WORKING PAPER
2016:49

Accessibility and Market Potential Analysis

Johan Klaesson, Johan P Larsson and Therese Norman

RESEARCH NETWORK DEBATE
SWEDISH ENTREPRENEURSHIP FORUM

Working Papers Series from Swedish Entrepreneurship Forum

In 2009 Swedish Entrepreneurship Forum started publishing a new series of Working Papers. These are available for download on www.entreprenorskapsforum.se, and are part of our ambition to make quality research available to a wider audience, not only within the academic world.

Scholars from different disciplines are invited to publish academic work with the common denominator that the work has policy relevance within the field of entrepreneurship, innovation and SMEs.

The working papers published in this series have all been discussed at academic seminars at the research institution of the author.

ABOUT SWEDISH ENTREPRENEURSHIP FORUM

Swedish Entrepreneurship Forum is the leading Swedish network organization for generating and transferring policy relevant research in the field of entrepreneurship and small enterprise development.

Swedish Entrepreneurship Forum is a network organization with the aim

- to serve as a bridge between the small business research community and all agents active in development of new and small enterprises.
- to initiate and disseminate research relevant to policy in the fields of entrepreneurship, innovation and SME.
- to offer entrepreneurship researchers a forum for idea sharing, to build national and international networks in the field and to bridge the gap between research and practical application.

Find out more on www.entreprenorskapsforum.se

Accessibility and Market Potential Analysis

Johan Klaesson, Johan P Larsson, Therese Norman
Centre for Entrepreneurship and Spatial Economics (CEnSE)
Jönköping International Business School (JIBS), P.O. Box 1026, 551 11 Jönköping, Sweden,
johan.klaesson@ju.se, johan.p.larsson@ju.se, therese.norman@ju.se

Prepared for the *Handbook of Research Methods and Applications in Economic Geography*

Editors: Charlie Karlsson, Martin Andersson and Therese Norman

Reference: Klaesson, J., Larsson, J. P., & Norman, T. (2015). Accessibility and Market Potential Analysis. In C. Karlsson, M. Andersson, & T. Norman (Eds.), *Handbook of Research Methods and Applications in Economic Geography* (pp. 412-435). Cheltenham, UK: Edward Elgar.

Abstract

The purpose of this chapter is to overview the two related concepts of accessibility and market potential. We consider the advances in the field of measuring and modeling the influence of geographic market potential or accessibility. In general the models are designed to assess the influence on location choices and growth performance. We trace the origins of these two ideas and show how they have been used in the literature. Moreover, we give an up to date review of the uses of these concepts, both in theoretical and empirical applications. We close the chapter by introducing an approach that employ the concepts in a somewhat novel way. The approach involves measuring accessibility in different distance bands while also considering the hierarchical (functional) structure in a system of regions.

1 Introduction

The purpose of this chapter is to overview the advances in the field of measuring and modeling the influence of geographic market potential and accessibility. In general the models are designed to assess the influence on location choices and growth performance.

Naturally, the area is too vast to allow for a thorough investigation into every detail of all models or applications. The route to be taken here is to paint a broader picture of the more important developments in the area since the mid-nineteenth century to the present day. The reasons for these limitations are obvious and manifold. Over and above the reason of the sheer mass of the literature, there is also the question of readability. We start this chapter by shortly reviewing some of the antecedents of the concepts of interest. These are spatial interaction, gravity and potential. In 1858 Carey made the following statement:

"Man tends of necessity to gravitate to his fellow-man. Of all animals he is the most gregarious, and the greater the number collected in a given space the greater is the attractive force there exerted, as is seen to have been the case with the great cities of the ancient world, Nineveh and Babylon, Athens and Rome, and as is now seen in regard to Paris and London, Vienna and Naples, Philadelphia, New York and Boston. Gravitation is here, as everywhere else in the material world, in the direct ratio of the mass, and in the inverse one of the distance". (Carey, 1858, as reproduced by Erlander, 1980)

In these short sentences, Carey manages to provide all the basic ideas that lay behind the later development of spatial interaction theory and market potential concepts. The two basic facts concerning spatial interaction are the importance of mass and distance. Interaction increases with mass and decreases with distance. Also, closely linked to these sentences are some ideas that seem central to the development of regional science at large and to economic geography and international trade theory. Today we would express this in terms of economies of specialization, increasing returns to scale and, in the case of regional science and economic geography, economies of localization and urbanization.

A partial statement of the theory of social gravitation can be found in the work of Ravenstein from 1885 (according to Carrothers, 1956, pp. 94-95). In an effort to explain migration Ravenstein stated that migratory movement tended towards large cities and that this movement tended to decrease with distance. According to Sen and Smith (1995, p. 2) the first formal analogy to Newtonian physics was made by Young in 1924. Young studied movement among farm populations. Carrothers (1956) states that Young hypothesized that the relative volume of migration to a given destination from each of several sources differs directly with the "force of attraction" and inversely with the square of distance. However, Young was apparently reluctant to formulate his hypothesis in an exact form. Sen and Smith (1995) report that Young stated that human migration *"does not lend itself to exact mathematical formulations"*.

Batten and Boyce (1986, p. 359-360) claim that the reference model and departure for modern economic analysis of spatial interaction is a study of retail trade. They refer to Reilly who performed this study in 1931. In this study he stated his law, which subsequently has become known as "Reilly's Law":

"Two cities attract trade from an intermediate town in the vicinity of the breaking point, approximately in direct proportion to the population of the two cities, and in inverse proportion to the squares of the distances of the intermediate town." (Reilly, 1931, p. 9, According to Batten and Boyce, 1986. From the very start of economics as a discipline in its own right, there has been a relationship between economics and physics. For many sciences, physics has been the ideal science. For a more general presentation of this relationship see Hsieh and Ye (1991) and Mirowski (1989). In a more recent article Isard (1999) advocates the use of analogies from physics to regional science. In particular he suggests that over and above the use of gravity analogies regional scientists ought to investigate possible parallels in regional science to the other three basic forces in nature[1].

