimension (of production systems, space and time) the question may be raised whether a certain good is new or not. By means of this cube it is possible to define several types of innovations according to their position in the cube, as we have done in a rather limited way by means of a distinction between primary and secondary innovations. Another feature of the innovation cube is that it is able to indicate the degree of novelty of an innovation (innovativeness) according to its position in the innovation cube.

By means of this innovation cube, the product life cycle concept, and the innovation-incubation hypothesis we have tried to develop a framework for a dynamic spatial innovation analysis. In this theory regions do not only differ concerning the timing of innovation cycles, but also concerning types of innovations. From this framework we have derived three hypotheses. The first hypothesis states

that relatively young sectors will be more innovative, especially concerning primary (product) innovations, than 'old line industries'. The essence of the second hypothesis is that metropolitan regions will be fertile concerning primary innovations (the 'simple' version of the innovation-incubation hypothesis), while the third hypothesis states that non-metropolitan areas will be fertile concerning secondary innovations (because of decentralization tendencies; and/or a delay in reaction time concerning the production and adoption of innovations, the 'complex' version of the innovation-incubation hypothesis). Due to a different phasing of qualitatively different innovations in different regions, it is not necessary that the differences between regions (concerning the total number of innovations per firm) are very pronounced!

This observation may be a first explanation for the fact that some (micro-based) empirical findings, based on cross-sectional data (and neglecting essentially the dynamics) do not confirm the 'simple' innovation-incubation theory. A second explanation may be that in a micro (firm)-based analysis the innovation phenomenon is studied from the frame of reference of individual firms. Although this may often be the best attainable strategy, it is sometimes difficult to distinguish between different types of innovations (the 'quality' aspect of innovations). According to our theoretical framework regions do not have to differ so much with regard to the number of firm-specific innovations, but especially concerning types and timing of innovations. As a consequence one should be cautious in rejecting the 'simple' innovation-incubation hypothesis on the basis of cross-sectional data.

In this context, the (seemingly) contradictory evidence concerning micro-(firm)based innovation studies and (high quality) innovation-specific studies should also be interpreted. As stated before, micro (firm) based studies have a tendency to reject any regional bias in innovative activities while studies which are concerned with the time-space trajectory of certain high quality innovations (informatics, computer-service firms, telecommunications) often find a metropolitan bias. Both studies are referring to a different part of the innovation cube. The high quality case studies are often concerned with innovations which are (quite) new to the whole country, or to whole sectors. So in our terms we would say primary innovations, while micro studies also consider innovations which are only new at the individual firm level, in our terms: secondary innovations.

In our framework the metropolitan areas should be fertile concerning primary innovations, while non-metropolitan areas should be fertile concerning secondary innovations, and, as a consequence, it is not a necessity that (at a certain moment in time) regions will differ very much concerning the total number of innovations per firm. This is (exactly) in accordance with the empirical results often found in

innovation case studies on the one hand and micro studies on the other hand. So in our framework, there is no contradiction, but rather complementarity between innovation case and micro studies.

In sections 5 and 6 we have tried to verify the above-mentioned hypotheses in a preliminary way. Our conclusions state that hypotheses 1 and 3 cannot be rejected by the available data. With regard to hypothesis 2 primary product innovations do not behave according to our expectations. Some possible explanations are:

- The data refer to 1983 which can be considered as a period of only slow recovery (the beginning of an innovation upswing) in which not yet very many primary innovations (in metropolitan areas) will be introduced.
- The really new growth sectors of tomorrow (informatics) are not yet reflected in statistics so it is difficult to extract these sectors (and their related primary innovations) from existing statistics.

In general the explanatory power of our estimated regression equations is rather poor. Possible explanations are:

- it is easier to explain whether firms will innovate or not than to explain the mere number of innovations per firm.
- Our regional classification was necessarily less detailed.
- We have neglected - because of data constraints - many factors internal to the firm, such as quality of management, financial position of the firm, organization structure, strategic aims of the firm, and structure of the market in which the firm operates.

Yet in our view, the results are promising, and we intend to refine our theory and especially its testing by means of a much layered inquiry among 1842 industrial firms in the Netherlands.

