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Multifunctional land use: an accessibility interpretation

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Abstract
The need for efficient urban land use has generated much interest in new forms of urban architecture. In The Netherlands, at present an intensive discussion is taking place on so-called multifunctional land use. This concept aims to concentrate and combine several socio-economic functions in the same area, so as to save scarce space and to exploit synergies. One of the problems with the measurement of multifunctional land use is that it depends strongly on the demarcation of the area considered and the ensuing neglect of activities located outside the demarcated area. This paper overcomes this problem by using an accessibility interpretation, since, from the viewpoint of spatial functionality, the appropriate demarcation should be based on transport costs and their impact on mutual interactions between actors. In order to incorporate the multifunctional character of accessibility, attention will also be paid to the multiplicity of interactions and to multipurpose trips. Addressing the notion of multifunctionality by means of accessibility is also relevant for the measurement of urbanisation economies. These will in this paper be replaced by accessibility economies, again in order not having to apply an arbitrary demarcation rule for metropolitan areas. An illustration of Stated Preference techniques as a tool to measure the 'multifunctional accessibility' will be given.

1. Introduction

Economic science has traditionally put great interest in land use. Economists have typically focussed on questions of efficiency and (more recently) sustainability of land use. These studies are generally concerned with 'monofunctional' land use patterns. Nowadays, however, cities have to reposition themselves in a conflicting force field. On the one hand, cities have become important actors in an international competitive game and have to safeguard the efficiency of economic activities. On the other hand, cities have to take the environmental quality issues serious, as this will be decisive for their long-term approach. Multifunctionality of urban space might be a proper response to these challenges. Multifunctional land use can be seen as an empirical phenomenon, and be studied as such from a spatial economic perspective, but it may also be conceived as a guideline for spatial planning initiatives. The central purpose of multifunctional land-use as a planning concept is to use scarce space as wisely as possible.

From an economic perspective, land is a scarce commodity, which has a market value depending on its usage (e.g., infrastructure, residential housing, and nature). Land has different functions that often compete with each other. The more functions have to be fulfilled in the same area, the scarcer the land concerned is becoming. Especially in densely populated areas we witness competing demands which give an upward push to land prices. For social and economic reasons this calls for a more efficient use of the available land, not only by differentiation of functions over time (e.g., sequentially over the day), but especially by seeking for a vertical combination of the functions (i.e., construction in multi-layer constellations). The popularity of the compact city concept is a clear illustration of the importance of this new trend. Furthermore, in many countries we see an emerging interest in spatial quality or spatial sustainability, which may be interpreted from an environmental angle as an increasing attention for quality of life in high-density areas.

Traditionally, spatial functions have been studied as alternative and mutually competing uses of scarce land. Clearly, market forces reflected inter alia in the price mechanism played a critical role in these analyses. In recent years however, it is increasingly recognised that spatial functions are not necessarily conflicting, but may be complementary with respect to each other. This means that a simultaneous fulfilment of different functions at the same place may create spatial synergy. The synergy benefits could be obtained, for instance, by means of economies of scale, localisation benefits, urbanisation benefits, and attractiveness economies.

This development has prompted the birth of the concept of multifunctional land use. Through multifunctional land use, economies of scale and diversity may be achieved, which lead to a saving in the use of scarce land and which may improve environmental quality. The present paper aims to offer a new contribution to the economics of multifunctional land-use by defining multifunctional land use from the perspective of accessibility. In Section 2, a definition of multifunctional land use will be presented, whereas Section 3 discusses the demarcation problem that arises with defining multifunctional land use. Section 4 then presents a solution by interpreting multifunctional land use in terms of accessibility. Section 5 analyses an interesting parallel between a pair of concepts related to the accessibility interpretation of multifunctional land use. In Section 6, opportunities for an application of the accessibility approach will be presented by means of stated preference techniques. Section 7 contains concluding remarks.

2. Definition of multifunctional land use

An empirical analysis of multifunctional land use requires a careful investigation of the different land use functions to be distinguished. Nine such (rather aggregate) functions have been distinguished by Rodenburg (2001), namely: residential housing, work and business, amenities, infrastructure, recreation and culture, water, agriculture, nature and landscape, and remaining land, which includes the use of land that can not be classified under one of the other land use functions. These spatial functions are defined to be mutually exclusive. To define multifunctional land use adequately, it is important to identify properly its time dimensions and its geographical scale levels. The longer the time-span, and the larger the geographical scale, the greater the extent of multifunctional land use. Namely, more land use functions will be exercised within a longer time-span, as well as in a bigger geographical area. Also the aggregation level of the land use functions is important in determining multifunctional land use. An operational definition of multifunctional land use should therefore envisage that the concept is best understood as a relative, non-binary one: it is better to define a degree of multifunctionality than to make a strict demarcation between mono- and multifunctional land use patterns. For a discussion on the definition of the degree of multifunctionality, it is useful to consider a hypothetical area for which we can then illustrate the various indicators of multifunctionality. Figure 1 is the starting point and shows a monofunctional land use pattern: only one land use function is present in the demarcated area (in which the index 1 represents a specific spatially uniform land use function).

