Urban Multifunctional Land Use and Externalities

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1 Introduction

Multifunctional land use is a spatial planning principle aimed at dealing with land scarcity. Multifunctional land use (MLU) is defined by Priemus et al. as "*the combination of different socio-economic functions in the same area*" (Priemus et al., 2000). Multifunctional Land Use (as a planning concept) differs from other mixed and compact land use concepts (e.g., New Urbanism and the Compact City Concept) in the clear focus on the exploitation of the economies of synergy (Rodenburg et al., 2003).

In this paper we investigate the possible effects of MLU by means of a literature review and a modelling approach. We focus especially on knowledge spillovers that might result from the presence of a diversity of land use functions in a MLU setting. We furthermore explore whether these effects are correctly reflected in market prices.

In section 2 we discuss the effects of MLU in more detail. In Section 3 we take MLU out of a spatial planning context and address it as a spatial-economic phenomenon and focus on the economic effects that might accrue from a MLU project. We discuss here the concept of agglomeration economics in general and 'returns to diversity' and knowledge spillovers in particular. In Section 4, we present a simple spatial-economic model and show the spatial equilibrium impacts of the existence of knowledge spillovers resulting from MLU projects. The main aim is to develop a spatial economic model which depicts the characteristics of MLU. The model should allow us to analyse the welfare effects of multifunctional land use. We furthermore, investigate the possible roles of governments and entrepreneurs in stimulating MLU. In Section 5 the paper is concluded.

2 Mixed and Compact Land Use

The spatial planning concept multifunctional land use is, just as Smart Growth, New Urbanism, and the Compact City concept, a form of mixed and compact land use. Mixed and compact land use is essentially a form of urban development based upon the concentration of different land uses within a specified area (see for overviews of concepts, Coupland, 1997; De Roo and Miller, 2000; Jenks and Burgess, 2000; Jenks et al., 1996). Planners often propose mixed and compact land use as a mean to limit and mitigate the effects of urban sprawl (Hall, 1998).

The term MLU emerged in Dutch spatial planning in the late 1990s and it gradually replaced the concept of mixed and compact land use. The concept of MLU places particular emphasis on the relationship between mixed and compact land use, infrastructure and city redevelopment (e.g. the redesigned railway station in Leipzig, the Amsterdam South-Axis). MLU is not only concerned with mixed and compact land use, but is also focused on the creation of synergy between the land use functions that are combined in a MLU project (Lagendijk, 2001; Laswick, 2002; Rodenburg et al., 2003). Major strategies of MLU are to increase density and to mix different land use functions. Density is increased by building on higher and subterranean levels, and by facilitating land use of different users at different moments in time. Furthermore, attention is devoted to the creation of synergy between the various functions, which are combined (Rodenburg et al., 2003).

Mixing different land uses is seen by planners as a mean to achieve various planning policies related to sustainable development (Coupland, 1997). It is believed that mixed land use, and especially the inclusion of residential land use, will lead to reduced (car) mobility. Furthermore, it is assumed that areas will become more attractive, lively, viable and safer. It is also assumed that concentrating a diversity of activities leads to an increased economic productivity. In Table 1, the assumed effects of mixed and compact land use are summarised.

Table 1. Possible advantages and disadvantages of mixed and compact land use.

Advantages	**Disadvantages**
Environmental effects	
Protection of open space and farmland.	Lack of access to open and green spaces in urban environments.
Reduction in mobility (multi-purpose trips) resulting in reduced fuel consumption and emissions.	Concentration of environmental problems in one location.
Reduction in building energy consumption	
Social effects	
Increased overall accessibility.	Conflicts between activities (noise, congestion, parking problems, etc.).
Reduction in crime rates.	Reinforces the perception of overcrowding and loss of visual privacy.
Increased quality of life.	
Economic effects	
Increased diversity leading to an increased attractiveness and vitality of neighbourhoods. Increased population base for public services and amenities	May limit economic development in rural areas.
Efficient provision and re-use of infrastructure.	Higher wages paid to workers employed. Congestion costs resulting from suboptimal urban size.
Increased productivity in the form of economies of scale, density and diversity.	

The first and most often stated reason for promoting mixed and compact land use is reducing the need to travel by providing a range of services in close proximity. It is expected that this will result in increased public transport usage, reduced car-usage and therefore reduced fuel consumption and emissions. Many authors in this respect refer to the city of Portland, Oregon, where a relatively dense city layout, encouraged investment in public transport and resulted in 43% of the city's commuters using the bus and light rail network (Girardet, 1992).

Central to the debate on urban compactness and energy use has been the work of Newman and Kenworthy (Newman, 1992; Newman and Kenworthy, 1989a; 1989b). For a number of large cities around the world, they have related petroleum consumption per capita to population density. Newman and Kenworthy found a consistent pattern with higher densities being associated with lower levels of fuel consumption. The conclusion from their research was that, if fuel consumption and emissions are to be reduced, urban compactness and public transport should be promoted. However, the results of various other studies give some mixed outcomes regarding this (Banister et al., 1997; Breheny, 1992; Cervero and Gorham, 1995; Cervero and Kockelman, 1997; Frank and Pivo, 1994; Gomez-Ibanez, 1991; Handy, 1996).

