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A geosimulation model of economic activity for supporting spatial planning and economic policy

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Explaining economic development from spatial configuration: The influence of similarity and complementarity

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1. INTRODUCTION

Economic development is vital for every society. Therefore, governments make efforts to create environments that facilitate economic development. In practice, this comes down to creating circumstances in which firms are likely to grow, new firms are likely to be formatted and mobile firms are likely to migrate into the area. To this end, authorities can apply such measures as tax regulations, supplying sufficient infrastructure, organising institutional support and making sure that appropriate parcels or offices are available to locate or grow. When developing such policies, it is important to make sure that the right measures are implemented in the right locations. This holds especially for the location specific policies such as providing infrastructure and parcels/offices. A complication in this respect is that the performance of firms only partly depends on external factors such as mentioned before and to a larger extent on the options to interact with customers and other firms (Knoben et al. 2010).

Interaction with other firms is vital for firms' development for various reasons (Van Oort et al. 2010). First, other firms may be clients or suppliers of the firm. In that case, it may be important to be located within a certain distance in order to be able to deliver goods or services timely and to be able to buy particular raw products or services. Second, certain firms may benefit from being located near similar firms, delivering the same products or services. This may be beneficial since it creates a critical mass for the availability of certain supporting services or facilities, and may also create a pool of skilled employees, who may transfer between firms. Such job changes serve as a way of exchanging knowledge between firms, which may help them to innovate and become/stay competitive. In general, firms may benefit from exchanging knowledge about products or market opportunities, even if they are competitors in the market. Therefore, certain firms will establish formal or informal networks to exchange knowledge to each other's benefit. Recently, it has been increasingly emphasized (Van Soest et al., 2006) that

exchanging knowledge, information and skills is not restricted to similar firms, but that complementarity also plays an important role. In this view, firms will profit most from interaction with firms who are to some extent similar (e.g. operating in the same economic sector) but differ in other respects (e.g. delivering to different types of clients). In such cases, the skills and knowledge of such firms are more likely to be complementary than when firms are more or less identical. A related issue is to what extent firms will profit from a homogeneous environment or a more diverse environment, in which many different types of firms are present (Frenken et al. 2007). Finally, it is noted that interaction between firms is not always positive. Especially when firms compete with each other, being located close to each other may have negative effects for the firm at the individual level. Competing for road space to remain accessible to clients and workers may lead to congestion. Competing for land or offices may lead to higher rent prices. Competing for clients potentially leads to lower prices and lower profitability.

It is noted that the aforementioned forms of positive and negative interaction do not apply equally to all types of firms. For instance, for large production sites, exchange of knowledge will be of lower importance than good accessibility by trucks and cheap parcels, whereas in financial services face-to-face contacts in order to exchange knowledge is much more important than rent prices (Van Dijk & Pellenburg 2000).

Much recent theoretical and empirical research in agglomeration economies focuses on these issues. Since the early 1990s, economists have shown an increasing interest in the question of whether spatial circumstances give rise to agglomeration externalities that endogenously induce localized economic growth (see e.g., Glaeser et al. 1992; Ciccone and Hall 1996; Combes 2000). This development can mainly be ascribed to the failure of mainstream economics to give appropriate explanations for the variation in the wealth and poverty of cities and regions. Inspired by the success of Silicon Valley, Cambridge (UK) and The Third Italy, compared to the decline of other regions in the West (in particular, the old industrial areas), questions have been raised about why industries or firms choose to locate in a particular area and which kind of concentration of economic activities is needed to foster economic growth. This rediscovery of space in economics has resulted in a large volume of empirical literature that has investigated the relationship between agglomeration benefits and local economic growth (Rosenthal and Strange 2004). A relevant criticism of the empirical literature on agglomeration might be that it pays little attention to the spatial configuration of cities and regions and the geographical scale of agglomeration benefits. A second and related criticism concerns the current lack of insight in microeconomic (firm-level) foundations of agglomerations.