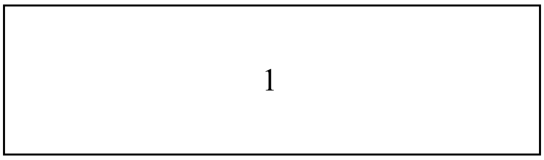


Figure 1: Monofunctional area

There are at present several definitions of multifunctional land use. That of Lagendijk and Wisserhof (1999) is the most commonly used in the Dutch literature. It states that one can speak of multifunctional land use if at least one of the following four conditions are satisfied: (1) intensification of land use (an increase in the efficiency of land use by a function); (2) interweaving of land use (which they define as the use of the same area for several functions); (3) using the third dimension of the land (the underground along with the surface area), and (4) using the fourth dimension of the land (use of the same area by several functions within a certain time-frame).
However, there are some caveats inherent in the use of this definition. In comparison with the other elements, intensification is a process, whereas the other three elements represent a state. This means that intensification itself cannot be observed in a static sense, but only in relation to developments over time or between different land use alternatives or areas. Interweaving as well as the use of the third and fourth dimension can be observed as being present or not, at a certain moment. Furthermore, intensification is not only observable in the case of multifunctional land use, but it can also be a characteristic of monofunctional land use. Besides, intensification may be a result of multifunctional land use or a goal in itself. It seems therefore, plausible to leave this aspect out of the definition of multifunctional land use.
The second element, interweaving of land use, is defined by Lagendijk and Wisserhof as ‘use of the same area by several functions’, but we prefer to call this ‘diversity’.

Figure 2a depicts the case of multifunctional land use by diversity: two land use functions are present in the demarcated area (indicated by the indices 1 and 2). Figure 2b shows an increased degree of diversity: the number of land use functions in the area has now increased from two to five.

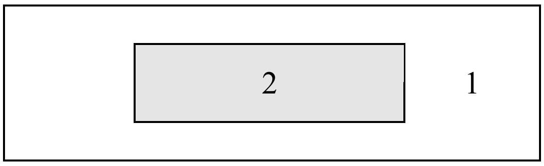


Figure 2a: Multifunctional land use by diversity: two land use functions

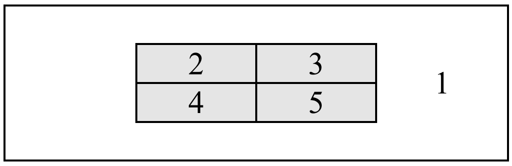


Figure 2b: Multifunctional land use: increased degree of diversity

The degree of *interweaving*, then, can be defined as the number of territories divided by the number of functions, in which a territory is an enclosed monofunctional area (which can be positioned in a two- or three-dimensional setting). Interweaving measures the degree of dispersion of functions over the demarcated area. This will be explained with the help of Figure 3. For example, a large area used for a grocery store (see Figure 2a) will be divided into four single units scattered over the area (see Figure 3). The individual areas consist of a bakery, a greengrocer's shop, a butcher, and a drugstore. In this case, where all four individual shops still belong to the land use function of amenities, the interweaving of functions in the areas will increase, since, compared to Figure 2a, the number of territories increased (5 instead of 2), whereas the number of functions remained the same.

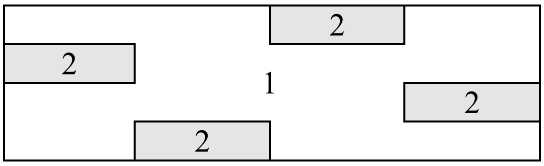


Figure 3: Multifunctional land use: increased degree of interweaving

Next to interweaving, there is the issue of *spatial heterogeneity* of functions, which is slightly different from interweaving. Spatial heterogeneity can be seen as the degree in which a given territory touches upon other (different) functions. It can be measured as the sum (over territories) of the number of other functions touching a territory divided by the number of territories. This will be illustrated by an example. If four different land use functions are clustered (see Figure 2b), the degree of spatial heterogeneity will be higher than if these functions are individually located in an area with a single land use function (see Figure 4). In the first case, each territory touches upon four different land use functions, whereas in the second case each function only touches upon one other land use function and only function 1 touches upon 4 different functions. If we express the spatial heterogeneity as the average number of functions that a territory touches upon, we find a number of $\frac{5*4}{5}=\frac{20}{5}$ for Figure 2b and a number of $\frac{4+4*1}{5}=\frac{8}{5}$ for Figure 4 (see calculations in Table 1).

