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TECHNOGENESIS: INCUBATION AND DIFFUSION

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TECHNOGENESIS:
INCUBATION AND DIFFUSION

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1 INTRODUCTION

Spatial dynamics has become a focal point of research in regional science. In this context, it is generally taken for granted that certain areas (e.g., large cities) are relatively more favourable generators of technical change than others, although these others areas may sometimes be more flexible adopters of new technologies. Thus both the incubation of new technologies (including new technological regimes or paradigms) and their diffusion (via a physical or non-physical communication network) deserves closer attention.

In the framework of economic restructuring metropolitan areas are often considered as large efficient production and information processing systems. Such 'urban fields' (cf. Pred. 1977) usually encompass a major share of the economic activities in a country and may even be regarded as the focal points of the interregional network across nations. The role played by metropolitan regions in such a network may be quite diverse and may vary from areas accommodating large scale industrial complexes to centres for business and governmental decision making, R&D or information processing. Their evolution does not only reflect stages of fast growth and stagnating maturity, but also obsolescence and decline, while over time they usually exhibit dynamic patterns of specialized roles in national (and international) systems. When these systems change, the specialization of a region may become less competitive or even out-dated, while inertia may prevent a revival of its activity pattern.

Metropolitan regions usually evolve with different growth rates and in different directions. This process has strong spatial and demographic repercussions. Migration and intra-urban relocation of households and firms, however, are not only reactions to the economic development, but have also their own dynamics, caused inter alia by population cycles for households (see Rima and Van Wissen, 1988) and by spatial evolution (see De Jong and Lambooy, 1985) or product life cycles (see Ciciotti, 1984, and Kamann, 1986) for firms. Some evolutionary patterns are common to all industrial nations and thereby common to metropolitan regions, even if they differ in many other respects. In general, spatial dynamics takes the form of activity expansion (or contraction) and of construction of new physical elements such as housing and industrial sites, infrastructure and transportation facilities. The evolutionary process itself has certain general consequences which may to a large extent be similar for all regions; more and more space becomes occupied by buildings, facilities and other extremely durable structures; the activity density increases especially in central locations etc. As time goes by, the inertia incorporated in this fixed structure affects the competitive power of an area, so that a process of decline may start. In case of regional specialisation, the social fabric and culture of the area may show the same inertia hampering new ideas and creativeness (see Storper, 1986).

Consequently metropolitan regions seem to develop from a young to an old structure which may have a long life but which may also extend its vitality through renewal processes. In this context, it has often been observed that a metropolitan area may act as a birthplace for new technologies in the form of new products and production (see for instance Hoover and Vernon, 1959). Studies of such urban incubator phenomena indicate that technology- and
knowledge-intensive industries locate in new places with a preference for regions with a rich variety of education, research and cultural opportunities (cf. Davelaar and Nijkamp, 1987).

Spatial dynamics is often exhibiting a link between the stages of metropolitan development (defined in terms of population or jobs) and economic development. The early urban concentration phase can usually be observed together with an early industrialization phase, where people and jobs concentrate in the already existing urban areas, characterized by the best infrastructure available at the time. As industrialization proceeds and per capita incomes rise, the demand for new housing as well as for private gardens, etc., leads to suburbanization. As the network of public and private infrastructure increasingly covers the entire country, urban areas appear to lose their comparative economic advantages and jobs begin to decentralize. In the post-industrial society, desurbanization tends to become a widespread phenomenon. In the context of such an urban life cycle hypothesis, the desurbanization phase should be followed by reurbanization, a trend which cannot as yet be firmly established statistically, although there are some signals which indicate that urban renewal in old city centres already leads to increases in the economic activity (gentrification). A further analysis of urban life cycles in the framework of 'long waves' theory can be found among others in Nijkamp (1985) and Nijkamp and Schubert (1985), where it has been conjectured that the evolution of metropolitan systems does not necessarily run parallel to that of national economic systems, although (metropolitan) systems may have many dynamic key factors in common. Thus, to a large extent, metropolitan areas may be regarded as a family of closely related "species".

The previous remarks on spatial dynamics imply also that the role of urban agglomerations in the process of regional and urban transformation is not always the same. For instance, it has been asserted by Malecki (1985) and Malecki and Nijkamp (1988) that although there is apparently a strong tendency toward agglomeration-oriented and agglomeration-induced new activities, the innovative capability of large cities tends to decrease in favour of medium-sized towns. Although small-scale enterprises (notably business services) may still find a favourable seedbed in large cities, many modern high-tech based firms tend to look for a location outside the large cities (the urban sprawl of enterprises). Especially the improved transport and communication infrastructure favours this dispersion to the rim of agglomeration areas (see Kamann, 1986). Apparently, in many geographical concentrations a situation of saturation (caused by diseconomies of scale) has come into being. Thus cities seem to pass through a life cycle in a way analogous to that of normal products. Various older cities may face an economic and social structure dominated by conventional (old-line) industries, leading to a structural spiral downward movement. Economic restructuring favouring new entrants in the existing structures and urban revitalization based on strategic R&D, are here key elements for ensuring a new rejuvenation potential of large cities. Those cities which are most creative (and hence offer the highest relative development potential for new activities) will become the winners in such a competitive evolutionary process. See for a representation of fluctuating spatial patterns also Figure 1.
Technogenesis: incubation and diffusion

FIGURE 1. The fluctuation of R&D intensity and market share of an area

It is taken for granted in the present paper that the key mechanism in explaining the behaviour of these "species" of urban areas in market-oriented countries over time is spatial competition. The growth of urban areas can then be explained by dynamic forms of spatial competition, both between urban areas at the national level and/or at the international level. An example of international competition of urban areas is the competition between major seaports such as Rotterdam and Antwerp or the competition between large agglomerations such as Singapore and Hong Kong.

It should be added, however, that the competitive position of an area does not only depend on its locational qualities, but also on the market performance of actors concerned and their degree of connectedness in a broader communication network, through which diffusion of innovations, acquiring of knowledge, adoption of new products or processes, and rapid transfer of commodities can be ensured. Thus the spatiotemporal development of a country is also strongly determined by the efficiency a physical network and the formal and informal networks of its actors, while the competitive position of a city is co-determined by its degree of nodality and connectivity in a network. An observation which is in perfect agreement with the traditional growth pole concept à la Perroux.

In the present paper, both the incubation and diffusion aspects of innovations of new technologies will be dealt with. First, in section 2 a brief review of elements of incubation (or nursery) theory will be given, with particular emphasis on the urban seedbed potential regarding innovations. Next, it will be argued that various models which have been developed in the recent past are often - despite their theoretical merits - not very satisfactory from the viewpoint of explaining entrepreneurial innovative behaviour. Then in section 4 various elements from diffusion and adoption theory regarding technological innovations will be presented. Here we will focus on the behaviour of actors in a network, on the attributes of such networks and on some methods for visualizing the relationships shaping a network. It will again be concluded that their behavioural content is not always very impressive. Finally, some policy implications and research recommendations will be discussed.
2 INCUBATION

Spatial patterns display a strong tendency toward concentration and agglomeration. Apparently, scale economies seem to emerge at places marked by a high information intensity, a high level of competence, a rich academic and cultural milieu, a high potential for external communication (including international connections), and a dynamic entrepreneurial climate. Schumpeterian entrepreneurship and spatial dynamics are essentially two sides of the same coin (cf. Suarez-Villa, 1988, and Thomas, 1987). Bruno and Tyebjee (1982) cite even 12 factors as essential for the environment for entrepreneurship:

- venture capital availability
- presence of experienced entrepreneurs
- technically skilled labour force
- accessibility of suppliers
- accessibility of customers or new markets
- favourable governmental policies
- proximity of universities
- availability of land or facilities
- accessibility to transportation
- receptive population
- availability of supporting services
- attractive living conditions

Clearly, several of the above mentioned factors are simply conditions common to most, if not all, large urban regions. For example, availability of land and facilities, accessibility to transportation, suppliers and customers, and attractive living conditions tend to be features found in virtually any major metropolitan region. Thus urban areas seem to provide important seedbeds for innovative entrepreneurial behaviour, an idea which is not only supported by the growth centre theory, but also by the incubation theory. To a large extent both conceptual frameworks - though developed in different cultures - are equal, although the incubation concept - in contrast with the growth centre concept - places more emphasis on the nursery conditions of new - often small-scale - enterprises.