Given that various forms of interaction will play a role in varying degrees for firms in particular sectors, a key issue is thus the role of distance. If interaction with other firms matters, the distance that firms are willing to cross for interaction (or the distance at which exchange processes are likely to occur) is important (as is the minimum distance avoiding interaction). This paper makes a contribution to the insight into the importance of interactions for economic development by making an analysis of the growth of individual Dutch firms from a wide variety of sectors in agglomerated (diverse and specialized) contexts. Growth is analysed as a function of various forms of interaction:

- market potential: to what extent do other firms act as clients and thereby add to the growth of the firm;
- agglomeration potential: to what extent does a firm benefit from the exchange of knowledge, skills and employees with similar firms;
- congestion: to what extent does a firm suffer from the competition for resources (land, accessibility, clients, employees);
- diversity: to what extent does a firm benefit from being located in a more diverse environment, including firms with complementary knowledge and skills.

The analysis is performed on a database of growth of birth firms of Dutch between 1997 and 2006. The paper is organised as follows. The next section presents the conceptualizations and definitions of market potential, agglomeration potential, congestion and diversity, as well as the optimisation procedure used to find optimal distance decay parameters. Section 3 explains the study area and data set. Section 4 draws conclusions about the spatial interdependencies between firm types with respect to growth and the differences between the distance sensitivity of different types of firms.

2. METHOD

2.1. Spatial interaction

The Von Thünen model describes the trade-off between land price and travel costs by farmers, leading to a pattern of concentric circles, due to differences in the minimisation of production and travel costs (Fujita et al., 1999). This model was reformulated by Alonso, assuming that residents are located according to the tradeoffs between the cost of space and travel cost in monocentric industrial cities (Alonso, 1964; Batty, 2003 a). These traditional economic models however do not account for the emergence of agglomeration effects, due to the location of actors relative to each other. For instance, they do not explain “what kind of factors affects the change of spatial force with respect to the distance” (Fujita et al., 1999). Distance effects have been frequently described using a negative exponential function that was firstly introduced by Bleicher and popularized by Clark, who assumed that population density decreases monotonically according to the distance from CBD (Clark, 1951; Batty et al., 1992; Torrens et al., 2000).

In this paper, we assume that the strength of spatial interaction is described by an exponential distance decay function, as in the Von Thünen model (Griffith et al., 2007). Equation 1 gives the basic form of the influence P of surrounding cells on cell i . d is the distance from gridcell i to j and N is the number of population (firms in this case) in gridcell j . The distance decay function controlled by parameter α . If α is higher, the influence decreases more rapidly with increasing distance. In contrast if α is lower the influence of distance is smaller.

$$P_i = \sum_{j=1} N_j e^{-\alpha d_{ij}} \quad (1)$$

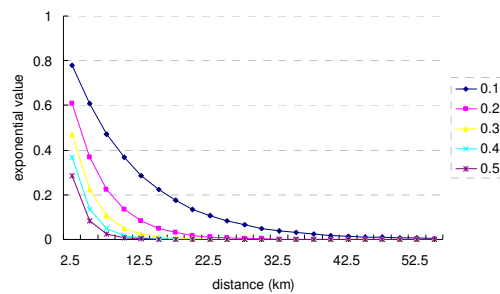


Figure 1. Exponential curve (parameter: 0.1 ~ 0.5)

In an earlier paper (Yang et al., 2008), the authors proposed a geosimulation model that is based on potential interaction (Batty, 2005). The model describes how spatial patterns of economic activity emerge due to the influence of agglomeration effects on firms' growth, location behaviour and closure. As seen in figure 2, agglomeration effects lead to concentration of economic activity, due to path dependent processes. The type of patterns, however, differs under different assumptions of distance decay. The current study aims at providing empirical support for the existence of such spatial interaction effects.

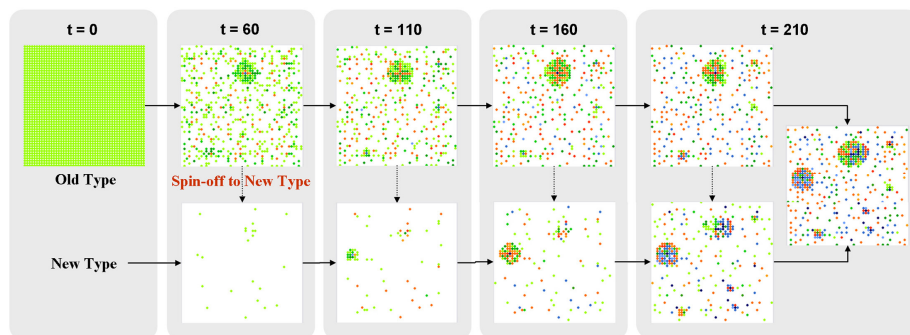


Figure 2. Spatial patterns on the potential by exponential function

(Yang et al., 2008; density: blue > red > green)