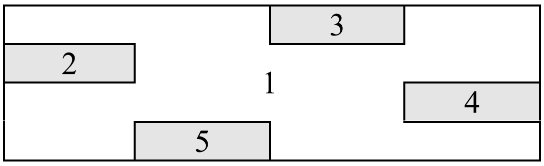


Figure 4: Multifunctional land use: decreased degree of spatial heterogeneity

Table 1: Example of spatial heterogeneity (SH)

Figure 2b	
Function	Number of (mutually) different land use functions it touches upon
1	4
2	4
3	4
4	4
5	4
Total SH	20/5

Figure 4	
Function	Number of (mutually) different land use functions it touches upon
1	4
2	1
3	1
4	1
5	1
Total SH	8/5

Given the above aspects of multifunctionality, a more suitable definition of multifunctional land use in a dynamic context is:

A land use pattern is said to become more multifunctional when, in the area considered, the number of functions, the degree of interweaving, or the spatial heterogeneity increases. An increased degree of multifunctionality may therefore result from the addition of functions to the area (multifunctionality by diversity), from an increase in dispersion of the number of functions over the area (multifunctionality by interweaving), or from an increase in the number of other functions touching a territory (multifunctionality by spatial heterogeneity).

This definition is used to provide an unambiguous description of the concept of multifunctional land use, in order to ensure that a common view on multifunctional land use is developed. However, there are different ways to look at the concept of multifunctional land use. This definition has been developed from the viewpoint of land use functions, but for other viewpoints this definition might need to be modified. This will be discussed in more detail in the following section.

3. Demarcation problem with definition of multifunctional land use

Since multifunctional land use addresses the presence of various land use categories in a certain area, it is illuminating to consider its dependence on geographical scale. Table 1 shows the shares of land use categories for different geographical scale levels in The Netherlands. The first column shows the national land use shares, then the land use shares of the province of North Holland and the city of Amsterdam (situated in North Holland) are shown, whereas the final column shows the land use shares of a specific site in Amsterdam, the so-called South Axis, an area with a concentration of road and rail infrastructure where rapid real estate developments take place.

Table 1: Land use shares in The Netherlands (%)

	National	Province of North Holland	City of Amsterdam	South Axis Amsterdam
Built-up area				
Residential	5.4	7.4	22.6	12.3
Manufacturing	1.5	1.8	8.6	0.0
Services	0.8	1.1	4.8	23.0
Infrastructure	3.2	3.2	6.0	50.4
Recreation, incl. city parks	2.0	2.8	10.5	11.3
Agriculture	56.6	40.8	13.8	0.0
Nature area	3.3	4.2	0.2	0.0
Water	18.4	34.5	25.1	3.0
Remaining	0.9	1.2	7.8	0.0

Source: CBS, 2002

Table 1 shows that, in general, the smaller the area considered, the higher the share of residential housing, services, infrastructure, and recreation, whereas the shares of agriculture, nature and water decrease with the size of the area. Dependent on the character of the specific site analysed (lowest scale level), specific land use shares will be higher compared to the average for the region. At the Amsterdam South Axis, office buildings and houses will be built on top of infrastructure, which explains its high shares for infrastructure, services and housing. If the focus would have been on an industrial site, the share of manufacturing would probably have had one of the highest shares.

The frame of reference for the evaluation of these shares obviously depends on the scale of the area considered. The multiplicity of functions has a different meaning at various spatial scales. This leads to the issue of demarcation. What is an appropriate spatial demarcation in the discussion of multifunctional land use? Note that Figures 1-4 all take a certain rectangular frame as a starting point. But how large should such a frame be? There may be administrative reasons behind this demarcation (for example, it may be a planning zone in a metropolitan area, or an area acquired by a private developer). But it is also possible to demarcate according to certain 'interaction' principles. For example, according to the area where 95% of all expected commuters originate from, or according to the area where the main customers of the services provided in the zone will be found, or where the main suppliers are located. For each perspective widely varying boundaries may be found, for example ranging from 30 km for workers, to 100 km for main customers to 500 km for main suppliers.