Since Hoover and Vernon (1959) claimed that large cities provided external scale economies for small new firms (e.g., cheap working space, joint cost sharing of overhead facilities, face-to-face contacts etc), an avalanche of literature has been published on the incubation concept. It was claimed that the external economies provided by other firms in the same city did not only lead to a geographical clustering of activities, but gave also birth to many new firms (cf. Leone and Struyk, 1976). In this context, Cameron and Johnson (1969) stated: "For firms offering a new product the key objective is to maximize the contacts with the new market for a given working capital and fixed capital investment. The central area may be optimal for this since it contains a concentration of highly accessible potential customers, allows distribution costs to be minimal and offers a readily available pool of labour and other inputs, and possibly cheap property as well" (p.259).
In the past decade the question has also been studied whether large cities provide a high incubation potential for innovative activities (cf. Malecki, 1979, and Norton, 1979). Whether or not the city may act as a generator of innovations, depends of course on the specific seedbed conditions for innovative behaviour. In general, the following factors are regarded as highly important for the creation of innovations:

- Creative entrepreneurial environment
- Presence of research institutes that may act as breeding places
- Presence of a highly-skilled labour force
- Public support for R&D activities of starting innovative firms
- Availability of venture capital
- Presence of a stimulating and innovative entrepreneurial climate
- Availability of inexpensive areas for new innovative entrepreneurs
- Access to information
- International accessibility

It should be added that the accumulation of a critical mass of production in an industry serves also as incubator for new firm generation (cf. Rees, 1969). In particular, the specialization trend implies that incubation forces are relatively strong in particular subsectors.

Economic-technological spin-offs appear to be most common in large urban areas. It is in such places that a sufficient number of potential entrepreneurs are present, as well as other 'environmental' factors that encourage entrepreneurship. Shapero (1971) studied technical company formation in relatively small American countries over a 28-year period. The variables most highly correlated with firm formation tended to be those related to city size and agglomeration, such as manufacturing employment, educational expenditures, and income.

Furthermore, it must be stressed that not all R&D generates new spin-off firms. The state of the local industry's technology must be sufficiently unstandardized, preferably with multiple market niches, and the barriers to entry by new firms must be low (see also Bollinger et al., 1983). Even so, it would seem that the European experience regarding branch plants with their lack of local linkages (Kamann, 1978) and with public sector R&D in peripheral regions has led to very low levels of entrepreneurship (Cooke, 1985).

It is noteworthy that the location of innovative firms and the geographical spread pattern of innovations has to be seen against the background of a product life cycle phenomenon. New technology firms are — according to Davelaar and Nijkamp (1987) — increasingly dividing their activities into routine (or standardized) and non-routine (or innovative) operations. The non-routine (mainly R&D-oriented) activities tend to be concentrated in only a few locations marked by significant scale economies such as a good geographical accessibility (see e.g. Cicotti, 1984, and Kamann, 1986). For instance, Hekman (1980) indicates that American computer firms tend to maintain their innovative activities in only a few regions (like California, Texas or Massachusetts). Standardized production and assembly operations are
either moving into small towns or peripheral areas or into low wage Third World countries (cf. also Bluestone and Harrison, 1982).

Next, non-routine activities in the new technology sector rely heavily on skilled and professional labour input, so that also the quality of the residential climate (including socio-cultural amenities) becomes a major locational motive for high technology firms (see also Brotchie et al., 1985). Similar results were found by Oakey (1981) in a study on the British instruments sector, who came to the conclusion that skilled workers largely determined the location of production. This result was supported by Malecki (1984) and Oakey (1983) who observed that locational preferences of technical personnel exert a large influence on the location decisions of R&D, as this personnel appeared to attach a high priority to cultural, educational and employment opportunities in urban areas.

With regard to routine activities, especially of multi-plant corporate corporations, it is evident that low-skill labour is still the main input. In as far as low-skill employment is abundantly present in various regions, it is mainly the presence of tax heavens, premiums, cheap land and a low wage level which are determining the locational pattern of these standardized activities (see Hansen 1980). It should be added, however, that these activities may be fairly capital intensive, so that aging and life cycle processes of capital stock may also exert a significant long-term impact on industrial location patterns of new technology firms.

In addition, it is noteworthy that a large concentration of new technology activities may lead to congestion phenomena, especially if innovative firms create spin-off effects which lead to a rise in routine activities. Premus (1982), for instance, observed that in recent years there is a tendency of American new technology firms to move from the Sunbelt states to the Mid-West due to bottleneck factors (such as high wage rates, high land rents, insufficient areas for industrial expansion, high local taxes and traffic congestion). Clearly, this 'crowding out' phenomenon may also be related to the firm's position in a product cycle. Similar results were found for Scotland by Cross (1981), for the Netherlands by Hoogteijling et al. (1985) and Wever (1984), and for Germany by Wettmann (1983).

Another (important) locational determinant of the new technology sector is its orientation towards an accessible communication and information network (see also Thwaites, 1982), so that this sector is either located in nodal points of a physical communication infrastructure or in areas near research and educational institutes (Levy, 1983). This may lead to job hopping, for instance, in the Silicon Valley.

Finally, another relevant component of an innovation infrastructure of the new technology sector is the availability of venture capital (Rothwell, 1982), especially in those countries which are marked by regional variations in the provision of venture capital. In small countries, however, it is plausible to assume that regional differences in venture capital are less pronounced, so that this is not a location specific factor (although it may be a generic determining factor for new technological innovations in the country as a whole).

In the foregoing sections we have described, more or less extensively, the incubating hypothesis with regard to the role of urban agglomerations as a
seedbed for both new firms and innovative activities.

Testing the above mentioned hypothesis (with regard to new firms) raises several problems (see also Fagg, 1980). A first problem is related to the fact that we have to define the geographical area which is supposed to induce an 'incubation function'. Should the area to be considered consist of the core region (Hoover and Vernon, 1969, and Vernon, 1960), the area just adjacent to the core region (Buit, 1970, and de Ruijter, 1978) or the whole agglomeration (Lambooy, 1984)? In case we intend to identify certain 'breeding places of new activities' in a national context, it seems reasonable to consider the whole agglomeration as a 'breeding place'. In an intra-urban analysis this viewpoint is not sensible of course. When we compare the incubation scores of agglomerations, large urban areas and remaining regions, we have to take into account the sectoral specialization (see Kamann, 1988). Some areas have a higher birth potential for specific activities (e.g. services) than others.

A second problem is the development of a measurable criterion by means of which we can decide whether or not a certain (part of an) agglomeration offers an incubator function. Then the question becomes how many new firms (absolutely or relatively) does a (part of an) agglomeration have to generate (attract) in order to speak of such a 'seed-bed function'?

Finally, it should be noted that rigorous empirical tests on the incubation hypothesis are still fairly rare (see Davelaar and Nijkamp, 1987). In Davelaar and Nijkamp (1988) a more comprehensive model based on a Partial Least Squares (PLS) approach has been developed in order to test the existence of this hypothesis in the Dutch context. Here a distinction was made between the innovation potential (the capacity of industrial firms to generate and adopt innovations), the innovativeness (the realized performance of industrial firms in terms of technology generation, diffusion or adoption) and the selection environment (the set of indicators reflecting the regional production environment). By means of a multivariate PLS model for micro innovation data of Dutch entrepreneurs it was concluded that a spatial product cycle could be identified in which the more routine-oriented activities were shifted away from the main agglomeration in the Netherlands toward the periphery.

3 URBAN INCUBATION MODELS

In recent years various types of dynamic urban incubation models have been developed. Some of them are relatively simple and only based on the assumption of economies of scale during a first stage of urban evolution, followed by diseconomies of scale in a later phase. Examples can be found in Dendrinos and Mullally (1983) and Nijkamp (1987). Both types of models will be discussed briefly in subsections 3.1. and 3.2., respectively. A more comprehensive model on urban dynamics and innovative behaviour can be found in Blommestein and Nijkamp (1986). This model will be treated in subsection 3.3.

