

15. Policy Measures to Support the Emergence of Localised Industrial Clusters

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1. INTRODUCTION

In recent years, regional phenomena have gained much attention within economics and politics. In economics, the question of why certain regions are economically successful while others are not has become intensively discussed. In politics, a search for adequate measures to improve the economic situation in certain regions has begun. Both developments have been triggered by several case studies on economically successful regions, such as the Silicon Valley and the Third Italy (such case studies can, for example, be found in Becattini 1997; Rosegrant and Lampe 1992; Saxenian 1994 and Dalum 1995). These case studies have shown that sometimes in certain areas, processes appear that lead to a high economic activity in these areas related to one or a few industries.

The question of what causes these regions to be successful was posed. Several theoretical concepts have been established that describe the main characteristics of such local systems. Examples are the concepts of industrial districts, industrial clusters, innovative milieus and regional innovation systems (descriptions can be found in Becattini 1990; Maillat and Lecoq 1992; Pyke and Sengenberger 1992; Scott 1992; Camagni 1995; van Dijk 1995; Markusen 1996; Lawson 1997 and Rabelotti 1997). Most of these works focus on the characteristics of existing successful local systems. However, if the political question of how regions can be made successful is to be answered, the focus has to be put on the evolution of such local systems.

In this context, the first step is an identification of the processes that have caused the evolution of the existing successful local systems. The large

amount of case studies offer some knowledge in this respect. A theoretical synthesis of this knowledge has been proposed in Brenner (2000). The concept of localised industrial clusters that has been developed there is also used in this approach. It is based on the identification of seven mechanisms of self-organisation that are responsible for the existence and crucial for the evolution of localised industrial clusters. Starting from these mechanisms, studies can be made on how politics can support the local self-organisation processes such that a localised industrial cluster evolves.

The basic assumption of such an approach is that there are certain industries and certain times when localised industrial clusters evolve (a more detailed discussion can be found in Brenner 2001a). In such a situation, it just remains to be determined where the localised industrial clusters evolve. Without any political intervention, this location will be determined by structural advantages, historical singularities and chance. It might be the aim of politics to influence this location process such that the localised industrial cluster evolves in a certain region. As a consequence, the political measures should be launched when the necessary circumstances for the evolution of such clusters are given. This is usually the case if a new market is established and the characteristics of this market satisfy the necessary requirements (for a more detailed analysis, see Brenner 2001a). This chapter deals with the remaining questions of which policy measures are adequate and what is the adequate timing for their usage.

The above assumption distinguishes this approach from most approaches on regional politics in the literature. Here, it is assumed that local policy measures have to be synchronised with the overall development of an industry or market. In contrast, most approaches in the literature concern one region when attempts are made to figure out how the state of this region can be improved (Miller and Côté 1985). The time and location of political action is determined by a politically anticipated need, while here certain windows of opportunities are identified that can be used to make certain backward regions economically more successful.

To model such a window of opportunity, a situation has to be depicted in which one or several localised industrial clusters evolve in one or a few regions. Therefore, a spatial system of regions is modelled. Due to the fact that several local mechanisms are considered here, a mathematical analysis of such a system is not feasible. Simulations have to be used. In the literature quite a number of approaches that are based on the simulation of spatial systems can be found (Camagni and Diappi 1991; Krugman 1991; Allen 1997a and 1997b; Schweitzer 1998; Caniels and Verspagen 1999; Brenner and Weigelt 2001). Some of these approaches share the goal of modelling the evolution of geographic concentration with this chapter (Camagni and Diappi 1991; Jonard and Yildizoglu 1998; Brenner and Weigelt 2001). However,

these approaches model the local mechanisms in less detail. Therefore, the model that is developed in Brenner (2001b) is used here. This model includes all mechanisms that have been identified to play a role in the evolution of localised industrial clusters (Brenner 2000). The influence of different policy measures can be easily included in this model. This allows us to study the effect of these policy measures and to identify the best suited measures and the adequate timing for their application.

The chapter proceeds as follows. In section 2, the simulation model is outlined. The different policy measures are discussed in section 3. Furthermore, the inclusion of these measures in the simulation model is described. Section 4 is devoted to the study of the impact of the different policy measures. For each of them, a detailed analysis of the effects is given, dependent on their temporal structure. Section 5 concludes.

2. DESCRIPTION OF THE MODEL

In this section, a description of the simulation model is given that explains the mathematical formulations. A more detailed description including the empirical background can be found in Brenner (2001b). In addition, a detailed analysis of the influences of each parameter is conducted there.

The model is based on local interactions between the population of firms and other local variables. The local variables that are explicitly considered are the human capital $K_q(t)$ ($\in \mathcal{R}_+$) accumulated in a region q , the cooperative attitudes $A_q(t)$ ($\in \mathcal{R}_+$) and $C_q(t)$ ($\in \mathcal{R}_+$) in the region, the attitude towards founding a firm $F_q(t)$ ($\in \mathcal{R}$), the political support for firms $P_q(t)$ ($\in \mathcal{R}_+$) and the local availability of venture capital $V_q(t)$ ($\in \mathcal{R}_+$). The dynamics of these variables are described below.

With respect to the firm population, entry, exit, innovations and firm growth are the processes that are explicitly considered here. Therefore, the number of firms changes endogenously. The state of a firm n ($\in N(t)$) is given at time t ($t \in \{0, 1, 2, \dots\}$) by its labour force $L_n(t)$ ($\in \mathcal{R}_+$) and its technology $T_n(t)$ ($\in \mathcal{R}_+$). Furthermore, each firm is assigned to a region $q_n(t)$ ($\in \mathcal{Q}$) that cannot be changed during the life of a firm (movement of firms is excluded).