References

- Andersson, A.E., and B. Johansson (1984), Knowledge Intensity and Product Cycles in Metropolitan Regions, Contributions to the Metropolitan Study, no. 8, Laxenburg.
- Aydalot, Ph. (1984), Reversals of Spatial Trends in French Industry since 1974. In: J.G. Lambooy (ed.), New Spatial Dynamics and Economic Crisis, pp. 41-63, Finn Publ., Tampere.
- Braverman, H. (1974), Labor and Monopoly Capitalism, Monthly Review Press, New York.
- Camagni, R. (1984), Spatial Diffusion of Pervasive Process Innovation, Paper prepared for the XXIV European Congress of the Regional Science Association, Milan.
- Davelaar, E.J. and P. Nijkamp (1986), De Stad als Broedplaats van Nieuwe Activiteiten: Theorie en Onderzoek, Stedebouw en Volkshuisvesting, no. 2, pp. 61-66.

- Elger, A., and H. Braverman (1983), Capital Accumulation and Deskill-
ing, The Degradation of Work?, (S. Wood, ed.), Hutchinson,
London, pp. 23-45.
- Feller, I. (1973), Determinants of the Composition of Urban Inventions,
Economic Geography, vol. 49, pp. 47-58.
- Freeman, C. (ed.) (1984), Design, Innovation and Long Cycles in Eco-
nomic Development, Design Research Publ., Royal College of
Art, London.
- Hagerstrand, T. (1967), Innovation Diffusion as a Spatial Process,
University of Chicago Press, Chicago.
- Hoogteijling, E., J.W. Gunning and P. Nijkamp (1986), Spatial Dimen-
sions of Innovation and Employment: Some Dutch Results,
Technological Change, Employment and Spatial Dynamics (P.
Nijkamp, ed.), Springer Verlag, Berlin.
- Hoover, E.M. and R. Vernon (1959), Anatomy of a Metropolis, Harvard
University Press, Cambridge.
- Howells, J.R.L. (1984), The Location of Research and Development: Some
Observations and Evidence from Britain, Regional Studies,
vol. 18, pp. 13-29.
- Jacobs, J. (1961), The Death and Life of Great American Cities,
Vintage Books, London.
- Kleinknecht, A. (1986), Crisis and Prosperity in Schumpeterian Inno-
vation Patterns, MacMillan, London.
- Kleinknecht, A. and A. Mouwen (1985), Regionale Innovatie (R&D): Ver-
schuiving naar de 'Halfwegzone'? In: Innovatie en regio,
W.T.M. Molle (ed.), pp. 125-142, Staatsuitgeverij, Den Haag.
- Koerhuis, H. and W. Cnossen (1982), De Software- en Computerservice-
bedrijven, Sociaal Geografische Reeks no. 23, Geografisch In-
stituut R.U. Groningen.
- Kok, J.A.A.M., G.J.D. Offerman and P.H. Pellenbarg (1984), Innovatieve
Bedrijven in Nederland, Sociaal Geografische Reeks no. 32,
Geografisch Instituut R.U. Groningen.
- Leone, R.A. and R. Struyk (1976), The Incubator Hypothesis: Evidence
from Five SMSA's, Urban Studies, vol. 13, pp. 325-331.
- Malecki, E.J. (1979), Corporate Organization of R and D and the Loca-
tion of Technological Activities, Regional Studies, vol.
14, pp. 219-234.
- Malecki, E.J. and P. Varaiya (1985), Innovation and Changes in Region-
al Structure, Handbook of Regional Economics, (P. Nijkamp,
ed.), North-Holland Publ. Co., Amsterdam.

- Mensch, G. (1979), The Stalemate Technology, Ballinger, Cambridge, Mass.
- Nelson, R.D., and S.G. Winter (1982), An Evolutionary Theory of Economic Change, Harvard University Press, Cambridge.
- Nijkamp, P. (ed.) (1986), Technological Change, Employment and Spatial Dynamics, Springer Verlag, Berlin.
- Norton, R.D. (1979), City Life Cycles and American Urban Policy, Academic Press, New York.
- Oakey, R.P. (1981), High Technology Industry and Industrial Location, Gower, Aldershot.
- Oakey, R.P., A.T. Thwaites and P.A. Nash (1980), The Regional Distribution of Innovative Manufacturing Establishments in Britain, Regional Studies, vol. 14, pp. 235-253.
- Pred, A. (1977), City Systems in Advanced Economies, Hutchinson, London.
- Sabal, C. (1982), Work and Politics, Cambridge University Press, Cambridge.
- Thwaites, A. (1982), Some Evidence of Regional Variations in the Introduction and Diffusion of Industrial Products and Processes within British Manufacturing Industry, Regional Studies, vol. 16, pp. 357-381.