2.2. Interaction functions

The literature mentions various types of spatial interaction that may affect the performance of firms. Location theory focuses on the optimal location choice that is determined by the attractiveness of a site for firm location (*pull* factors). Relocation theory takes into account the *push out* of the present location (Brouwer et. al, 2004). Firms' relocation factors may include internal, external and locational factors (Van Dijk et. al, 2000). The main internal reason for moving is related to firm growth: limited expansion space at current location or limited representativity of the present location (the need for moving usually increases with the size and age of the firm). External factors include limited accessibility, deterioration of the building, environmental considerations, limited labour supply, or high location costs (Pellenbarg et. al, 2002). A special reason may arise if, at a macro level, relocation of firms is profitable and, therefore, individual firms are encouraged to move by Local Government Policy (Van Dijk et. al, 2000).

In addition, this paper assumes that the location of a firm relative to other firms may affect a firm's performance. In this respect four factors are distinguished. Market potential (MP, eqn. 2) refers to the availability of other firms in the neighbourhood, which may serve as clients of the firm, and also are a proxy for the presence of consumers in the area. Agglomeration potential (AP, eqn. 3) refers to the presence of specific types of firms, that offer specific knowledge, skills or support for another firm. Congestion potential (CP, eqn. 4) refers to the competition with other firms for space and accessibility, and is considered a negative effect. MP and CP are defined relative to all firms, and AP is defined relative to firms of the same type.

$$MP_i = \sum_{j=1} N_j e^{-\alpha_1 d_{ij}} \quad (2)$$

$$AP_i = \sum_{j=1} N_j e^{-\alpha_2 d_{ij}} \quad (3)$$

$$CP_i = \sum_{j=1} N_j e^{-\alpha_3 d_{ij}} \quad (4)$$

The fourth factor refers to the benefit that firms get from exchanging ideas, technology, know-how and human capital generated with other industries (Jacobs, 1969), which triggers innovation and creates knowledge externalities (Van Oort, 2004). A necessity is that firms are located close enough to each other (Jaffe et al., 1993; Audretsch and Feldman, 1999; Kelly and Hageman, 1999; Van Oort, 2004), but also that skills and knowledge are complementary. This suggests that firms should be related, but not similar, and that diversity with the sector could be an important stimulating factor for innovation and growth. To represent this effect, we apply the diversity index (function 5) of Soest, Gerking and Oort (2002). DU_i^s is the diversity of sector s in gridcell i and E_i is the total employment in gridcell i . E_i^n is the employment in the m biggest industries excluding sector s in gridcell i (eqn. 5). Soest, Gerking and Oort (2002) suggests $m = 5$ as the number of sector excluding itself. The diversity index DU is applied in the diversity potential $DIVU$ in gridcell i and sector s (function 6).

$$DU_i^s = \frac{\sum_{n=1}^m E_i^n}{E_i} \quad (5)$$

$$DIVU_i^s = \sum_{j=1} (DU_j^s)^{-1} e^{-\alpha_4 d_{ij}} \quad (6)$$

2.3. Regression Model

A central notion in this paper is that growth is dependent on various types of interactions, weighted by distance. Therefore we investigate growth as a function of these interactions. Given that we have a georeferenced population database of all Dutch firms (see section 3.), it is possible to construct indicators of various forms of interactions.

Gibrat’s law states that relative growth is proportional to size, but the validity of this assumption is questionable (Van Wissen, 2000) and from an empirical point of view this prediction has gained varying support (Laursen et. al, 1999; Van Wissen, 2000). Jensen (1997) argues that the vast majority of variation in firm performance is apparently not associated with traditional observables such as location, industry, size, age or capital; rather it is associated with factors specific to the firm or business unit. Schutjens (2000) suggests that important factors include human capital factors such as educational level and working experience. Hoogstra (2004) mentioned that during periods of economic recession the rivalry between firms is more intense and the location of market plays a key role in the survival of firm. Marshall (1890) argued that the externalities only exist in the same type of industry due to economies of scale. Porter (1990) insisted that local competition decreases firms’ benefits but positively affects to the growth in long-term. Jacobs (1969) described that the innovative activity across all industry and region holds a key position in externalities, which is called economies of scope or urbanization economies. This paper therefore assumes that the growth of firms is affected by the relationship between firms and their environment.