There is no explicit production function used in this approach. Instead, the productivity of a firm describes its production process. The productivity of a firm n is defined by

$$a_n(t) = \left(k_{q_n}(t) + (1 - k_{q_n}(t)) \cdot a_u \right) \cdot T_n(t) \cdot \left((1 + C_{q_n}(t)) \cdot (1 + M_n(t)) \cdot P_{q_n}(t) \cdot L_n(t)^{\alpha - \beta L_n(t)} \right) \quad (2.1)$$

where k_q denotes the share of experienced employees within the labour force of the firm, a_u ($0 < a_u < 1$) the productivity of unexperienced labour divided by the productivity of experienced labour, $C_q(t)$ the effect of cooperative activities, $M_n(t)$ the mutual productivity profits due to the proximity of other firms, $P_q(t)$ the political support and $\alpha - \beta L_n(t)$ determines whether there are economies of scale in labour input. The share of experienced employees $k_q(t)$ depends on the available human capital in the region. If $K_q(t)$ exceeds the total number of employees in the region, $k_q(t) = 1$ for all firms in this region. Otherwise, the experienced employees are distributed such that each firm in the region has the same value of $k_q(t)$ and all experienced people are employed. The mutual productivity profits are given by

$$M_n(t) = \mu \cdot \sum_{\tilde{n} \neq n} L_{\tilde{n}} \cdot \exp[-\chi \cdot \delta_{\tilde{n}n}] \quad (2.2)$$

where μ (>0) is a parameter that determines the strength of this effect and χ (>0) determines the geographical stickiness of its effect. The distance between two firms is given by

$$\delta_{\tilde{n}n} = \sqrt{(x_{q_{\tilde{n}}} - x_{q_n})^2 + (y_{q_{\tilde{n}}} - y_{q_n})^2} \quad (2.3)$$

where x_q denotes the x -coordinate of region q and y_q its y -coordinate (coordinates are taken in the middle of a region). In the simulations, 99 regions are assumed to exist in the form of squares, one next to the other on a 9×11 grid.

2.1 Innovation

The technology $T_n(t)$ of a firm is driven by innovations and catch-up processes. There is an autonomous rate of innovations ($m_0 + m_L \cdot L_n$) that depends linearly on the number of employees in a firm. m_0 (>0) and m_L (>0) are parameters. It is assumed that a fixed share of the employees engage in research and development (R&D). In addition, spillovers are explicitly considered. These spillovers are assumed to decrease with the geographical distance between firms. Furthermore, it is assumed that firms create more spillovers, the larger they are. Finally, spillovers are assumed to be dependent on the technological gap between the firm and the most advanced technology $T_{max}(t)$ used by some other firm. A firm that is somewhat behind is able to profit most from spillovers, while spillovers are smaller for firms that are too far behind or at the front of the technological development. This aspect is modelled as proposed in Caniëls (1999). The rate of innovations due to spillovers is therefore given by

$$s \cdot \exp \left[- \left(\frac{T_{\max}(t) - T_n(t)}{\gamma \cdot g \cdot T_n(t)} - \frac{G}{g} \right)^2 \right] \cdot \sqrt{\sum_{\tilde{n} \in N} L_{\tilde{n}} \cdot \exp[-\eta \cdot \delta_{\tilde{n}n}]} \quad (2.4)$$

where $s (>0)$, $g (>0)$, $\gamma (>0)$, $G (>0)$ and $\eta (>0)$ are parameters.

Furthermore, innovations are also produced by cooperations between firms (for example joint R&D projects). It is assumed here that such cooperations increase the frequency of innovations. The effect of cooperative R&D in a region is denoted by $A_q(t)$. The respective dynamics are modelled below.

Including all these aspects leads to a probability $p_n(t)$ for firm n to innovate at time t that is given by

$$p_n(t) = m_0 + m_L \cdot L_n + A_q(t) + s \cdot \exp \left[- \left(\frac{T_{\max}(t) - T_n(t)}{\gamma \cdot \mu \cdot T_n(t)} - \frac{G}{\mu} \right)^2 \right] \cdot \sqrt{\sum_{\tilde{n} \neq n, \tilde{n} \in N} L_{\tilde{n}} \cdot \exp[-\eta \cdot \delta_{\tilde{n}n}]} \quad (2.5)$$

Whether a firm n innovates at time t is a random event. The probability of such an event is given by Equation (2.5). All innovations are assumed to be incremental and of the same size, which is given by parameter $\gamma (>0)$. Hence, the effect of an innovation at time t is given by

$$T_n(t+1) = (1 + \gamma) \cdot T_n(t) \quad (2.6)$$

Finally, the values of $T_n(t)$ are normated at each time such that the average value of $T_n(t)$ equals 1.

2.2 Exit and Entry of Firms

It is assumed that firms exit if their labour force decreases below 1. Two forms of entries are considered: independent start-ups and spin-offs.

Start-ups are assumed to appear in each of the regions with a probability that depends on the human capital $K_q(t)$, the availability of venture capital $V_q(t)$ and the opinion $F_q(t)$ of the population in the region. It is given by

$$\varepsilon_q \cdot \left(1 + \frac{K_q(t)}{L_q(t)} \right) \cdot V_q(t) \cdot F_q(t) \quad (2.7)$$

where Ω_q denotes the basic rate of start-ups in region q . The technology used by a start-up firm equals the average technology $T_{av} = 1$ used by all existing firms. The initial number of employment is randomly determined. It ranges between 1 and $L_{init} (\in \mathcal{R}_+)$.

With a certain probability each firm n creates a spin-off firm \tilde{n} . The spin-off firm starts with the technology that firm n currently uses: $T_{\tilde{n}}(t) = T_n(t)$. The initial number of employees of the spin-off firm is again drawn from a uniform distribution between zero and L_{init} . The probability of a spin-off depends on the number of workers in a firm and again on the human capital, the availability of venture capital and the opinion of the population in the region. Therefore, the probability of a spin-off from firm n is given by

$$\phi \cdot L_n(t) \cdot \left(1 + \frac{K_q(t)}{L_q(t)}\right) \cdot V_q(t) \cdot F_q(t) \quad (2.8)$$

where $\phi (>0)$ is a parameter. Spin-offs are often located near to the firm in which the founder has worked before. Therefore, the probability of the spin-off firm \tilde{n} to be located in region q is given by

$$P(q_{\tilde{n}} = q) = \frac{\exp[\zeta \cdot \delta_{qq_{\tilde{n}}}]}{\sum_{q \in Q} \exp[\zeta \cdot \delta_{qq_{\tilde{n}}}] \quad (2.9)$$

where $\zeta (>0)$ is a parameter that characterises the geographical stickiness of spin-offs.