Many planners argue that mixed and compact land use may enhance social cohesion by ensuring a feeling of community and making areas safe and nicer places to live. Jane Jacobs (1961) was the first who discussed the relation between mixed land use and safety. In her influential *book The Death and Life of Great American Cities*, Jacobs proposed that diversity in land uses and an active street life could reduce opportunities for crime. She promoted small-scale development and diversity of uses as the keys to a lively and safe city. According to Jacobs (1961), such neighbourhoods not only provide natural surveillance, but also help to establish a stable social structure, where people know what is acceptable and unacceptable behaviour. Many theorists and practitioners today have built their ideas upon the core principles advocated by Jacobs (Coleman, 1985; Fowler, 1992; Sucher, 1995). They emphasise that the presence of more people for more hours results in increased ‘natural surveillance’ which contributes to crime reduction.

Various authors have also identified a number of disadvantages related to mixed and compact land use. First this form of urban development might reduce the quality of life in existing urban areas. Extra development in the form of higher densities might increase already existing problems in urban areas, resulting in a reduction of the quality of life of citizens. Furthermore, the lack of access to open space and green areas may further reduce the quality of life. In general, there is a perception of overcrowding in cities and mixed and compact development might further reinforce this perception (Breheny, 1992).

3 MLU, agglomeration economies and knowledge spillovers

From the spatial economic literature is well known that agglomeration economies are important reasons for spatial agglomeration. Since MLU is explicitly aimed at creating synergy effects by combining a diversity of land use functions it is fruitful to analyse the types and sizes of such effects. Theoretical studies regarding agglomeration emphasise that two opposing forces are responsible for the spatial allocation of economic activities, agglomeration forces and dispersion forces. Among the dispersion forces are increased transportation costs and negative externalities, such as congestion and pollution. According to Fujita and Thisse (2002), increasing returns in production, externalities and imperfectly competitive markets, are essential for explaining agglomeration processes. The neoclassical economist Alfred Marshall was the first who investigated the role of increasing returns to scale in the process of agglomeration and distinguished four sources of agglomeration economies, *scale economies at the firm level*, *local non-traded inputs*, *local skilled labour pool* and *information spillovers*. In his classification of so-called Marshallian externalities, Hoover (1936; 1948) focussed on the (spatial) scope of agglomeration economies. He distinguished *internal returns to scale at the firm level*, *sector specific localisation economies* and *economic diversity related urbanisation economies.* Localisation economies occur when the production costs of firms in a particular sector decrease at a particular location if the total output of the sector concerned near that location increases. Localisation economies are external to the firm but internal to the sector concerned. Urbanisation economies originate from the same sources as localisation economies and are also external to the firm. However, urbanisation economies result from the scale (and possibly) the diversity of the entire urban economy (Jacobs, 1969). An overview of the various findings regarding the spatial economic literature is given in Table 2.

Table 2. Spatial economic theory, agglomeration economies and relevance for MLU.

Theory	Findings	Relevance for MLU
Von Thünen	Allocation of land use based on transportation costs.	Monofunctional land use allocation.
Alonso	Allocation of land use based on transport costs. Factor substitution.	Monofunctional land use. Intensification of land use.
Marshall Hoover	Characterisation and classification of agglomeration economies.	Identification of synergy effects Overview of possible costs and benefits of MLU projects.
Perroux Chinitz Myrdal	Growth-pole model Incubator model Core-periphery model. Spatial concentration of economic growth.	Selection of key cluster members. Diversity as instigator of growth.
Vernon	Life-cycle model. Economic activities are spatially separated according to the stage in the life-cycle of the product concerned	Selection of cluster members on the basis of development stage a firm is in. Focus on innovation and high-tech firms.
Porter	Competitiveness of regions/clusters is based on strong localisation economies and proximity of industry members.	Local competition is vital for an MLU cluster. Theory forms a foundation for the selection of cluster members (competitors).
New Economic Geography	Diversity and demand linkages are important for clustering	NEG explicitly investigates the role of linkages and product diversity and in clustering.

Several researchers have studied the existence of agglomeration economies empirically. The various studies and their findings are summarised in Table 2. Empirical studies can roughly be classified into three categories. The first category of studies is often referred to as MAR (Marshall, Arrow and Romer) and focuses on localisation economies in the light of a monopolistic market situation. It is argued here that in a situation with little competition rents resulting from sector-specific agglomeration economies can be internalised which fosters further innovation (van Oort, 2002).

The second category of empirical studies is based on Porter's hypothesis that localisation economies in combination with local competition enhance the competitiveness of the cluster at hand (Porter, 1990; 1998). Porter argues that clustering of firms is an alternative form of organisation and that this clustering maximises the transfer of information and technologies between firms. Furthermore, proximity to competitors encourages firms to improve their competitiveness.

The third category of empirical studies is influenced by the work of Jacobs (Jacobs, 1969). Although Jacobs agrees with Porter that local competition is indeed important for innovation and economic growth, she argues that it is the diversity in economic activity (urbanisation economies) that is essential for economic growth.

