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SPATIAL DISPERSION OF INDUSTRIAL INNOVATION:

A CASE STUDY FOR THE NETHERLANDS

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SPATIAL DISPERSION OF INDUSTRIAL INNOVATION: A CASE STUDY FOR THE NETHERLANDS

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1. Introduction

The economic developments in the seventies have exerted a deep impact on the industrialized world. It is increasingly being realized that the economic dynamics in the past decade is reflecting a situation of structural change, which has to be understood in the context of a long-term economic-technological evolution. Such profound changes are taking place at many geographical levels ranging from continents (witness the Atlantic Basin - Pacific Basin dichotomy) to cities (witness the competition between metropolises and medium-sized cities).

At both a global and regional scale the past years have exhibited a profound interest in technological change and innovation. In line with Kondratieff's and Schumpeter's view, it is increasingly believed that entrepreneurial innovation is one of the driving forces behind structural dynamics. In this respect, there is a high degree of concensus between the 'technology-push' and the 'demand-trigger' view on industrial innovation.

In the present paper, innovation will be interpreted as the design, construction and successful introduction of new (or improved) commodities, services, production processes or distribution processes. The commercial implementation of innovations distinguishes in general innovations from inventions.

It has been demonstrated in many studies that knowledge intensity, capital intensity and communication infrastructure are necessary (though not sufficient) conditions for innovation processes. The blend of all such conditions is sometimes also denoted by the generic term R & D infrastructure (cf. Freeman et al., 1982, OECD, 1982 , Rothwell and Zegveld, 1979, and Thwaites, 1978).
The importance of R & D is also reflected in many policies aiming at stimulating innovation by either direct incentives (e.g., subsidies on the creation of technological know-how) or indirect measures (e.g., the development of knowledge centres, science parks, transfer centres and the like).

In the present paper much attention will be given to the regional dimensions of innovation. These regional dimensions are present in two respects: (1) innovative activities are not uniformly distributed over all regions or cities, but exhibit much spatial variation depending on sectoral and locational aspects; (2) public policies aiming at stimulating innovative activities have usually a geographical component, for instance, an urban incubator policy, a regional science park policy, etc. Consequently, there is much scope for a closer analysis of the spatial aspects of innovative activities (see also, Bruder, 1983, Ewers and Wettmann, 1980, Gillespie, 1983, Goddard, 1981, and Malecki, 1983).

The second section of this paper is devoted to a general orientation on regional/urban innovation issues (such as the role of large agglomerations, the incubator

hypothesis, R & D infrastructure etc.). In subsequent sections the results of an extensive case study for the Netherlands will be presented, in which the locational dimensions of innovative activities (including the impacts of public policies) will be analyzed in greater detail. It will be shown that the empirical evidence from the Netherlands does not support the generally accepted hypothesis that innovative activities are particularly favoured by agglomerated areas.

2. Innovation as a Regional Development Strategy

There is a striking diversity in the economic and technological performance of various regions. Some regions exhibit a stagnating or even declining pattern (various regions in Ireland, the Italian Mezzogiorno), whereas others show a 'boom' effect. Therefore, it may be important to briefly discuss the backgrounds of the success of the Greater Boston Area, and especially the impact of Route 128.

The success of this area - as the source of many advanced technological activities - is not in the first place determined by its favourable locational and infrastructural conditions, but is much more the result of an integrated breeding place function of the area concerned. The production environment as a whole appears to play a prominent role, viz. the integrated geographical presence of academic research institutes, of an institutional and political willingness, of an effective cooperation between the private and the public sector (contract research, e.g.), and of venture capital.

The history of Route 128 (since the 1950s) shows that initially the availability of cheap land was in many cases a driving force for the offspring of new firms in the Boston area. The continuation of the success of Route 128 (and also later of Route 495) was based on an interplay of the availability of inexpensive industrial areas with a favourable geographical accessibility, the presence of an accessible knowledge infrastructure in the Cambridge/Boston area, and the provision of a favourable residential and living climate. Furthermore, the prevailing innovative industrial climate and the innovation-oriented academic climate induced many spin-off processes, marked by advanced high-tech and computer activities. These spin-offs were also favoured by the available venture capital.

Thus the incubator function of the Greater Boston area is based on an integrated breeding place providing an advanced knowledge infrastructure (including a varied supply of high-skill labour), a geographically favourable location, an institutional and financial support for risk-taking innovative behaviour, and a public support (via contracts, e.g.) for R & D activities.

It is clear from the Boston example that the implementation of such a breeding climate may take many years and even decades. Public policy has to be aware of these

time limits in order to avoid a bias toward short-term successes (cf. Nelson and Winter, 1982).

In the context of the present section, it is an important question whether large agglomerations are favouring innovative ability. The conventional urban economic view supports the hypothesis that city size induces the innovative potential of entrepreneurs. In recent years however, it has been demonstrated that large urban agglomerations loose their innovative potential in favour of medium-size towns (see Malecki, 1983). Apparently there are urban bottleneck factors that are prohibitive for a further expansion of innovative activities. In addition, there may be a close relationship between the phase in a product cycle and the locational requirements of a firm (see Malecki, 1983). These observations may imply that the incubator function is not necessarily best fulfilled in large cities, but may as well be fulfilled in smaller agglomerations. Therefore, it may be worthwile to gather more empirical evidence regarding the relationship between industrial innovations and their geographical location.

Another important research issue concerns the question whether knowledge infrastructure (universities, R & D institutes) are mainly regionally oriented with respect to innovations, or whether - given their position on an accessible network - they may have a nation-wide effect. This is especially important for public policy aiming at fulfilling equity goals by means of the creation of knowledge and transfer centres in specifically designated areas. Thus the regional dimensions (including the spatial diffusion aspects) of an innovation-oriented regional policy are of utmost importance (see also Mouwen and Nijkamp, 1985, and Pred, 1977).

In addition, one may raise the question whether a <u>generic</u> innovation policy (without discriminating among firms or sectors) may be successful in a regional context, given the specific locational aspects of innovative firms(focussing on spatially segmented markets, desiring high quality residential areas, or needing specifically-trained personnel in certain areas)(see also Thwaites, 1978). Consequently, it is extremely important to know how the innovation potential of regions can be favoured by a selective public policy (see also Andersson and Johansson, 1984). The answer to this question requires more detailed insight into the reaction patterns and the geographical orientation of entrepreneurs with regard to the supply of an innovation-oriented public R & D infrastructure (such as the provision of regional transfer centres). These questions will also be dealt with in subsequent sections on the basis of an extensive case study for the Netherlands.

For the moment, it may already be concluded that a stimulation of innovative activities is necessary for a regional economic revitalisation, but that the specific conditions and impacts of innovations (for instance, on the labour market) are often vaguely known in a concrete regional or urban setting. Therefore, more empirical evidence based on micro-based entrepreneurial research is necessary.

3. A Case Study for the Netherlands based on an Agglomeration Index

3.1 Conceptual introduction

The major objective of this paper is to analyze the relationship between (urban and regional) agglomeration economies and innovation, assuming that agglomeration economies are an explanatory variable for the regional dispersion of innovation.

While agglomeration economies are often used in the regional and urban literature, they have not adequately been measured as yet, mainly due to lack of an operational definition of an agglomeration area. This problem was also confronting us, as is generally accepted that the existing regional classifications of the Netherlands are not very satisfactory from the point of view of agglomeration analysis.

Therefore, we have developed an alternative (measurable and practical) concept of agglomeration economies, which is especially suited for the Dutch situation marked by a high concentration of urban agglomerations and, correspondingly, the existence of significant inter-urban influences. It was a starting-point that such a concept had to satisfy the conditions of simplicity and comprehensibility. In this framework a one-dimensionial agglomeration index has been constructed that was able to take into account various practical and methodological conditions. After a brief summary of the concept of agglomeration economies, the measurement of the agglomeration index will be discussed.

The concept of agglomeration economies arises mainly because of the indivisibility of various production factors and production processes, resulting in spatial concentration of production. The advantages of scale associated with such a concentration are called external economies and can be subdivided into:

- localization economies, for all firms in a single industry at a single location, consequent upon the enlargement of the total output of that industry at that location;
- urbanization economies, for all firms in all industries at a certain location, consequent upon the enlargement of the total economic size (population, income, output, wealth) of that location, for all industries taken together (Carlino, 1977).

3.2 Inter-urban influences

The relevance and applicability of various - often Anglo-Saxon oriented - urban theories for Dutch urban/regional studies can be questioned on the grounds that the urbanization in the Netherlands cannot be compared with urban developments at a different geographical scale like, for instance, the American one. The Dutch agglomerations are not in the least isolated; it is, for instance, questionable whether one may regard the region enclosed by Amsterdam, Rotterdam, and the Hague (the Randstad) as one agglomeration or as a group of different agglomerations.

In this connection Pred stated that "almost the whole physical area of the Netherlands lies within a 100 mile radius, or the 'urban field', of the Randstad metropolitan complex, and can therefore benefit from its external economies to some extent" (Pred, 1977, p. 194).

It is in this context plausible that inter-urban influences cause relatively high urbanization economies in those locations that lie in the sphere of influence of more than one large urban area. This simple statement constitutes one of the corner stones of the agglomeration index that is discussed in the following subsection.

3.3 The agglomeration index

The agglomeration index presented here is a tool for the analysis of the relationship between agglomeration economies and innovation. Population scale will be used as an important factor in the agglomeration index, although Carlino (1977) described population scale as a poor proxy to capture the effects of business agglomeration economies. Nevertheless, as indicated in section 2 there is much empirical evidence that agglomeration economies in relation to innovation are - to a large extent - population dependent.

Formally, the agglomeration index (AI) of a certain location is defined as a function of:

- city size (c),
- distance to main city centre (d),
- inter-urban influences (i),

or

$$AI = f(c, d, i).$$

The variable 'city size' is measured in a non-linear way as a function of urban population size by making a distinction into two classes, viz.

(a) cities with low spread effects,

(b) cities with strong spread effects.