2.3 Size of Firms

The amount of labour $L_n(t)$ that is employed by a firm is determined by the demand for its products. Capital and labour are assumed to be complements, so that they always change simultaneously. Firms adapt the number of their employees to the demand they face ($L_n(t)$ becomes equal to the demand divided by the productivity), if such an adaptation is feasible. It is assumed that labour and capital inputs can be reduced with a maximal rate of 10 per cent per day. The speed for increasing labour and capital inputs is assumed to be limited to a maximal increase by $\lambda \cdot L_n(t)$ within one time step, meaning one day. $\lambda (>0)$ is a parameter. The demand function is assumed to be linear. It is given by

$$d_n(t) = D - \frac{b}{a_n(t)} - \rho \cdot \sum_{\tilde{n} \in N} Y_{\tilde{n}}(t) \quad (2.10)$$

where $D (>0)$, $b (>0)$ and $\rho (>0)$ are parameters, denoting the maximal demand, the elasticity of demand and the heterogeneity of products, respectively. For a constant wage and interest rate, the production costs are proportional to the inverse productivity. Assuming that firms use mark-up pricing, their price is also proportional to the inverse productivity. Thus, the productivity might be used in the demand function as it is done in Equation (2.10). The last term on the right-hand side of Equation (2.10) represents the impact that other firms have on the demand faced by firm n . $Y_{\tilde{n}}(t)$ denotes the sales of firm \tilde{n} at time t . These sales reduce the demand for the products of firm n by $\rho Y_{\tilde{n}}(t)$. All firms are assumed to supply the same market, so that the location of firms does not influence the demand for its products.

2.4 Human Capital

It is assumed that the human capital within a region has a basic value $K_{init,q}$ and increases proportionally to the number of employees in firms in this region (due to the collection of experience on the job). Furthermore, it is assumed that each region contains a certain number of employees that might develop the skills and accumulate the non-transferable knowledge that are important in the considered industry. The maximal number of qualified employees is denoted by $K_{max,q}(t)$. The less people are left in a region that might become qualified, the more slowly the human capital increases in a region. Therefore, the increase in human capital is proportional to the difference between the number of employees and the current amount of human capital and the difference between the maximal human capital and the current one. In addition, a certain share $\xi (>0)$ of the qualified labour force drops out of the labour market, due to retirement, migration and economic change. The dynamics of the human capital in region q are modelled as

$$K_q(t+1) = \kappa_q \cdot \frac{K_{max,q}(t) - K_q(t)}{K_{max,q}(t)} \cdot \left(\sum_{n \in N} L_n(t) - K_q(t) \right) - \xi \cdot (K_q(t) - K_{init,q}) \quad (2.11)$$

where $\kappa (>0)$ is a parameter that denotes the speed of the accumulation of human capital.

The maximal number $K_{max,q}(t)$ of qualified employees in a region depends on the willingness of the population to invest in industry-specific skills. People are assumed to learn skills that are related to an industry that dominates in the region more willingly. They see better future opportunities in these industries. Therefore, $K_{max,q}(t) = K_{0,q} \cdot (1 + I_q(t))$ where $I_q(t)$ is the

willingness of the population in region q to invest in the respective skills. The dynamics of $I_q(t)$ are given by

$$I_q(t+1) = I_q(t) + j_{a,q} \cdot \left[\frac{j_{e,q} \cdot L_q(t)^2}{j_{p,q} + L_q(t)^2} - I_q(t) \right] \quad (2.12)$$

$L_q(t)$ denotes the total number of employees in the industry in region q at time t . $j_{a,q}$, $j_{e,q}$ and $j_{p,q}$ are parameters.

2.5 Cooperation

Two kinds of local cooperations are considered: cooperations that increase the likelihood of innovations, such as joint R&D projects, and cooperations that increase productivity, for example, the joint use of facilities. The consideration is restricted to cooperations within regions.

It is assumed that cooperations lead to a fixed profit, either in the form of a certain increase in the likelihood of an innovation denoted by $m_C (\geq 0)$ or in the form of a certain increase of the productivity factor $(1 + C_{p,q}(t))$ by $a_C (\geq 0)$. The success of cooperation depends on several other aspects, which are discussed in detail in other chapters of this book. Here, the systematic dependencies are neglected. Only successful cooperation is considered as this is assumed to appear randomly with a probability given by Equation (2.15), so that at least on a stochastic level, the fact that other aspects might interfere is included. If a new cooperation occurs, the cooperation profits increase according to

$$C_q(t+1) = (1 - c_a) \cdot C_q(t) + a_C \quad (2.13)$$

and

$$A_q(t+1) = (1 - c_a) \cdot A_q(t) + m_C \quad (2.14)$$

Cooperations that have been established in the past still have an effect on the actual productivity and innovativeness. However, their impact decreases with each time step by a factor of $(1 - c_a)$ ($c_a > 0$) due to the termination of such cooperations.

The probability of a cooperation to be established depends on the number of potential cooperation partners in the region and on the attitude of the firms with respect to cooperation. This attitude consists of two parts, a culturally determined basic attitude c_c and an additional value $p_c(t)$ due to experiences in the past. The dynamics of this additional value are given by

$$p_c(t+1) = p_c(t) + \varphi \cdot (p_{\max,c} - p_c(t)) \quad (2.15)$$

if a cooperation is established at time t . Otherwise the value of $p_c(t)$ is reduced to $p_c(t+1) = (1-\varphi) \cdot p_c(t)$. $\varphi (>0)$ and $p_{max,c}$ are parameters. The probability of the establishment of a new cooperation is given by

$$[c_c + p_c(t)] \cdot N_q(t) \quad (2.16)$$

where $N_q(t)$ denotes the number of firms in region q at time t .

2.6 Public Opinion

In addition to the willingness to invest in industry-specific skills that are modelled above, a second aspect of public opinion is considered in the model. The expectations about the profitability of start-ups in a region and industry are assumed to influence the probability that a person in this region founds an enterprise. The success of start-ups influences these expectations. A variable $F_q(t)$ is defined for each region, which starts with a value of zero, increases each time a new firm is founded in this region, and decreases each time a firm has to shut down in the region. The amounts of increases and decreases are given by the parameters f_+ (>0) and f_- (>0). Furthermore, events that have occurred further in the past have less influence on the actual opinion of the population. Therefore, the value of $F_q(t)$ is reduced at each time according to

$$F_q(t+1) = (1 - f_m) \cdot F_q(t) \quad (2.17)$$

where f_m ($0 < f_m < 1$) is a parameter that determines the decay of memory. The opinion $F_q(t)$ of the population with respect to founding a firm influences the number of start-ups and spin-offs as modelled in Equations (2.7) and (2.8).