Since agglomeration economies, for example knowledge spillovers between workers, are difficult to observe directly, and researchers therefore have to rely on indirect measures such as wage differences, employment, output and economic growth to investigate them (see for an overview of studies, Hanson, 2000; Rosenthal and Strange, 2004). From the various empirical studies it does not become clear whether sector specific (localisation economies) or diversity related agglomeration economies are most dominant in the clustering process.

Table 3. Empirical studies regarding the measurement of agglomeration economies.

Focus	Studies	Findings
Location decisions	Carlton, 1983 Wheeler and Mody, 1992	Firms (foreign) are attracted to own industry
Productivity	Sveikauskas, 1975	Urbanisation economies are significant. Doubling of city size results in a productivity gain of 6%.
	Nakamura, 1985 Henderson, 1986	Localisation economies are significant.
	Ciccone and Hall, 1996	Doubling of employment density raises labour productivity with 6%
Growth	Glaeser et al., 1992	Diversity does matter for economic growth
	Henderson et al., 1995	Diversity does only matter for new firms to grow.
Innovation	Audretch and Feldman, 1996	Innovations and knowledge centres are spatially clustered
	Jaffe et al., 1993	Innovations, patents have a clustered pattern
Education and human capital	Rauch, 1993	Wages and rents are higher in regions with higher educated inhabitants
Market potential Demand linkages	Davis and Weinstein, 1999 Dumais et al., 1997 Hanson, 1998 Wolf, 1997	Regional demand linkages contribute to agglomeration.

Adapted from Rosenthal and Strange (2004).

For example, Henderson's (1986) results indicate that larger cities are more productive because they have large concentrations of specific industries (localisation economies). Sveikauskas (1975), however, claims that diversity and therefore urbanisation economies do matter. His results indicate that an average productivity gain of about 6 percent might be expected with each doubling of city size (see also (Glaeser et al., 1992; Henderson, Vernon et al., 1995).

To conclude, it is clear that sources of agglomeration economies are manifold, ranging from knowledge spillovers between workers to the influence of diversity of economic activities at a location. The various empirical studies suggest that spatial wage differences are consistent with benefits resulting from proximity to more educated workers, dense concentrations of economic activity, and areas of high consumer or industrial demand. One limitation of the existing empirical research is that most studies tend to explain the role of one factor in spatial agglomeration, in isolation from other possible effects. Therefore, we are not sure whether there are multiple types of externalities that contribute to agglomeration or whether each of these effects simply capture a different aspect of a single unified force. From a review of the empirical literature it becomes clear that the effects of agglomeration may be significant. Therefore, agglomeration effects should be taken explicitly taken into account when assessing the effects of MLU projects. In the remainder of this paper we focus more on a special type of agglomeration economies, namely knowledge spillovers that might result from a MLU project.

Instead of focussing on the sources of agglomeration economies one can also look at the various mechanisms that generate and transfer agglomeration economies. In their excellent overview Duranton and Puga (2004) distinguish three mechanisms, *sharing*, *matching* and *learning*. By modelling these mechanisms the authors show how increasing returns to scale may come into existence at the aggregate urban level.

Duranton and Puga (2004) discuss various mechanisms related to the sharing of indivisible facilities, the variety of input suppliers, specialisation, and the sharing of risks. The authors conclude that indivisibilities play a limited role in agglomeration. The authors furthermore show that the sharing of a wider variety of intermediate inputs or risks leads to a situation with increasing returns scale, resulting in the agglomeration of economic activities. Durantion and Puga (2004) also discuss mechanisms behind the matching of various economic agents (e.g., workers and employers). They argue that agglomeration improves the expected quality and probability of matches between economic agents. Agglomeration in this situation results from two mechanisms. Firstly, an increase in the number of agents trying to match improves the chance of matching. Furthermore, this also improves the expected quality of each match and will mitigate hold-up problems associated with bilateral relationships, for example, between firms and workers.

Duranton and Puga (2004), like many other researchers, argue that proximity to other firms and workers is essential for the generation and diffusion of knowledge. Various theoretical reasons exists for the explaination of this relationship. It is often argued that knowledge is tacit, informal and uncodified and that a distinction can be made between information and knowledge (Pavit, 1987). Audretsch and Feldman (1996) argue that the cost of transmitting information may be invariant to distance, but that the cost of transmitting knowledge increases with distance. Knowledge transfer mechanisms such like learning-by-doing and learning-by-using are only effective when the distance to customers, suppliers, competitors etc is small (Von Hippel, 1988; 1994).

Regarding theoretical studies regarding agglomeration and knowledge spillovers we refer to Lucas (1988), Eaton and Eckstein (1997) and, Black and Henderson (1999). These researchers investigated the relationship between learning and agglomeration and developed dynamic models in which worker learn from eachother. It is argued that as a worker becomes more productive, as a result of education or training, all workers in the locality also become bit more productive (Hanson, 2000).