3.1 A dynamic urban Volterra–Lotka model

The urban Volterra–Lotka Model has been described and advocated by Dendrinos and Mullally (1984). Cities may exhibit fluctuating patterns depending on
their (dis)economies of scale and their economic performance or incubation potential. The authors argue that many urban areas in the U.S.A. exhibit stable dynamic behaviour, which can be depicted by spiralling sink type paths recorded on two key variables of aggregate metropolitan dynamics: relative population and per capita income. Two differential equations, defined over the ratio of urban to national population size and over the ratio of urban to national average income, are shown to describe an urban area's dynamic behaviour in accordance with the Volterra-Lotka predator-prey model from population dynamics.

The urban Volterra-Lotka model has the following form:

\[ x_{t+1} = x_t(-Q_t - Q_t + \alpha_t y_t) \]

and

\[ y_{t+1} = y_t(\beta_t - \beta_t x_t) \]  

Subscript \( i \) stands urban area \( i \). Variable \( x \) represents relative urban population size, and variable \( y \) represents relative per capita income in the city concerned. Assuming some plausible values of the parameters \( \alpha \) and \( \beta \), the dynamic trajectory of a city may be simulated.

Various interesting empirical results for American cities were found by Dendrinos and Mullally (1983). These findings suggest a general validity of the urban Volterra-Lotka model. Its major advantage is of course its flexibility, so that the model is able to generate a wide spectrum of dynamic behaviour of a city (including stable or unstable trajectories). A major disadvantage, however, is the lack of a rigorous econometric and statistical test procedure, so that the validity of results cannot be judged in a proper way. The lack of micro data once more is not very appealing, as then entrepreneurial behaviour cannot be satisfactorily dealt with.

3.2 A dynamic urban quasi-production function

In the second type of model for urban evolution the assumption is made that the growth (or incubation) potential of a city depends to a large extent on the available R&D resources. In this framework a simple quasi-production function has been developed in Nijkamp (1987).

A quasi-production function is a generalized production function, which — in addition to traditional production factors such as productive capital, labour and landuse — also incorporates infrastructure capital (or public overhead capital) and R&D (or innovative) capital. Infrastructure capital — as a complement to private productive capital — serves to enhance the efficiency of entrepreneurial activities, while R&D capital (both private and public) aims at favouring the innovative potential. Then the following quasi-production function for a certain area (region or city) may be assumed:

\[ Y = f(C,S,R) \]  

where
By assuming a Cobb-Douglas specification, one may rewrite (3.2) as follows:

\[ Y = \alpha C^\beta S^\gamma D^\delta \]  

(3.3)

where the parameters \( \beta, \gamma \) and \( \delta \) reflect production elasticities. These elasticities are assumed to be positive on the range \( (Y_{\text{min}}, Y_{\text{max}}) \). \( Y_{\text{min}} \) reflects a minimum threshold level of the regional production volume which has to be reached before a self-sustained growth will take place, while \( Y_{\text{max}} \) reflects a bottleneck level (or maximum capacity level), beyond which congestion factors lead to a negative marginal product. Consequently, the following conditions hold:

if \( Y \leq Y_{\text{min}} \), then \( \beta, \gamma, \delta = 0 \)  
(4.4)

if \( Y \geq Y_{\text{max}} \), then \( \beta, \gamma, \delta \leq 0 \)

By assuming now a time-dependent quasi–production function, the shifts in the regional share of the national production volume can be written as:

\[ \Delta Y_t = (\beta C_t + \gamma S_t + \delta R_t) Y_{t-1} \]  

(3.5)

with:

\[ \Delta Y_t = Y_t - Y_{t-1} \]  

(3.6)

and:

\[ C_t = (C_t - C_{t-1})/(C_{t-1}) \]  

(3.7)

\[ S_t = (S_t - S_{t-1})/(S_{t-1}) \]  

(3.8)

\[ R_t = (R_t - R_{t-1})/(R_{t-1}) \]  

(3.9)

The economy reflected by (3.5) will exhibit a stable growth path without structural changes within the range \( (Y_{\text{min}}, Y_{\text{max}}) \). The lower limit \( Y_{\text{min}} \) is in the present context of innovation and capacity limits less interesting, so that we will focus our attention mainly on the effect of the bottleneck value \( Y_{\text{max}} \).

This bottleneck value reflects congestion phenomena due to too high a concentration of productive capital in a certain area leading to diseconomies of scale, environmental decay, and inefficient land use. Beyond \( Y_{\text{max}} \), each additional increase in \( C \) will have a negative impact on the regional production share. Such a situation of a negative marginal product of capital can be represented as:

\[ \beta_t = \hat{\beta} [ (Y_{\text{max}} - \kappa Y_{t-1})/Y_{\text{max}} ], \kappa \geq 1 \]  

(3.10)
where $\hat{\beta}$ represents the (fixed) production elasticity of $C$ on the range $(Y^\min, Y^\max)$. Consequently, the adjusted production elasticity has become a time-dependent variable. Similar relationships may be assumed for $\gamma_t$ and $\delta_t$, so that substitution of $\beta_t$, $\gamma_t$ and $\delta_t$ into (3.5) yields the following result:

$$AY_t = (\hat{\beta} \ C_t + \hat{\gamma} \ S_t + \hat{\delta} \ R_t) \ (Y^\max - \kappa Y_{t-1}) \ Y_{t-1}/Y^\max$$

(3.11) with:

$$Y_t = \hat{\beta} C_t + \hat{\gamma} S_t + \hat{\delta} R_t$$

(3.12)

$Y_t$ may be regarded as the rate of change in the original quasi-production function. Relationship (3.11) is essentially a Volterra-Lotka-type model, which has often been used in population biology, for instance, to describe predator-prey relationships, notably in the May-type of models.

Relationship (3.11) has some interesting features: models of this type - despite their mathematical simplicity - may exhibit a remarkable spectrum of dynamical behaviour, such as stable equilibrium, stable cycles, stable cyclic oscillations, and chaotic trajectories with a-periodic (but bounded) fluctuations. The behaviour of such a model is determined by the initial conditions of the system and by its growth rate (depending on $Y_t$), but in principle this model is able to generate a wide variety of dynamic growth patterns. Consequently, in a spatial context long-term fluctuations depend on the initial values of a spatial system and its growth rate (which is codetermined by the production elasticities of production capital, overhead capital and R&D capital).

The growth rate, however, is a time-dependent variable, which can also be controlled by (private and public) policy measures. If the model is used in the framework of optimal control theory, generalized geometric (signomial) programming algorithms can be used to identify optimal controls.

A next step may be to introduce an additional relationship for R&D investments, given the assumption that R&D may serve as a tool to remove bottlenecks (the so-called depression-trigger hypothesis). Then we may hypothesize the following relationship, as soon as an area has reached its critical bottleneck level $Y^\max$:

$$R_t = \hat{R}_d(Y_{t-1} - \pi Y^\max)/Y^\max$$

(3.13)

where $R_t$ is the rate of change in R&D capital beyond the value $Y^\max$.

Substitution of (3.13) into (3.11) yields:

$$AY_t = (\hat{\beta} C_t + \hat{\gamma} S_t + \hat{\delta} R_t) \ (Y^\max - \kappa Y_{t-1}) \ Y_{t-1}/Y^\max + (Y^\max - \kappa Y_{t-1}) \ Y_{t-1}/Y^\max$$

(3.14) with:

$$Y_t = \hat{\beta} C_t + \hat{\gamma} S_t$$

(3.15)

The latter relationship is a nested dynamic model. This model may exhibit even
more complicated dynamic growth patterns, depending on the superimposition over two dynamic phenomena. The perturbations caused by the bottleneck factors may be neutralized or reinforced by R&D investments, depending on the fine tuning of new technology investments and spatial fluctuations. Thus in conclusion, incubation models of the May type do not ensure a stable spatial equilibrium.