The demarcation suggested by Figures 1-4 suggests that the focus is on mutual deliveries and interactions on the site, but by doing so one looses information on the extent to what these mutual deliveries can be substituted by links with other sites nearby or further away.

4. New interpretation: in terms of accessibility

From the viewpoint of spatial interaction a more appropriate demarcation should be based on accessibility; i.e., transport costs and their impact on mutual interactions between actors. Consider the extreme case that transport costs do not matter implying the 'death of distance'. In that case the natural demarcation would be the country border (or even wider). A narrower demarcation would simply yield misleading results. Another extreme case would be that transport costs are infinite. In that case, firms and consumers only benefit from the presence of other firms in the immediate vicinity, i.e., being within arm's reach. Thus, an implicit assumption behind very narrowly demarcated zones seems to be that the only relevant transport modes are walking and using rolling sidewalks and elevators to have face-to-face contact within a few minutes. Thus, *proximity* seems to be an important concept behind much of the literature on multifunctional land use.

Proximity is an important basis for the theory on geographical concentration of economic activity, especially in cities. Due to economies of scale and agglomeration economies, cities used to be centres of agglomeration of material production. In a world of declining transportation costs, one observes an increasing dispersion of manufacturing away from the major cities. However, the service sector as well as people still agglomerate in cities. Therefore, theories of agglomeration have progressively turned away from transport costs of physical goods as their causal mechanism and started to concentrate on immaterial transactions. Nowadays the major force of agglomerations is the production and exchange of ideas, knowledge, information and experience. Storper and Venables (2002) give a nice illustration. They identify different means of co-ordinating economic activities, in view of the kind of knowledge that needs to be transacted within the activity at hand, and in light of its external environment. The demands for proximity between agents of each mode of co-ordination are shown schematically in Table 2. Buzz relates to the physical co-presence that is vital for knowing what is happening, face-to-face contacts or the force of 'being there'. It is what enables the circulation of information to happen and the functioning of networks.

Table 2: Proximity requirements of different modes of co-ordination

Bureaucracy	Low
Networks	Medium
Search/matching under numbers uncertainty	Medium
Search/matching because of specialisation	High
Anonymous markets	Low
Buzz	High

Source: Storper and Venables, 2002

However, this focus on proximity has its limitations, because for many types of interactions also longer distance classes play a role. The standard way of addressing longer distance interactions is to use the notion of accessibility, based on gradual distance decay as can be found in spatial interaction modelling. Distance-decay can be attributed to the cost, effort or time required to overcome the friction that distance imposes on interaction (Berry, 1976). It reflects the relationship between the intensity of spatial interaction and distance. This means that there is an observed decrease in spatial interaction when the distance increases. Distance decay of spatial interaction of course has implications for the demarcation of a zone since when the impact of distance is strong one will arrive at a small area within which interactions take place. It is important, however, to note the difference between the two concepts. Demarcation is by definition crude: it implies a zero-one approach to spatial units that are relevant and units that are to be ignored. Distance decay does not require such a binary approach: it just leads to probabilities of spatial interaction between a zone and other zones in a spatial system. Therefore, the issue of determining the relevant range for demarcation is replaced by determining the relevant parameter of the distance decay function. However, the latter determination is much more fine-tuned than the first, since for the latter we have an empirical basis that can be derived from spatial interaction patterns.

The starting point for an analysis of spatial interactions is a spatial system as presented in Figure 5. The grey area (A) gives, for example, interactions between origin (i) and destination (j) in an existing area that will be extended by a new area (project area) with cells M+1, …, N leading to additional spatial interactions B, C, and D.

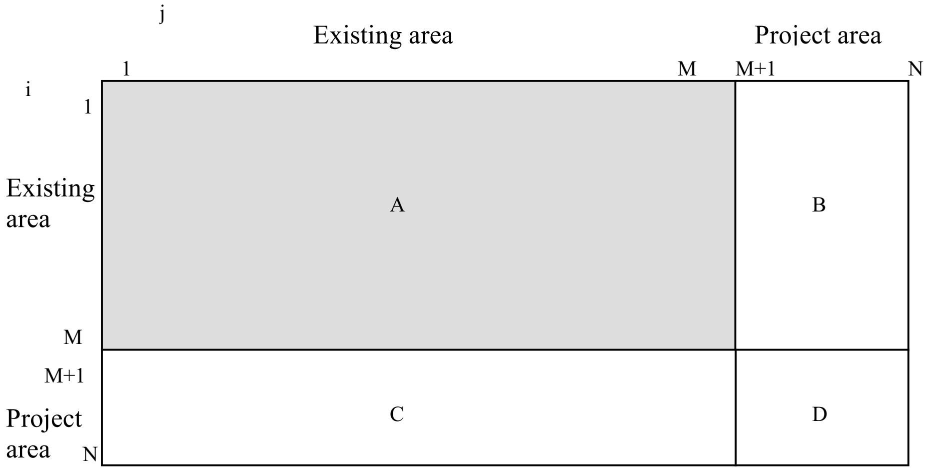


Figure 5: Spatial interactions within spatial system consisting of cells in the existing area (1, …, M) and in the new area (M+1, …, N)