Nijkamp et al. (1983) explains that city size has to pass a certain threshold level before a city can actually act as a generator of agglomeration spread effects. Given the Dutch context, this threshold level is in our study assumed to be approximately equal to 100 000 inhabitants. Furthermore it is assumed that cities with more than 200 000 inhabitants exhibit a significantly higher level of agglomeration spread effects compared to those falling in the range 100 000 - 200 000 inhabitants.

These assumptions result in the following binary scale for measuring city size:
(a) 100 000 - 200 000 inhabitants,
(b) more than 200 000 inhabitants.

The distance to a main city centre is measured in physical road distance, adjusted for the quality of the infrastructure and communication network.

The inter-urban influences are measured implicitly by including the distances to and the sizes of other neighbouring cities.

Another problem is caused by inter-urban influences across borders, as the Netherlands is not isolated from its neighbours. There is relatively free access for persons and goods across the Dutch, German and Belgian border, so that inter-urban effects with respect to foreign cities may also exert a (modest) impact. Therefore it was decided to adjust the threshold level for city size to 200 000 for foreign cities and to expect relatively low spread effects from those.

The foregoing can now be applied for the construction of our agglomeration index, which, for reasons of simplicity, is defined as a one-dimensional output:

$$AI = f_I \left(\prod_{k=1}^{n} A_k + w^* \prod_{j=1}^{m} B_j \right).$$

where :

- A_k is the distance to the k-th closest city with strong spread effects (over 200 000 inhabitants) (k=1,...,n);
- B_j is the distance to the j-th closest city with low spread effects (100 000 - 200 000 inhabitants, and foreign cities with more than 200 000 inhabitants) (j=1,...,m ; all distances measured on a 6-interval scale);
- the parameter w is a weighing factor representing the relative importance of the largest cities ;
- f_I is an index function that transforms the data input into a measurement scale ranging from 1 to 9 (measured as integers). The actual form of the index function used

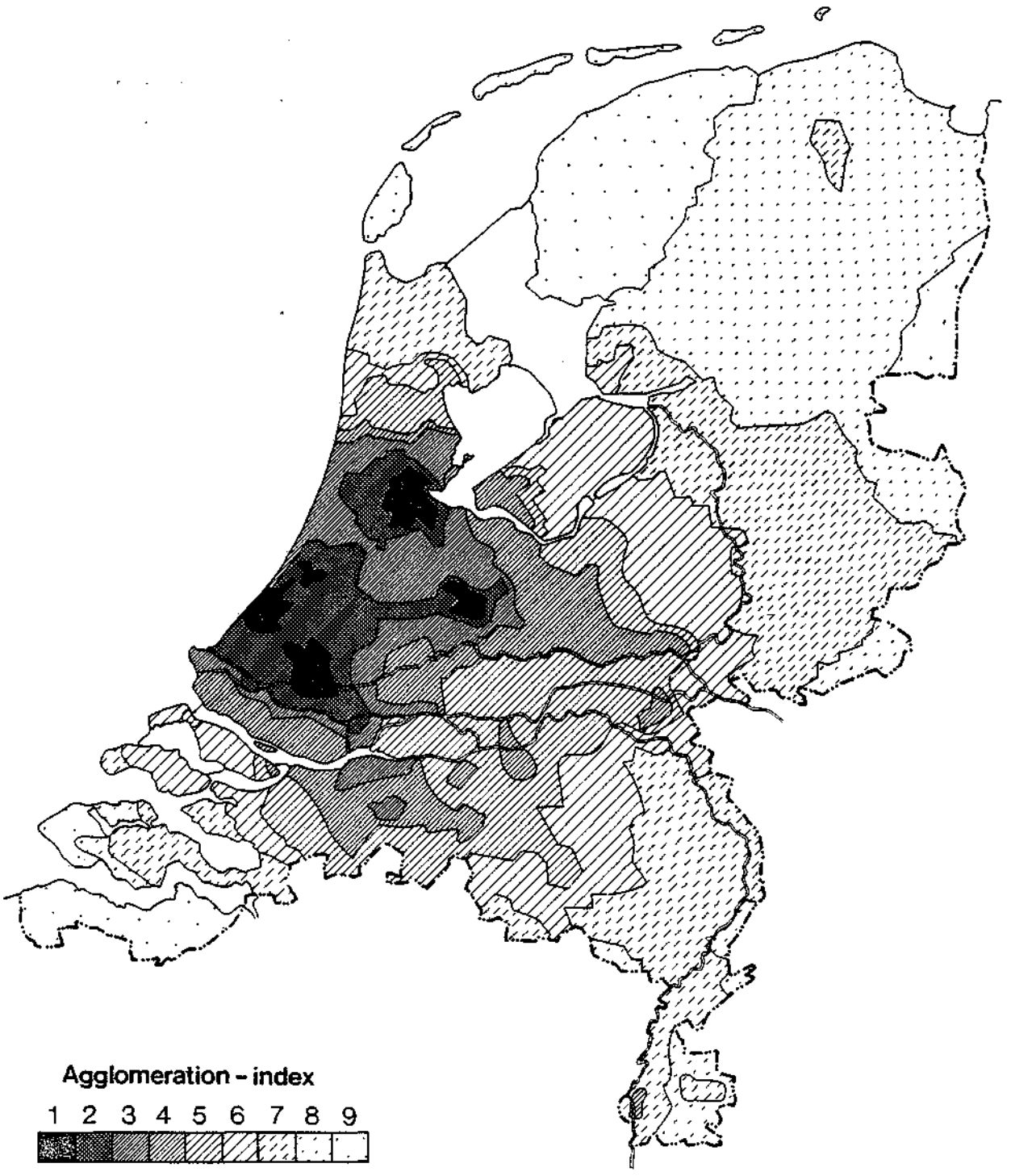


Fig. 1. The agglomeration index.

in our study is based on a third-order spatial impact and is specified as follows:

$$AI = \left[\frac{A_1 * A_2 * A_3 + 0.5 * B_1 * B_2 * B_3}{32.5}\right]_{entier}$$

It is worth noting that the multiplicative terms ensure decreasing marginal inter-urban influences when the distance increases.

Fig. 1 gives a visual representation of the results. Note that the index ranges from 1 (strong agglomeration economies) to 9 (very low agglomeration economies).

In the next section the agglomeration index is used to analyse the regional dispersion of innovation and R & D with respect to the agglomeration index.

4. Regional Distribution of Innovation and R & D

4.1 General remarks

Various data in this study are derived from an inquiry on technological innovation, recently held by Kleinknecht (1985) among Dutch entrepreneurs. A sample of 2917 industrial firms resulted in a 63.1 percent response-rate (n=1842).

In our study, regional indicators were added for each firm at a later stage. The postal questionnaire contained several questions concerning various common innovation indicators, such as patents, licences and realized product and process innovations (innovation output indicators), as well as R & D expenditures and R & D manpower (innovation input indicators).

The way in which innovation should be measured is still one of the most important and as yet unsolved problems in this field. None of the abovementioned indicators describe the innovation performance adequately.

- Patents and licences do not capture even a major part of all innovations because of the complex administrative procedures and insufficient protection against imitations.
- Product innovations are sometimes difficult to detect because (1) there is no generally accepted standard, so that different firms will react different on the question whether or not some new product is indeed an innovation (see Hoogteijling, 1984), and (2) some firms tend to make a mystery of their innovation behaviour for strategic reasons.
- Process innovations show the same handicap as far as measurement is concerned. New technologies are continuously adjusted to the production environment and it is extremely difficult to determine whether and when process innovations materialize.
- Input indicators such as R & D manpower ignore the differences in R & D labour intensities across different industrial sectors, nor do they include the rapid

technological changes within the innovation itself. Furthermore, there is no necessary relationship between innovation input and output, although a certain correlation is shown by Dieperink and Den Ronden (1985, forthcoming).

Consequently, a single indicator analysis does not do justice to the complexity of innovation. Therefore a number of innovation indicators are considered here partly leading to some strong results applying to all indicators and partly to more diffuse results.

Those are discussed in the next part of this section.

4.2 Product innovations

Fig. 2 shows the percentage of firms in each region that had one or more product innovations realized in 1983.[1])

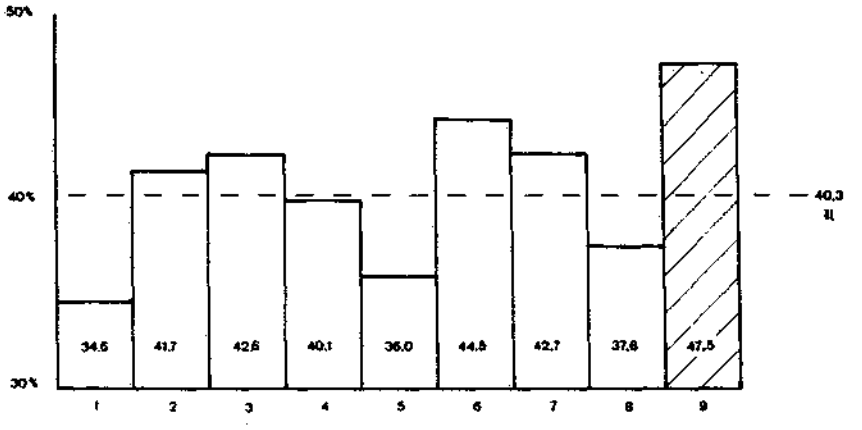


Fig. 2. Percentage of firms with one or more product innovations in 1983.

Rather striking is the significant difference between region 1 (high agglomeration economies) and the regions 2 and 3, and even more surprising are the relatively high outcomes for the regions 6 and 7 which have only low agglomeration economies.

Figs. 3a-3f show the same indicator divided into six categories of firm size. Note that regions of type 1 perform bad in all categories except for the small-sized firms. Regions of category 6 perform best, or nearly best, for firms between 50 and 500 employees. For regions of type 2, 5, and also 7 there are significant differences among the various categories, that cannot easily be explained. The most interesting region at this stage is region 7 which performs best in the category of small-sized firms, while having a rather poor score in the categories of larger firm sizes.

[1]) In this and the following statistics some caution is necessary concerning the interpretation of the outcomes for region of type 9 due to the low number of observations.