3.4 A comprehensive dynamic urban Verhulst-type model

In the present subsection an illustrative model based on a Verhulst specification will be used as a framework for treating urban dynamics in a spatial system (see for details Blommestein and Nijkamp, 1986). The fundamental growth equation for city i is supposed to be:

$$x_i = \alpha x_i \left(N + \sum_k v_i^k - x_i\right) - \beta x_i$$

(3.16)

where $\alpha$ is the birth rate of new urban entrepreneurial activities, $\beta$ the death rate of existing activities, $N$ the initial physical-economic carrying capacity for economic activities of the city, $v_i^k$ the volume of new activities in sector k generated in city i (measured in appropriate units), and $\varepsilon$ the impact of new activities in sector k on the growth of city i. Thus the expression $\sum_k v_i^k$ indicates the capacity growth in the original volume $N$ of city i due to the introduction and implementation of new activities k.

Next, the growth of these new activities in sector k in city i may be represented as follows (see also Allen et al., 1981):

$$v_i^k = \eta v_i \left(e^k_i - \delta^k v_i^k\right)$$

(3.17)

where $\eta$ is the growth rate of these new activities, $e^k_i$ the volume of employment (or, in general terms, production factors) that might potentially be generated in sector k in city i (i.e., a ceiling for new urban activities), and $\delta^k$ a market threshold coefficient in sector k.

In addition, one may assume:

$$e_i^k = \mu^k d_i^k$$

(3.18)

where $d_i^k$ is the demand for the products generated by sector k in city i, and $\mu^k$ a (constant) parameter linking the effective demand for k to their potential employment opportunities (usually, $\mu > 1$).

Besides, the total demand in city i generated by residents of other cities j is - in case of absence of spatial competition - equal to:

$$d_{ij}^k = \lambda^k x_i^j / \left(p_{ij}^k\right)^\nu$$

(3.19)

where $p_{ij}^k$ is the c.i.f. price of a unit of product from sector k, produced in i and shipped to residents in j; $\lambda^k$ and $\nu$ are just normal reaction parameters.

Now the price $p_{ij}^k$ is supposed to depend on communication costs between
cities \(i\) and \(j\) as follows:

\[
P_{ij}^k = p_i^k + \phi^k \delta_{ij}
\]

(3.20)

where \(p_i^k\) is the f.o.b. price, \(\delta_{ij}\) the distance between \(i\) and \(j\), and \(\phi^k\) the unit communication cost.

Next, one may introduce spatial competition between cities on the basis of an attractiveness indicator \(a_{ij}^k\) for sector \(k\) which incorporates urban facilities and price levels of sector \(k\):

\[
a_{ij}^k = \rho \, n_i / (p_{ij}^k)^\theta
\]

(3.21)

where \(a_{ij}^k\) is the relative attractiveness of city \(i\) for residents of city \(j\), \(n_i\) the share of facilities is city \(i\), while \(\theta\) and \(\rho\) are standardisation parameters.

Consequently, the demand in city \(i\) generated by households outside \(i\) is co-determined by the relative attractiveness of city \(i\), so that the urban demand equation may be adjusted as follows:

\[
d_{ij}^k = \lambda^k x_j a_{ij}^k / (p_{ij}^k)^\nu = \lambda^k x_j \rho n_i / (p_{ij}^k)^{\nu + \theta}
\]

(3.22)

It is easily seen that the total sectoral demand can be directly calculated from (3.21), while also (dis)economies of scale may be incorporated. By substituting now (3.22) into (3.18), followed by a substitution of (3.18) into (3.17), equations (3.16) and (3.17) describe a highly non-linear dynamic evolution (of the May type) for a spatial system composed of competing regions, which might lead eventually to competitive exclusion (see also Johansson and Nijkamp, 1986). Thus various types of dynamic behaviour ranging from stable growth to chaotic behaviour may emerge, depending on the initial conditions and the various parameters of the system. Various simulation experiments for similar types of urban incubation models can be found in Nijkamp et al (1988).

3.4 Concluding remarks

The previous selection of dynamic urban incubation models is of course rather selective, but nevertheless leads to some important conclusions. Finally, a rigorous test of such dynamic models has not been achieved yet, mainly because dynamic micro data (or longitudinal data sets) do hardly exist in this field. Thus to some extent most models are too aggregate to test the underlying micro processes of urban dynamics. Simulation experiments may be helpful of course but do not lead to statistically solid inferences.

In addition to the incubation potential of urban areas, also the second attribute of technogenesis, viz. the role of its actors vis-à-vis diffusion and adoption, has to be given adequate attention. This will be done in section 4.
4 NETWORKS

4.1 The 'network' approach

The previous sections focussed mainly on locational and institutional features of the selection environment of actors and dealt with the question whether a spatial differentiation in these elements would lead to spatial differences in new firm formation and innovative behaviour. The present section focusses attention on the individual actor in a network of relations with the various actors in his environment. We will in particular concentrate our attention on diffusion and adoption phenomena and hence emphasize here mainly network links (Kamann, 1988). This set contains actors that are specific for the product/market combinations of an actor and the industrial organisation the actor is part of.

Networks are increasingly becoming popular in the literature. There is a growing awareness in economics and geography that firms should not be seen as individual organisms that live their own lives independently from other actors in their economic, social and cultural environment. Waves of merger activities and take-overs have resulted in noticeable effects and disruption, not only in financial circles, but also in local employment situations and welfare (Flynn and Taylor, 1986). Technological change, e.g. in telecommunications - information technology -, has resulted in locational changes of parts of multinational organizations and the contents of the activities involved (Kamann, 1985; Hepworth, 1987; Nijkamp, 1987; Everts and Kamann, 1987). Government efforts to stimulate innovative industries, and the growing interest for autonomous growth potential, territorial industrial complexes (Premus, 1985; Levitt, 1985; Stöhr, 1985) and local initiatives (Boekema and Verhoef, 1987) have induced a great deal of interest in the networks of relations between firms, including the diffusion of innovations (Pavitt, 1984).

When reviewing the available theories in regional science, we find that Perroux (1955) already dealt with networks of firms in his concept of the Growth Pole. Unfortunately, his theory about clusters of industries in economic space was poorly 'translated' into the Growth Centre theory with industrial firms that were clustered in geographical space although they could well belong to different clusters in economic space (for a review of the Growth Centre theory, see Moseley, 1974; Richardson, 1979, or Stöhr and Tödtling, 1979). A more recent concept originating from France which we will describe later on in more detail - the filière - seems to be more in line with the original ideas of Perroux. Policies based on this concept have already shown to be more valuable than conventional growth centre policies (Groenewegen 1987). However, given the results of studies of various disciplines, we will argue that the filière concept has to be 'expanded' (Kamann, 1988) in order to provide appropriate answers to the following questions:

what is a network;
how and why do actors participate;
how do we visualise the relations that make up a network;
how does diffusion take place?
4.2 Definitions: networks and actors

According to Perroux (1955/1970), firms operate on a plain in an abstract economic space, where they meet other actors. Actors refer first of all to individual entrepreneurs or firms in their role of competitor, supplier, customer, producer of potential substitutes or possible newcomer (Porter, 1980, Devine, 1979; Sherer, 1983; Kamann, 1985, 1986), but this concept may also include subsidiaries, profit centres or business units belonging to a corporate network. In the tradition of Perroux we assume a 'natural' tendency among actors to dominate a relationship and network as much as possible (Hermanssen, 1972). Or, as Johannisson (1987, p. 54) states, an actor exploits his environment; the plain where he meets the other actors is an arena. Authors in the tradition of Lewin's (1951) field theory, like Melin (1983), would even state that the position of an actor in the network - the field - is determined by both external and internal forces. Examples of external forces are demand, public policies, new technologies, labour relations, and other participants. Internal forces or drives are, for instance, the internal organisation and are assumed to be non-rational. Such a model however tends to underestimate the influence from the individual actor on his environment in his attempts to externalize the internal problems (resulting in negative external effects) and to internalize his external problems (by means of e.g. internal labour markets, information systems, capital supply). It is noteworthy that this approach amalgamates Mitchell's (1973) three categories of networks:

1. information network; vehicle for the diffusion of innovations;
2. 'exchange' network; characterized by mutual dependency;
3. normative network; common interest versus dependency.