The independent variables of suggested regression equation (function 7) include MP, AP, CP, DIV, SCALE (table 1) and AGE. The dependent variable $Growth_{fst+1}$ is the growth rate of firm f , sector s , gridcell i , in time step $t+1$, which is described as the change of firm size in employees, $(Size_{t+1} - Size_t) / Size_t$. β_{1-6} are regression coefficients. MP_{it} is market potential in gridcell i and time step t . AP_{ist} is agglomeration potential in gridcell i , sector s and time step t and CP_{it} is congestion potential in gridcell i and time step t . DIV_{ist} is diversity potential in gridcell i , sector s and time step t . $SCALE_{ft}$ is a dummy variable based (see table 1) that denotes the size of the firm and AGE_{ft} is the age of the firm f in time step t .

$$Growth_{fst+1} = \beta_1 MP_{it} + \beta_2 AP_{ist} + \beta_3 CP_{it} + \beta_4 DIV_{ist} + \beta_5 SCALE_{ft} + \beta_6 AGE_{ft} + \varphi \quad (7)$$

Table 1. The size classification as firm’s employees

| Scale | Size | Scale | Size |
|-------|-------|-------|---------|
| 1 | 1 | 5 | 26~50 |
| 2 | 2~5 | 6 | 51~100 |
| 3 | 6~10 | 7 | 101~500 |
| 4 | 11~25 | 8 | 501+ |

Figure 3 shows the distribution of distance of firms’ out-migration ordered by rank of their size with a concentration around 50 km (see section 3). The in-migrations show a similar distribution. This paper therefore assumes that the maximum distance of the potential boundary of interaction is near 50 km, implying a value of parameter α of 0.1 as seen in figure 1.

Table 2 represents the set of tested values of α in the various interaction functions. Market potential (MP) is more global than congestion (CP) and agglomeration potential (AP) is tested in every

distance. Diversity potential (DIV) is set as two cases of local and global. This parameter set is applied to the regression model for evaluating the relative effect of potential combination in terms of firm's growth.

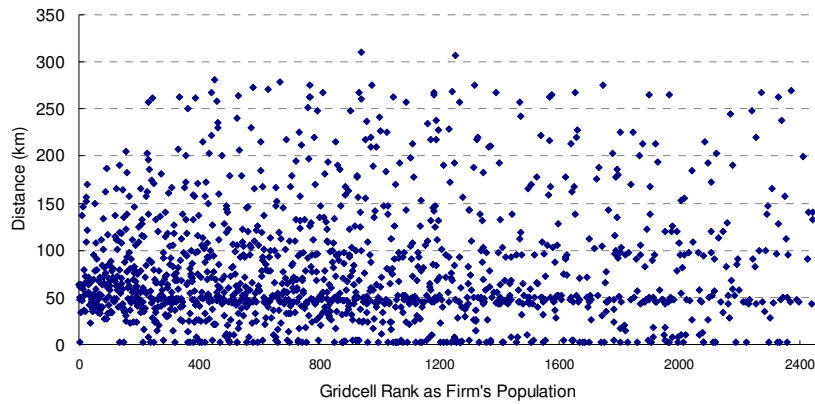


Figure 3. Average relocation distance of firm's out-migration in gridcell, 1998

Table 2. Parameter setting

| MP | CP | DIV | AP |
|-----|-----|-----|-----|
| 0.1 | | 0.1 | 0.1 |
| 0.2 | | | 0.2 |
| 0.3 | | | 0.3 |
| 0.4 | | | 0.4 |
| | 0.5 | 0.5 | 0.5 |

2.4. Optimisation Procedure

The independent variables of the regression equation (MP, DIV, AP) can have different distance decay effects. Therefore a procedure was followed to find the optimal values of them. The first step of the optimisation procedure is the regression analysis of block 1 that consists of MP and CP (table 3). The regression equation of function 8 is defined for finding the parameters related with the relationship between individual firm's growth and economic environment. Thus, the distance decay factor is selected for MP that gives the best model fit.

$$Growth_{fsit+1} = \beta_1 MP_{it} + \beta_2 CP_{it} + \varphi \quad (8)$$

After choosing the MP parameter of each sector in the first step the regression model is extended as follows:

$$Growth_{fsit+1} = \beta_1 MP_{it} + \beta_2 CP_{it} + \beta_3 AP_{ist} + \beta_4 DIV_{ist} + \beta_5 SCALE_{ft} + \beta_6 AGE_{ft} + \varphi \quad (9)$$

In the second step combinations of distance decay factors for DIV and AP are tested for the optimal value of MP, to arrive with the best fitting model.