The pioneering impetus in the development of the gravity model originates from the work of Stewart (1948) and Zipf (1949). Stewart drew the analogy of physics to the limit by presenting his theory on demographic gravitation. Stewart formulated concepts directly analogous to its physics counterparts. Thus, he introduced concepts like *demographic force*, *demographic energy* and *potential of population* (Stewart, 1948, pp. 34-35). In introducing these concepts he formulated an agenda for social physics. Apparently Zipf made his contribution to the theory of gravitation in the social science totally unaware of the work of Stewart. In his work Zipf launched his "*Principle of Least Effort*", by which he meant that "every individual's movement, of whatever sort, will always be over paths and will always tend to be governed by one single principle". It is interesting to note that both Stewart and Zipf justify their method of research by drawing on the success of the natural sciences compared to

[1] These forces are the weak and the strong force and the electromagnetic force. Possibly the use of these concepts can replace the relatively outmoded set of concepts (according to Isard) of scale, localization and urbanization economies.

the social sciences. Stewart (1948, p.31) encourages social scientists to study society as a whole and draw analogies to physical laws of gases. He states that if a physicist would study the temperature or the pressure of a gas he would not get a hint of these phenomena from studying *"... the rapid and intricate movement of a single molecule". He also states that progress in the social field "has been very slow because they (the social scientists) always insist on knowing too much"*. Zipf (1949) states in the foreword that *"we might gain considerable insight into the mainsprings of human behaviour if we viewed it purely as a natural phenomenon like everything else in the universe, and if we studied it with the same dispassionate objectivity with which one is want to study, say, the social behaviour of bees, or the nestbuilding habits of birds"*. Carrothers (1956) illustrate parallels to physics in the conclusion of his article:

"The behavior of molecules, individually, is not normally predictable, but in large numbers their behavior is predictable on the basis of mathematical probability. Similarly, while it may not be possible to describe the actions and reactions of the individual human in mathematical terms, it is quite conceivable that interactions of groups of people may be described in this way."

Carrothers also discuss the differences between molecules and humans, in the following way:

"... the individual human being can make decisions with respect to his actions, while the individual molecule (presumably) cannot. This does not imply that interaction of humans in large numbers cannot be described mathematically, but it does mean that the threshold where the power of individual decision-making critically affects the result must be determined before the concepts can be broadly applied in practice."

The rest of this chapter is organized as follows. In the next section we introduce the concept of market potential. In this section we briefly discuss its relation to gravity and spatial interaction modeling. Section 3 introduces the related concept of accessibility and its various uses and definitions. Section 4 discusses different forms of the distance-decay function, which is an integral part of most variants of the accessibility measure. Section 5 introduces the different fields of research where variants of market potential and accessibility have been used. In section 6 we mathematically derive the notion of market potential as understood and used in the theoretical and empirical literature based on the modeling tradition of "new economic geography". Section 7 and 8 introduces some specific uses of accessibility and market potential in the literature. In these two sections some elaborations of the measures is also introduced. Section 9 concludes and gives a summary of the previous expositions and discussions.

2 Background of the concept: Market Potential

According to Isard (1960), Stewart speaks of population potential of a point as a measure of the proximity of people to that point, or of aggregate accessibility, and more simply as a measure of influence at a distance, i.e. spatial discounting. It is interesting to observe that Stewart (1948, p. 35) noted that demographers at that time lacked a measure like potential *"... of the influence of people at a distance."*

Population potential can be thought of as the nearness of a given place to the population of the entire system. If calculations of population potential are performed for every place in the system the resulting values can be mapped to give a surface of population potential. (Dicken and Lloyd, 1990, pp. 181-182)

The gravity model of spatial interaction was originally designed in analogy with the physical law of gravitation formulated by Isaac Newton in 1687. The law of gravity states that the force between two objects is proportional to the product of the two masses and inversely proportional to the square of the distance between them. In mathematical terms this can be written as:

$$F = g\frac{m_1 m_2}{r^2} \tag{2.1}$$

Where F is the force of gravity between the masses m_1 and m_2, r is the distance between them and g is the constant of gravity. Below we can see the similarity between equations (2.1) and (2.2).

In order to show the relationship between spatial interaction and potential we start out by stating the basic gravity formula:

$$T_{ij} = kO_iD_jf\left(c_{ij}\right) \tag{2.2}$$

T_{ij} is some flow (e.g. commuting, migration or trade) from location i to location j. O_i and D_j measures the mass (e.g. population or some measure of economic activity) at locations i and j. c_{ij} denote some measure of generalized travel costs (e.g. distance, travel time, costs or a combination of these) between location i and location j. f is a decreasing function of distance and is often referred to as a distance-decay or distance-friction function. The distance-decay function replicates the empirical fact that the interaction between two locations decrease as the distance between them increase. k is a parameter. If we sum up all T_{ij}:s over all j:s and divide by kO_i we obtain:

$$P_i = \frac{\sum_j T_{ij}}{kO_i} = \sum_j D_j \, f(c_{ij}) \qquad (2.3)$$

In equation (2.3) P_i can be thought about as the potential of location i. P_i is expressed as the sum of all flows leaving location i divided by the size location i. The interesting formula, however, is found on the right hand side of the second equality sign. The size of the potential in location i increases with the size of the surrounding locations (D_j) and it decreases with the distance to those locations. So, the potential measure is a sum of location sizes where a function of distances works as weights.

In a classic study by Harris (1954) a similar measure was used. He studied retail sales per county in the US and defined market potential as:

$$MP_i = \sum_{j=1}^{n} \frac{M_j}{d_{ij}} \qquad (2.4)$$

In this formula MP_i is the market potential in county i, M_j measures the size of the market at j in terms of retail sales per county and d_{ij} is the distance between i and j in terms of estimated transportation cost. We can see that equations (2.3) and (2.4) are qualitatively the same. In Harris definition the distance-decay function is just the reciprocal of distance.

3 Background of the concept: Accessibility

Intuitively the idea of accessibility can be understood in a fairly straightforward way. However, there is an abundance of concepts, which have been termed accessibility. When it comes to defining accessibility in an operational form there is perhaps more consensus among scholars. Still, accessibility remains a somewhat vague concept as it lacks a clear and agreed upon definition.