The first two categories fit in with Cook and Emerson's (1978, p. 725) statement that between actors, "sets of two or more connected exchange relations" are established, shaping the network. The obvious question is here, how many relationships have to exist before we can use the term 'network'. Tichy (1981) refers to three levels of networks. The first is a cluster of relations, for example coalitions or cliques. The second level is an organisational network, while the third level is an inter-organisational network, referring to interacting organisations. While this is a valuable distinction from a theoretical perspective, it does not give a practical rule for demarcating the three categories. Since Mitchell's third category is often an implicit social phenomenon that even is not recognized as a network (Hellgren and Stjernberg, 1987, p.89), further problems in the visualisation arise. Johannisson (1987) therefore makes a sub-division into the formal and the informal structure. The formal structure is defensive, instrumental and exists apart from streams of activities. It consists of regulations, contracts and rules. Informal structures fulfill the social needs and are dynamic. "Informal structure represents the sedimentary organizing capacity of a collectivity" (Johannisson, 1987, p. 4). Leaders in the informal network translate external changes and are as such comparable with those who have orientation activities' with their broad socio-economic external scanning (Goddard, 1973). Having studied a great many studies that tried to visualise...
networks, we prefer to use a different distinction: manifest and latent network relations. Manifest network relations are flows of goods, services, information and contacts. They are the manifest signs of some kind of relationship and can be registered and measured. The strategic value of these flows and the dependency for the actors involved, are however very rarely visualized. Therefore, we would name this the latent relations. They contain some of Johannisson’s elements, but focus on the strategic value of a relation related to the issue of dominance and performance. Manifest relations are the materialized dimension of latent relations.

An important part of latent relations in a network are the social relations. The essence of the social network is that results of the one relation depend on the other relations (Johannisson, 1987, p. 9). The existence of a social system also means that the individual actors only have a limited freedom in their decision-making: a bounded freedom of choice. This idea is also reflected in discussions on the social paradigm and its resulting technological paradigm, determining technological trajectories (Dosi, 1982; Nelson and Winter, 1977). In an urban context, it is reflected in the discussion of social dominance in industrial centres, e.g. Detroit, Houston, Washington (Storper, 1986). This freedom of behaviour of the individual participants of the network is a direct result of the degree of dominance an actor has obtained. Thus inside the network, individual actors try to increase their freedom of decision, given the social constraints that apply in the network concerned.

4.3 The manifest network relations

4.3.1 The contents of relations.

Networks based on physical exchange

The first and most wellknown type of network is based on flows of goods and services between actors. Some authors (Vernon, 1966) use this to describe the spatial distribution of labour and production. Others emphasize their role in the diffusion of innovations in networks (Perroux, 1955; Pavitt, 1984; Camagni, 1985; Davelaar and Nijkamp, 1986, or the various contributions to the Venice Conference on Innovative Diffusion, 1986). The idea, common to most contributions is that a product is invented by an actor in one branch of industry and applied in products and processes of a different branch of industry. After this, it will spread over other sub-sectors. Chips and robots are well-known examples. Depending on the origin of an innovation, three types of network relations are usually found. First of all, the supplier dominated relation has to be mentioned, for instance the chemical network described by Baranson (1978). The second type is the user dominated relation like for instance in the semi-conductor industry (von Hippel, 1977). The third type of relation is the research dominated network, for instance the Swedish laser network (Laage Hellman, 1987). The phenomenon of users sectors – e.g., the food sector – explains why some sectors with a relatively low R&D expenditure still are able to raise productivity by using new technologies. These
innovations originate in other sectors (Mueller and Culbertsen, 1986).

The question of the origin of an innovation is related to the question who gave the impetus to the innovation or the invention that preceded (see Häkansson, 1983; Laage Hellman, 1987; Pavitt, 1984; cf. also the discussion on technology push or demand pull described by Mowery and Rosenberg, 1979). This is not necessarily the actual producer. Laage-Hellman (1987) for instance found that in more and more situations, supplier and user undertook the R&D together. This supports the statement (Dosi, 1983; Häkansson, 1987) that innovations cannot exclusively be explained by either the technology push or demand pull theory. Innovations are the result of the joint efforts of various actors.

Capital

Minority stakes in firms prove to affect the behaviour of the management involved when it is more than 17 percent because of "The mere threat of acquiring control that gives partial control over manager's behaviour" (Neun and Santerre, 1986, p. 207). Complete control is realised after 52 percent has been reached (ibid.). This means, that not only majority shareholders have to be taken into account, but also minority shareholders and their interests and policies. From the various attempts to visualise financial participations (see Vlieg, 1977) we may derive the conclusions that these networks are very complicated, interwoven and - because of the obvious reluctance of firms to provide this information - hard to map. The strategic value - a latent feature - of capital participation is very rarely empirically observed. It can be inferred however from case studies. We will describe some of these effects in section 4.5.

Information: personal networks

The exchange of information can take place via printed matter, by hiring persons (from universities or competitors: i.e. the human embodied information) and finally via personal contacts (face-to-face or by telecommunication).

Printed matter - mainly journals - are an important source for diffusion and innovation. Bramer (1986) found that among the small- and medium sized establishments journals played an important role as stimulus for innovations and also in the more advanced stages of a development process. This is confirmed by studies of Docter and Stokman (1987, 1988).

The role of exchange of human embodied information and knowledge seems to show culturally determined differences. For instance in the Netherlands exchange in terms of job-transfers between universities and the market sector does not play the same role as in the U.S.A. (Bartels, 1983). Exchange between firms that operate on the same plain seems more common. This is in a number of cases a matter of transfers within the same conglomerate; this could of course also indicate the existence of kartels where strategic information is shared by its members. Given the problem that very few firms will admit they buy out personnel to acquire information, empirical evidence is scarce here.
The third category consists of personal contacts. "Personal contacts are at the heart of interaction between organizations" (Cunningham and Turnbull, 1982, p. 314). Through personal contacts, policy decisions are prepared, formulated, attuned and negotiated. Much 'strategic information' - about competitors, suppliers and buyers - is obtained through personal information. These - face-to-face - contacts are the source of a multiple set of other types of contacts. For example to confirm something in writing by mail, telex or fax; the telephone call and the expedition of the agreed upon good. Although modern communication systems substitute some of the face-to-face contacts - especially the more routinized - they fulfill also better their supplementarity. We will discuss here two forms of personal contacts. The first is based on face-to-face contacts that occur in interlocking systems. The second is based on contact systems that use both face-to-face contacts and telecommunication contacts.

(A): Interlocking systems

A growing number of authors (Helmers et.al., 1975; Uitham et. al., 1977. Pennings, 1980) studied personal contacts between actors in interlocking systems and 'meeting places' of employees of government agencies, private firms and semi-state bodies. In an interlocking situation, someone is member of the Board of Directors of - at least - two companies (Scott, 1985, p. 1). Interlocks are "intrinsically meaningful as a channel of communication" where the total network "constitutes a web of communication through which general business information and opinion can be transmitted" (Mills, 1956; quoted by Scott, 1985, p. 1). This 'opinion' coincides with what we term "paradigm fixation".

Studies on interlocking systems draw up a hierarchy in the firms that are part of it. The more interlocking relations they are involved in, the higher their position in the hierarchy. We find five different theoretical models, which differ in their selection of explanatory aspects and variables. The first model emphasizes the role of financial institutions; the finance-capital model (Stokman e.a., 1985). A second variant assumes that the economy is "structured into competing groups of co-ordinated companies, each group being subject to a specific locus" (Scott, 1985, p. 8). This co-ordination and control model focusses on the role of banks, and family- or general holdings (Ziegler, et. al., 1985). The third variant is the resource dependent model and focusses on the way large companies regulate their mutual dependence in their attempt to gain access to valuable resources. Central theme is the way "to establish links ... to regulate their interdependence" (Scott, 1985, p. 9). In general, very few large and systematic networks are found here; "dyads, triads, linked together through a sparse nexus of random interlocks" (ibid. p. 10). The fourth variant is the managerial model, by many nicknamed the gin and cigar model. It assumes that senior executives of large companies have almost complete autonomy, independent from share holders and capital suppliers. Although sometimes their role as socio-economic scanning device is admitted, in this perception persons in interlocking systems - members of the Board of Directors - are figure heads or token women, just for show and public
relations. They are selected to increase the prestige of the company, not its ability to solve problems. Finally, as a fifth variant, we mention the class cohesion model. In this approach, "directors are recruited from an upper class and that the patterns of interlocks express and contribute to the cohesion of this class" (Scott, 1985, p 11; Ziegler, et. al., 1985).