Table 3. Case setting

| CASE | Block 1 | | Block 2 | |
|------|--|-----|---------|-----|
| | MP | CP | DIV | AP |
| 1 | 0.1 | 0.5 | - | - |
| 2 | 0.2 | 0.5 | - | - |
| 3 | 0.3 | 0.5 | - | - |
| 4 | 0.4 | 0.5 | - | - |
| 5 | MP parameters of each sector extracted from Case 1~4 | 0.5 | 0.1 | 0.1 |
| 6 | | 0.5 | 0.1 | 0.2 |
| 7 | | 0.5 | 0.1 | 0.3 |
| 8 | | 0.5 | 0.1 | 0.4 |
| 9 | | 0.5 | 0.1 | 0.5 |
| 10 | | 0.5 | 0.5 | 0.1 |
| 11 | | 0.5 | 0.5 | 0.2 |
| 12 | | 0.5 | 0.5 | 0.3 |
| 13 | | 0.5 | 0.5 | 0.4 |
| 14 | | 0.5 | 0.5 | 0.5 |

3. DATA

The study area of this paper is the Netherlands with $41,526 \text{ km}^2$, which is divided by gridcells of $2.5 \times 2.5 \text{ km}$. As seen in figure 4 the total number of gridcells is 6263 and the number of occupied gridcells that locate firms is 2662 in 1996. For the period 1996-2006 we have information about all Dutch firms, with respect to size, location, closure and emergence.

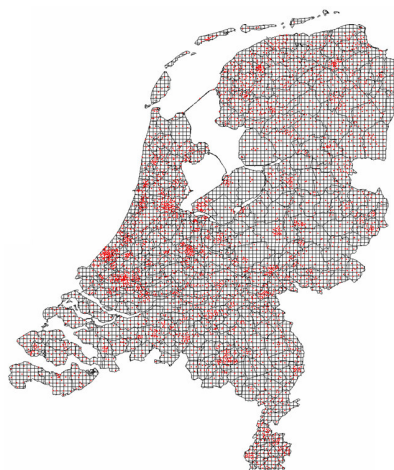


Figure 4. Netherlands overlaid by gridcell and post code

The firm data consists of 26 industrial sectors as shown in table 4. Figure 5 shows that the number of firms between 1996 and 2006 increases linearly and the number of employees is increases until 2001. Since age is an explanatory factor in our model, we selected firms that were founded in 1996 or later (since otherwise, year of establishment was not available). The data allowed us to observe growth and firm characteristics, needed for the regression analysis, but also to calculate AP, MP, CP and the diversity index based on all Dutch firms.

Table 4. The classification of industrial sectors (CBS: Statistics Netherlands)

| Name | Class | Name | Class |
|-----------------------|-------|------------------------|-------|
| Pottery / Glass | 1 | Retail | 14 |
| Publishing / Printing | 2 | Wholesale | 15 |
| Construction | 3 | Transport by air | 16 |
| Chemical industry | 4 | Inland | 17 |
| Wood industry | 5 | Water transport | 18 |
| Clothing production | 6 | Services for transport | 19 |
| Leather / Rubber | 7 | Communications | 20 |
| Mining / Oil / Gas | 8 | Catering | 21 |
| Create industry | 9 | Banking | 22 |
| Paper industry | 10 | Business Service | 23 |
| Textiles industry | 11 | Government | 24 |
| Utility industry | 12 | Education | 25 |
| Food industry | 13 | Healthcare | 26 |