Accessibility has played a major role in transport and regional research for several decades (Martellato and Nijkamp, 1998). Measurements of accessibility have become important monitoring instruments of regional development for policy makers and practitioners. This is due to the vast amount of scientific literature pointing to the fact that accessibility to markets, services and infrastructure is a major determinant of economic status and welfare (Yoshida and Diechmann, 2009). In itself, accessibility is important for regional development since locations with better access to input materials and markets will be more productive, gain competitive advantage over more remote locations and hence be more successful (Spiekermann and Wegener, 2007). The benefits households and firms in a region have access to due to the existing transport infrastructure can be measured by the region's accessibility. The quality of the transport infrastructure in terms of capacity, connectivity, and travel speeds, etc. affects the region's accessibility, which will determine its locational advantage in relation to other regions (Spiekermann and Wegener, 2007).

There are basically two ways of approaching the measurement of accessibility. They can be labeled micro-oriented and macro-oriented respectively. The first approach relates to consumer surplus in microeconomic theory. The second approach is of an older date and relates to gravity-potential type of measure. (Weibull, 1980)

Reggiani (1998) state that in its most basic form accessibility can be interpreted as the potential of opportunities. It can be operationalized as:

$$Acc_i = \sum_j D_j f(c_{ij}) \qquad (3.1)$$

Acc_i is the accessibility of location i to opportunities D_j in locations j where c_{ij} is the distance between locations i and j. Notice that this corresponds exactly to the potential measure in equation (2.2).

In table 3.1 below, six different accessibility measures are presented. The table is adapted from Martellato, Nijkamp and Reggiani (1998, p. 162) and Reggiani (1998, p. 2). The table presents the respective mathematical formulation and a list of authors using the individual accessibility measures

Table 3.1: *Measures and Formulations of Accessibility*

Accessibility Measure	Formulations	Authors
Potential of opportunity	$Acc_i = \sum_j D_j e^{-\beta c_{ij}}$	Hansen (1959) Ingram (1971) Wilson (1971) Domanski (1979) Weibull (1980) Bröcker (1989) Bruinsma and Rietveld (1993) Rietveld and Nijkamp (1993) Forslund and Johansson (1993) Suarez (1995)
Physical Measure	$Acc_i = \sum_j d_{ij}$ or $Acc_i = \sum_j W_j d_{ij}$	Wachs and Kumagai (1973) Vickerman (1974) Mattson and Weibull (1981) Moretti (1989) Cattan (1992)
Utility	$Acc_i = \ln \sum_j D_j e^{-\beta c_{ij}}$	Neuberger (1971) Wilson (1976) Williams (1977) Leonardi (1978) Williams and Senior (1978) Ben-Akiva and Lerman (1979) Leonardi and Tadei (1984) Bröcker (1989) Forslund and Johansson (1993)
Inverse function of competition	$Acc_i = \frac{1}{A_i}$	Wilson (1982) Fotheringham (1983) Reggiani (1985) Matthes (1994)
Joint Accessibility	$Acc_i = \sum_j Acc_j D_j e^{-\beta c_{ij}}$ Where $Acc_j = \sum_k D_k e^{-\gamma c_{jk}}$	Domanski (1979) Fotheringham (1986) Reggiani (1985) Nijkamp and Reggiani (1992)
Dynamic accessibility	$Acc_i(t) = \frac{1}{A_i^*(t)}$	Nijkamp and Reggiani (1988)

Source: adapted from Martellato, Nijkamp and Reggiani (1998)

The following discussion of the six different accessibility measures draws heavily on Martellato, Nijkamp and Reggiani (1998, pp. 163-170)

Accessibility as a potential of opportunity

This measure of the nearness to opportunities is the most widely used concept. According to Weibull (1980 p. 54) this concept of accessibility is often related to concepts like:

1. Nearness
2. Proximity
3. Ease of spatial interaction
4. Potential of opportunities of interaction
5. Potentiality of contacts with activities or supplies

These opportunities can concern, for example, work places, medical care, shopping, leisure activities and so on. Each of these particular opportunities is connected to attributes such as distance, mode of transport, travel time/cost, supply capacity, price, quality, congestion, queuing time etc. The accessibility measure considered here includes a measurement of the opportunities at node *j* discounted by the spatial distance (travel time/cost) of *j* from a reference node *i*. Thus, the total accessibility of all opportunities implies a discounting of the total number of opportunities at all nodes by the sum of distances from the reference node. Formally it can be written as:

$$Acc_i = \sum_j D_j f\left(c_{ij}\right) \qquad (3.2)$$

Where Acc_i is the accessibility at node i, D_j is a measure of opportunities at node j, c_{ij} is the cost of travelling from node i to node j and $f(c_{ij})$ is the distance-decay function from node i to node j. Different forms of the distance-decay function will be discussed later in the text. The accessibility measure in equation (3.2) has some limitations. The first limitation is concerned with aggregation, i.e. the consideration that all individuals in the same node have the same accessibility. The second limitation is concerned with the size of the nodes. In effect this means that intranodal improvements in infrastructure are neglected. Both these limitations can be solved however by a finer zonal subdivision. A more profound limitation with (3.2) is that opportunities inside one zone or in different zones are simply summed (after some spatial discounting). This implies that the variability in the supply of opportunities cannot be accounted for.

Accessibility as a Physical Measure

Another measure of accessibility is a direct function of the distance d_{ij} from node i to node j. In this approach the physical separation of two nodes is a measure of the accessibility of one to the other. This can be defined as:

$$Acc_i = \sum_j d_{ij} \quad (3.3)$$

In this expression d_{ij} is the distance between node i and node j. Of course, this measure can be weighted by attributes of activities in node j:

$$Acc_i = \sum_j W_j d_{ij} \quad (3.4)$$

Here W_j is a weight related to node j. The main difference between equation (3.2) and (3.4) is that the former will get higher for higher efficiency in the infrastructure while the latter will get lower (if distance is measured as time or cost).