All five models - and the studies related to them - have in common that they do not deal with the actual contents of the information, only with its assumed strategic value. Studies that empirically tried to measure this were unable to demonstrate this however. The contents are assumed to be be conspiracies or the opposite, twaddle. In the next sub-section on contact systems we describe a model that looks at the actual contents of information and its role and application.

(B): Contact systems

The Swedish Lund-school and the British Newcastle-school have established a long and rich tradition in research on contact systems. The underlying theoretical assumption in the work of both schools is, that the hierarchical organisational structure is linked to the hierarchical urban system (Wärneryd, 1968). This assumption coincides with Vernon's (1966) observation of the distribution of production in multinational corporations. In this spatial variant of the product life cycle theory, the division of activities in the organisation follows a Tayloristic approach: head-office functions separated from basic research and production; pilot plants at reasonable distance from head-office and laboratory; standardized mass production in peripheral, rural areas (Andersson and Johansson, 1984; Kamann, 1985a; Storper, 1985). Decreasing levels of knowledge required for activities imply a more rural orientation and increasing distance from the focus of activities (Kamann, 1985b).

Wärneryd also drew from Christaller's (1933) Central Place theory, including Pred's (1966) amendments. Localities higher up in the national or international hierarchy provide more specialized services. These range from hamburgers to loop-holes in the tax-laws: personal services, business services and public services; the urbanisation effects. Elsewhere (Kamann, 1988) we used a Generalized Least Squares model (LISREL) to test both the product life cycle theory and the central place theory on their empirical validity. We found they are not valid for all occupational categories but agricultural, administrative and clerical, nor for all areas. This blurs the real processes, especially when using aggregated data. It supported the assumption that network segments, related to particular activities and/or sub-sectors, have their own foci with industrial agglomeration effects and that these do not necessarily coincide with the urban area highest in the national hierarchy. The implication of this is that actors that require frequent face-to-face contacts with actors of the financial world, accountants, marketing agencies, consultants or politiciens prefer to be located in large urban areas or the metropolitan area. Wärneryd assumes that activities in the organisation differ in their mix and types of internal and external contacts, with different actors involved. Some of the external actors are supposed to be exclusively located in metropolitan areas. These assumptions were supported by various
studies (Thorngren, 1972; Goddard, 1973; Törnqvist, 1970; Andersson and Johansson, 1984). Using relocation costs and opportunity costs of missed information, an organisation could optimize its location. A first problem in this rather academic approach is that persons have a mix of activities and therefore may have different priorities and preferences for certain localities. In an organisation with numerous actors the usual social processes will take place, where coalitions or cliques and power rather than individual ratio will decide where the total group will locate.

4.3.2 Techniques to visualise manifest networks

Physical exchange: industrial clusters and filières

Input/output analysis (Leontief, 1954; Oosterhaven, 1981) is the best known technique to visualise flows of goods and services between actors. A major draw-back of this technique is its usually high level of aggregation. Of course, this is more related to the data used than to the principles of the analysis. Czamanski (1974, 1976) in his various analyses of industrial clusters, used two types of linkages between industries: forward linkages. symbolized for industry A as $X_{AB}$ representing the flow of goods from A forwards towards B, and backward linkages, symbolized as $X_{BA}$. The forward linkage from A coincides with the backward linkage from B. The relative importance of a link is expressed by four coefficients, $A_{AB}$, $A_{BA}$, $B_{AB}$, $B_{BA}$ each expressing the percentage of a particular link between two industries as a percentage of all supplies to, respectively, from a particular industry. The coefficient $e_{AB}$ stands for the degree of dependence, where

$$e_{AB} = \text{MAX} \left[ A_{AB}, A_{BA}, B_{AB}, B_{BA} \right]$$

(4.1)

where each of the four elements is derived using

$$A_{AB} = \frac{X_{AB}}{\sum_{B} X_{AB}} \quad A_{BA} = \frac{X_{BA}}{\sum_{A} X_{BA}}$$

$$B_{AB} = \frac{X_{AB}}{\sum_{A} X_{AB}} \quad B_{BA} = \frac{X_{BA}}{\sum_{B} X_{BA}}$$

(4.2)

For $e_{AB} > 0.2$, a link between A and B is significant.

The spatial attraction between industries is included in the following way. The urban attraction is expressed as follows:

$$E_{ir} = b_i P_r + E_{ir},$$

(4.3)

where $b_i =$ urban attraction on industry $i$, $E_{ir} =$ employment of industry $i$ in region $r$, $P_r =$ population of region $r$.

Elimination of the urban attraction when focusing on the spatial attraction of industry $i$ on $j$ gives:

$$e_{ir} = \alpha_{ij} + \beta_{ij} E_{jr},$$

(4.4)
where \( E_{jr} \) = employment in industry \( j \) in region \( r \)
\( \beta_{ij} \) = spatial attraction between industries \( i \) and \( j \)

A new variable \( \phi_{ij} \) is introduced because of the asymmetric relation between \( i \) and \( j \):

\[
\phi_{ij} = \beta_{ij}/\bar{E}_j + \beta_{ji}/\bar{E}_i
\]  \hspace{1cm} (4.5)

where \( \bar{E}_i, \bar{E}_j \) = average employment in a region in industry \( i,j \).

Using these formulas, Czamanski found 216 spatial industrial clusters in the U.S. economy of 1963.

The major problem with this clustering approach is the cut-off point, which is often rather arbitrarily determined. In theory, one could include all exchange relations between actors. However, the usual implicit assumption is that the relations should be 'of importance' to the actor. However, for actor \( A \) a customer \( X \) buying 15 percent of his production may be insignificant. Customer \( Y \) however may require very specific products that stimulate \( A \) to improve its range of products while \( Y \) also provides the required assistance in meeting \( A \)'s objectives. Still, \( Y \) may only buy 10 percent of \( A \)'s production. Although the volume of a flow may give some indication of its strategic importance, this is only valid under rather strict assumptions of homogeneous goods, homogeneous information and homogeneous actors.

A different, more descriptive approach to visualize exchange flows is found in the filière approach: "a submode of production organization, constituted by the economically and technically interrelated operations placed between the point of availability of the raw material and that of the finished product" (Boulianne, 1982). Burink and Groenewegen (1983) give a broader definition, referring to a class of sectors, related in a chain between raw materials and capital goods at one end, and distribution and service at the other end. Machin and Wright (1985) emphasize in good Perrouvian tradition the role of nationalized corporations. Although conceptually an improvement on input/output analysis, a number of weaknesses remain in the filière concept. First of all, operationalization still leads to serious measurement problems. Again, a subjective cut-off point for relations has to be decided on. A second weakness is the static character of a filière. It reflects relations at a certain point of time, and does not indicate growing or shrinking flows, nor does it indicate the rise or fall of actors. As we know, actors are also faced with the threats of substitutes and newcomers. Products have their life cycles, technologies change and exogenous 'facts' may change, like demand and environmental demands. None of these aspects are included. A third weakness, common to all approaches in this category is that filières - as they are visualized - do not include the other manifest flows, let alone latent relations between actors. Therefore, the notion of expanded filières (Kamann, 1988) may be developed, incorporating at least information flows and capital relations. Even expanded filières still have the above mentioned disadvantage that they do not show the strategic relevance of its various components.

Pavitt's (1984) taxonomy could be incorporated to trace diffusion processes within filières. Since a filière should be drawn up at a single establishment level, it also is a very useful instrument for translating actors in economic space into locations in geographical space.
Analogous to the filière approach, we find that in dynamic networks, the actual configuration of actors and their relations—in case of e.g., telecommunication industries even the names involved—have changed already by the time the ink of the text describing the network has dried. An added problem for the researcher is that minority interests are difficult to trace.

Contact systems: interlocking systems and personal contacts

A great number of studies are available on interlocking systems. In some cases, the spatial dimension is implicitly present, e.g., the distribution of nationalized companies, located in the capital and companies owned by the local authorities (e.g., Ziegler et. al., 1985, pp. 73–79). Chiesi (1985, p. 209) explicitly studied spatial aspects of interlocks. He found Milan, Rome, Turin and Genova as centres for specific activities which also supports our focus concept. Bearden and Mintz (1985, p. 241) found that "... the American interlock system was divided into regional groupings within which corporations maintained denser connections to local concerns than to distant companies". These local concentrations should however be seen as "local pockets of densely interlocked corporations into a larger network, rather than as autonomous centres" (ibid.).