2.7 Politics

Local politics can favour a certain industry, so that the firms of this industry become more profitable. The basic support is modelled by a value $P_q(t) = 1$ that represents a factor in Equation (2.1). If the employment in a certain industry increases above a certain level L_{pol} , this industry becomes more influential in local politics. The politicians can be expected to give more support to the firms in this industry. This is modelled by an increase of the value of $P_q(t)$ by π . Thus, $P_q(t)$ is given by

$$P_q(t) = \begin{cases} 1 & \text{if } L_q \leq L_{pol} \\ 1 + \pi & \text{if } L_q > L_{pol} \end{cases} \quad (2.18)$$

where $\pi (>0)$ is a parameter.

2.8 Venture Capital

The local availability of venture capital is crucial for start-ups. Its availability might change over time, due to existing firms already in the region. Here, it is assumed that the basic availability of venture capital is $V_q(0) = V_{init}$. The value of $V_q(t)$ influences the probabilities of start-ups and spin-offs according to Equations (2.7) and (2.8). It changes according to

$$V_q(t+1) = V_q(t) + \nu \cdot \left(\frac{V_{init} + N_q(t)}{1 + N_q(t)} - V_q(t) \right) \quad (2.19)$$

where $\nu (> 0)$ is a parameter and $N_q(t)$ is the number of firms of the considered industry in region q . The availability of venture capital influences the number of start-ups (see Equations (2.7) and (2.8)).

3. POLICY MEASURES TO CREATE LOCALISED INDUSTRIAL CLUSTERS

There are no policy measures that are able to guarantee the emergence of a localised industrial cluster in a certain region. The location of clustering depends on many random circumstances. In many case studies, specific circumstances are highlighted that have supported the evolution of an industrial cluster. However, often other regions provide similar conditions without becoming successful. According to the view that is taken here, localised industrial clusters emerge at a certain time due to the characteristics of the industry and the respective markets (see the respective argumentation in Brenner 2001a). Where they emerge is determined by chance and the specific local situation. It is assumed here that the local circumstances determine the probability of the evolution of a cluster in this location. Simulations confirm this assumption.

Therefore, political measures are not able to create localised industrial clusters but they are able to increase the likelihood of certain locations of industrial clusters. This depends on the timing and the specific measures that are taken. The aim of this chapter is to study the effects of different political measures with different timings. Several ways to influence the local

circumstances are studied. In this section, the considerations behind these measures are discussed and their inclusion in the model is outlined.

3.1 Support for Start-ups

A local support of start-ups can already be found in many regions all over the world. It lowers the barriers for entrepreneurs to start their own firm and therefore increases the number of start-ups and their survival. This is attained by helping new firms to make the necessary contacts and to receive a sufficient amount of information and venture capital.

Start-ups and spin-offs play a major role in the evolution of localised industrial clusters. Thus, it can be expected that an increase of the number of start-ups and spin-offs in a region increases the chances for the localised industrial cluster to evolve there.

The political measures that support start-ups are modelled here by an increase of the frequency of start-ups and spin-offs in a region. These probabilities, given by Equations (2.7) and (2.8), are multiplied by a certain factor that represents the impact of the policy measure on the frequency of new enterprises. In the simulation, the probabilities of start-ups and spin-offs are multiplied by three, respectively, in the region that is assumed to be supported.

3.2 Public Research Institutes

Policy makers have a strong influence on the existence and research orientation of public research institutions. This offers another possible way to influence the local economic development. For example, the creation of new institutes at the Aalborg university has been crucial for the evolution of the Telecommunication cluster in north Jutland (Dalum 1995). The creation of such research institutes has two impacts on the local system. First, a research institute creates scientific knowledge and acts as a potential partner for R&D projects. Through this, it increases the innovative capacity of firms in the region (for empirical evidence on this fact see, for example, Audretsch and Feldman 1996 and Anselin et al. 1997). Second, research institutes employ mainly people that have just finished their education, usually in the form of a university study. While doing research, they gain experience and tacit knowledge. Some of these people move to private firms after a few years, taking their skills and tacit knowledge with them. Therefore, research institutes also increase the human capital in the labour market.

In the above model, it has been assumed that there is a certain basic probability of innovations in firms. It can be assumed that the existence of public research institutes increases this probability if the research that is done in these institutes is related to the production technology or the products of local firms. To model this aspect, the basic rate of innovations m_0 is assumed to be different in different regions. In regions where research institutes are

located, this rate can be expected to be higher. In the simulations, the basic rate m_0 is assumed to be twice or three times as high in the supported region (with respective research conducted in a public research institute) as it is in all other regions.

The skills and tacit knowledge that are accumulated in research institutes can be seen as a constant flow of human capital to the local labour market. There is clear evidence that people tend to stay within their location if they switch from one to another job. Therefore, although some of the human capital that is accumulated in research institutes flows out of the region, the region where the research institute is located profits more from this creation of human capital than all other regions. Mathematically, the creation of human capital in research institutes and its flow to private firms can be modelled as the creation of human capital at a constant rate within the region. This process maintains a certain amount of human capital in the region that has been called the initial amount of human capital $K_{init,q}$ above. In the simulations, $K_{init,q}$ is assumed to be three times as high for the region that is politically supported (by a respective public research institute) than in all other regions.

3.3 Creation of Local Networks

Cooperations between firms and information flows through informal contacts have been repeatedly put forward as reasons for the success of certain local systems. These are enhanced by networking. Therefore, it has been claimed that creating local networks of firms boosts the economic success in a region. Many policy measures have been launched that aim to create such networks. These networks can be expected to have various impacts. They increase trust between the local actors, increase the frequency of their interaction, improve their knowledge about potential local partners for cooperations and create informal contacts between local actors. In this approach, the focus is on two aspects that are influenced by these changes: the increased likelihood of cooperations between firms and the improved flow of information within the region.

Informal contacts between employees lead to an exchange of information about technologies and new developments in the industry. Therefore, they increase, for example, the diffusion of innovations within the region. This means that more spillovers between firms should be expected if networks exist. The amount of spillovers from which firms profit is denoted by the parameter s in the above model. Therefore, in the simulations, the value of s is multiplied by three in the respective region.