Accessibility as utility

In this approach accessibility is related to consumer surplus in microeconomic theory. Here the welfare associated with opportunities at j for an agent can be derived as:

$$u_{ij} = v_{ij} - \beta c_{ij} \quad (3.5)$$

Where u_{ij} represent the net benefit, consisting of a component v_{ij}, which refers to the value of accessing, i minus communication costs c_{ij} and β is a cost-sensitivity parameter. Here the maximum net benefit is an indicator of locational advantage. From the theory of stochastic choice one can derive two accessibility measures (see Ben-Akiva and Lerman, 1985):

$$Acc_i = \ln \sum_j \exp(u_{ij}) \quad (3.6)$$

or

$$Acc_i = \ln \sum_j D_j \exp(-\beta c_{ij}) \quad (3.7)$$

In equation (3.7) $D_j = \exp(v_{ij})$ is a measure of utility in node j rather than opportunities in node j. The utility-maximizing approach offers an economic background to accessibility and is used to derive welfare measures for cost-benefit assessment of transport investments and other transport policies. It has also been applied in integrated transport and land-use models to locate activities such as households, workplaces etc.

Accessibility as an Inverse Function of Competition

This approach relates accessibility to the inverse balancing factors in a constrained gravity model (Wilson, 1971; Neuburger, 1971). It takes both the supply and demand side of accessibility into account since it gives an indication of the number of opportunities and the number of opportunity seekers (Manaugh and El-Geneidy, 2012). In this formulation accessibility can be measured as:

$$Acc_i = \frac{1}{A_i} = \sum_j B_j D_j f(c_{ij}) \tag{3.8}$$

for a doubly constrained model, and:

$$Acc_i = \frac{1}{A_i} = \sum_j D_j f(c_{ij}) \tag{3.9}$$

for an origin-constrained model. Although these definitions are formally equivalent to accessibility as a potential of opportunity as discussed above, Acc_i here comes from a calibration process in a spatial interaction model and are not given a priori. This measure calculates the supply and the demad potential for all of the zones iteratively, making sure that the number of trips to and from each zone is equal to the number of opportunities (Geurs and Ritsema van Eck 2003).

Accessibility as Joint Accessibility

This accessibility measure arises from the concept of sequential decision-making. In the case of a two-stage decision making process towards two levels of nodes *j* and *k*, the joint accessibility can be written as:

$$Acc_{J,i} = \sum_j Acc_j D_j \exp\left(-\beta c_{ij}\right) \tag{3.10}$$

where

$$Acc_j = \sum_k D_k \exp\left(-\gamma c_{jk}\right) \tag{3.11}$$

This can be thought of as embedding in node *i*:s accessibility to node *j*, the easiness of reaching opportunities in other nodes *k* from node *j*.

Dynamic Accessibility

An attempt at deriving a dynamic accessibility measure is presented in Nijkamp and Reggiani (1988). They use a dynamic entropy approach with related dynamic accessibility factors. Their dynamic factors can be written as:

$$Acc_i(t) = \frac{1}{A_i^*(t)} \tag{3.12}$$

where

$$A_i^* = \left(\sum_j B_j^* D_j \exp(-\beta c_{ij}) \right)^{-1} \tag{3.13}$$

and

$$B_j^* = B_j G_j \tag{3.14}$$

A_i and B_j are calibration factors and G_j is a dynamic accessibility factor. All variables in this approach are time dependent.

One much used application of the potential and accessibility concept is to use them to draw maps. In the same way as a topological map records lines of equal height above sea level, a map can be constructed that record lines of equal accessibility or potential. Accessibility measures can also be used in a production function framework (e.g. Bergman and Sun, 1996, p. 20). That is, when estimating a regional production function an argument can be in the form of an accessibility measure. An advantage with such a specification is that one can represent factors in a smaller region, which are not actually located there. For example, a smaller region may not have its own university, but inhabitants may still have access to higher education elsewhere. Accessibility measures are also used in activity location models, where accessibility is the way through which the quality of the transport system influences the land use.

Rietveld and Bruinsma (1998, pp. 39-41) points out that there are some important problems in the measurement of accessibility. In their opinion these are:

1. The dimension of measurement. Some measures of accessibility have a clear dimension and are easy to interpret. However, some accessibility measures do not have a clear dimension and must use indexing for the purpose of comparing nodes.
2. The choice/demarcation of nodes. Three different approaches can be identified. First, an approach is to use nodes that do not cover the entire area under study. This

approach can be chosen when for example, studying major cities. A second approach is to use nodes that represent regions so that the total area is covered. Third, the emergence of GIS has made it possible to use grids. The advantage of this choice is that the nodes are exogenously given. However, when the accessibility of cities or other places are to be assessed one needs to decide which grids that should represent actual places.

3. Demarcation of total area. The demarcation of the area studied is very important. In general, the smaller the distance sensitivity is the larger the total area should be. In many studies the spatial demarcation coincides with borders (e.g. regional borders, national borders, or, for example, the borders of the European Union). The problem is that locations near borders of the study area tend to get low accessibilities compared to central locations. In reality, borders are not generally completely closed so accessibility measurement should not stop at borders. On the other hand, it is likely that the distance-decay function ought to reflect borders.
4. Treatment of internal accessibility. For some accessibility measures the internal accessibility have a substantial effect. The general problem is that the internal transport infrastructure data are weak. One route is to ignore internal accessibility, but this may lead to counterintuitive results. For instance, small towns near a big city might have higher accessibility than the big city itself.

What accessibility precisely indicates depends on the formulation of the measure. For example, accessibility to population is an indicator of market size for suppliers of goods and services, whereas accessibility to GDP could be an indicator of the market size for suppliers of high-level business services (Spiekermann and Wegener, 2007).

4 The Distance-Decay Function

In this section the distance-decay function referred to above will be discussed. Above the particular form of the function was not thoroughly discussed. Of course in pure theory it suffices to use a general function, whose properties are known (or assumed). However, for empirical work the form of the distance-decay function is of great importance. Essentially, the distance-decay function is a description of how spatial phenomena are discounted across space.

Beckmann (1999, p. 1) states that the role of distance can be summarized as: Interaction decreases with distance. He asserts that this "law" is as universal as the "law of demand". Distance influence relations in economics and economic geography in two ways: first, natural resources are distributed unevenly across space, and second, distance separates various activities from each other.