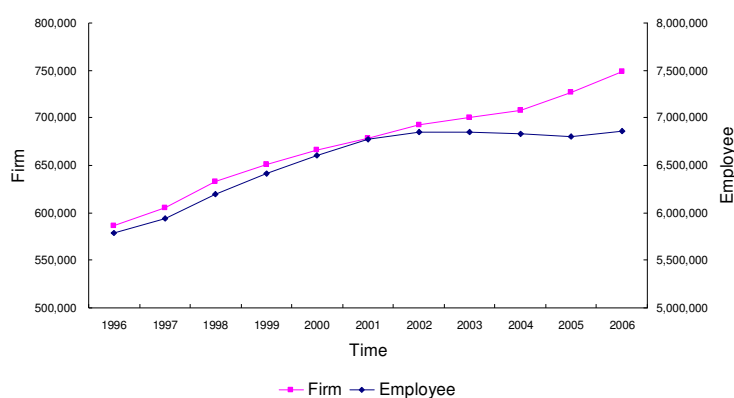


Figure 4. Time series for the firm population and employee (CBS: Statistics Netherlands)

4. RESULTS

As mentioned, the optimisation procedure consists of two steps. In the first step, the distance decay for MP is optimised. The results are displayed in Table 5. The results suggest that local markets (MP's $\alpha_1 = 0.4$) are observed for clothing, textiles, food, inland, healthcare. Slightly more global markets ($\alpha_1 = 0.3$) are found for construction, leather/rubber, create, catering. Communications and banking have a more global market ($\alpha_1 = 0.2$) and the other sectors have the largest market area. It is logical that the clothing and textiles industry ($\alpha_1 = 0.4$) have a more local market than chemical and utility industry ($\alpha_1 = 0.1$) because the latter deliver more specialised products. In the transportation group the inland sector ($\alpha_1 = 0.4$) such as rail and road transport is more local than the sectors of air or water transport ($\alpha_1 = 0.1$). In the business group the market distance of banking sector ($\alpha_1 = 0.2$) is smaller than business service ($\alpha_1 = 0.1$) such as consulting activities. In the public group the healthcare ($\alpha_1 = 0.4$) is much more local behaviour than the government and education sectors ($\alpha_1 = 0.1$).

Table 5. Relative effects of MP and CP to firm growth using first stepwise regression analysis

| Sector | α | | Regression estimates | | | Sector | α | | Regression estimates | | |
|--------|----------|-----|----------------------|-------|--------|--------|----------|-----|----------------------|-------|--------|
| | MP | CP | sig. | R^2 | F | | MP | CP | sig. | R^2 | F |
| 1 | 0.1 | 0.5 | 73.7 | 0.1 | 0.305 | 14 | 0.1 | 0.5 | 32.3 | 0.0 | 1.129 |
| 2 | 0.1 | 0.5 | 40.8 | 0.0 | 0.897 | 15 | 0.1 | 0.5 | 1.8 | 0.0 | 4.003 |
| 3 | 0.3 | 0.5 | 0.0 | 0.0 | 10.180 | 16 | 0.1 | 0.5 | 49.9 | 0.4 | 0.696 |
| 4 | 0.1 | 0.5 | 86.9 | 0.1 | 0.141 | 17 | 0.4 | 0.5 | 1.2 | 0.1 | 4.466 |
| 5 | 0.1 | 0.5 | 4.8 | 0.1 | 3.036 | 18 | 0.1 | 0.5 | 6.0 | 0.2 | 2.810 |
| 6 | 0.4 | 0.5 | 0.4 | 1.1 | 5.603 | 19 | 0.1 | 0.5 | 20.2 | 0.0 | 1.600 |
| 7 | 0.3 | 0.5 | 23.8 | 0.4 | 1.438 | 20 | 0.2 | 0.5 | 22.3 | 0.1 | 1.499 |
| 8 | 0.1 | 0.5 | 14.2 | 0.1 | 1.955 | 21 | 0.3 | 0.5 | 7.0 | 0.0 | 2.663 |
| 9 | 0.3 | 0.5 | 3.6 | 0.0 | 3.330 | 22 | 0.2 | 0.5 | 0.3 | 0.1 | 5.806 |
| 10 | 0.1 | 0.5 | 39.9 | 0.8 | 0.921 | 23 | 0.1 | 0.5 | 13.5 | 0.0 | 2.004 |
| 11 | 0.4 | 0.5 | 48.6 | 0.2 | 0.722 | 24 | 0.1 | 0.5 | 36.1 | 0.2 | 1.021 |
| 12 | 0.1 | 0.5 | 65.4 | 0.3 | 0.425 | 25 | 0.1 | 0.5 | 83.3 | 0.0 | 0.183 |
| 13 | 0.4 | 0.5 | 53.1 | 0.1 | 0.634 | 26 | 0.4 | 0.5 | 0.0 | 0.1 | 10.002 |

R^2 and significance are percent.