The frequent interaction of local actors within networks increases their trust in each other. In addition, networks increase the knowledge about possible cooperation partners. Both effects can be expected to cause the number of

cooperations that are set up in the region to increase. It has been shown that cooperations between firms are related to the emergence of localised industrial clusters (see Brenner 2002).

In the above model, two kinds of cooperations are explicitly modelled: joint R&D projects and the joint use of local facilities. The probability of the occurrence of each of them depends on the local attitude towards cooperation and the experience that has been accumulated in the region. Local networks can be expected to influence the basic attitude towards cooperation. Thus, their impact can be modelled by an increase of c_c . In the simulations, a value that is three times as high as the value for all other regions is used for the supported region.

3.4 Local Education

In recent years learning has become a central aspect of research into economic development. Under the label of the 'learning region', it has been argued that the capabilities of the local population to learn and to adapt to new technological developments are crucial for the regional economic development. As a consequence, a search has begun for policy measures that increase such capabilities. It is argued that the education system has to be revised such that learning becomes the centre of education. People have to become more flexible and faster learners.

In the model that has been developed above, two kinds of employees have been distinguished: experienced and unexperienced workers. It has been assumed that people are unexperienced when they start work. Then, they become experienced on the job. If they have better learning capabilities, this process can be hastened. This means that skills and tacit knowledge are acquired faster. In the model, an increase of the parameter κ_q results. It is set to three times the value in the other regions in the considered region in the simulations below.

3.5 Direct Support of Firms

The traditional political measure to improve the economic situation in a region is the subvention of firms that are located there. This might, of course, also be used to increase the likelihood of the evolution of a localised industrial cluster in a certain region. It is assumed here that such a subvention increases the productivity of the firms in the region. This can be obtained by improving the infrastructure, renting cheap land to the firms or offering tax reductions. However, the model that is developed above already includes the aspect that local policy makers support the firms of certain industries. It is assumed in the model that the firms are supported if the number of employees in the

respective industry exceeds a certain value. In this case, the industry becomes an important local player so that policy makers favour this industry. It might now be assumed that this support can also be given to an industry with less employees if either local or global policy makers have an interest in promoting this industry. This can be modelled by setting the value of L_{pol} to zero that is done in the simulations for the region in which the firms are supported.

4. IMPACT OF POLICY MEASURES ON THE LOCATION OF INDUSTRIAL CLUSTERS

To examine the impact of the policy measures that have been discussed above, this section examines whether these measures increase the likelihood of the localised industrial cluster to evolve in the region where these measures are applied. The above model allows the simulation of economic development with respect to one industry in 99 regions. One of these regions (region 25 in Figure 15.1) is assumed to be politically supported by one of the measures that are discussed above. It is also studied in this section whether this region is more likely to become the location of industrial clusters due to the political support. Two assumptions are implicitly made in this approach. First, it is assumed that the policy measures succeed in influencing local conditions. We study here whether successful policy measure are able to make the emergence of a localised industrial cluster in a certain region more likely. The question of how policy measures have to be chosen to be successful is not addressed here. Second, for the simplicity of the analysis, it is assumed that only one region is influenced by policy measures. In reality, other regions are usually supported as well. However, this approach is set up to analyse the spatial distribution of economic activity if one region is extraordinarily supported. The effects, of course, spill over to some extent to neighbouring regions due to different processes implemented in the model.

Five different policy measures have been previously discussed. Two of these measures have two effects on the local economic development. The impact on the evolution of localised industrial clusters are studied for each of these effects separately. Thus, in total, there are seven effects of policy measures that have to be studied:

- an increase in the number of start-ups and spin-offs;
- an increase in the number of innovations;
- an additional creation of human capital outside of firms;
- a higher amount of local spillovers;

- a higher frequency of local cooperation between firms;
- an increase in the speed of the accumulation of human capital;
- a local support for the industry, independent of the number of employees in the region.

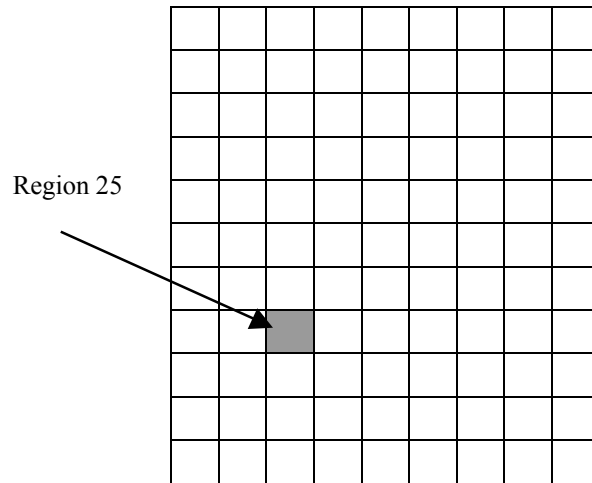


Figure 15.1 Analysed space with 99 regions and the location of region 25

According to the concept of localised industrial clusters, the existence of such clusters depends on industry-specific characteristics (the respective arguments are given in Brenner 2001a). Therefore, it cannot be expected that policy measures create localised industrial clusters. It can only be expected that they cause evolving industrial clusters to locate in a certain region instead of somewhere else.

This implies that the simulation analysis should be restricted to situations in which localised industrial clusters evolve. In Brenner (2001b) the conditions for local clustering are comprehensively studied. There the ranges for the parameters of the model have been deduced from empirical knowledge and the impact of the different parameters on clustering has been analysed. Many parameters have been found to influence clustering. Nevertheless, it was not possible to identify a clear-cut area in the parameter space for which clustering takes place. Furthermore, the characteristics of clustering vary between different parameter sets. In some cases, a large number of small firms evolve that group in some regions. In other cases, a few very large firms evolve that are located in different places. There are also parameter sets that lead to a certain variation in the size of the established firms. In addition, the geographic concentration varies.