Ever since gravity models became popular in the 1940:s and 1950:s much of the debate has centered on the distance effect. How should one model the effect of distance on spatial interaction? In the early models of spatial interaction (e.g. Stewart (1948), Zipf (1949), Carrothers (1956) and Hansen (1959)) distance entered as a reciprocal (or negative power) function. Thus, distance would enter according to c_{ij}^{-k}. Where c_{ij} is the distance between i and j and k is a constant. Early on (Stewart (1948), p. 34), k was considered to be an integer in line with the physical concepts gravitational force ($k = 2$) and gravitational energy ($k = 1$). Hansen (1959) and Carrothers (1956) saw no reason why k ought to be an integer. Their argument was that the size of the constant should be determined empirically and not be subject to any physics analogy.

Later the negative exponential function became popular (Ingram (1971)). Using this formula distance would enter as $\exp(-\lambda c_{ij})$. Where h is a constant.

These two formulations can be combined to form a measure based on the normal or Gaussian curve. According to Ingram (1971) the reciprocal and the negative exponential function has a major disadvantage. This disadvantage is that they decline rapidly close to the origin and then level out. The Gaussian curve amends this shortcoming by having a relatively flat top. A representation for the Gaussian curve can be written as $\exp(-hc_{ij}^{-k})$. Figure 4.1 below shows the general form of different types of distance decay curves.

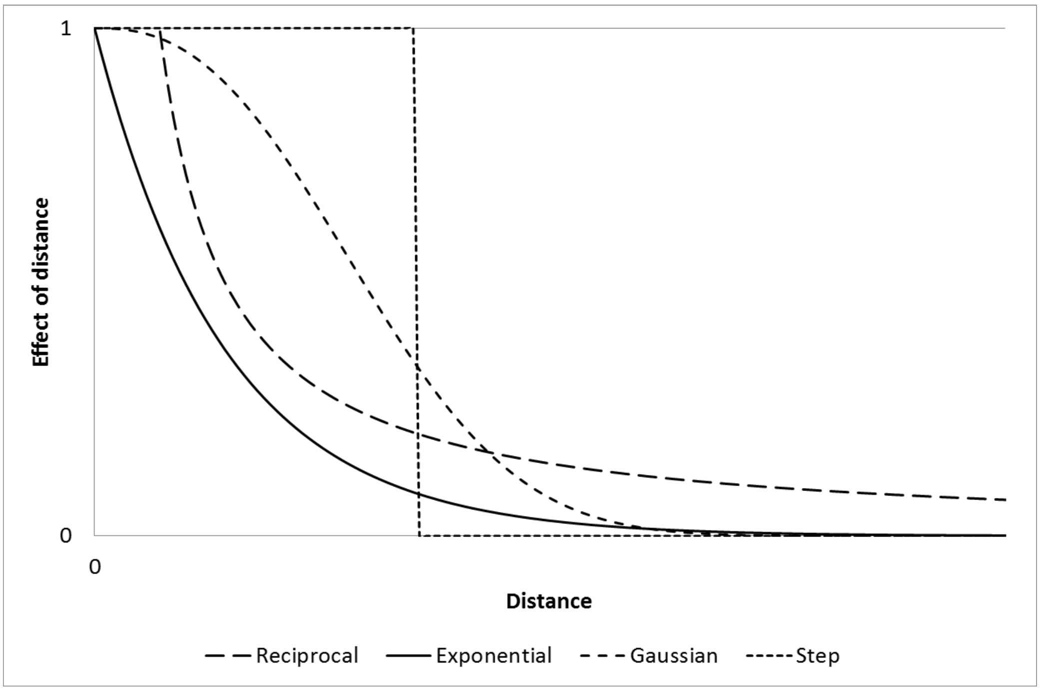

Figure 4.1: *Four different distance-decay functions*

Another way to let distance play a role is to use a step (or rectangular) function (Ingram, 1971). According to this approach distance does not have any effect at all for small distances. For distances larger than some fixed value the effect is infinite. Such a step function is also shown in figure 4.1. These functions are also often called distance deterrence functions since they represent the disincentive to travel as distance, time or cost increases.

Song (1996) evaluates nine different accessibility measures by means of regression analysis. He tries to explain population density by accessibility to jobs. Using maximum explanatory power as the criterion he concludes that the accessibility measure with an exponential distance-decay function [$\exp(-\lambda c_{ij})$] performs best. This functional form is the one with the most well-founded theoretical underpinning, e.g. from random utility theory. In the case where theory does not provide any specific functional form one way to go forward is to let the empirical setting decide using some criteria for evaluating the "best fit". This means that one must choose both functional form and the values of the parameters determining the curve simultaneously.

5 Accessibility and market potential in different fields of research

The concept of accessibility and market potential has been applied to many different, but related, fields of research. In urban sciences accessibility is a key variable in the determination of urban land rents and densities (Alonso, 1964). In regional sciences, accessibility plays an important role for analyzing the spatial distribution of economic activity and regional development (Krugman, 1991; Fujita et al., 1999). Within regional science, the attempt to predict and explain the spatial distribution of economic activity has become known as economic geography (Head and Mayer, 2005). Research in economic geography attempts to answer the question: what forces cause agglomeration? After the formative publications of Krugman in 1991, the focus of research turned to models that moved agglomerative forces out of the production function and into the interaction between transport costs and plant-level scale economies (Holl, 2007). Krugman's approach have later become known as the 'New Economic Geography'.

The main difference between urban economics and New Economic Geography is that "inter-city" interdependencies are typically not taken into account in the urban economics literature (Brakman, Garretsen, van Marrewijk, 2009). The New Economic Geography stresses spatial linkages between locations in order to describe the attractiveness of a region, whereas it is the intraregional characteristics that matters most in urban economics. From an accessibility perspective, intraregional accessibility is analyzed in urban economics while interregional accessibility is of interest in New Economic Geography theory. Taking inter-city interdependencies into account requires distance deterrence functions with thicker tails. Empirical work on the New Economic Geography, such as the papers by Davis and Weinstein (1999, 2003), Hanson (2005), and Redding and Venables (2004) statistically link the spatial distribution of production and wages to the spatial distribution of demand. These papers show that a complex construction of access to demands originating from all regions – the real market potential – is key to the economic progress of regions (Holl, 2007).