In the following formulas, we will use i for the project area (B, C and D), and j for the area represented by all cells (A, B, C, and D, so including the project area cells). Figure 5 shows the possible interactions: A contains interactions between locations inside the existing area, D contains interactions between locations inside the new area, B contains interactions between locations in the existing area and locations in the new area, and C contains interactions between locations in the new area and locations in the existing area.

A standard definition of accessibility of an arbitrary spatial unit *i* is:

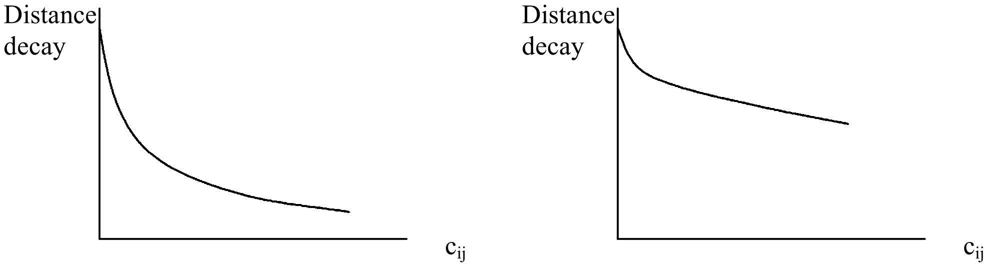
$$Outbound\ accessibility_i = \sum_j D_j f(c_{ij}) \qquad (4.1)$$ [1]

where f is the distance decay function, c_{ij} are the costs of interaction (time, money or distance) between units i and j, and D_j is the mass of activity in unit j. An example of outbound accessibility are residents of the new area travelling to their work destination in the existing area. The distance decay function ($f(c_{ij})$), that is part of this definition of accessibility, has not been specified yet. There are different possibilities to express the distance decay. An example of a suitable formulation of the distance decay function ($f(c_{ij})$) is the one as proposed by Wilson (1971):

$$f(c_{ij}) = exp(-\beta c_{ij}) \qquad (4.2)$$

[1] In order to determine the total accessibility, also the inbound accessibility should be taken into account: $Inbound\ accessibility_j = \sum_i D_i f(c_{ij})$. An example of inbound accessibility are employees that commute from the existing area into the new area.

Figure 6 gives an example of distance decay for an activity with high and low proximity requirements implying a high and low value of β, respectively.



6a: High proximity requirements 6b: Low proximity requirements

Figure 6: Relation between distance decay and costs of interaction

One has to keep in mind that there is a difference between the concept of accessibility defined above and that of multifunctional land use: the first is defined for each spatial unit (e.g., a firm, or a grid-cell), whereas the second is measured as an aggregate across spatial units (e.g., a project area). This difference can be removed by adding the accessibility scores for all relevant spatial units in the new area:

$$Outbound\ accessibility_i = \sum_{i=M+1,\dots,N} \sum_j D_j f(c_{ij}) \qquad (4.3)^2$$

An advantage of the accessibility approach above that of multifunctionality is that for measuring accessibility different spatial scale levels can be used at the same time. For example, with multifunctional land use, the focus is mainly on the project area, whereas with accessibility it is possible to look at the accessibility of the project area from the surrounding areas as well, irrespective the spatial scale level of the surrounding areas (i.e., this allows us to analyse different scale levels (e.g., grid-cell, zipcode, etc.) at the same time).

A disadvantage of the above formulation of accessibility is that it does not yet reflect the multiplicity of interactions. Therefore, it has to be specified in terms of accessibility with respect to a series of activities k = 1, …, K. In order to overcome this limitation, the above indicator can be generalised to become:

$$Outbound\ accessibility_i = \sum_{i=M+1,\dots,N} \sum_k \sum_j D_{jk} f_k\left(c_{ij}\right) \qquad (4.4)^3$$

where the distance decay function can be different for each type of activity m: for those types of spatial interaction where face-to-face contact is important distance decay would be strong, whereas for other types of interaction it would be much more moderate.