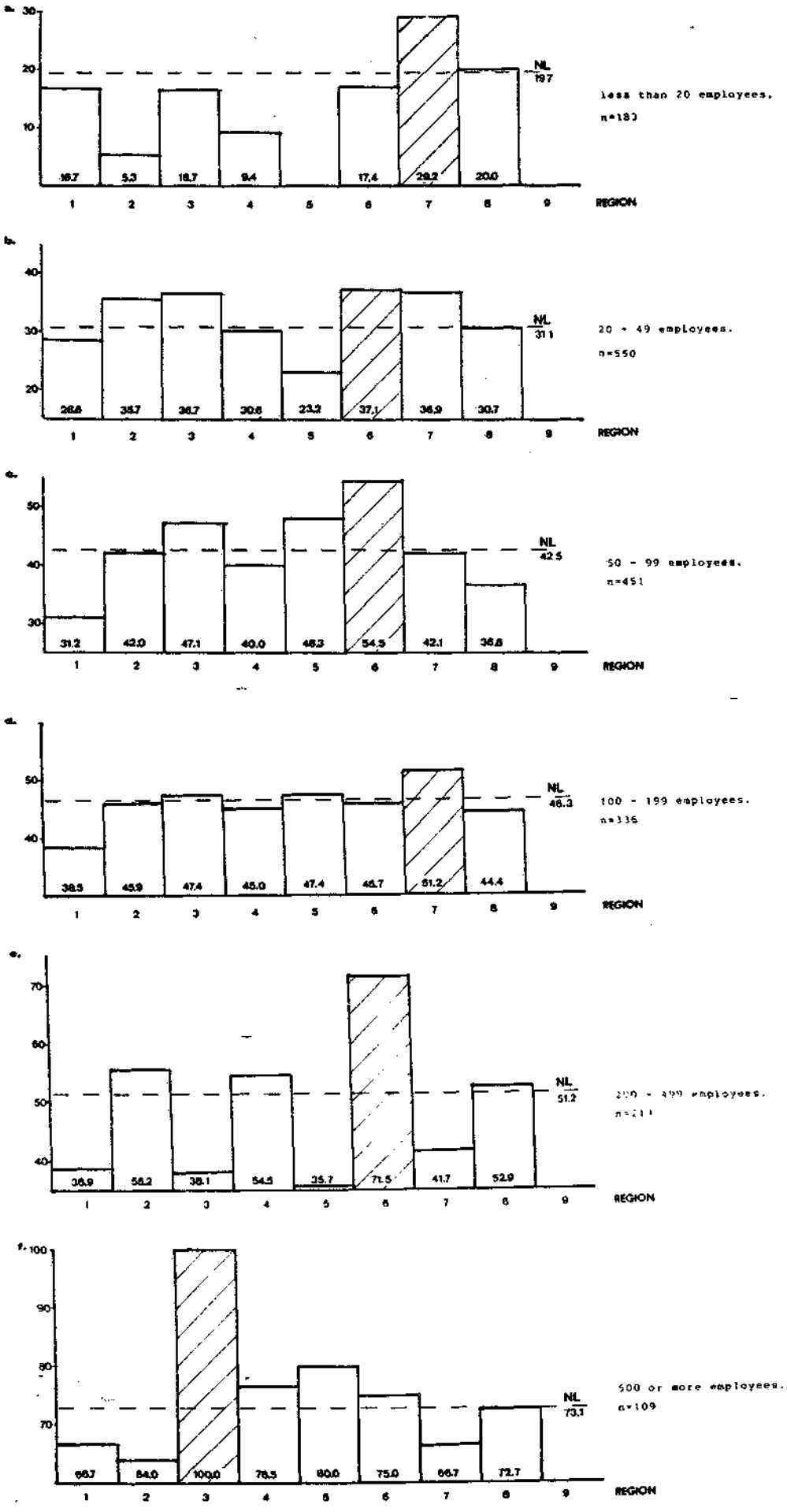


Fig. 3. Percentage of firms with one or more product innovations in 1983 for different firm size catagories. (regions of type 9 are excluded because of low number of observations)

Especially the result for small-sized firms seems to contrast with the idea that small innovative firms tend to establish in the core or ring of large agglomerations; on the other hand, these results show a parallel with the findings on the Boston route 128, mentioned earlier in this paper.

Another indicator based on product innovation is the total number of product innovations divided by the number of firms in a region. The consequence of this modification is that first of all firms with a relatively large output contribute to a better performance of that region, and secondly a large number of firms in a region with a relatively high innovation output means a better performance as well. The results are visualized in fig. 4.

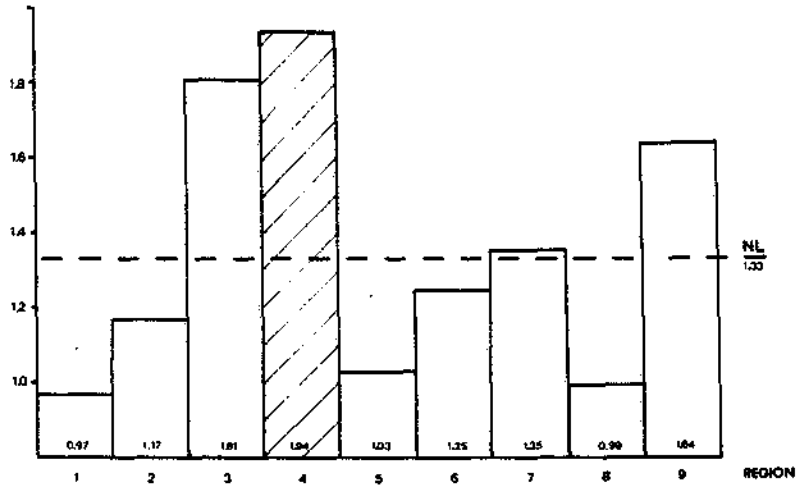


Fig. 4. Number of product innovations / number of firms.

It is worth noting that figures 2 and 4 differ significantly. Regions of type 4 appear to score at the 6th place only for the share of innovative firms. Nevertheless, with the number of innovations included, region 4 performs best of all regions. Further examination of the underlying data shows that a few firms in region 4 had an extremely high number of product innovations, whereas for instance region 6 contains firms that have nearly all zero or one product innovation. This explains the fall for region 6 from the first place in fig. 2 to the fifth place in fig. 4.

This illustrates perfectly the difficulties in choosing a right innovation indicator, for it is a priori not certain that a situation with more innovative firms is more favourable than one with a few very strong innovative firms, or vice versa. The conclusion after examining figs. 2 and 4 indicate that regions of both type 1 and 5 perform bad, while regions of type 3 and 7 are relatively strong in both figures.

The last indicator based on product innovation is the number of realized product innovations divided by the number of employees (see fig. 5).

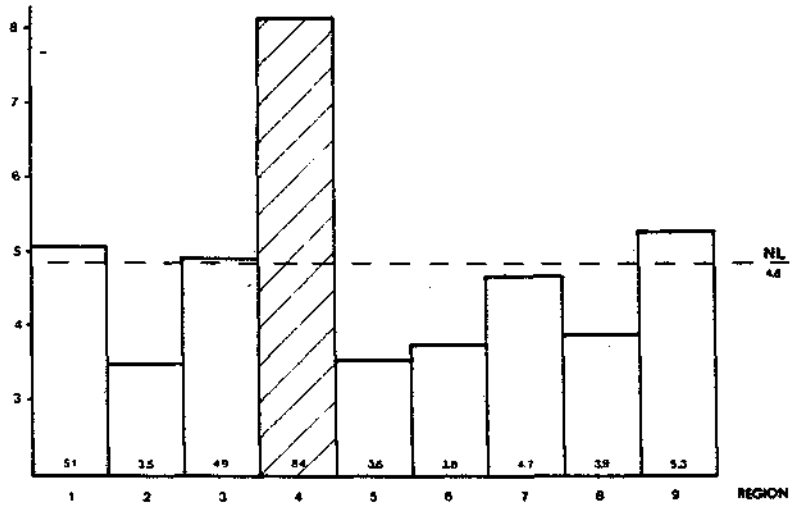


Fig. 5. (Number of product innovations / number of employees) x 100%.

A closer examination of the data teaches that the firms in regions of type 4, are mainly medium-sized firms. The transformation proposed here puts a heavy weight on the outliers in the small and medium-sized firms. This is also the reason why regions of type 1 perform relatively good. In general, however, it is advisable to use only estimators that are at most little sensitive to outliers, whenever possible (see Andrews et al., 1972).

4.3 Process innovations

The same indicators used to product innovations can be used in the context of process innovations as well. Fig. 6 shows the spatial dispersion of the percentage of firms that had one or more process innovations realized in 1983.

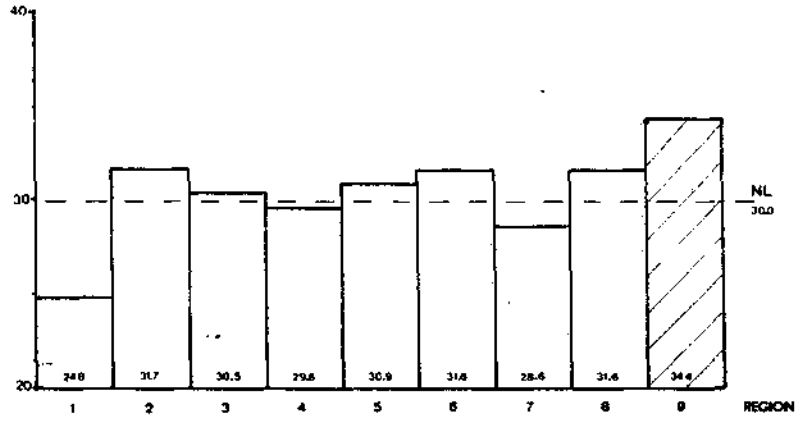


Fig. 6. Percentage of firms with one or more process innovations in 1983.