Based on the optimal distance decay parameter for MP, the parameters for AP and DIV were optimised. The results are presented in table 6. Table 7 represents the spatial configuration of AP and DIV parameters in stepwise regression of step 2. In the manufacturing group the agglomeration advantage of chemistry, clothing, mining/oil/gas, manufacturing industry occurs within 15km but for leather/rubber, paper, textiles industry this is 50km. In the business group the agglomeration advantage of banking occurs within 50km and business service is 15km. In the public group the education sector is 50km and the government and healthcare is 15km.

Table 6. Relative effects of potentials to firm growth using second stepwise regression analysis

| Sector | α | | | | Regression estimates | | | Sector | α | | | | Regression estimates | | |
|--------|----------|-----|-----|-----|----------------------|-------|-------|--------|----------|-----|-----|-----|----------------------|-------|-------|
| | MP | CP | DIV | AP | sig. | R^2 | F | | MP | CP | DIV | AP | sig. | R^2 | F |
| 1 | 0.1 | 0.5 | 0.1 | 0.4 | 0.0 | 13.8 | 2.642 | 14 | 0.1 | 0.5 | 0.5 | 0.2 | 0.0 | 0.6 | 6.325 |
| 2 | 0.1 | 0.5 | 0.1 | 0.2 | 26.7 | 1.4 | 1.106 | 15 | 0.1 | 0.5 | 0.5 | 0.4 | 0.0 | 0.4 | 3.434 |
| 3 | 0.3 | 0.5 | 0.5 | 0.2 | 0.0 | 0.4 | 3.338 | 16 | 0.1 | 0.5 | 0.5 | 0.1 | 96.1 | 14.0 | 0.684 |
| 4 | 0.1 | 0.5 | 0.5 | 0.5 | 38.2 | 11.9 | 1.049 | 17 | 0.4 | 0.5 | 0.1 | 0.1 | 0.0 | 1.3 | 1.811 |
| 5 | 0.1 | 0.5 | 0.1 | 0.4 | 14.1 | 1.1 | 1.195 | 18 | 0.1 | 0.5 | 0.5 | 0.1 | 96.2 | 1.9 | 0.700 |
| 6 | 0.4 | 0.5 | 0.5 | 0.5 | 79.1 | 5.1 | 0.846 | 19 | 0.1 | 0.5 | 0.1 | 0.5 | 0.0 | 1.3 | 2.433 |
| 7 | 0.3 | 0.5 | 0.5 | 0.1 | 93.6 | 5.9 | 0.733 | 20 | 0.2 | 0.5 | 0.5 | 0.1 | 60.9 | 1.3 | 0.940 |
| 8 | 0.1 | 0.5 | 0.1 | 0.5 | 1.5 | 1.2 | 1.432 | 21 | 0.3 | 0.5 | 0.1 | 0.5 | 0.0 | 1.1 | 4.442 |
| 9 | 0.3 | 0.5 | 0.1 | 0.5 | 0.0 | 0.6 | 2.734 | 22 | 0.2 | 0.5 | 0.5 | 0.1 | 2.6 | 0.7 | 1.378 |
| 10 | 0.1 | 0.5 | 0.1 | 0.1 | 0.4 | 40.0 | 1.725 | 23 | 0.1 | 0.5 | 0.5 | 0.5 | 0.0 | 0.1 | 2.780 |
| 11 | 0.4 | 0.5 | 0.1 | 0.1 | 79.7 | 6.4 | 0.843 | 24 | 0.1 | 0.5 | 0.1 | 0.5 | 19.3 | 5.2 | 1.158 |
| 12 | 0.1 | 0.5 | 0.5 | 0.2 | 77.3 | 18.1 | 0.851 | 25 | 0.1 | 0.5 | 0.5 | 0.1 | 79.8 | 0.4 | 0.847 |
| 13 | 0.4 | 0.5 | 0.1 | 0.3 | 0.0 | 4.5 | 1.775 | 26 | 0.4 | 0.5 | 0.1 | 0.5 | 0.8 | 0.3 | 1.491 |

R^2 and significance are percent. R^2 of grey colour is higher as a meaningful degree.