[2] Also here the inbound accessibility should be taken into account: $Inbound\ accessibility_j = \sum_{j=1,\dots,M} \sum_i D_i f(c_{ij})$. An example of inbound accessibility are employees that commute from the existing area into the new area.

[3] $Inbound\ accessibility_j = \sum_{j=1,\dots,M} \sum_k \sum_i D_{ik} f_k\left(c_{ij}\right)$

The importance of synergy effects between activities within the demarcated area compared with the rest of the world can easily be determined by making a distinction in (4.4) between activities k that take place within an area and those that are located elsewhere:

$$Outbound\ accessibility_i = \sum_{i=M+1,\dots,N} \sum_k \left[\sum_{j=1,\dots,M} D_{jk} f_k\left(c_{ij}\right) + \sum_{j=M+1,\dots,N} D_{jk} f_k\left(c_{ij}\right) \right] \qquad (4.5)^4$$

where the first sum between brackets relates to interactions with locations outside the project area, and the second sum concerns the interactions (synergy effect) within the project area. From this formula it is clear that the synergy measured as the share of internal interaction in a project area compared with total interaction is large when:

- the level of internal activities D_{jk} is large
- costs of interaction c_{ij} within the project area are low
- there is a combination of activities in the project area that have high intensities of interaction $f_k(c_{ij})$
- the slope of the distance decay function $d[f_k(c_{ij})]/dc_{ij}$ is steep, so that interactions with activities further away is low.

Williams (1977) has demonstrated the link between accessibility measures and user benefit measures such as consumer surplus (CS). Based on the logit model, the log sum formula

$$Consumer\ Surplus = \left(\frac{1}{c}\right) \ln\left[\sum_i \sum_k \sum_j D_{jk} f_k\left(c_{ij}\right)\right] \qquad (4.6)$$

where c is the marginal utility of income, represents the total consumer benefits of travelling. The contribution of the sites at the project area to total benefits equals:

$$\Delta\, CS = \left(\frac{1}{c}\right) \ln\left[\sum_i \sum_k \sum_j D_{jk} f_k\left(c_{ij}\right) - \sum_{i=1,\dots,M} \sum_k \sum_{j=1\dots,M} D_{jk} f_k\left(c_{ij}\right)\right] \qquad (4.7)$$

This evaluation criterion can also be used to compare one investment in the project area with other investment plans at various locations and see whether it has a beneficial impact on consumer surplus. Thus, when a well-developed spatial interaction model exists, the increase in consumer surplus owing to various multifunctional alternatives can be estimated.

Not only the different individual activities that take place at one location and that form the goal for people to travel to that location are interesting to analyse, but also the possibilities to combine activities by means of making multipurpose trips. This could be regarded as an important advantage of multifunctional land use projects. There are several ways to deal with multipurpose trips related to the above mentioned

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[4] $Inbound\ accessibility_j = \sum_{j=1,\dots,M} \sum_k \left[\sum_{i=1,\dots,M} D_{ik} f_k\left(c_{ij}\right) + \sum_{i=M+1,\dots,N} D_{ik} f_k\left(c_{ij}\right) \right]$

formulas. Martellato et al. (1995) state that in the case of a two-stage decision process towards two levels of destination j and k, the joint accessibility results as follows:

$$Acc_i = \sum_j Acc_j D_j \, exp\left(-\beta c_{ij}\right) \tag{4.5}$$

where,

$$Acc_j = \sum_s D_s \exp\left(-\gamma c_{js}\right) \tag{4.6}$$

embeds the accessibility of a destination j to further destinations s with a cost-sensitivity parameter γ.

Using the above-mentioned concepts allows us to analyse interrelationships both within the planning area and in a broader context. The analysis can even be a combined one in which different spatial scale levels will be analysed at the same time. For example, spatial interactions related to a certain location can be analysed on the site level (e.g., by means of number of visitors), but the interactions with stakeholders around the site can be included in the analysis as well (e.g., at zip-code level). This creates interesting possibilities for the analysis of multifunctional land use at transport junctions. The presence of a railway station generates passenger flows that can be a potential user group for the different activities located near the station. These flows can be incorporated in the accessibility function as presented above. The distance decay function will be different for people that have their destination at the station than for people that only transfer. In contrast, with a binary demarcation as presented in Figures 1-4, it is much more difficult to incorporate interactions from outside the project area and to classify different types of interactions (according to user type, distance, etc.).