The literature in New Economic Geography suggests that improving accessibility to large cities or markets allows rural communities to take advantage of economic and employment opportunities. Furthermore, in this line of literature, accessibility to urban agglomeration could also lead to negative externalities due to congestion, competition and high input prices. Various hypotheses from the New Economic Geography on externalities from urban agglomeration have been tested using accessibility indices; such as whether access to urban agglomeration causes firms to become more productive (Yoshida and Diechmann, 2009). Niebuhr (2006) investigates the significance of market access for regional wages and the geographic extent of demand linkages for a cross section of European regions. One of the main propositions of the New Economic Geography is confirmed; that access advantages raise factor prices and that demand linkages affect the geographic distribution of economic activities.

In order to measure direct micro-economic welfare effects in a cost-benefit analysis in theory two classical economic benefit measures are usually applied: Marshallian consumer surplus (income effect) and Hicksian compensation variation (substitution effect). Previously, the production function approach based on macro-economic theories with GDP as a measure of welfare benefits has been used to analyze the wider economic benefits (indirect welfare effects) of land-use or transport changes (Aschauer, 1989; Munnell, 1990; for overview see: Rietveld and Bruinsma, 1998;). In recent years however, accessibility indicators play a key role in the calculation of economic benefits of transportation or land-use investments (Song, 1996; Johansson et al., 2002, 2003).

In the evaluation of transport policies, researchers use infrastructure-based accessibility measures. Geurs and van Wee (2004) identify four components that should be incorporated into an infrastructure-based accessibility measure: (i) the quality of transport services (transport component), (ii) the amount and distribution of the supply of and demand for opportunities (land-use component), (iii) temporal constraints (temporal component) and (iv) it should take individual needs, preferences and abilities into account (individual component). Earlier infrastructure-based accessibility measures aim to describe how the transport system functions, such as travel times, congestion and operating speed on the road network. These infrastructure based measured are all easy to interpret and communicate but do not prove to be useful in the evaluation of accessibility impacts of land-use and transport system strategies since they commonly do not incorporate the land-use component, and temporal- and individual elements (Geurs and van Wee, 2004).

Furthermore, in traditional transport project appraisals access is used as input for the established rule-of-half measure of consumer surplus (Tressider et al., 1968). The measure estimates the full benefits obtained by original travelers and half the benefit obtained by new travelers (Geurs and van Wee, 2004). This measure has received repeated criticism since it results in incorrectly measured welfare effects of land-use policy plans; it only estimates benefits for the origin–destination combinations where (generalized) costs change and ignores changes in the relative attractiveness of locations due to land-use changes (Geurs et al., 2006; Neuburger (1971). In recent years, the logsum benefit measure has been applied to calculate infrastructure-based accessibility measures since it provides a more accurate benefit estimate of transport projects than the rule-of half benefit measure (de Jong 2005; Geurs et al., 2010). Geurs, Zondag, de Jong and de Bok (2010) show that logsum accessibility benefits from land-use policy strategies can be quite large compared to investment programs for road and public transport infrastructure.

6 Market potential in the New Economic Geography literature

The New Economic Geography literature provide a theoretical foundation for the concept of market potential. This section outlines a model of market potential derived from the New Economic Geography, which many empirical applications are based upon. The following mathematical derivations build on the work by Fujita, Krugman and Venables (1999), Brakman, Garretsen and van Marrewijk (2009), and Combes, Mayer and Thisse (2008).

We start with the demand side of the economy. Consumers derive utility from two goods. The first is a homogenous agricultural good (*F*, food) produced under constant returns and perfect competition. The second is a manufactured good (M) consisting of a large number of differentiated varieties produced under increasing returns and imperfect competition. The consumers (in region *j*) preferences are of the Cobb-Douglas type and utility is given by:

$$U_j = M_j^{\delta} F_j^{1-\delta}, 0 < \delta < 1 \qquad (6.1)$$

δ denotes the manufactured goods expenditure share. M_j is defined as an aggregate of R varieties. The standard Dixit-Stiglitz approach uses the constant elasticity of substitution (CES) function to construct the aggregate consumption of manufactures:

$$M_j = \sum_{i=1}^{R} \left(n_i c_{ij}^{(\varepsilon-1)/\varepsilon} \right)^{\varepsilon/(\varepsilon-1)}, \varepsilon > 1 \qquad (6.2)$$

c_{ij} denotes consumption in region j for a variety produced in region i. ε is the elasticity of substitution. Let Y_j denote the income (expenditure) of region j and p_{ij} denote the price of a variety produced in region i and sold in region j. The standard two-step utility maximization yields the following demand in region j for products produced in region i:

$$c_{ij} = \delta Y_j I_j^{\varepsilon-1} p_{ij}^{-\varepsilon} \qquad (6.3)$$

I_j is the price index in region j, defined as:

$$I_j = \left(\sum_{i=1}^{R} n_i p_{ij}^{1-\varepsilon} \right)^{1/(1-\varepsilon)} \qquad (6.4)$$

Introducing the simplified iceberg transport technology whereby for every unit shipped only $1/T_{ij}$ arrives at the destination and T_{ij} is the transport cost. This means that the demand in region j for products produced in region i must be rewritten as:

$$c_{ij} = \delta Y_j I_j^{\varepsilon-1} \left(p_i T_{ij} \right)^{-\varepsilon} \qquad (6.5)$$

The total sales of a firm in region i, c_i, is obtained by summing sales over all regions taking into account that the quantity shipped times T_{ij} corresponds to the quantity consumed:

$$c_i = \delta \sum_{j=1}^{R} T_{ij} Y_j I_j^{\varepsilon-1} \left(p_i T_{ij}\right)^{-\varepsilon} \qquad (6.6)$$