Jaffe et al. (1993) analysed the role of knowledge spillovers in the agglomeration process empirically and studied the geographical localisation of US patent citations. They found that new patents and cited patents are much more likely to have originated from the same city. This suggest that there are location-specific spillovers associated with innovation and knowledge creation (see also, Audretsch and Feldman, 1996). Rauch (1993) and Peri (1998) both found that wages and rents are higher in cities with higher average education levels. They conclude that higher wages in cities give educated workers a stronger incentive to locate in cities than less-educated workers (see also, Borjas et al., 1992; Glaeser et al., 1995). These results support the view that knowledge spillovers between workers play an important role in the agglomeration of economic activities. However, the theoretical and empirical studies above do not take distance explicitly into consideration when investigating knowledge diffusion.

Keller (2002) empirically studied the amount of technological knowledge spillovers from R&D expenditures on a geographical basis. In his research he made a clear distinction between knowledge spillovers as being global or local. It is widely argued that technological knowledge is truly global because increasing economic integration through trade and other forms of communication ensure that firms or countries have access to the same pool of knowledge. In such a situation the geographic distance should not have influence with regard to technological knowledge diffusion. By means of regression analysis, he found that technology is to a large degree local, not global, as the benefits from technological knowledge spillovers are declining with distance.

In the next sections we will investigate the role of distance, diversity and knowledge spillovers more closely from a theoretical point of view. Explicit attention is given to the role of these aspects in MLU-projects. Furthermore, we take a look how MLU-projects can be established and designed in the most effient way.

4 A Toy Model

In our model two sectors are present, sector a and sector b. Both sectors use two input factors to produce their product. They both use *labour* and *land*. Furthermore, we assume perfect competition on the factor and output markets concerned. As a result a zero-profit condition holds for both sectors. We assume that a firm's proximity to other firms will result, via knowledge spillovers between workers, in an increased productivity. This is reflected by the parameter ß in the production function presented in equation 1. The Leontief production function for a firm belonging to sector j operating at location {x,y} is given by:

$$q^j_{\{x,y\}} = f^j_{\{x,y\}}(L^j_{\{x,y\}}, G^j_{\{x,y\}}) = \beta^j_{\{x,y\}} * \min\left\{\alpha^j_L L^j_{\{x,y\}}, \alpha^j_G G^j_{\{x,y\}}\right\} \qquad \text{Equation 1}$$

where:

- $q^j_{\{x,y\}}$, is the output a firm belonging to sector j at location {x,y};
- $L^j_{\{x,y\}}$, is the amount of labour used in production by the respective firm;
- $G^j_{\{x,y\}}$, is the amount of land used in production by the respective firm, which is exogenously determined;
- α^j_L and α^j_G are technical coefficients;
- $\beta^j_{\{x,y\}}$, is the parameter reflecting the productivity of the respective firm.

Total output of sector j is defined by the summation of the output of firms belonging to the sector:

$$Q^j = \sum_{x=1}^{x}\sum_{y=1}^{y} \delta^j_{\{x,y\}} q^j_{\{x,y\}} \qquad \text{Equation 2}$$

Where $\delta^j_{\{x,y\}} = 1$ if the firm operating at location {x,y} belongs to sector j otherwise this variable attains the value of 0. Since the production structure of firms in our model is characterised by Leontief technology they use the input factors labour and land in fixed proportions. The firms in our model must operate at the point where $q^j_{\{x,y\}} = \beta^j_{\{x,y\}} \alpha^j_L L^j_{\{x,y\}} = \beta^j_{\{x,y\}} \alpha^j_G G^j_{\{x,y\}}$.

Hence, if a firm wants to produce $q^j_{\{x,y\}}$ units of output, it must use $\frac{q^j_{\{x,y\}}}{\beta^j_{\{x,y\}}\alpha^j_L}$ units of labour and $\frac{q^j_{\{x,y\}}}{\beta^j_{\{x,y\}}\alpha^j_G}$ units of land no matter what the prices for the input factors are.

The cost function for a firm operating at location {x, y} subject to Leontief production technology is given by.

$$C(q^j_{\{x,y\}}) = c\left(L^j_{\{x,y\}}, G^j_{\{x,y\}}, q^j_{\{x,y\}}, \beta^j_{\{x,y\}}\right) = q^j_{\{x,y\}}\left(\frac{W}{\beta^j_{\{x,y\}}\alpha^j_L} + \frac{R_{\{x,y\}}}{\beta^j_{\{x,y\}}\alpha^j_G}\right) \qquad \text{Equation 3}$$

where W, $R_{\{x,y\}}$ are the factor prices for one unit of labour and land. W is exogenously and $R_{\{x,y\}}$ is endogenously determined. Furthermore, both sectors operate as export sectors on a perfectly competitive world market hence, the output price for their products is given by P^j. We assume that the total amount of land $\overline{G}$ is fixed and determined by: $\overline{G} = \sum_{x=1}^{X}\sum_{y=1}^{Y} G_{\{x,y\}}$ Equation 4

In equilibrium the average total costs of a firm must equal the output price of the product. $ATC^j_i = P^j$ Equation 5

Average total cost of a firm belonging to sector j is equal to the total cost function of that firm divided by the output of that sector.

$$ATC^j_{\{x,y\}} = \frac{1}{B^j_{\{x,y\}}} * \left(\frac{W}{\alpha^j_L} + \frac{R_{\{x,y\}}}{\alpha^j_G}\right) \qquad \text{Equation 6}$$