5. Urbanisation economies and accessibility

Addressing the notion of multifunctionality from an accessibility point of view is also relevant for the measurement of urbanisation economies (see Rietveld and Bruinsma, 1998). Urbanisation economies reflect higher productivity owing to the proximity of markets for various inputs and outputs within the same urban region. Accessibility essentially does the same thing, but at a wider spatial range by including the markets in other metropolitan areas located further away. According to this interpretation, urbanisation economies are part of accessibility economies. The choice for accessibility economies above urbanisation economies has the advantage that there is no need to apply an arbitrary demarcation rule for metropolitan areas.
Consider for example two metropolitan areas A and B with identical activity levels, but the area of A is double that of B. Then the average distance of activities in A is higher than that in B so that costs of communication and transport within A are also higher. Therefore one would expect productivity in B to be higher than in A. A possibility to address this would be to use density as a proxy for urbanisation economies (see for example Ciccone and Hall, 1996). However, density does not fully cover the issue of measuring urbanisation economies, because also the internal spatial structure of the metropolitan area matters. In addition, urban centres nearby may also

contribute to the proximity advantages mentioned above. It is clear that the way of measuring urbanisation economies has been influenced strongly by data availability. During the last decade GIS developments have greatly improved the spatial detail of data availability. This offers new opportunities to measure urbanisation economies based on much smaller spatial units.

Thus we arrive at an interesting parallel between the pair of concepts *'Multifunctional land use'* and *'Multifunctional accessibility'* on the one hand, and *'Urbanisation economies'* and *'Accessibility economies'* on the other. The first pair refers to land use issues, whereas in the second pair the emphasis is on accessibility related to land use. In both pairs the first term relies on some arbitrary spatial demarcation, whereas the second term depends on distance decay as observed in spatial interaction patterns. In both cases the interpretation in terms of accessibility is attractive since its avoids the demarcation problem implying the neglect of activities located outside the demarcated area.

Although interpretation in terms of accessibility seems to be attractive, one has to keep in mind that accessibility is not an unambiguous concept. Many different definitions of accessibility, but also many different ways to measure it can be found in the literature. The basic features of these different definitions, however, seem to be opportunities and effort. Opportunities arise from the economic possibilities that location in space offers to actors who have chosen it. In order to take advantage of these opportunities, the actors have to make effort since they have to bridge geographical distance, which takes time – and therefore has a cost – and pay the service price. The definition of accessibility as presented in Section 4 will be starting point for an illustration of possibilities for the application of accessibility as measure for multifunctionality in Section 6.

6. Stated Preference techniques as a tool to use the accessibility approach

The analysis of spatial interactions within the demarcated area and with stakeholders outside the demarcated area creates interesting possibilities for an analysis of multifunctional land use at transport junctions. The interactions made will be dependent on, for example, distance to the site (expressed in travel time and travel costs), and the range of activities present at the site. The relationship between the intensity of spatial interaction and distance is expressed by distance decay (see also section 4). However, in order to be able to say something about distance decay for a specific site or a specific user group, more information is needed about the considerations that people make in their decision to make a trip, or the value they attach to specific attributes of the trip / site.

There are different economic valuation methods that can be used to illustrate elements of the distance decay function of multifunctional land use projects. Since the willingness of people to make use of a multifunctional land use project (and with that, the value they attach to it) is not directly traded on a market, and no market price can be observed, the use of non-market valuation methods is required. An economic valuation method is a procedure for determining the value of a good or service in terms of the social welfare it provides (Ruijgrok, 2000). The concept of economic valuation has its foundations in welfare economics. It focuses on the welfare of individuals, and in turn depends on the theory of consumer behaviour. Therefore, valuation in an economic sense is always the result of an interaction between the subject and an object. However, whatever typology is used to describe types of economic value, it will always deal with multifunctional land use projects performing functions that are somehow perceived as valuable by society. Functions in themselves are therefore not necessarily of economic value; such value derives from the existence of a demand for these functions or for the goods and services they provide (Turner et al., 1998).

Economic valuation methods can be divided in methods based on observed market behaviour (*revealed preferences* of consumers) and methods based on responses to hypothetical markets (*stated preferences* of consumers). Revealed preference techniques are assumed to be based on 'real world' data, that is, choices and decisions that have actually been made. Revealed preference methods try to reveal the values that consumers place implicitly through their actions on certain aspects of land use. They make trade-offs involving sacrificing some monetary benefits to limit the use of environmental resources or gain some environmental benefit. An example is the willingness of people to pay to live away from a noisy airport or road or to pay a premium for a hotel room away from a busy street. The common feature of revealed preference methods is a dependency on a relationship between a market good and an intangible good.