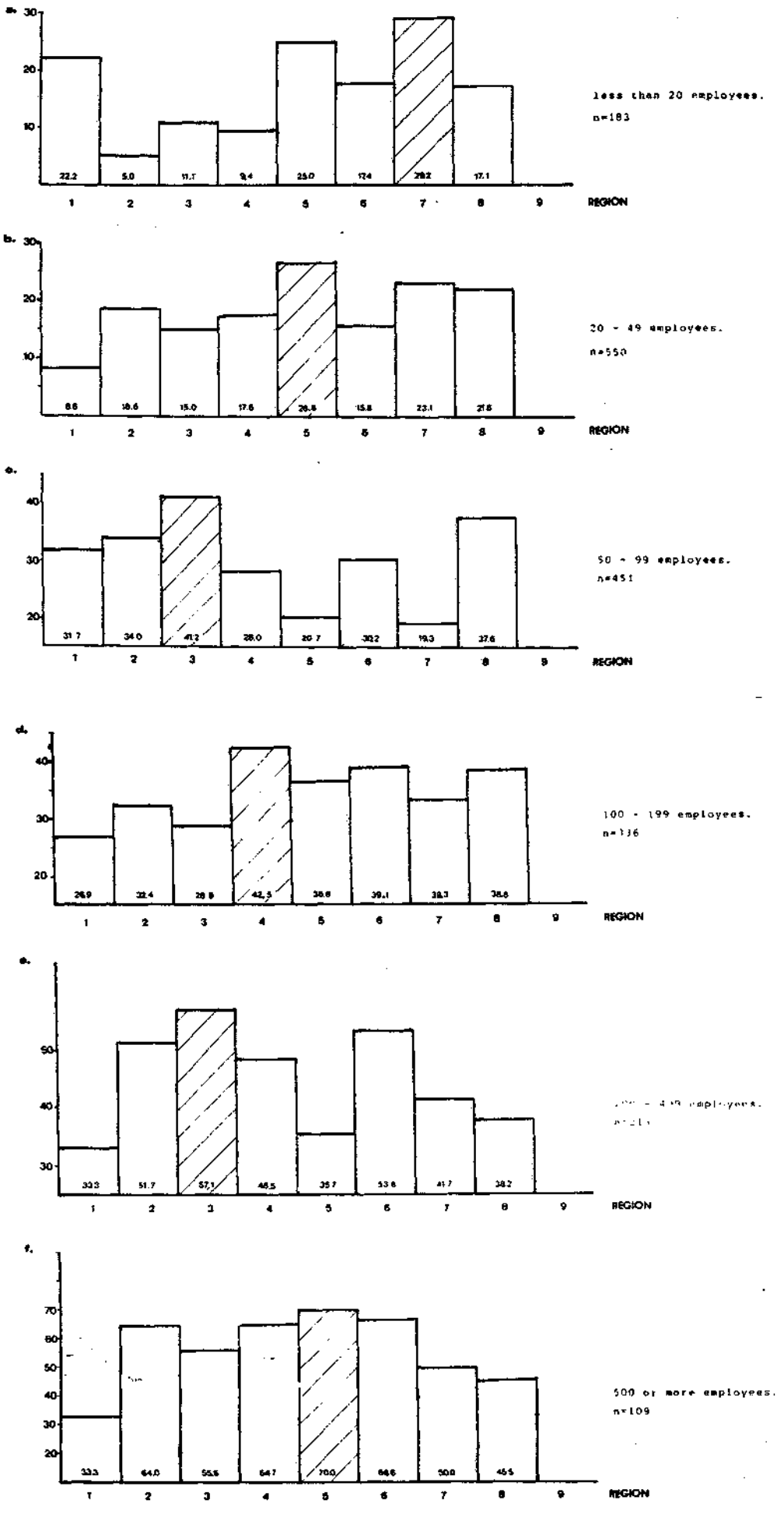


Fig. 7. Percentage of firms with one or more process innovations in 1983 for different firm size categories. (regions of type 9 excluded, see fig. 3)

Although there are to some extent similar conclusions for both product and process innovations in figs. 2 and 6, a clear distinction arises concerning the variance in both figures. While the first one exhibits a more diffuse pattern with a variance of 15.38, the latter shows a more stable pattern (variance 6.23).

At this point a careful conclusion can be drawn. The percentage of firms that had one or more process innovations in 1983 seems to be determined less by location than the percentage of firms that had one or more product innovations.

Similar to the product innovation approach, the above indicator is divided into six categories of firm size (see fig. 7 a-f). In fig. 3 the regions of type 6 and 7 dominated in nearly all categories. In fig. 7 there is no such dominance. Again region of type 7 scores best in the small size category but for other categories the regions 3 to 5 perform better.

It is interesting to note that the variances of the data in fig. 7 are all higher than those of the aggregated data in fig. 6. This could mean that the stability over the regions in fig. 6 is merely a result of the fact that all firm size categories have different distributions over the regions that coincidently enumerate to a rather stable pattern.

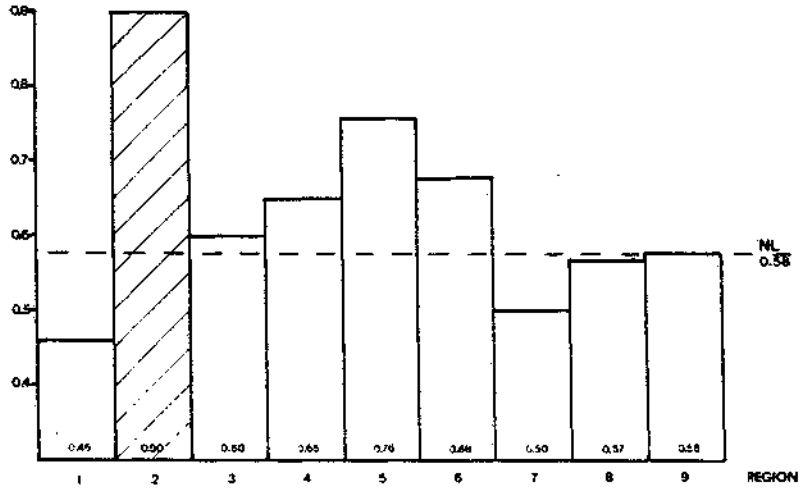


Fig. 8. Number of process innovations / number of firms.

The next indicator is the total number of process innovations divided by the total number of firms (see fig. 8). The remarks made in the context of product innovations do also apply here. Fig 8 shows a complete different pattern compared to that of figs. 6 and 7. It is plausible to assume that outliers caused this significant change. Nevertheless, note that regions of type 1 perform bad for nearly all data and that the regions of type 2 to 7 always contain the best and second best area from an innovation viewpoint.

The last innovation output indicator, the total number of realized process innovations divided by the total number of employees, will be discussed only shortly. This indicator is not a robust estimator (comparable with its product innovation equivalent), as the results may be extremely sensitive to outliers.

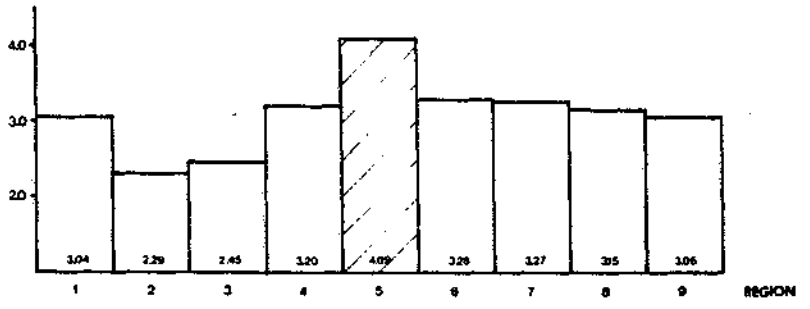


Fig. 9. (Number of process innovations / number of employees) x 100%.

It should be noted that figs. 8 and 9 are based on the same data set and that both express the same variable, namely process innovation. But while region 2 performs far better with the one transformation, it scores worst with the other one.

The interpretation is cumbersome and requires, for instance, a log-linear analysis and, at a later stage, methods for structural analysis of latent variables (Jöreskog, 1979, Leamer, 1978). A log-linear analysis on both product and process innovations in relation to the agglomeration index and the firm size led for both types of innovation to a similar result.

It can be concluded that there is no independence between innovation output and agglomeration, whether this innovation output is adjusted to firm size or not. This dependency is strongly related to the overall bad performance of region 1.

In the next part of this section several innovation input indicators are examined more closely.

4.4 Research and Development

The R & D indicators are often assumed to be more reliable than the previous output indicators (Kleinknecht, 1985). Furthermore, R & D indicators can quite easily be aggregated, in contrast to the output indicators mentioned earlier.

R & D expenditures take place through internal R & D as well as through external R & D. Fig. 10 shows the relative importance of internal R & D. Only a few companies have exclusively external R & D.

R & D:

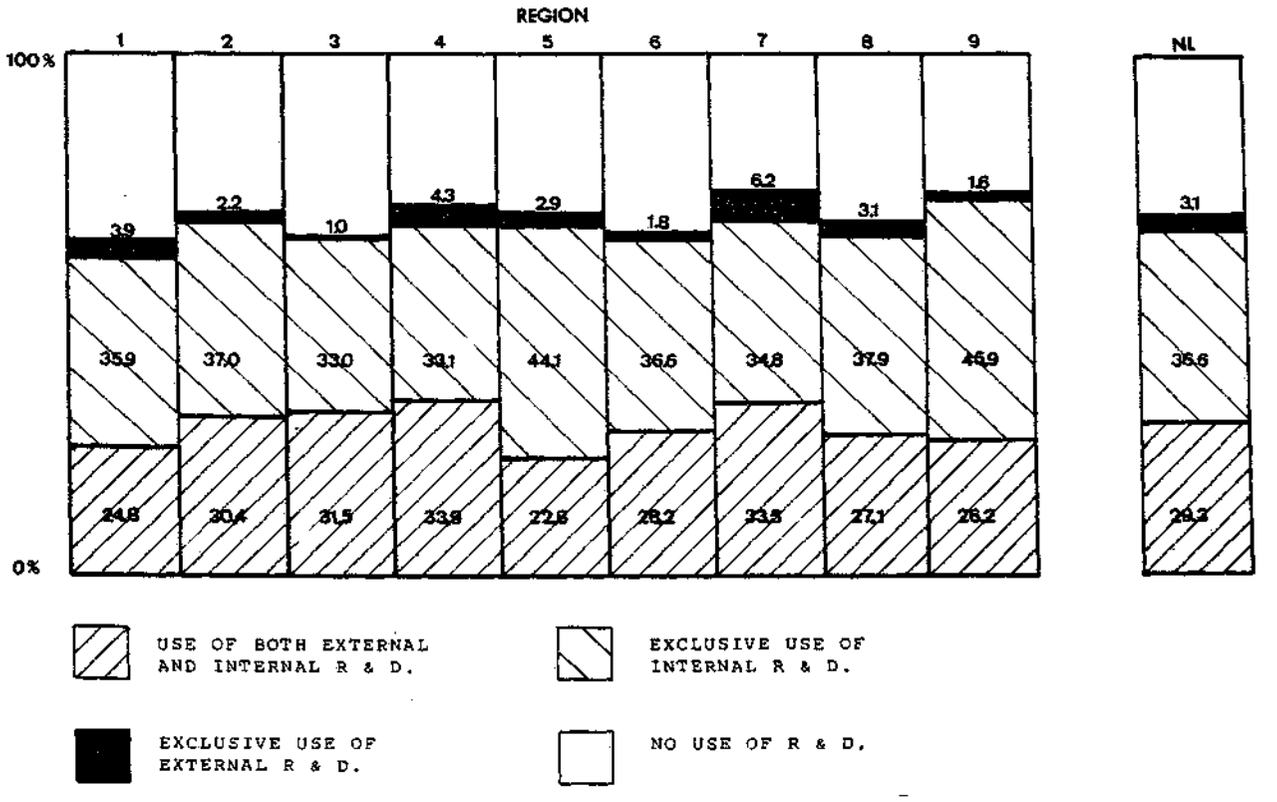


Fig. 10. Percentage of firms that used external and/or internal R & D in 1983.

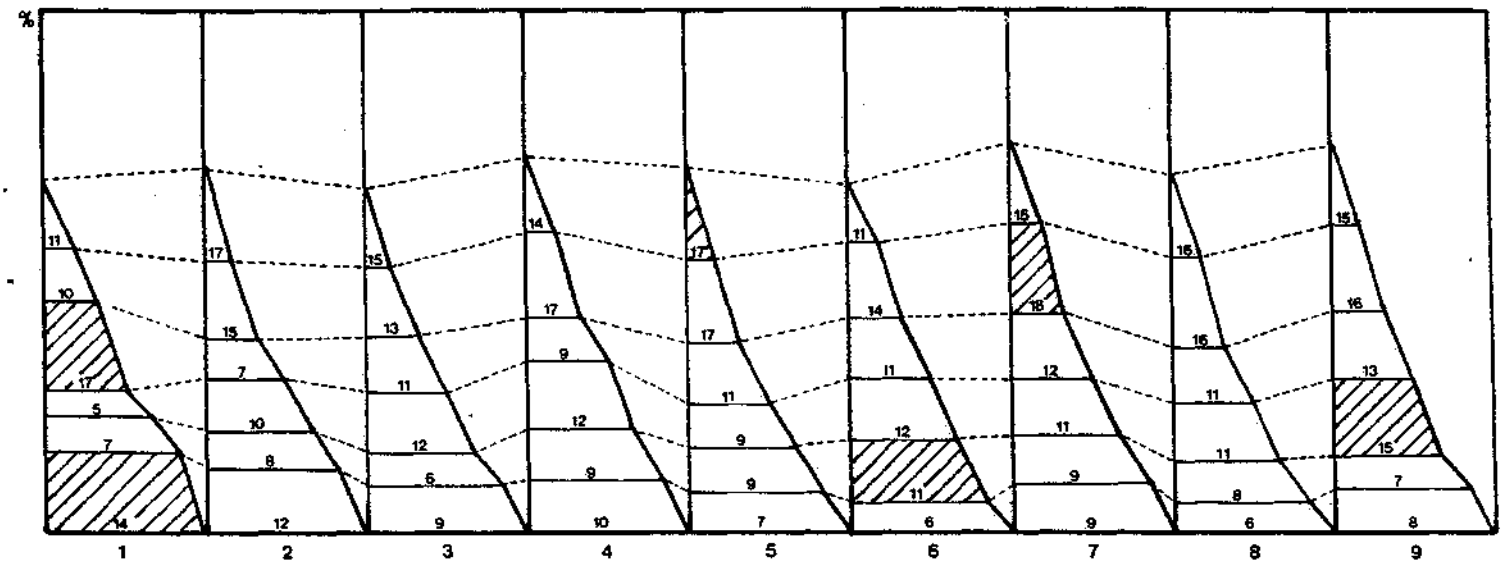
Regions of type 5 appear to have only a very low amount of external R & D, but they compensate that fact by having the almost largest percentage of internal R & D. Again regions of type I score worst, so that apparently a certain similarity does exist between R & D use and innovation output.

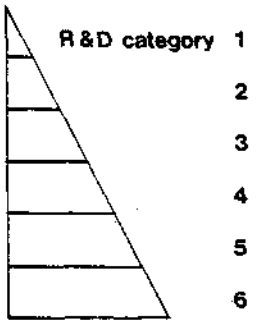
Regions of type 4 and 7 have the highest scores on external R & D as well as on the combined internal/external R & D. However, this is partly offset by a relatively low internal R & D. A further discussion on this topic in connection with the regional dispersion of transfer centres will be given later on.

The two R & D indicators that have been used in our study were measured by means of manyears, viz. one standardized for the firm size and the other one without further adjustments. The latter indicator will first be examined.

This indicator is measured on a 7-point scale:

R & D = 0, if no R & D took place in 1983,
= 1, if less than 1 manyear was spent on R & D,
= 2, if $1 \leq$ R & D manyears < 2,
= 3, if $2 \leq$ R & D manyears < 3,
= 4, if $3 \leq$ R & D manyears < 5,
= 5, if $5 \leq$ R & D manyears < 10,
= 6, if 10 or more manyears were spent on R & D.





		R&D						
		0	1	2	3	4	5	6
Region	1	35.3	11.1	9.8	17.0	5.2	7.2	14.4
	2	30.4	17.4	15.2	7.4	10.0	7.8	11.7
	3	34.5	14.7	13.2	10.7	11.7	6.1	9.1
	4	28.8	14.0	16.7	8.6	12.5	9.3	10.1
	5	30.1	16.9	16.9	11.0	8.8	8.8	7.4
	6	33.5	11.0	14.5	11.5	12.3	11.5	5.7.
	7	25.6	15.0	17.6	12.3	11.0	9.3	9.3
	8	31.9	15.8	16.4	11.0	11.0	8.2	5.6
	9	26.2	14.8	16.4	13.1	14.8	6.6	8.2

Fig. 11 . Percentage of firms that spent a certain amount of R & D manyears in 1983.

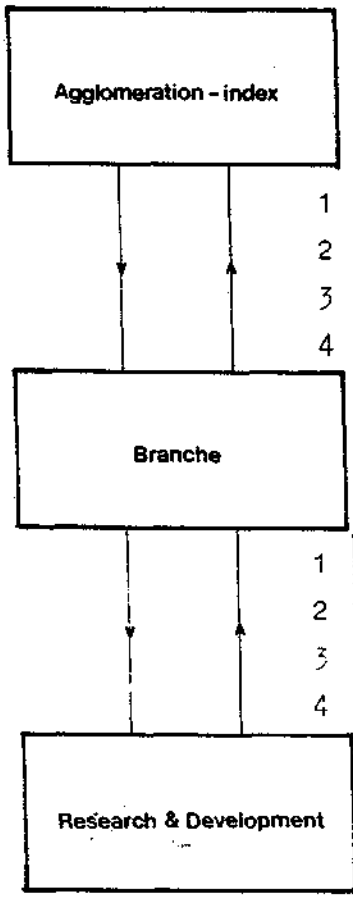
		R & D						
		0	1	2	3	4	5	6
REGION	1	16	11	5	11	5	11	41
	2	22	11	17	3	11	14	22
	3	18	18	11	7	11	7	28
	4	18	3	18	9	17	12	23
	5	15	8	39	8	0	15	15
	6	32	5	21	0	16	21	5
	7	0	6	24	12	6	12	40
	8	4	7	22	22	15	15	15
	9	22	11	11	11	34	11	0

Fig. 12 . Percentage of firms in the chemical and oil sector that spent a certain amount of R & D manyears in 1983.

The results of a cross tabulation of this indicator versus the agglomeration index are visualized in fig. 11a and b. Especially fig. 11b shows that although regions of type 1 have the highest percentage of firms without any R & D, this region has also the highest percentage of firms that spent 10 of more R & D man-years. It is therefore difficult to conclude that regions of type 1 are strong or weak in the R & D context, as this depends on the weights attached to relatively large R & D departments. As the input-output correlation in innovation is not straightforward to determine, it is impossible to state that a 10 person R & D department is twice as innovative as a 5 person R & D department.

Not only in region of type 1, but in all regions of type 1 to 4 a relatively high percentage of large R & D departments can be observed. This is probably linked to the location of the larger firms in regions 1 to 4.

If we only look at a segment of the whole industry, the pattern of results hardly changes. For instance, in the oil and chemical sector (see fig. 12) the larger R & D departments dominate also in regions of type 1-4. The percentage of firms where no R & D took place decreases sharply, as could be expected. Only



Interaction parameters
agglomeration index - industrial branche

	1	2	3	4	5	6	7	8	9
1	1.00	0.74	0.61	0.51	0.22	0.58	0.92	1.04	0.11
2	1.00	0.56	0.34	0.51	-0.31	0.00	-0.09	0.30	-.59
3	1.00	0.33	0.19	0.39	-0.37	0.33	0.33	0.82	-1.01
4	1.00	0.18	0.09	0.62	0.22	0.49	0.34	0.81	-1.19

(Underlined values mean significance at 0.05 level).