The contents of information contacts are studied by Goddard (1973) using a multivariate analysis. As a result, he divides contacts in three categories:

1. Orientation contacts, required for long term planning and scanning of the socio-economic environment; new developments inside our outside the actor's sub-sector should be noticed;

2. Planning contacts, related to "processes and related information flows concerned principally with the development of specific alternatives that have been identified through higher level orientation processes" (Goddard, 1973, p. 27). Both applied R&D and activities of Strategic Business units belong in this category. Telecommunication is frequently used. These activities can be performed in second order cities with good access to larger urban areas or metropolotan areas;

3. The bulk of pre-programmed activities require routine contacts, related to progress reports, routine matters and fixed decision rules. Telecommunication is frequently used. These activities can be performed at more distant places, as long as good and reliable telecommunication facilities at reasonable prices are available.

4.4 The selection process

4.4.1 The potential network and the final segment selected

Given the potential number of actors to have contacts with, an actor selects a certain network segment. This term coincides with the term microposition (Johanson and Mattson, 1984) and net (Hågg and Johanson, 1982) and stands for the actual configuration of relations between actors. In such a segment, there
are some actors an actor very rarely meets, while he may have intensive contacts with others. Because of this, the terms direct, indirect, weak and intense contacts are used.

4.4.2 Direct versus indirect; weak versus intense

When an actor has no direct contacts with particular actors since he assumes that other persons - who are included in his list of contacts - do meet these actors, this is termed indirect contacts. "I know someone, and they know someone, but I don't know who they know. The power of the network is that the participants all know it exists. we all know that we know lots of people in the Valley ... the rate of rumor-passing in Silicon Valley is simple phenomenal. Reputations, successes, people leaving a firm, new products. the mill grinds out these rumors at a prodigious rate" (Rogers and Larsen, 1984. p. 80; quoted by Hamfelt and Lindberg, 1987, p. 179).

Infrequent contacts of weak relations are 'kept in storage' for moments they become of importance: public agents in charge of e.g. building permission, grants, or subsidies. They are of no importance for the regular operation of the firm (Håkansson, 1987, p. 216). Relations with frequent and intensive contacts are termed intensive.

4.4.3 The role of personality in the actual choice

The choice of the actual network segment - whether contacts will be direct or indirect, weak or intensive - is a strategic choice. This choice is in spite of its importance very rarely made under full information on the potential network. The resulting incompleteness is caused by a geographical limitation of the actor's scope and his sub-sector fixation. This aspect seems to be open for improvement with government aid as part of an industrial policy (see Schenk and Kamann, 1987).

This stage of the selection process is largely determined by the personality of the actor, his business routines and goals (Kamann, 1986, 1988). When we leave the holistic concept of the firm and add the behaviour of more actors within the firm, we in fact add actors in different functions, roles and tasks, where each actor has his own personality and groups of actors show subcultures and coalition behaviour; "individuals are multidimensional and have many roles in the total network" (Hamfelt and Lindberg, 1987, p. 180). This implies that the proper mix of actors is of great importance to the organisation. It also means that a single actor firm with restricted time available, will find it hard to have proper network contacts he actually should have. A larger multiple actor organisation can specialise and distribute the various contacts. Although this requires an internal network that also consumes time, special gatekeepers act as interface with the environment and provide relevant external information, translated into the jargon of the internal network (Allen, 1977; Tordoir, 1984). As a result of this, activities that draw their information from the internal network are less dependent on location in the source area of their relevant information - the focus - as long as the gatekeepers are in the right spot.
4.4.4 Motives for participation and types of partnership

A part of the network participation is directed towards collecting information about customers, suppliers, the competitors and his products, prices, R&D programmes and policies, new markets and changes in market shares of existing markets. Keeping or increasing the market share still is one of the most important strategies of actors. Here, in particular the information contents are important. However, in his attempts to increase his share of the market or simply to meet the challenge posed by competitors or newcomers, an actor is likely to run into obstacles or may well find some bottlenecks when implementing a proper and adequate strategy. The bottlenecks can be in research, development, finance, production, distributing, marketing, organisation and so on. It is realised by actors, that technological developments these days very rarely take place in a single firm. It is an "interplay between different organizations where independent activities are taking place simultaneously in different parts of the network" (Laage-Hellman, 1987, p. 31). This implies that firms realise that in a number of cases it is better to co-develop product- and process innovations with suppliers, buyers or even competitors. "Different units have different resources and skills which are complementary in nature" (ibid. p. 37; see also Williamson, 1975). The value of the network in this case is the combination of "resources" and "skills" which as such is unobtainable for each of the actors involved. This positive value remains positive, even when the individual actor has to increase his dependency on other actors. Active network participation and distribution of activities enable increased specialisation of each of the actors, while increasing the need for interaction because of the required coordination. "The establishment of development relationships may in other words be a pre-condition for increasing specialization of the in-house development process" (Axelsson, 1987, p. 131). Actors start partnerships depending on the bottleneck they find on their way and the type of specialisation they prefer (Laage-Hellman, 1987; Gold, 1986; Sundin, 1986). We find in practice that 'partnership' stands for a whole variety of forms.

Exchange of production between two or more competitors enable all actors involved to obtain scale effects. This may be required to compete with foreign producers.

An other form is the joint venture. This can be applied (de Jong, 1987) for:

1. the development of products and the penetration of markets;
2. the expansion on markets;
3. consolidation of markets by horizontal integration;
4. retreat from markets.

A third form of cooperation takes place using long term contracts between suppliers and one of their important buyers. They should guarantee timely and reliable deliveries, and enable suppliers to invest in innovations required by their buyer. One step further is the joint production planning between suppliers and buyers to enable zero-stock-inventories and just-in-time deliveries. The final step on this scale is the joint planning of suppliers and their industrial buyers where the latter give active support in R&D and
4.5 The latent network relations and their characteristics

In manifest network relations three categories of latent features may be distinguished: (see also Håkansson, 1987, p. 84):

- multiple dependencies
- instability or fluidity
- paradigm fixation

The two forms of paradigm fixation, viz. the technological trajectory (Dosi, 1983; 1983) and the social network aspect (Storper, 1986; Kamann, 1988), have already been discussed.

4.5.1 Multiple dependencies

Various activities between network participants are linked together. In transaction chains of actors various types of dependency between actors may be distinguished:

*Technical dependency*, where products and services fit technically together and result in inter-industry standards. A very *rigid fit* between products means an improvement of the product may upset the fit with products further upstream or downstream and therefore requires close *co-operation* between actors (the "Japanese model"; Korpel and Schenk, 1986). Actors that operate in a less rigid chain will find it easier to leave their network and enter new networks when they want to change their products.

*Knowledge dependency* means that the supplier has to know the requirements of those who use their products, while users have to know what they actually can do with their input materials, machines, hardware and software.

*Continuity dependence* occurs, when a supplier sells a large share (e.g., more than 10 or 30 percent) of his output to a single buyer. The actual percentage is a function of the power of the actors involved, the profit margins and the profitability of other activities of the firm. Again, there is a reverse side; when producers are dependent on a single supplier for a particular product or service they require. Firms will try to prevent this situation by applying *dual sourcing*: at least two firms supply the same product. However, in a large number of cases, increased specialisation has led to single sourcing. The question is, whether it is cheaper, safer, better, faster, possible to take-over the actual supplier to ensure the continuity, make the product in-house or buy the product (Williamson, 1975, 1979).

*Social dependency* is the result of normal social group behaviour, where participants are likely to cooperate with other participants before establishing contacts with actors outside the network. Axelsson (1987, p. 159) uses the term *soft distance* to indicate the socio-cultural distance between actors or entire networks: attitudes, values, norms, culture (Ronen, 1987). The term *hard distance* indicates the distance in kilometers.

*Logistic and administrative dependency* is of increasing importance in a time
of improved information technology and the strategic role information handling plays these days. It means that suppliers and buyers have to use the same system to be able to communicate. Lack of standardisation between the various systems means in practice that small suppliers have to use their buyer's system and cannot easily switch to other buyers, with different systems.