Combining equations 6 and 7 gives us the bid rent for a firm in sector j operating at location {x,y}:

$$B^j_{\{x,y\}} = \left(P^j - \frac{W}{\beta^j_{\{X,Y\}}\alpha^J_L}\right) \cdot \beta^j_{\{X,Y\}} \cdot \alpha^j_G \qquad \text{Equation 7}$$

or

$$B^j_{\{x,y\}} = \left(P^j * \beta^j_{\{X,Y\}} - \frac{W}{\alpha^J_L}\right) * \alpha^j_G \qquad \text{Equation 8}$$

The rent for a specific location {x,y} in spatial equilibrium is determined by:

$$R_{\{x,y\}} = \underset{j}{Max}\left\{B^j_{\{x,y\}}\right\} \qquad \text{Equation 9}$$

4.1 Specification of the knowledge spillovers

In our model we investigate the influence of spatial proximity on the diffusion of knowledge and the productivity of firms. We calculate per location the concerned received knowledge spillovers. The value of the received knowledge spillovers is determined by the distance-weighted labour input at other locations in the lattice. The productivity variable ß is therefore determined by the distance between the location concerned and the other lots[1]. In various modelling exercises it is assumed (see Caniels and Verspagen) that new knowledge stems from three sources:

- exogenous growth which reflects the knowledge impact of exogenous R&D activities by firms;
- learning-by-doing or the Verdoorn-Kaldor effect which states that a positive relation exists between the growth of productivity and the growth of output;
- spillovers received from surrounding firms.

For simplicity, we disregard any sources of knowledge growth other than the presence of knowledge in surrounding firms. We omit the exogenous growth rate and Verdoorn-Kaldor effect in order to focus on the relation between proximity of firms and knowledge spillovers and not on the temporal dimension of knowledge creation.
The amount of knowledge spillovers received by a firm is determined in our model by the following equation:

$$\beta_{ij} = 1 + \sum_{k=1,k\neq i}^{I} \sum_{m\{a,b\}} d_{mk} \frac{s_{mj}}{\delta_{ik}} \qquad \text{Equation 10}$$

In which β_{ij} denotes the by distance weighted total knowledge spillovers received by a firm located at parcel i and belonging to sector j. These knowledge spillovers are the summation of all knowledge spillovers between the firm located at parcel i and all other firms. The transfer of knowledge between two firms is dependent upon the type of firm present at parcel k, (e.g. does the firm belong to sector A or B). d_{mk} will assume a value of 1 in case the firm in k is from type m, otherwise it assumes the value of 0, it is used to select the type of agglomeration economies that is present. A distinction can be made between localisation economies, knowledge spillovers between firms of the same sector, and urbanisation economies. S_{mj} denotes the amount of knowledge spillovers received by firm j and generated by the firm located at parcel k. Furthermore, S_{mj} reflects the amount of localisation or urbanisation economies being received by the firm. δ_{ik} represents the distance between parcel i and k. From the model it becomes clear that an increase in the distance between the two firms will result in a higher value for δ_{ik}. This will lead to lower knowledge spillovers received by firm j located at i.

Since we do not relate the growth of knowledge to output growth, we have to provide a mechanism that explains the amount of knowledge present at a location. In our model the amount of knowledge is determined by the amount of labour applied at a location. Due to the application of Leontief production technology the amount of labour is determined, in fixed proportions, by the amount of land that is used in production. In our model we assume that a firm uses only one parcel of land in its production process. As a consequence, the amount of labour applied at a parcel is also fixed at unity. The fixed proportion condition does not apply to a Cobb-Douglas production technology, the

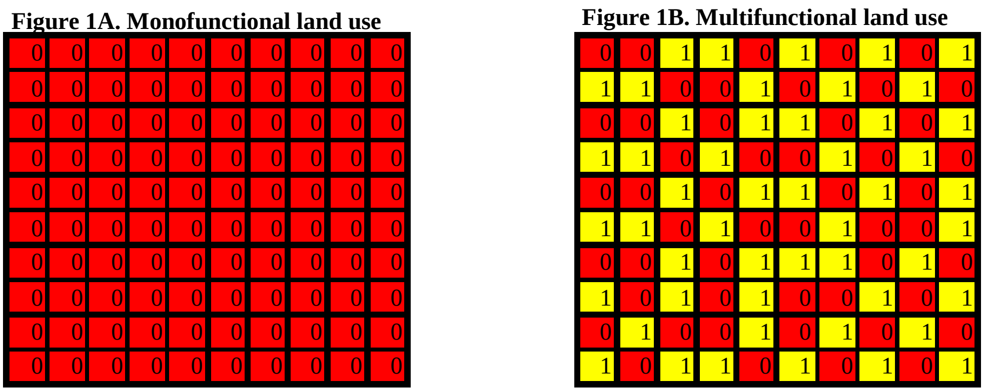
[1] In order to calculate the distance between two locations in our model we used Pythagoras' theorem.

application of such a production function would allow us to calculate the relative intensity of labour used at a location. In our numerical interpretation of the model we will vary the value of S_{mj} to analyse the effects of knowledge spillovers.