Interaction parameters
industrial branche - R & D

	0	1	2	3	4	5	6
1	1.00	-0.37	-0.46	-0.79	-0.73	-1.14	-1.01
2	-0.15	-0.66	-0.07	-0.66	-0.39	-0.36	0.15
3	1.77	1.10	1.09	0.87	0.76	0.59	0.55
4	1.42	0.42	0.45	0.08	0.08	-0.27	-0.76

N=1842

Branche 1 : food
2 : oil, chemicals
3 : steel, construction
4 : other

Fig. 13. Optimal loglinear model for agglomeration index - industrial branche - R & D.

in regions 6 the R & D share in the chemical sector is equal to the total industrial share. Other sectors have been examined as well. The results of those cross-tabulations have been further inspected by means of a log-linear analysis with the following indicators: R & D - agglomeration index - industrial branche. The results show that the assumption of independency between R & D and industrial branche is to be rejected, as well as that of independency between agglomeration index and industrial branche. There is however no need for a rejection of the independency between agglomeration index and R & D (see fig. 13). Of course, this does not mean the acceptation of the hypothesis that the spatial dispersion of R & D is independent of agglomeration economies: there is only insufficient justification to reject this hypothesis.

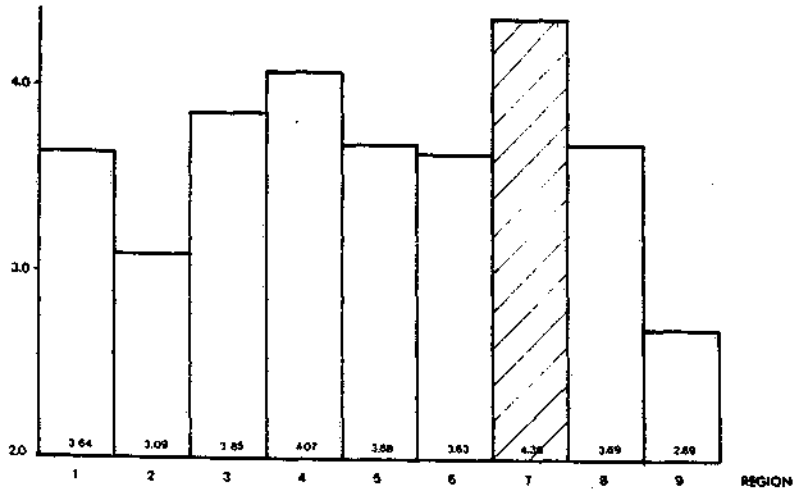


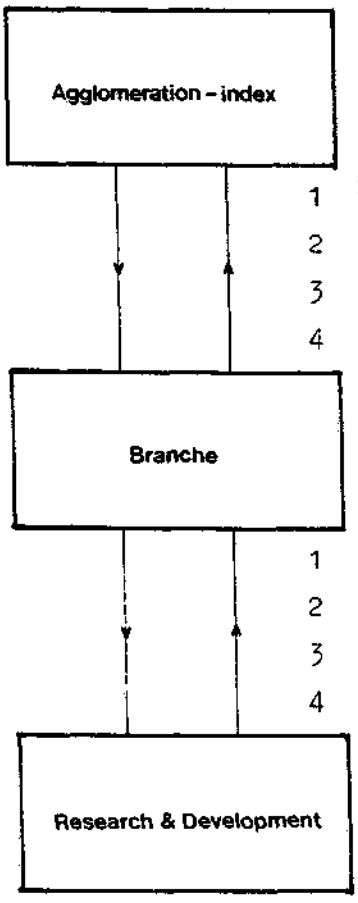
Fig. 14 . R & D manyears as a percentage of the total number of employees of firms with R & D in 1983.

The second R & D indicator studied here is R & D intensity, viz. the R & D manyears as a percentage of the total number of employees in a region (see Kleinknecht, 1985). It has been shown above, that the results from such transformed variables may be sensitive to outliers. One way to reduce this is to exclude all firms that had no R & D at all in 1983. Fig. 14 shows that again regions of type 4 and 7 perform much better than the other regions and particularly better than regions 1 and 2, although regions of type 1 score relatively higher than with any other indicator.

The low score of regions of type 9 illustrates again the complex and sometime indeterminate results on the connection between innovation input and output.

In the same way as with respect to the first (unstandardized) R & D indicator, a similar set of cross-tabulations was calculated, followed by a log-linear analysis with regard to the three variables (adjusted) R & D indicator, agglomeration index and industrial branche. Only the last results will be presented here, because of some rather surprising outcomes.

The optimal log-linear model turned out to be exactly the same as the optimal model in the previous part of this section with nearly the same parametervalues (see fig. 15 , R & D measured on a 6-point scale).



Interaction parameters
agglomeration index - industrial branche

	1	2	3	4	5	6	7	8	9
1	1.00	0.75	0.63	0.52	0.22	0.59	0.94	1.06	0.12
2	1.00	0.58	0.34	0.52	-0.02	0.00	-0.10	0.31	-0.60
3	1.00	0.33	0.19	0.39	-0.38	0.33	0.33	0.83	-1.02
4	1.00	0.19	0.09	0.62	0.22	0.49	0.34	0.82	-1.19

(Underlined values mean significance at 0.05 level).

Interaction parameters
industrial branche - R & D

	0	1	2	3	4	5
1	1.00	0.00	-0.25	-0.46	-1.10	-2.07
2	-0.14	-0.49	-0.35	-0.01	0.25	-0.25
3	1.78	1.06	1.07	1.31	1.14	0.40
4	1.43	0.63	0.43	0.49	0.01	-0.94

N=1842

Branche 1 : food
2 : oil, chemicals
3 : steel, construction
4 : other

Fig. 15 . Optimal loglinear model for agglomeration index - industrial branche - R & D (adjusted to firm size).

The patterns and related conclusions are thus the same for both R & D indicators. This result implies that the number of R & D employees/total number of employees ratio is distributed rather homogeneous over all regions.

In the sequel of this section the dynamics of innovation will be examined, based on the following question in the postal questionnaire: "How did the R & D expenditures in your firm change in the past 3 years?".

R & D budgets are often thought to be a relatively stable variable in time (Kleinknecht, 1985), especially if they are compared with normal investments. It is therefore often taken for granted that changes in R & D expenditures have a structural impact on the medium-term perspective of the firm concerned. The answers on the above question are summarized in fig. 16.
The hight of each regional block shows the relative growth in R & D expenditures with regard to the other regions.

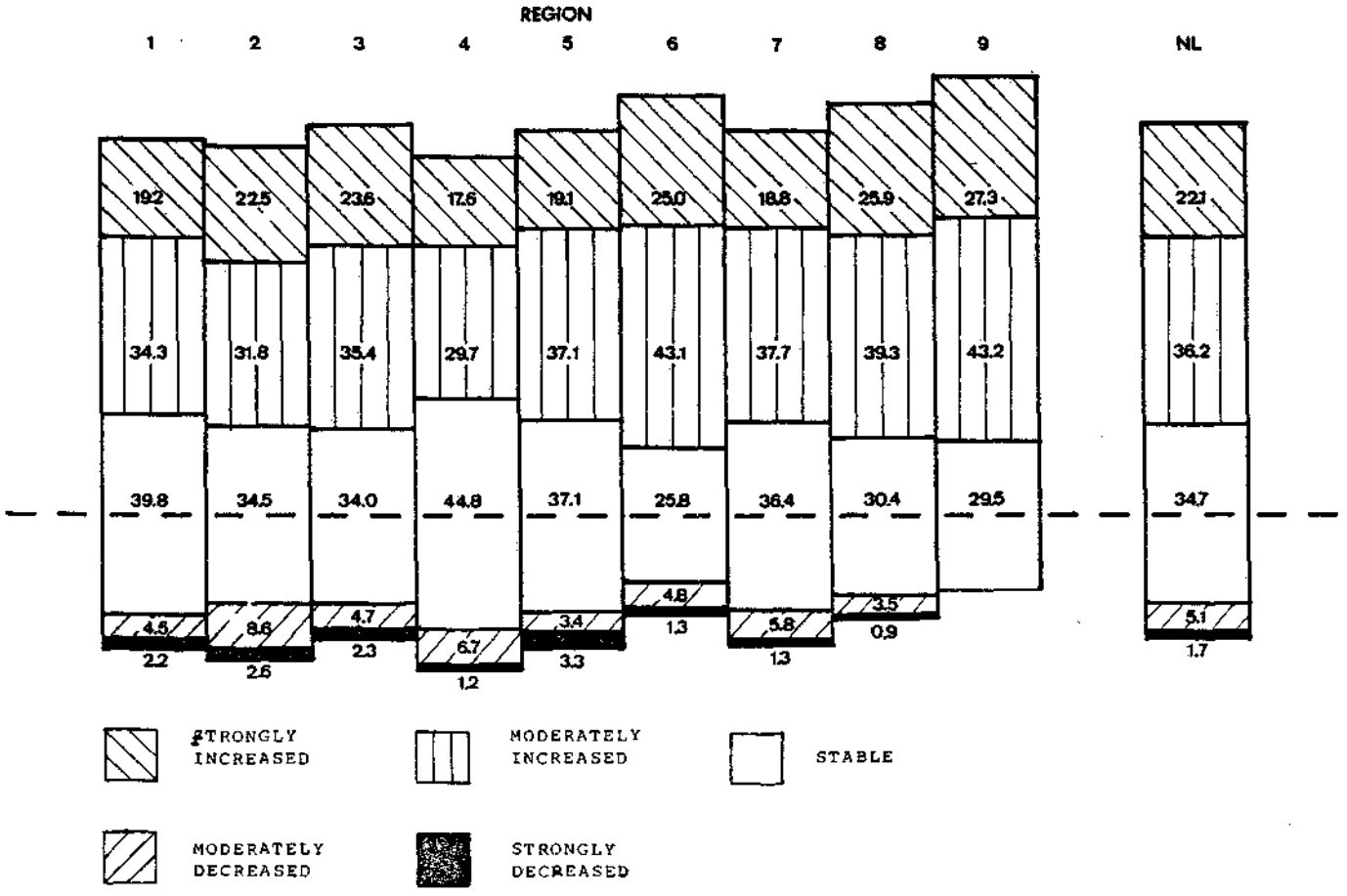


Fig. 16. Percentage of firms, where R & D expenditures increased, decreased or stabilized in 1980-1983.