Stated preference methods do not attempt to place values on multifunctional land use projects by observing actual trade-offs, but rather seek to elicit information on the trade-offs individuals would make when confronted with particular situations. In contrast to the revealed preference methods, the stated preference method asks people to express their economic values for non-market goods. The fact that stated preference methodology is based on hypothetical transactions that reflect market situations means that the development of constructed markets/situations through the use of questionnaires is required.

In line with the spatial interaction model presented in section 4, consumers, workers, travellers and employers compare the use of facilities in the plan area with facilities at other places. For example, workers at the plan area that would get ample opportunities for shopping at the place of work because of the expansion of activities at the plan area would compare these with alternative locations for shopping, for example near their homes. When no transport model is available to compute the changes in consumer surpluses of consumers, direct interviews with workers may be used. Such interviews would include questions on whether or not workers would make use of the new shopping facilities. Also, interview questions can be asked about their willingness to pay (or willingness to accept a lower wage) when facilities are available near the work place. The answers give an indication of the consumer surplus created by the activities in the plan area.

By means of questionnaires one can ask people for their willingness to pay (WTP) to make use of certain facilities on multifunctional land use sites. Also the use of different activities at the site within one trip is important to know. If people consider this as an important positive characteristic of multifunctional land use, it will influence their willingness to pay.

On the consumer level, measuring the consumer surplus, four different levels of users are to be distinguished: workers, shoppers, residents and travellers. Workers are people who's job location is at the multifunctional site, shoppers are people who explicitly use the site for shopping purposes, residents are the people who live at the multifunctional site, and travellers are the people who travel to and from the site, but have no specific purpose at the site other than to change transport means. In this paper, the focus will be on people working at multifunctional land use sites. These are the people who probably have the largest variation in facilities they use at the site

(shops, catering facilities, different kinds of infrastructure, and facilities such as childcare, parks, sport facilities, a post office, a museum, etc.) and might have a high value of time compared to shoppers and residents. Travellers might also have a high value of time, but will probably use less different facilities than workers will.
Examples of suitable (more general) questionnaire questions for workers are:

- How often would you use certain facilities at the site?
- How important is the presence of certain facilities for you?
- Is the use of one facility related to the use of other facilities?
- Which part of your groceries would you buy at the site and which part at home (for different price levels)?
- What is your most important means of transport to the site?

The most important and interesting questions nevertheless are related to their willingness to pay for products they buy or services they use at the site. One way to analyse this is to ask workers for their willingness to accept a lower wage or to pay higher prices for products and services at the multifunctional site.
Examples of such (more specific) questions for workers are:

- Which percentage of your total expenses on supermarkets do you expect to spend at your regular supermarket and which percentage do you expect to spend at the supermarket on this multifunctional site, if different price levels do exist? (provide alternative options, for example price differences of 10, 25, and 50 % between peoples regular supermarket and supermarkets at the multifunctional site)
- Suppose that you might choose between: (1) your current job at this multifunctional site, without presence of any shops, and (2) your current job at this multifunctional site, where there are several shops present, but your monthly salary would be € 25 less. Which option would you choose?

By means of specific Stated Preference techniques for analysis of the answers on the questionnaires, the consumer surplus of the people using the multifunctional site can be quantified. This information is important for investors in multifunctional land use sites. If they have information about people’s willingness to pay for the use of facilities at multifunctional sites, they can indirectly cover their investment costs by asking higher rents for real estate, which organisations are often willing to pay if they can cover their higher costs by asking higher prices to customers.

7. Conclusion

The concept of accessibility is based on two components: the distribution of activities in space, and the transport costs implied by moving from one place to the other. Policy discussions on improving accessibility often focus on the second element: reducing transport costs. The good thing of the concept of multifunctional land use is that it also incorporates the first component: a better match of closely related activities in space by avoiding monofunctional land use.
Most indicators of multifunctionality appear to depend on a rather arbitrary spatial demarcation of zones. This paper indicates that the use of distance decay concepts derived from spatial interaction problems provides a natural solution to this problem. The concept of distance decay provides a solid link between land use, the notion of multifunctionality and spatial interaction models. As noted in Section 4, another advantage of using the accessibility notion is that it has close links with welfare

measures so that it also provides a useful input for the economic valuation of measures aiming at improving multifunctional land use.

The use of economic valuation methods creates interesting possibilities for an analysis of multifunctional land use at transport junctions, especially since not all interactions made at, from and to multifunctional sites are easily measurable. By means of questionnaires information can be obtained about the willingness of people to pay for specific services offered at multifunctional sites, and in the end, the consumer surplus of the people using the multifunctional site can be quantified.

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