4.2 MLU and the efficiënt market outcome

We developed the model above to analyse the welfare consequences of MLU in the presence of externalities. Externalities in our model take the form of distance affected knowledge spillovers. In this section we analyse the free-market equilibrium outcome of the model and compare this with the outcomes of the social optimum or efficient equilibrium. In other words, we analyse whether the free-market equilibrium outcome is economically efficient.

Figure 1. Spatial outcome resulting from the free-market equilibrium.



Dominant monofunctional land use.
The outcome depends on the initial situation.
The presence of 1 firm belonging to sector A,
will result in the dominance by A.

Multifunctional land use

We assume that the firms present in our model operate at a small island which is represented by a checkerboard style lattice of 10x10 cells (see Figure 1A). Furthermore, the firms operate under a zero-profit condition, and the rent is determined according to the leftover principle. As a consequence possible positive productivity effects resulting from knowledge spillovers between firms is reflected by an increase in the rent paid for a specific parcel. This rent is collected by an absentee landlord. However, we assume that this landlord cannot exercise his market power. In case possibilities exist for this landlord to exercise market power, her or she will try to **maximise total rent revenues**.

To determine whether the market is economically efficient, we have to determine whether **social welfare** is maximised in such a situation**.** Social welfare can be defined here as the social total benefits resulting from production minus the total social costs of production. However, this implies the maximisation of the pre-rent profit of each firm. Since the firms operate under a zero-profit condition, this implies that maximising social welfare is the same as the strategy our monopolist uses, maximising the total rent revenues. In our analysis, we will therefore compare the free-market equilibrium outcomes with the results of maximising total rent revenues to see whether the free-market equilibrium is efficient.

To focus on the effects of knowledge spillovers we assume that all firms in sector A and B are faced with the same market price for their output and the same factor prices for the inputs they use in producing their output. Furthermore, the value of the technical coefficients α_L^j and α_G^j are equal for both. As a consequence, rent differences between firms of both sectors are therefore only influenced by the degree and valuation of knowledge spillovers the firms receive.

With regard to the spillovers of knowledge we distinguish three possible situations.

Localisation economies, dominant monofunctional land use. The situation refers to the case where knowledge spillovers are only facilitated between firms belonging to the same sector, for example, sector A. This results in a situation of monofunctional land use. Firms belonging to sector A will outbid the B firms (see Figure 1). The maximum rent paid in the free-market equilibrium is the highest in the centre of our lattice and depends mainly on the value of S_{mj}. However, this equilibrium outcome is not unique and depends on the initial situation. At least one A firm should be present in the initial situation to start the process of clustering. In case sector A firms also receive knowledge spillovers from sector B firms, the monofunctional land use situation, with only the presence of sector A firms, will also appear as the equilibrium outcome (Figure 1A). The presence of a sector B firm in the initial situation induces the clustering of sector A firms.

Maximising total rent revenues will result in the same land use pattern fully dominated by sector A firms. Therefore we may conclude that the resulting free-market equilibrium outcome is economic efficient. The social surplus, calculated by the difference between total social benefits and total social costs, is maximised.

Urbanisation economies, dominant monofunctional land use. This second case relates to a situation wherein sector A receives knowledge spillovers from sector B (S_{ba} > 0). However, firms belonging to sector B do not profit from the presence of sector A or B firms (S_{ab} = S_{bb} = 0). The resulting free-market equilibrium is monofunctional in nature and only sector A firms are present (see the right-hand side of Figure 2). This outcome is unique and independent from the initial situation.

Figure 2. The equilibrium outcomes when Sector A profits from the presence of Sector B.