It is clear that regions of type 1 and 2 show less growth in R & D expenditures. After region 4 comes region 1, the most stable region with only a small amount of strong growth. The stability and lowest growth of region 4 is rather surprising

and, given our remarks above, one would expect relatively less innovations in the years to come in regions of type 4 compared to the other regions.
If one compares the score of regions of type 9 in fig. 16 with that in fig. 15, it is evident that regions of type 9 are lagging far behind.
It is worth noting that according to most firms the innovative potential has on average considerably increased in the Dutch industry since 1980.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1														
2	0.74													
3	0.53	0.75												
4	0.65	0.51	0.32											
5	0.49	0.59	0.22	0.74										
6	0.46	0.49	0.43	0.41	0.55									
7	0.26	0.40	0.58	0.19	0.30-	0.67								
8	0.48	0.27	0.32	0.85	0.60	0.59	0.38							
9	0.62	0.85	0.62	0.38	0.52	0.43	0.62	0.13						
10	0.35	0.65	0.62	0.16	0.34	0.64	0.79	0.16	0.79					
11	0.15	0.48	0.63	0.15	0.45	0.52	0.84	0.31	0.56	0.74	-			
12	0.73	0.46	0.46	0.73	0.39	0.68	0.32	0.77	0.32	0.34	0.10			
13	0.67	0.42	0.45	0.87	0.47	0.36	0.14	0.76	0.31	0.18	0.58	0.85		
14	0.23	0.42	0.46	0.27	0.59	0.27	0.52	0.25	0.53	0.51	0.78	0.83	0.27	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

1 = Percentage of firms that had one or more product innovations.
2 = # product innovations / # firms.
3 = $\left(\frac{\text{\# realized product innovations}}{\text{\# employees}}\right) \times 100\%$.
4 = Percentage of firms that had one or more process innovations.
5 = # process innovations / # firms.
6 = $\left(\frac{\text{\# realized process innovations}}{\text{\# employees}}\right) \times 100\%$.
7 = Percentage of firms that used external R&D only.
8 = Percentage of firms that used internal R&D only.
9 = Percentage of firms that used both internal as external R&D.
10 = R&D employees as a percentage of the total number of employees.
11 = Percentage of firms with a stable R&D 1980-1983.
12 = Percentage of firms with a moderate growth of R&D 1980-1983.
13 = Percentage of firms with a strong growth of R&D 1980-1983.
14 = Agglomeration economies.

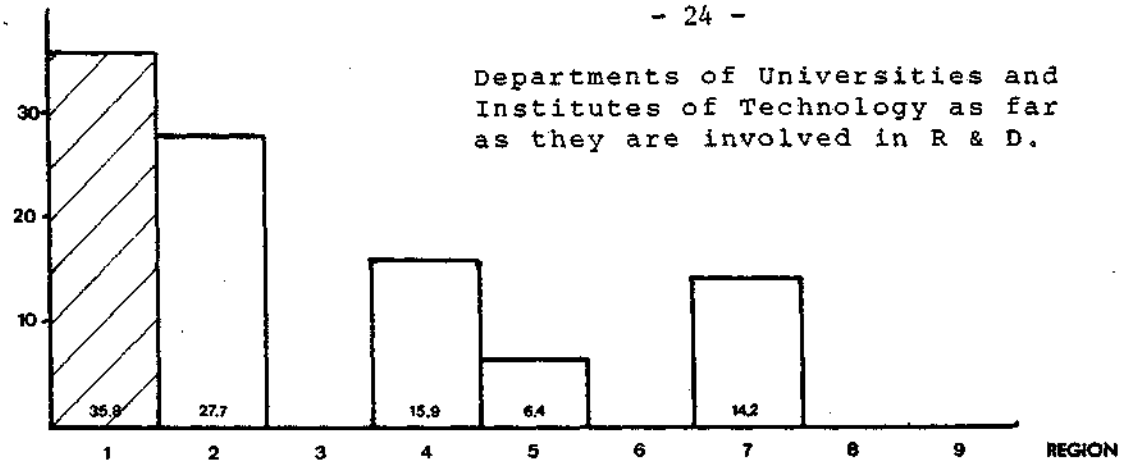
Fig. 17. Kendall concordance coefficients.

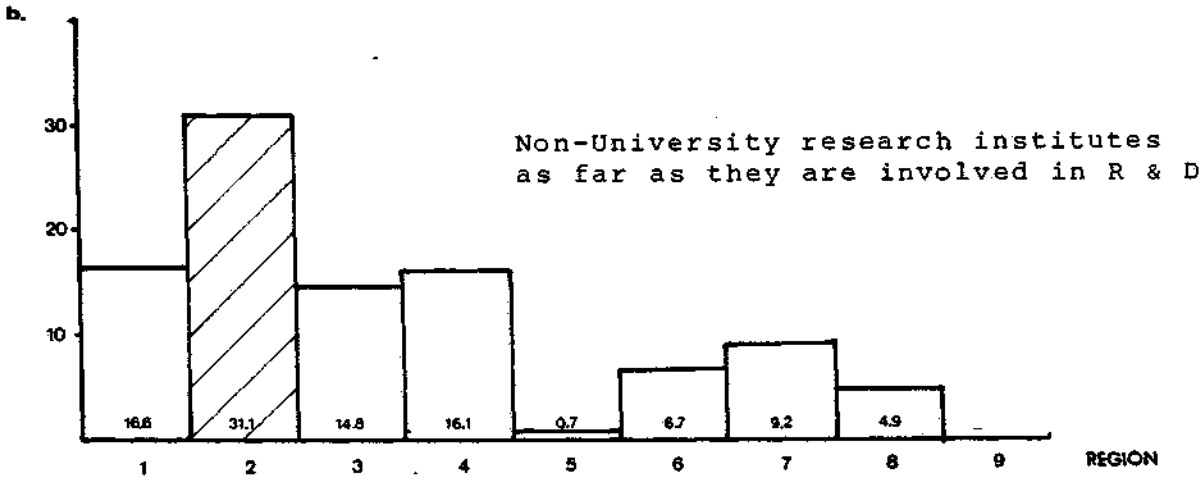
Finally, we will show by means of a brief concordance analysis some similarities and dissimilarities in the pattern of variables used in this paper. We will use here the Kendall concordance coefficient which is only based on rank orders, so that there are no scale or dimension problems. A value of more than 0.5 means a rejection of the statistical null-hypothesis that there is no similarity in two patterns, while a value of 1.0 means total concordance.

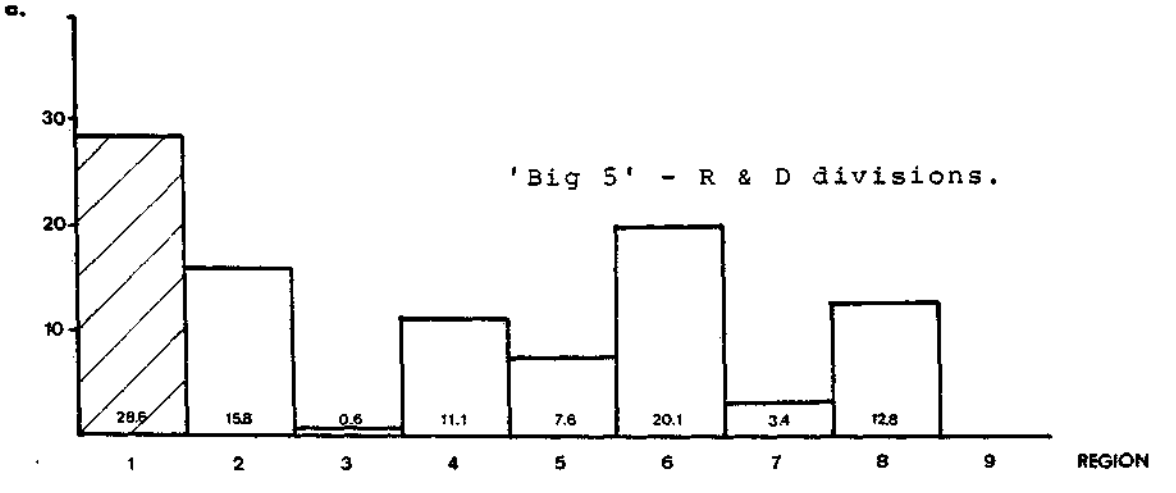
The results for 14 indicators are summarized in fig. 17. First of all, it is remarkable that all product innovations indicators have a similar pattern. The same holds true for process innovations indicators. It can be derived from variables 4, 5, 6 and 8 that the exclusive use of internal R & D and process innovations are correlated. This is probably so because process innovations require knowledge about specific productionprocesses; this knowledge will normally be available only within the firms themselves. On the other hand, variables 2, 9 and 10 show that product innovation needs external R & D. These results once more illustrate the need for a cautious use of innovation indicators.

Another noteworthy result is the concordance between variables 8, 12 and 13. Regions with relatively many firms that use only internal R & D have also the highest growth in R & D. This could mean that the growth in R & D can be attributed to firms that exclusively use internal R & D. Variables 7 and 1 show the same connection between exclusive external R & D and stability in R & D expenditures over the years 1980 to 1983. It is also interesting to observe that the stability and decline of R & D expenditures is concordant with the agglomeration index (or with agglomeration economies). This suggests to some extent a structural change, viz. that large agglomerations relatively loose their innovative potential (see also Malecki, 1983).

The foregoing results indicate the existence of a link between external R & D and various innovation indicators. A considerable part of external R & D is made up by knowledge centres, science parks, scientific research institutes etc. The regional dimension of this knowledge infrastructure and innovation will be examined more closely in the next section.