1981-1	E. Vogelvang	A quarterly econometric model for the Price Formation of Coffee on the World Market
1981-2	H.P. Smit	Demand and Supply of Natural Rubber, Part 1
1981-3	R. Vos	The political Economy of the Republic of Korea; A proposal for a model framework of an open economy in the ESCAP-region, with emphasis on the Role of the State
1981-4	F.C. Palm	Structural Econometric Modeling and Time Series Analysis - Towards an Integrated Approach
1981-5	P. Nijkamp in co-op. with H. v. Handenhoven and R. Janassen	Urban Impact Analysis in a Spatial Context: Methodologie and Case Study
1981-6	R. Ruben	Primaire exporten en economische ontwikkeling
1981-7	D.A. Kodde	Het genereren en evalueren van voorspellingen van omzet en netto winst: een toegepast kwantitatieve benadering
1981-8	B. Out	Financiële vraagstukken onder onzekerheid
1981-9	P. van Dijk and H. Verbruggen	A Constant-Market-Shares Analysis of ASEAN Manufactured Exports to the European Community
1981-10	P. Nijkamp, H. de Graaff and E. Sgar	A Multidimensional Analysis of Regional Infrastructure and Economic Development
1981-11	P. Nijkamp	International Conflict Analysis
1981-12	A.J. Mathot	L'Utilisation du Crédit lors de l'Achat d'une Voiture
1981-13	S.P. van Duin en P.A. Cornelis	Onderzoek naar levensomstandigheden en opvattingen over arbeid bij mensen zonder werk, deel 1
1981-14	W. van Lierop and P. Nijkamp	Disaggregate Models of Choice in a Spatial Context
1981-15	Hidde P. Smit	The World Vehicle Market
1981-16	F.C. Palm	Structural Econometric Modeling and Time Series Analysis: An Integrated Approach
1981-17	F.C. Palm and Th.E. Nijman	Linear Regression Using Both Temporally Aggregated and Temporally Disaggregated Data

1981-18	F.C. Palm and J.M. Sneek	Some econometric Applications of the exact Distribution of the ratio of Two Quadratic Forms in Normal Variates
1981-19	P. Nijkamp and P. Rietveld	Soft Econometrics as a Tool for Regional Discrepancy Analysis
1981-20	H. Blommestein and P. Nijkamp	Soft Spatial Econometric Causality Models
1981-21	P. Nijkamp and P. Rietveld	Ordinal Econometrics in Regional and Urban Modeling
1981-22	F. Brouwer and P. Nijkamp	Categorical Spatial Data Analysis
1981-23	A. Kleinknecht	Prosperity, Crises and Innovation Patterns: Some more Observations on neo-Schumpeterian Hypotheses
1981-24	Hidde P. Smit	World Tire and Rubber Demand
1982-1	Peter Nijkamp	Long waves or catastrophes in Regional Development
1982-2	J.M. Sneek	Some Approximations to the Exact Distribution of Sample Autocorrelations for Autoregressive-moving Average Models
1982-3	F.E. Schippers	Empirisme en empirische toetsing in de wetenschapswetenschap en in de economische wetenschap
1982-4	Piet van Heijdingen maart 1982	Mantelproject 'Management & Politiek': Productiebeleid en overheid; een onderzoek naar de invloed van de overheid op het productiebeleid in de verpakkingsmiddelenindustrie
1982-5	Peter Nijkamp Jaap Spronk	Integrated Policy Analysis by means of Interactive Learning Models
1982-6	Ruud Ruben (ed.)	The Transition Strategy of Nicaragua
1982-7	H.W.M. Jansen mei 1982	Een alternatieve modellering van het gedrag van een besluitvormer: 'satisficing' i.p.v. 'maximizing'
1982-8	J. Klaassen and H. Schreuder mei	Confidential revenue and Profit Forecasts by management and financial analysts: some first results
1982-9	F. Brouwer and P. Nijkamp	Multiple Rank Correlation Analysis