Turning to the supply side of the economy we concentrate at the manufacturing sector. This sector is subject to economies of scale. It is assumed that all firms use the same technology and that the labor requirements (l_i) for producing the amount c_i is given by:

$$l_i = \alpha + \beta c_i \qquad (6.7)$$

Where α is the fixed labor requirement and β is the marginal labor requirement. The wage is given to be w_i and profits are:

$$\pi_i = p_i c_i - w_i(\alpha + \beta c_i) \qquad (6.8)$$

Maximizing profits while using the expression for total sales above and taking the price index as exogenous gives the optimal mark-up pricing rule:

$$p_i = {}^{\beta w_i}\Big/_{\left(1 - \frac{1}{\varepsilon}\right)} \qquad (6.9)$$

Using the expression for total sales above again and solving for p_i and setting this equal to the pricing rule gives:

$$^{\beta w_i}\Big/_{\left(1 - \frac{1}{\varepsilon}\right)} = \left(\frac{\delta}{c^*} \sum_{j=1}^{R} T_{ij} Y_j I_j^{\varepsilon-1} \left(p_i T_{ij}\right)^{-\varepsilon}\right)^{\frac{1}{\varepsilon}} \qquad (6.10)$$

Solving for the wage rate gives:

$$w_i = \left(\frac{\beta\varepsilon}{\varepsilon-1}\right) \left(\frac{\delta}{c^*} \sum_{j=1}^{R} T_{ij} Y_j I_j^{\varepsilon-1} \left(p_i T_{ij}\right)^{-\varepsilon}\right)^{\frac{1}{\varepsilon}} \qquad (6.11)$$

This is the so-called wage equation where c^* is equilibrium production. In this expression we see that MP_i can be interpreted as market potential as defined below:

$$MP_i = \sum_{j=1}^{R} T_{ij}^{1-\varepsilon} Y_j I_j^{\varepsilon-1} \qquad (6.12)$$

The classical market potential function states that the market potential of region i is large when firms in this region face a large demand from surrounding regions j. Thus, the size of a regions' market potential depends positively on demand coming from other regions and negatively on the distance to these regions.

In expression (6.12) the market potential depend negatively on transport cost ($T_{ij} \approx$ distance or transport cost). It depends positively on the demands coming from other regions (Y_j). The third effect is not present in the traditional measure of market potential, which is the effect of competition as measured by the price index I_j.

Then we can write the total sales of a firm in region i as:

$$c_i = \delta p_i^{-\varepsilon} MP_i \tag{6.13}$$

The wage equation can be expressed as:

$$w_i = \left(\frac{\beta\varepsilon}{\varepsilon-1}\right) p_i \left(\frac{\delta}{c^*} MP_i\right)^{\frac{1}{\varepsilon}} \tag{6.14}$$

These two last equations give that the sales of a representative firm in region i increases with higher market potential and that the wage rate also increases with higher market potential.

Variations of these two last equations have been used as a basis in numerous empirical studies. Examples of analyses in this tradition includes Crozet (2004) assessing migration, Head and Mayer (2011) dealing with economic development in terms of income per capita, Fingleton (2006) investigate local wage rates, Fallah, et. al. (2011) analyze wage disparities, López-Rodriguez et. al. (2005) focus on attainment of education levels and Klein and Crafts (2012) investigate the location of manufacturing. This is not an exhaustive list of studies but rather examples of different types of questions analyzed. The emphasis of the market potential measure derived in the framework of New Economic Geography is on spatial interdependencies; i.e. the performance of a region heavily depends on the developments in and characteristics of neighboring regions. In the next section, we briefly discuss some applications of market potential and accessibility in the literature.

7 Empirical applications: the case of Sweden

We close this chapter with a discussion of a applicable measure for market size, taking the surrounding geography into account. In the construction of this market potential, or accessibility measure we follow Johansson et. al. (2002, 2003), in taking a step towards a continuous view of geography.

Accessibility to the sum of all Swedish wages in a municipality is used as the proxy for market potential in that municipality. The sum of all wages generated in a geographical unit is a reasonable measure of the amount of economic activity taking place there. By calculating the accessibility to wage sums we account for economic activity generated in neighboring places and hence acknowledge the fact that there almost certainly exist spillover effects across borders. Let D_i be the sum of all wages in region i and c_{ij} denote the distance measured in travel time between region i and region j. Finally, let β be a distance sensitivity parameter. Then the accessibility to wage sums in region i can be calculated as (equivalent to formula 3.2):

$$Acc_i = \sum_j D_j e^{-\beta c_{ij}} \tag{7.1}$$

Thus, Acc_i is the accessibility measure for region i, summing over all regions in the country. As in Johansson et. al. (2003) we recognize that the influence of accessibility may differ between different categories of regions from the viewpoint of i. To allow for this possibility we divide the sum in equation (7.1) into three parts. Starting with the region the accessibility is to be calculated for, i, that part of the sum is separated and is referred to as local accessibility. Second, the regions belonging to the same functional economic region (FER) as region i, is also separated from the sum and is referred to as inter-regional accessibility. Typically, a FER is a collection of regions (municipalities) between which there are frequent cross-border contacts. These contacts are in the form of commuting, retail travel and unplanned service contacts. Sweden is divided into 290 municipalities (urban regions), which are divided into 81 FERs based on the level and frequency of such cross-border relations. Hence, the FERs are highly integrated in terms of commuting flows, and inter-FER interaction is limited.

In figure 7.1 below the principal geographical layout is illustrated. The inner ring represents municipality i, the outer ring represents the functional economic region and the outer square represents the nation. The market potential as calculated for municipality i consist of i itself, the sum of accessibilities coming from municipalities j in the functional economic region, R, to which i belong, and the sum of accessibilities coming from municipalities in the rest of the country.