Most local systems that are analysed in the case studies consist of only small firms or a mixture of small- and medium-sized firms. Some examples include one or two larger firms. However, regions that contain only one very large firm are neither in the literature nor according to the concept of localised industrial clusters considered as a cluster. Therefore, the following analysis concentrates on three parameter sets¹ that lead to a few (between one and six) industrial clusters. The three parameter sets are chosen as far as possible according to empirical findings (see Brenner 2001b for a detailed discussion of empirical evidence for each of the parameters). They differ mainly with respect to the economies of scale. This causes the size distribution of firms to differ between the sets. In the first set, the firms are all very small (with 13 employees on average). The second parameter set causes a quite flat distribution of the firm size with an average of 57 employees per firm. The third set is chosen such that a mixture of small firms (1–15 employees) and medium-sized firms (around 100 employees) is obtained. Furthermore, the parameter in the third set is chosen such that all the mechanisms which are assumed to cause the evolution of localised industrial clusters, have somehow the same impact on the geographic concentration. To this end, the respective parameters have been adapted such that the same increase of the strength (twice the value) of any of the mechanisms has the same impact on geographic concentration. Therefore, some impact should be expected for all policy measures, at least for the latter parameter set.

Nevertheless, the relatively arbitrary choice of three specific parameter sets constitutes the major shortcoming of this approach. It would be much more convincing to choose the parameters in correspondence with reality. However, this is only feasible for part of the parameters. In the case of many parameters, it is not even known whether the modelled mechanisms play a role in reality (for a discussion on this see Brenner 2001b). An analysis of many different parameter sets is not feasible due to the enormous amount of time (around 10^{12} days for a complete study of two values for each parameter) that would be necessary for such an approach that would, indeed, lead to a quite detailed

¹ common parameter values: $m_L = 0.00001$, $\eta = 10$, $a_u = 0.8$, $\varphi = 0.001$, $L_{pol} = 200$, $f_+ = 0.005$, $f_- = 0.01$, $f_m = 0.1$, $v = 0.001$, $V_{init} = 0.3$. Set 1: $T_{init} = 40$, $\varepsilon_q = 0.00015$, $\phi = 0.00003$, $\zeta = 30$, $\gamma = 0.002$, $m_0 = 0.003$, $s = 0.01$, $g = 10$, $G = 10$, $\mu = 0.0002$, $\chi = 35$, $L_{init} = 5$, $\alpha = 1.02$, $\beta = 0.004$, $D_x = 150000$, $b = 1600000$, $\rho = 0.77$, $\lambda = 0.0008$, $K_{init} = 7$, $K_{max,q} = 5600$, $\kappa_q = 0.004$, $\xi = 0.00007$, $c_c = 0.01$, $c_a = 0.001$, $a_c = 0.0001$, $m_c = 0.0007$, $p_{max,c} = 0.01$, $\pi = 0.002$, $J_{p,q} = 400$, $J_{e,q} = 0.7$ and $J_{a,q} = 0.00007$. Set 2: $T_{init} = 40$, $\varepsilon_q = 0.001$, $\phi = 0.000005$, $\zeta = 30$, $\gamma = 0.001$, $m_0 = 0.01$, $s = 0.004$, $g = 10$, $G = 10$, $\mu = 0.0001$, $\chi = 35$, $L_{init} = 20$, $\alpha = 1.15$, $\beta = 0.0001$, $D_x = 300000$, $b = 1600000$, $\rho = 0.77$, $\lambda = 0.0008$, $K_{init,q} = 10$, $K_{max,q} = 1000$, $\kappa_q = 0.0001$, $\xi = 0.00005$, $c_c = 0.02$, $c_a = 0.005$, $a_c = 0.00005$, $m_c = 0.0005$, $p_{max,c} = 0.02$, $\pi = 0.002$, $J_{p,q} = 400$, $J_{e,q} = 0.7$ and $J_{a,q} = 0.00007$. Set 3: $T_{init} = 1$, $\varepsilon_q = 0.001$, $\phi = 0.000005$, $\zeta = 10$, $\gamma = 0.005$, $m_0 = 0.005$, $s = 0.0003$, $g = 5$, $G = 5$, $\mu = 0.00005$, $\chi = 10$, $L_{init} = 10$, $\alpha = 1.05$, $\beta = 0.000067 - 0.00000031 \cdot L$, $D_x = 10000$, $b = 7000$, $\rho = 0.8$, $\lambda = 0.002$, $K_{init,q} = 2$, $K_{max,q} = 20$, $\kappa_q = 0.001$, $\xi = 0.0001$, $c_c = 0.005$, $c_a = 0.001$, $a_c = 0.0003$, $m_c = 0.0002$, $p_{max,c} = 0.02$, $\pi = 0.01$, $J_{p,q} = 40000$, $J_{e,q} = 30$ and $J_{a,q} = 0.003$.

picture. Thus, the approach that is taken here is the only feasible alternative. This implies that all impacts that are found are only relevant if the respective local mechanisms play a role in the local economic development, which might not be given in all places and for all industries. Furthermore, the strength of the impacts depends on the strength of the respective mechanisms, which is unknown for real systems. Nevertheless, the structural findings with respect to the timing of the policy measures can be expected to be of general validity.

4.1 Temporal Structure

The time at which policy measures are launched plays an important role for their impact on the local economic development. Localised industrial clusters evolve when the situation in an industry changes such that the requirements for clustering are satisfied. This might be caused by a change in the characteristics of the industry or by the development of new products or technologies that is accompanied by an increase in demand. The latter cause is the one that is usually observed in reality. Therefore, the evolution of a new industry is simulated here. The temporal structure of policy measures strongly matters in such a situation. Once localised industrial clusters have evolved in other regions and the demand stagnates, it can be expected to be difficult to establish a localised industrial cluster in another region. Similarly, if the policy measures are launched before the demand increases, there might be no effect on the location of clusters. What kind of timing is most effective in such a situation is studied in detail below. To this end, the temporal aspects of demand have to be defined and the possible timings of policy measures have to be fixed.

The total time span that is to be studied here is approximately 30 years. It is assumed that at time $t = 0$ (time is measured in days) the system starts from scratch. There is no demand and there are no firms in any of the regions. It is assumed that the industry takes around 10 years to increase to its final size. The demand is modelled to increase linearly from time $t = 0$ to time $t = 3600$ (approximately 10 years) when it reaches its final value. This is modelled by a linear increase of D from $D(0) = b/a_n(0)$ (n denotes a fictive firm since there is no firm existing at time $t = 0$) to $D(3600) = D_x$. After this the demand $D(t)$ remains constant for the remaining approximate 20 years.