Monopolist

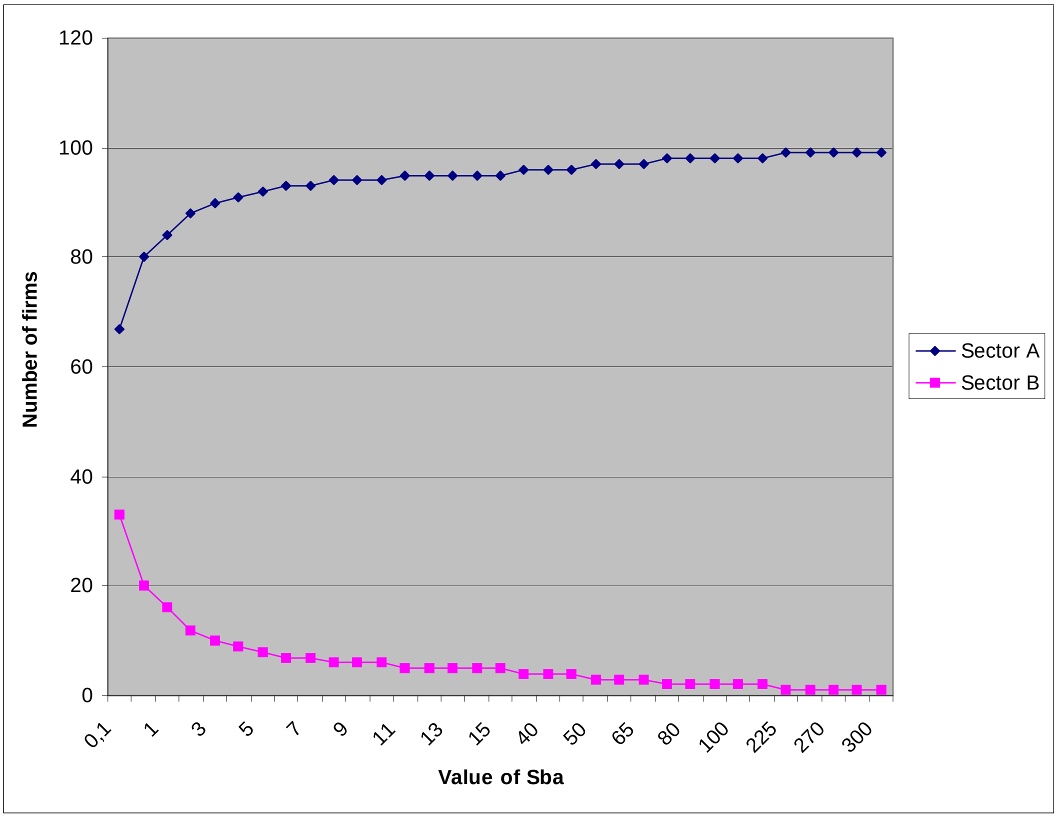
0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	1	0
0	0	1	0	0	0	0	1	0	0
0	1	0	0	1	0	0	0	0	0
0	0	0	0	0	1	0	1	0	0
0	0	1	0	0	0	0	0	1	0
0	0	0	0	1	0	0	1	0	0
0	0	1	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0

Equilibrium

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

By allowing the presence of sector B firms, the Monopolist is able to maximise his total rent revenues. Since we do not allow the clustering of B firms, these firms are allocated in a dispersed pattern over our lattice. This dispersion in influenced by the value of S_{ba}. In case S_{ba} increases the number of Sector B firms decreases since Sector A is able to outbid sector B (see Figure 3). Furthermore, a higher value for S_{ba} forces the B firms to located more in the centre of our lattice.

Figure 3. The number of A and B firms related to the value of S_{ba}.



The free-market equilibrium is not economically efficient. The total rent revenues produced are significantly lower than the ones obtained by our monopolist.

A situation of monofunctional land use also occurs when sector A and sector B firms profit from the presence of sector B firms. However, we assume that the spillovers from B to A are higher than between sector B firms ($S_{ba} > S_{bb} > 0$). We do not allow for other forms of knowledge spillovers, such as from A firms to B firms and between sector A firms ($S_{aa} = S_{ab} = 0$). The free-market equilibrium depicts a monofunctional land use situation dominated by sector A firms. The monopolist, however, will allow the presence of sector B firms. While in the previous situation these firms were scattered over our lattice, this is not the case here. Due to the allowance of intrasectoral clustering of B firms ($S_{bb} > 0$), the monopolist will position sector A firms at the edges and sector B firms in the centre of the island. Furthermore, more sector B firms are present on the island than in the previous situation. The presence of sector B firms decreases when S_{bb} is held constant and S_{ba} increases (see Figure 5). If S_{ba} increases, sector A profits more from the presence of sector B and will outbid this sector. As a consequence firms belonging to sector B are chased away from the island.

Figure 4. Equilibrium outcomes when both sectors profit from the presence of sector B.

Monopolist

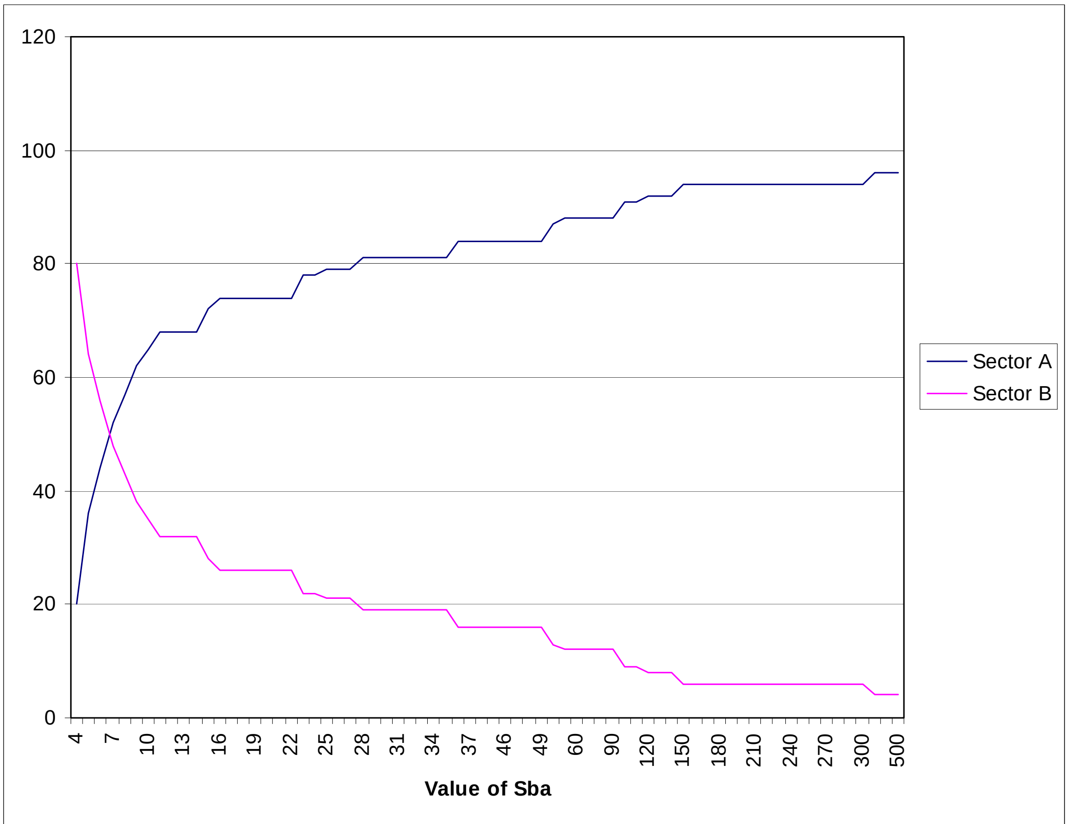
0	0	1	1	1	1	1	1	0	0
0	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	0	0