Innovative dependency is in particular of interest for this paper, reason why we already discussed the question who gives the impetus to an innovation. Financial dependency may have rather important effects. First of all, profits generated by the firm concerned will tend to be paid as dividends instead of reinvestments in new technologies and products. Secondly, the shareholding actor will obtain strategic information about new developments in techniques, products and markets and will know the actors strategy. A third point is that the actor involved may be forced to use licences, products or services supplied by its shareholder. Finally, existing actors in the firms network may be replaced by actors of the shareholders network; likewise the prices of supplies to existing network participants may be increased to weaken their competitive position on the market for final products.

Complete take-overs tend to lead to centralisation of production activities in a particular location and centralisation of overhead activities in another location. The actor involved runs the risk of being converted into a standardized production branch plant. Even when it remains relatively independent as business unit, corporate planning, investment decisions and tax management are transferred to the parent company.

The various types of dependency - usually in a user dominant relationship - may result in a dual production organization (Berger and Piore, 1980). Based on the dual segmentation theory this theory assumes a primary and a secondary sector. Large and technically sophisticated corporations are part of the primary sector or core of the economy. They operate on stable and safe segments of markets applying modern, capital intensive Fordist mass production techniques. In the secondary sector or peripheral sector, relatively small firms operate with flexible technologies, catering for fluctuating and riskfull markets. Companies in the core sector externalize uncertainty and labour costs to the peripheral firms (Piore and Sabel, 1984; Stöhr, 1985). In secondary firms, wages are low, prospects are poor, working conditions are bad. Allan Scott (1985, p. 17) for instance finds that many secondary firms in Orange County employ Mexican and Asian workers since these "cannot perceive or are able to demand ... recognition of rights".

Although it increases local linkages compared to the situation with branch-plants, it dominates local firms and segments the labour market. It is a new variant of Myrdal's (1954) cumulative causation.

4.5.2 Instability

Networks are not stable, they are volatile. We may divide the discussion about the dynamics of networks into three levels: the micro level, the meso level and the macro level.
**The micro level**

Individual actors grow when they are successful. They then evolve from a single establishment along the normal development path of functional-divisional to matrix organisations, with at present a movement to reduce decision lines resulting in semi-dependent Business Units (Chandler, 1973; Galbraith and Nathanson, 1978; Wissema, 1987). Each step in this evolution results in a redistribution in space of functions, tasks, incomes earned and decision power. In the process of growth, take-overs and mergers are used, leading to horizontal, vertical and diagonal integration (Sherer, 1980: see James, 1985, for the various 'war-games' involved). As a result of these take-overs, economic concentration increases, as does the role of internal networks compared to dependency on external networks.

**The meso level: dynamics of the merger cycle**

De Jong's (1976) merger cycle gives a theoretical concept to explain and predict the dynamics in merger behaviour. It shows that *the reasons for merging activities or desintegration of activities differ and depend on the situation of the product concerned in the market.* In the early stages of the product life cycle, backward integration may take place to secure appropriate deliveries of specific goods or to meet security risks (cf. Pavitt, 1984). The next bottle-neck occurs when large scale production requires much capital. Inventors may join into partnerships and this early oligoploy (Dosi, 1983) may be successful in raising capital. Others sell their company to large corporations. In the next stage, the market expands resulting in general scale effects which enables further specialisation on niches or segments of the market. Both horizontal and vertical desintegration occurs. When saturation of the market sets in, we will find actors try to consolidate their position. "... producers drop out because of losses [caused by overcapacity and reduced prices] or mergers occur in order to withstand and eliminate the heavy competition" (de Jong, 1979, p. 117). Again, we find oligopolies rising. Finally, when the market is about to collapse, sensible actors diversify, using the profits they earned in the final stages of the oligopolistic markets to purchase new firms and inventions that just started their cycle.

The concept of the life cycle has many weaknesses (Kamann, 1985; 1986; Storper, 1985; Schenk and Kamann, 1987). It has very little value ex-ante as a predicitive instrument and is ex-post only valid for mass-produced goods that reach the stage of mass production. Still, as a concept, it is the most attractive available when explaining mergers.

While the merger theory relates to mono-product firms, many actors in fact are multi-product firms, with products in various stages of their life cycles. This is one reason why actors these days do not merge all their activities, but only those related to a specific product or product-group. The remaining actors who deal with customized small-batch products are not included in the theory. Except that the technology used may be subject to a life cycle behaviour, which makes every step on the technological trajectory (Dosi, 1982; 1983) subject to a cycle.
The macro level: general trends

External to all these processes is a general trend that shortens life-cycles of products and techniques used. Together with a shift in the perceived core of innovative economic power, they force companies to re-organise, to adapt. The consequence for the organisation of production is that along two separate 'scales' new positions are developed. On one scale the two polarities: spatial product life cycle behaviour with head-offices and standardized branch plants as one pole and semi-dependent strategic business units. The poles on the other scale are mass-produced goods versus small-batch customized goods in flexible production. The two poles are in fact an organisational paradox. This paradox was solved by large corporations with the introduction of the dual production organisation.

Another macro trend is the increased interest for local initiatives, related to the organising power of actors in an area (Boekema and Verhoef, 1986). It results in a renewed interest in small firms of a more or less atomistic type. Some of these are organised in networks to overcome deficiencies in their selection environment (Stöhr, 1985; Sundin, 1986; Piore and Sabel, 1983, 1984; Kamann, 1988). Sometimes, they only have in common that they operate in the same location or area where they organise joint training facilities, financial institutions; in some cases competition is transformed into partnership.

4.7 Summary of the spatial aspects

(i): Spatial differentiation in the selection environment causes differences in opportunities for actors. This is a first cause for the dynamics of rising and dying actors.

(ii): New products and technologies give rise to new networks, possibly with different actors involved. Location of such a new network benefits the area concerned, while the location of the products substituted by the new network product will show decay.

(iii): Whether participants of a rising network actually receive an equal share of the benefits or not depends on the power relationship: equal partners or the dual production organisation.

(iv): Further points of importance are whether all activities – managerial, research, production, sales – of the actors involved are located in one area or spread over the globe. Relevant is here, whether actors are part of a corporate network organised in the style of the spatial product life cycle or with business units.

(v): Take-overs of actors in a region by actors that operate within the same region will result in job losses because of rationalisation of production and overhead, but may increase the region's competitiveness with actors from other regions. External control varying from minority shareholding to complete take-overs may in its worst form result in closure of other local actors in the network concerned and loss of jobs and capital. In cases where a large soft distance between head-office and local actor is involved, this may have long term consequences for investments in new activities in the area.
Areas with exclusively branch plant activities or with secondary firms operating in a dual production organisation are caught in a cumulative causation spiral. Dominance of the social networks by the branch plant managers and core actors may even be a serious obstacle for new activities.

The existence of a focus - centre of activities that require many face-to-face contacts - is of importance for an area. Lack of such a centre, or a distance to such a focus that is prohibitive, reduces the potential for further development of existing activities and requires something completely new. These completely new activities however prove to be unpredictable in their locations of origin and further growth.

The concept of the extended filière, together with Pavitt's taxonomy is an instrument to visualise manifest network relations in economic space and is when translated into geographical space possible useful for regional industrial policies. Further research should be devoted to the development of models and techniques to measure latent network relations, since these determine the actual distribution of strategic information and incomes over the network participants.

5. CONCLUSIONS

The spatial differentiation in the selection environment is an important aspect of the origin of new ideas and innovations. It also plays an important role in the opportunities actors have to be informed about new developments of relevance to them. Whether they can actually use new developments is to a large extent determined by their network freedom and participation. Network cooperation between actors creates a synergetic surplus. Those actors who succeed to dominate other actors or even entire network segments will consume that synergetic surplus at the cost of others.

Areas where dominant actors are located will therefore through these network relations dominate areas where the dominated actors are situated. Distribution of power over the participants of a network and ability to monopolize strategic information in a network are of importance for the diffusion of innovations and for the related distribution of incomes generated.

Unfortunately, so far only a few analytical models have been devised that seek to cover the above mentioned conflicting patterns of spatial development.

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