Table 7. Spatial configuration of AP and DIV effects in second stepwise regression

| AP | Manufacture | Distribution | Infrastructure | Business | Public |
|------------|--|-------------------|--|----------------------------|------------------------|
| 0.1 (50km) | Leather/Rubber, Paper, Textiles | | Air, Inland, Water transport, Communications | Banking | Education |
| 0.2 (25km) | Publishing, Construction, Utility | Retail | | | |
| 0.3 (20km) | Glass, Wood | Wholesale | | | |
| 0.4 (15km) | Chemistry, Clothing, Mining/Oil/Gas, Create | | Transport services | Catering, Business service | Government, Healthcare |
| DIV | Manufacture | Distribution | Infrastructure | Business | Public |
| 0.1 (50km) | Glass, Publishing, Wood, Food, Mining/Oil/Gas, Create, Paper, Textiles | | Inland, Transport services | Catering | Government, Healthcare |
| 0.5 (10km) | Construction, Chemistry, Clothing, Leather/Rubber, Utility | Retail, Wholesale | Air, Water transport, Communication | Banking, Business service | Education |

The value of R^2 in table 6 is much higher than the first stepwise regression and the R^2 of sector 1, 4, 6, 7, 10, 12, 16, 24 is more than 0.05. For the optimised distance decay factors, coefficients of various spatial interactions were estimated, indicating the sign and significance of a specific interaction effect (Table 8).

The pottery/glass sector gets positive effects from chemistry, catering, business service and negative effects from publishing/printing, paper industry in terms of agglomeration. Pottery/glass manufacturing includes chemical processes and needs the business support like consulting. In contrast, the publishing/printing and paper industry differ from pottery/glass’s process and has same MP parameter 0.1 (table 5) that means the competition for space or clients.

Table 8. Positive or negative effects between sectors using third stepwise regression

| | Pottery/Glass | Chemistry | Clothing | Paper | Utility | Government |
|---------------------|---------------|-----------|----------|-------|---------|------------|
| CP | - | | | | | |
| Publishing/Printing | - | | | | | |
| Chemistry | + | | | | | |
| Wood | | | | - | | |
| Create | | | | | | - |
| Paper | - | | | | | |
| Utility | | | | | + | |
| Catering | + | | | + | | |
| Business Service | + | | | | | |
| Government | | | | | | + |
| Chemistry | - | | | | | |
| Clothing | | + | | | | |
| Utility | | | | | - | + |
| 1 (size: 1) | | | | | | + |
| 2 (size: 2~5) | | | | | | + |
| 3 (size: 6~10) | | - | | | | |
| 5 (size: 26~50) | | - | | | | |
| Age | | | - | | | |

Chemical industry gets negative effects from SCALE3 and SCALE5 as firm's size, suggesting that smaller firms show lower growth rates. Diversity within the clothing sector is a positive factor for growth in the chemical industry. Clothing production gets negative effects from AGE, suggesting that new firms grow faster. The paper industry gets negative effects from being close to the wood industry and positive effects from being close to catering firms. The utility industry gets positive effect from utility itself, suggesting that exchange of resources (in a broad sense) is important in this sector. The government sector gets negative effects from manufacturing industry and positive effects from government itself. This implies that governmental organisations benefit from being in close distance, and have different locational preferences than industrial firms. Also, small governmental sites appear to grow faster than bigger ones.

5. CONCLUSION

This paper suggests the importance of interactions contexts for economic development, which was tested by using various forms of urban (agglomeration) circumstances (market potential, agglomeration, congestion and diversity) to explain growth of firms.

In order to find the scale at which various effects are manifest, a stepwise approach was applied, in which optimal distance decay factors were derived from fitting models to a Dutch database of firms. In the first step the distance sensitivity of market potential and congestion potential was investigated and in the second step the distance sensitivity of agglomeration potential and sectoral diversity in each sector was tested.

The final models that were estimated provide some support for the hypothesized impact of spatial configuration in firm growth. Some firm types (government, utilities) showed strong agglomeration effects, and other firm types benefit from adjacency to other types, in ways that were sometimes logical and sometimes puzzling. However, the explanatory power of the models is very limited for most sectors. This suggests that other factors, such as quality of management or wider market circumstances, may be much more decisive for firms' performance than their geographical location relative to other firms.

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