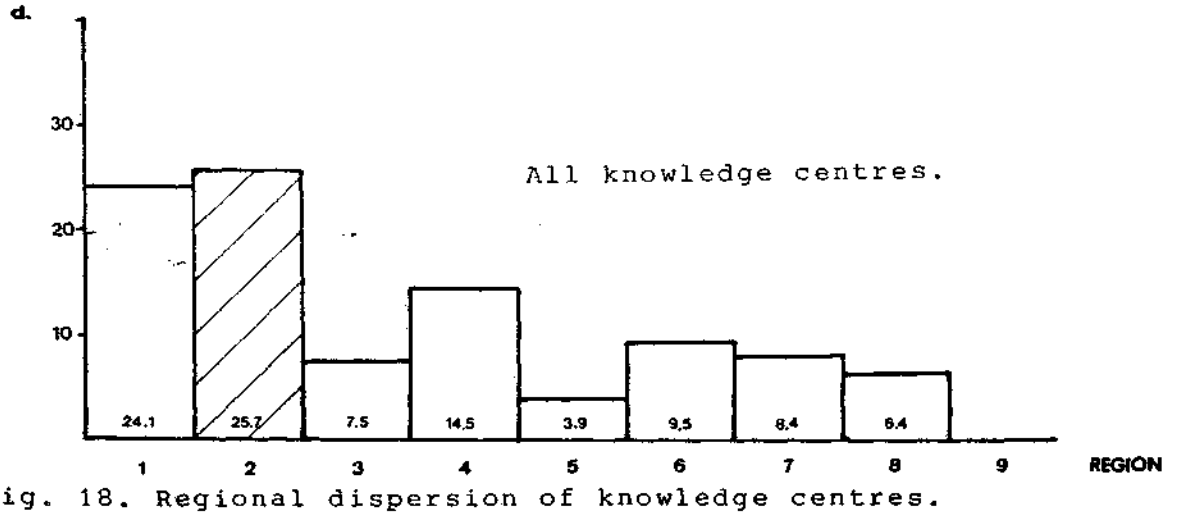


Fig. 18. Regional dispersion of knowledge centres.

5. The Regional Pattern of Knowledge Infrastructure

In this section the regional use of knowledge infrastructure will be examined as an illustration of the regional use of R & D facilities in the Netherlands. The main question here is whether knowledge infrastructure (universities, R & D institutes etc.) are mainly regionally oriented with respect to innovation, or whether - given their position on an accessible network - they may have a nation-wide effect.

It is increasingly accepted that knowledge and information form a necessary though not sufficient basis for innovation. Consequently, one may expect a certain correlation between the spatial dispersion of knowledge and that of innovation. If such a correlation would exist, the location of knowledge centres could be used as a strategic tool in regional policy (Mouwen and Nijkamp, 1985). The spatial dispersion of several innovation indicators has already been analyzed in the previous section. The spatial dispersion of knowledge is yet to be analyzed, followed by a comparison of both dispersion patterns in order to obtain insight into the underlying spatial correlation structure.

Three categories of knowledge centres are considered in our case study, namely:

1. departments of universities and institutes of technology as far as they are involved in R & D;
2. non-university research institutes as far as they are involved in R & D;
3. R & D divisions of the five biggest Dutch multinationals in private sector; recent outcomes showed that more than 70% of the private R & D is concentrated in these five companies.

Fig. 18 a-d shows for each category the percentage of R & D employees working in a certain region.

It can be seen that knowledge centres of universities and technological institutes are primarily concentrated in regions of type 1 and 2. The non-university research institutes show also a concentration in region of type 1 to 4 (78,6%), although region 1 has a relatively low percentage compared with the first category (the academic research institutes).

Finally, the 'big-5' R & D divisions seem to have the same location as the firm's headquarters, rather independent of the presence of other kinds of knowledge infrastructure.

As a whole, there is a strong concentration of knowledge infrastructure in regions of type 1 and 2. This is confirmed by a Kendall concordance test, which showed a strong correlation between agglomeration economies (or agglomeration index) and

presence of knowledge infrastructure (cc = 0.94). A series of Kendall tests was carried out between several innovation indicators and the results from fig. 18 a-d.

The indicators for the knowledge infrastructure variables are:

1. percentage of departments of universities and institutes of technology as far as they are involved in R & D;
2. percentage of non-university research institutes as far as they are involved in R & D;
3. percentage of all knowledge centres considered;
4. percentage of all knowledge centres adjusted for the number of firms in each region.

The innovation variables considered here are:

1. percentage of total number of firms that used only external R & D in 1983;
2. percentage of total number of firms that had R & D in 1983;
3. total number of product innovations/total number of employees;
4. total number of process innovations/total number of employees.

		Knowledge centre var.			
		1	2	3	4
Innovation variables	1	0.75	0.43	0.48	0.44
	2	0.63	0.32	0.50	0.27
	3	0.67	0.33	0.45	0.37
	4	0.62	0.26	0.49	0.39

Fig. 19. Kendall concordance coefficients.

The 4x4 matrix of Kendall's concordance coefficients are shown in fig. 19. Note that the innovation variables 2, 3 and 4 have no significant correlation with any knowledge infrastructure variable. It may therefore be concluded that in the Netherlands the knowledge needed for innovations is mostly obtained at a national scale. This result is clearly also a result of the geographical scale of the country. Innovation variable 1 however, shows a slightly positive correlation with all knowledge centre variables. The hypothesis of 'no correlation' is rejected by the Kendall test. It can therefore be concluded that firms that use exclusively external R & D tend to obtain their external assistance and consultancy in their neighbourhood.

We conclude that there is no significant correlation between the dispersion of innovation and that of knowledge infrastructure, except possibly for the rare exclusive use of external R & D. Mainly due to the compact and highly structured communication infrastructure in the Netherlands, a policy aiming at reinforcing

the regional potential of lagging regions by creating a new large-scale knowledge infrastructure in these regions is likely to have no substantial impact. Such a policy does not affect the innovative impetuousness of the entrepreneurs located in these regions (Mouwen and Nijkamp, 1985).

6. Conclusion

The main conclusion which has been reached by analyzing the regional dispersion of all innovation indicators is that regions of type 1, i.e., the large agglomerations, are not as innovative as they are often thought to be. These regions never obtained a best or second best position in the ranking of innovative behaviour; instead, for many indicators regions of type 1 performed relatively bad.
A second conclusion, that is supported by nearly all indicators is that region of type 4, the intermediate regions, turned out to be the most innovative regions, although this positive result is somewhat offset by the fact that these regions performed bad in terms of growth of R & D expenditures (see fig. 20).

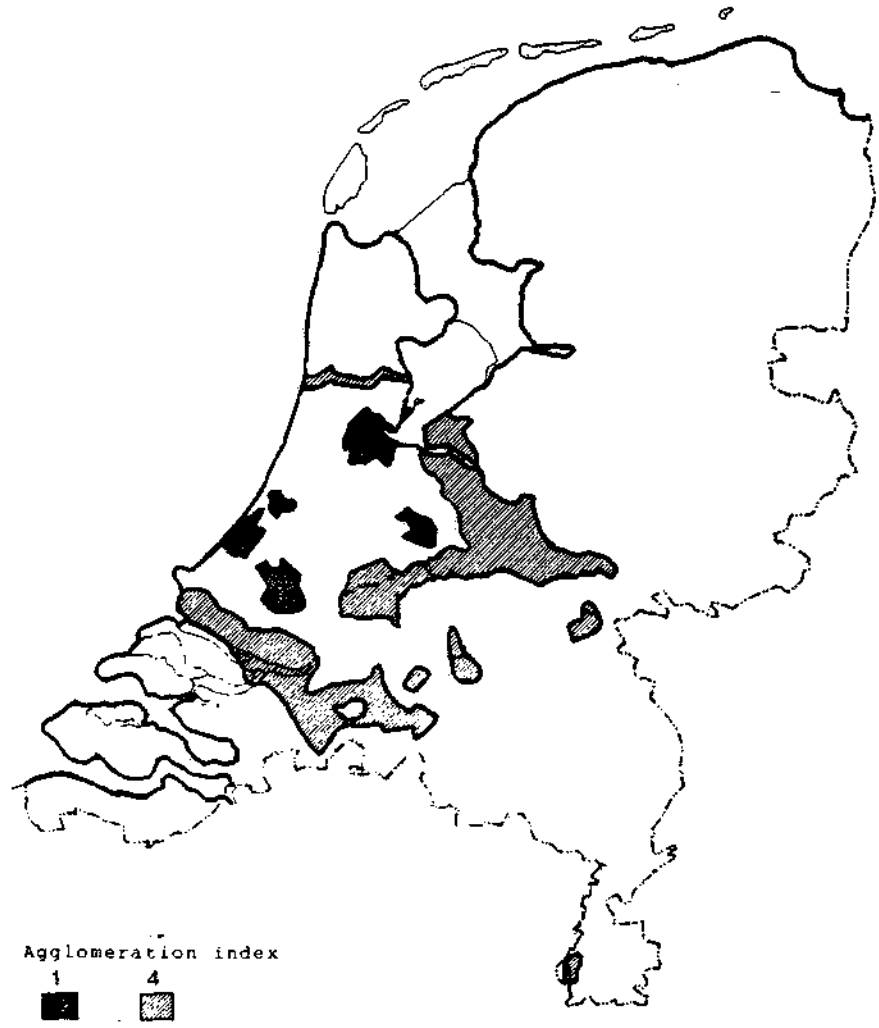


Fig. 20. Regions of type 1 and 4.

These two conclusions support the hypothesis that large cities loose their innovative potential in favor of medium-size towns (see Malecki, 1983).
For the remaining regions it is more difficult to draw unambiguous conclusions, because different indicators seem to give mutually contrasting results. However, a closer look at groups of indicators leads us to the following conclusions:
Region 7 performs good for product innovations and bad for process innovations. The same holds true for region 3.
Regions 2, 5 and 8 perform bad for product innovations, but good for process innovations.
Regions 7 and 3 are oriented toward product innovation, while regions 2, 5 and 8 are relatively oriented toward process innovations. Thus, it can be concluded that there exists a distinct specialization in either product or process innovation in some regions.
Thus, this paper has shown that no correlation did exist between the regional dispersion of innovation and that of knowledge infrastructure. It was concluded that a locational policy for knowledge centres is probably not an effective tool for regional development, as far as it concerns the stimulation of innovation.
Clearly, this does not imply that such a policy has no effect at all. It is merely concluded that the regional effects of knowledge infrastructure policy do apparently not discriminate among various types of regions.
Furthermore, it has become clear from our empirical analysis that the incubation phenomenon of the biggest Dutch cities does not imply a higher rate of innovative behaviour of industrial firms. In this respect medium-sized towns in 'half-way zones' appear to offer a more favourable innovation potential.

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