Five times at which the policy measures might be launched are studied. These are $t = 0$ (at the beginning), $t = 720$ (after around 2 years), $t = 1800$ (after around 5 years), $t = 3600$ (after around 10 years) and $t = 5400$ (after around 15 years). To make their effects comparable, it is assumed that each policy measure stays effective for around 5 years (1800 simulation steps). This means that the policy measures are terminated at least 10 years before the end of the simulations. Their impact is only studied with respect to their effect

on the distribution of firms and employment at the end of the simulations. The reason for such an approach is as follows. It is not doubted that the support of a region increases the economic activity in this region by a certain amount as long as the support is active. Whether such support is economically efficient depends on the relationship between its costs and benefits. It has rather to be doubted that this relationship is positive for most policy measures but a detailed analysis is out of reach for the approach that is taken here. In contrast, a policy measure that is restricted to a certain period of time but has an effect at least on the development in the medium-term seems to be much more promising. In this case, the policy measure gives only the impulse for a development that is then self-sustainable. Therefore, only the medium-term effects of short-term policy measures are studied here.

4.2 Impact of Different Policies and Timings

To examine whether policy measures are successful in supporting the emergence of localised industrial clusters, the simulation is run with and without the policy measure. Each simulation run represents one realisation of a stochastic process. Therefore, two runs, with and without a studied policy, cannot be compared. However, if many simulations are run for each setting, the results can be compared statistically.

It has been argued that regions take one of two states: one with a low economic activity and one with a cluster (Brenner 2001a). If the policy measures are effective, region 25 should take the latter state more often than it takes this state without any policy measure. Hence, to test the effectiveness of policy measures, the frequency of the occurrence of a cluster in region 25 should be compared statistically for the different settings.

Before this can be done, it has to be defined how localised industrial clusters are identified. In the empirical literature, different approaches can be found (Sforzi 1990; Isaksen 1996). One defines clusters by the condition that the number of employees in an industry in the respective region has to be at least three times as high as should be expected according to the size of the region (Isaksen 1996). This seems to be an adequate definition and one that can be transferred easily to the simulations that are run here. However, three times as many employees as the expected average for a region means that at least 3.03 per cent of the total number of employees have to be concentrated in a region. Whether this is the adequate border line here has to be tested. To this end, a large number of simulations have been run and the resulting distributions of employment have been observed.

Two kinds of distributions have been quite easy to distinguish: one in which some employment is found in all regions and one in which employment is concentrated in some – most of the time between 1 and 6 – regions. In the

first case, the distribution is, of course, not a uniform distribution. Some regions have by chance a higher level of employment. Numbers of employees that represent 5 per cent or 6 per cent of the total number of employees are found repeatedly. These cases should not be called localised clusters, since no concentration of the employment in a few regions has occurred. Therefore, a localised cluster is defined here as a region that contains more than 8 per cent of the total number of employees.

Given this definition, the total number of clusters can be counted and the probability that these clusters are located in region 25 can be calculated. Theoretically, 1.01 per cent of all clusters should be expected to be located in Region 25. However, the specific location of this region might have an impact. Therefore, the probability of the clusters to be located in region 25 is studied for the simulations without any policy intervention. For the three parameter sets, the probabilities of 0.84 per cent, 1.24 per cent and 0.89 per cent are found. They do not deviate from the theoretical value significantly and the average is 0.99 per cent. Therefore, the results for the different policy measures are compared to the theoretical value of 1.01 per cent. The location of region 25 seems to have been successfully chosen such that it neither decreases nor increases the probability of clusters to be located there.

The probabilities that result in those simulation runs in which the development in region 25 is supported by policy measures are given in Table 15.1. The results that are listed in this table do not allow for a comparison between the policy measures. As has been argued above, the strength of the impact of the policy measures depends on the strength of the respective local mechanisms. The latter is not known and has been arbitrarily fixed in the simulations. Thus, the results in Table 15.1 represent a combination of real impacts and arbitrarily chosen parameters in the simulations.

However, Table 15.1 also shows that the impact of policy measures depends strongly on the time at which they are launched. This dependency is in most cases not due to the arbitrarily chosen parameters. The simulation results show similar dependencies for the three parameter sets for most policy measures. Hence, these results reflect structural aspects of the efficiency of policies. They deserve further discussion.

4.3 Windows of Opportunity

Although all policy measures that were studied above are able to increase the likelihood of an industrial cluster to locate in region 25 (the parameters have been chosen such that all mechanisms matter), some of them have no impact at certain times. Thus, if policy measures are launched too early or too late, they turn out to be a clear waste of money. To apply certain policies when there seems to be a need for the improvement of a region might be doomed to

failure. There are certain windows of opportunities where policies can be successfully launched. Outside of these, policy makers should rather refrain from using certain policies. The above analysis offers some knowledge about the windows of opportunities, at least for an industry where the demand increases for a certain period of time and then stagnates.

Table 15.1 Likelihood of the occurrence of an industrial cluster in region 25 that is supported by different policy measures

| Policy in the | para- meter set | Likelihood of cluster in Region 25 | | | | |
|----------------------------------|-----------------------|------------------------------------|---------|---------|---------|---------|
| | | Launch of policy after (in years) | | | | |
| | | 0 | 2 | 5 | 10 | 15 |
| Number of start-ups | Set 1 | 1.65% | 3.18%** | 0.44% | 0.42% | 1.21% |
| | Set 2 | 3.86%** | 2.74%** | 1.81%* | 1.25% | 0.75% |
| | Set 3 | 8.05%** | 6.51%** | 8.23%** | 4.05%** | 1.83% |
| Number of innovations | Set 1 | 0.44% | 0.41% | 0.81% | 1.33% | 0.85% |
| | Set 2 | 1.68%* | 2.18% | 0.91% | 1.03% | 0.52% |
| | Set 3 | 1.99% | 1.87% | 3.38%** | 3.49%** | 2.58%* |
| Initial human capital | Set 1 | 1.21% | 1.24% | 1.27% | 2.47%* | 0.90% |
| | Set 2 | 1.67%* | 1.20% | 0.90% | 0.87% | 0.39% |
| | Set 3 | 0.66% | 0.99% | 0.00% | 0.00% | 0.00% |
| Local spillovers | Set 1 | 2.10%* | 0.00% | 0.42% | 1.98%* | 1.67% |
| | Set 2 | 1.85%* | 3.13%** | 3.07%** | 1.97%* | 1.89%* |
| | Set 3 | 2.06% | 1.12% | 1.91% | 1.23% | 0.73% |
| Cooperation between firms | Set 1 | 0.00% | 2.15%* | 0.87% | 0.88% | 1.67% |
| | Set 2 | 0.78% | 1.73%* | 1.80%* | 0.81% | 0.93% |
| | Set 3 | 0.38% | 0.75% | 2.17% | 6.06%** | 3.16%** |
| Human capital accumulation | Set 1 | 1.38% | 1.38% | 0.85% | 2.40%* | 1.67% |
| | Set 2 | 1.14% | 1.15% | 0.75% | 1.76%* | 1.32% |
| | Set 3 | 2.26% | 1.79% | 1.49% | 1.15% | 0.00% |
| General political support | Set 1 | 1.19% | 0.85% | 1.63% | 0.83% | 1.69% |
| | Set 2 | 1.77%* | 0.95% | 1.02% | 1.34% | 1.78%* |
| | Set 3 | 2.86%* | 1.61% | 1.56% | 0.38% | 0.38% |