Equilibrium

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

In case the difference between S_{bb} and S_{ba} is small, we obtain some interesting results. While the monopolist maximises total rent revenues by means of a monofunctional land use situation with B sector firms, in the free-market equilibrium 100 A sector firms are allocated to our lattice. The latter outcome is economically inefficient. The total rent revenues produced by the free-market are significantly lower than the ones generated by our monopolist.

Figure 5. The chasing effect related to urbanisation economies.



Urbanisation economies, multifunctional land use. We allow here for the spillovers of knowledge between firms of different sectors. Furthermore, we assume these spillovers are positive and of equal size ($S_{ba} = S_{ab} > 0$). The land use pattern resulting from the free-market and a monopolistic situation is depicted in Figure 4. Both result in the dispersion of A and B firms over our lattice, both types of firms are equally present (50 sector A firms and 50 sector B firms). The total rent revenues accruing from the free-market equilibrium is of the same size as our monopolist would have realised. We may therefore conclude that the free-market situation has produced an economically efficient outcome.

Figure 6. Multifunctional land use pattern resulting from urbanisation economies.

Monopolist

1	0	0	1	0	1	0	1	1	0
0	1	1	1	1	0	1	0	1	0
1	0	0	0	0	1	0	1	0	1
0	1	1	0	1	0	1	0	1	0
1	0	0	1	0	1	1	0	1	0
0	1	1	0	1	0	0	1	0	1
0	1	0	1	0	1	1	0	1	0
1	0	1	0	1	0	0	1	0	1
0	1	0	1	0	1	1	0	1	0
1	0	1	0	1	0	0	1	0	1

Equilibrium

0	0	1	1	0	1	0	1	0	1
1	1	0	0	1	0	1	0	1	0
0	0	1	0	1	1	0	1	0	1
1	1	0	1	0	0	1	0	1	0
0	0	1	0	1	1	0	1	0	1
1	1	0	1	0	0	1	0	0	1
0	0	1	0	1	1	1	0	1	0
1	0	1	0	1	0	0	1	0	1
0	1	0	0	1	0	1	0	1	0
1	0	1	1	0	1	0	1	0	1

5 Conclusions

Multifunctionality of urban space might be a response to these challenges. The concept of multifunctional land use has turned out to be a very interesting one in urban planning.

Multifunctional land use is a spatial planning principle aimed at dealing with land scarcity. Furthermore the concept is aimed at creating synergy between the land use functions included in a MLU project. A vast amount of literature does exist about the role of agglomeration economies in the forming of economic clusters. Since MLU is a form of spatial planning based upon the forming of clusters of land use functions it is evident to study the literature concerning agglomeration economies. By doing so we gain insight into the processes behind economic clustering and the associated effects of MLU.

From the empirical literature it becomes clear that sources of agglomeration economies are manifold and that various mechanisms are responsible for the clustering of firms and workers. One of such mechanism is the transfer of knowledge between firms and workers. Various authors indicate that that knowledge is tacit, informal and uncodified and that the cost of transferring and knowledge increases with distance (Pavit, 1987; Audretsch and Feldman 1996). In this paper we related the distance related effects of knowledge spillovers with MLU by means of a simple spatial-economic model. The model results indicate that the free-market equilibrium is only economically efficient when firms from sector A and B equally profit from eachother's presence (see Figure 6). If other types of knowledge spillovers are present in the system this will result to monofunctional land use. A chasing effect occurs when for example sector A profits from the presence of sector B, this sector is outbid by the other sector.

In order to realise MLU project and to capture the knowledge spillover effects an important role is played by special agency (e.g. a firm or the government) which can act as a monopolist. In contrast to the free-market this monopolist is able to capture the effects of knowledge spillovers as is shown by the results of our model. This will lead to a market outcome which is economically efficient. If we assume that a role is played by governments in the realisation of MLU projects, we much be aware that various forms of government failures might be associated which such a role.

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