Note: Values that are significantly different from 1.01% are bold (significance level: * = 0.05 and ** = 0.01).

An important result in Table 15.1 is the fact that most of the policy measures have no significant effect or a relatively low effect on the economic activity in the region if they are launched at a time when the spatial distribution of employment has already settled. This is even more evident if we consider the fact that an observed impact of a policy measure that is launched after 15 years would mean that this impact holds for at least 10 years, while an observed impact of a policy measure that is launched at the beginning means that this impact holds for at least 25 years. Hence, the results of this study clearly recommend not to launch policy measure in situations where demand and the spatial distribution of employment has settled down, at least not if the aim is to establish an industrial cluster.

Two of the above-studied policy measures, however, show an effect even if they are launched after the situation has settled. In the case of supporting cooperation between firms, this effect is smaller than if this policy measure had been launched earlier. Nevertheless, supporting cooperation shows some effect for two of the three parameter sets even if it is launched at a much later time. In the case of a general support of firms, the results are mixed. In general, however, a direct support of firms seems to be most effective at the beginning and after the situation has settled down. The latter seems to hold for two of the three parameter sets.

Most of the policy measures are most effective if they are launched at a time when the demand for the respective products starts to increase. This holds very clearly for the policy measure that increases the number of start-ups, and to some extent for the policy measures that increase the amount of spillovers and the general support of firms. While the latter also has a significant impact if it is launched later, the impact of the former vanishes quickly if they are applied later. The support for start-ups leads to an initial comparative advantage of the region. It is an adequate measure to give a region a comparative edge at the beginning of the evolution of a new market, technology or product. However, it is not adequate to induce a catch-up process in a region, once some dynamics have been started elsewhere. For the support of spillovers, the picture is less clear. The most significant effects are found if this policy measure is launched before the situation has settled. However, it seems to depend on the parameter set whether spillovers are more important at the beginning or at the end of the growth of a new market.

The support of cooperation between firms seems to be most effective if it is launched in the middle or at the end of the growth of the new market. At the beginning, cooperation has been found for all three parameter sets to have no significant positive impact on the developments in the region. Some activity has to be started before the emergence of industrial clusters can be supported by cooperation effectively. Similarly, the support of the learning capabilities of people seems to be effective rather in a situation where competition is

fierce, just before the demand levels off. A local labour force that is able to quickly learn new skills seems to help firms most when demand becomes scarce and it is determined which firms or clusters of firms will be able to dominate the market. Hence, the support of cooperation among firms and the increase of learning capabilities are policy measures that help regions where some activity already exists to grow into clusters.

In the case of the policy measures that relate to the number of innovations and the initial human capital, no consistent results are found. The results seem to depend very much on the structure of the industry.

To sum up, in each phase of the evolution of an industry or market, different policy measures are adequate for supporting the clustering within a certain region. The above study has shown that once the dynamics have settled down, an impact on the local economic development is hard to reach. If, instead, policy measures are taken while the respective market grows, there are plenty of possibilities. Their effectiveness depends on the relevance of certain mechanisms on the local development. This relevance depends strongly on the industry that is studied. A general analysis of this relevance is missing and out of reach for this study. Thus, this analysis has to be restricted to the above findings about the adequate timing of policy measures.

5. CONCLUSIONS

This chapter presented a rare approach that studies the effect of different policy measures with the help of simulations. Due to the progress in computer technology, it is currently possible to simulate the interactions of various processes. This opens new possibilities for research, also for the discussion of policies. In this chapter, simulations are used to study the impact of different policy measures on the evolution of localised industrial clusters. It has been shown that such an approach has advantages and disadvantages.

The major disadvantage of such an approach is the enormous number of parameters that automatically occur if quite complex dynamics are studied. Most of the parameters, at least in the situation that is studied here, cannot be fixed according to empirical findings. There is a lack of respective empirical studies of the mechanisms. This lack of knowledge implies that some parameters have to be set arbitrarily, although in many cases at least realistic ranges can be identified for the parameters. The arbitrary choice of the parameters also makes the results of the simulations arbitrary. This is a major shortcoming of a simulation approach that can only be solved if more empirical knowledge is acquired. Many results, such as the strength of the effects that are caused by each of the policy measures in the above approach,

become worthless. Only if the results are found to be similar for many (all) different parameter sets, can they be assumed to be generally valid. This restricts the aspects that might be examined.

Nevertheless, simulation studies can supplement the analysis of different policy measures. Here, the dependence of the impact of policies on the time they are launched is analysed. It has been shown that for different policies, there are different windows of opportunities for an effective application. This aspect has not been discussed in the literature. The above analysis resulted in some quite robust findings about the times when different policies should be implemented.

Within the research on the creation of localised industrial clusters through policy measures, this is the first approach that is based on simulations. It should have become clear that such an approach has something to offer. Therefore, it can be hoped that more researchers use simulations to study the impact of policies. Furthermore, it would be helpful if these researchers join forces with empirically working economists, so that those aspects will be studied empirically in detail that are crucial for the implementation of simulation models. This would enrich economic research on industrial clusters tremendously.

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