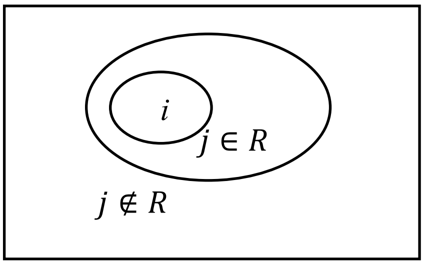

Figure 7.1: *Market potential divided into three parts*

Equations (7.2), (7.3) and (7.4) define the division of the accessibility into the three parts as described above. When calculating the three sub-sums we use the empirical finding in Johansson et. al. (2003) and recognize that the β:s are not the same, but particular for each component. For the municipal component β_1=0.02, for the regional component β_2=0.10, and for the extra-regional component β_3=0.05.

$$Acc_i = D_i e^{-\beta_1 c_{ii}} \tag{7.2}$$

$$Acc_R = \sum_{j\in R\setminus i} D_j e^{-\beta_2 c_{ij}} \tag{7.3}$$

$$Acc_{exR} = \sum_{j\notin R} D_j e^{-\beta_3 c_{ij}} \tag{7.4}$$

The parameters may be interpreted as mimicking a continuous "S" shaped curve (depicted in figure 7.2), where the distance-sensitivity for the average commuter is relatively low within the own urban region, quite high for commutes within other municipalities belonging to the same FER, and then again quite flat for commutes to the rest of the nation.

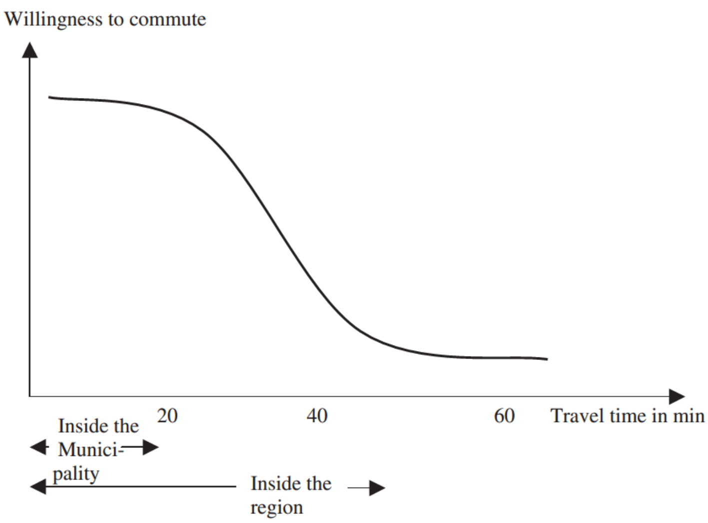

Figure 7.2: *Willingness to commute to other municipalities as observed for a medium-sized Swedish Functional Economic Region(FER).*
Source: adapted from Johansson et al. (2003).

Below in figure 7.3 three maps are shown depicting the three components of the accessibility measure. The maps show accessibility to wage sums for municipalities in the Stockholm region in Sweden. In the leftmost map we see the intra-municipal accessibility which basically depict the economic size of the municipalities discounted by their internal geographical size. In the middle map we see the regional accessibility. This basically high-lights municipalities with relatively large (in economic terms) neighbors in the same FER. The right map show inter-regional (or external) accessibility and high-lights municipalities belonging to FER:s neighboring other large (in economic terms) FER:s.

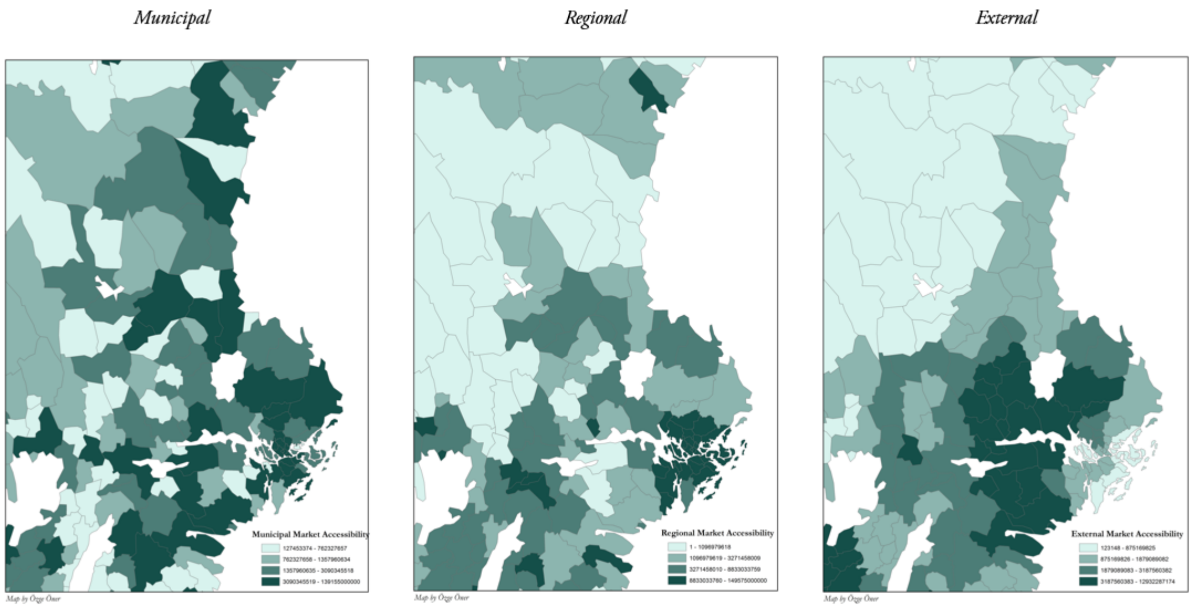

Figure 7.3: *Municipal, regional and extra-regional(external)market accessibility in Swedish municipalities*

Above, we have defined an exact and deliberate definition of an accessibility measure that we will use to exemplify market potential in this section. Next, we outline a methodology that can be used in empirical applications of these particular accessibility measures.

We follow Johansson (2007), and divide municipalities into three different categories. These three categories of municipalities include (i) all *central* municipalities in Sweden (the largest municipality in each FER), (ii) *non-central* municipalities in large FERs and (iii) *non-central* municipalities in small FERs.

These three types of municipalities differ in their empirical relevance, and they show substantial differences, both in their economic performance and in their industry composition.

Andersson and Klaesson (2009) show how such a categorization has empirical relevance for the development of diversity in retail and durables in Swedish municipalities.

The main difference is that type (iii) municipalities do not have convenient access to a large market place. Type (i) municipalities are the centers of their respective FERs, while type (ii) municipalities are still attractive, not least as a place to live, because of their close proximity to a large market; they are experiencing a kind of *"agglomeration shadow effect"* (Krugman, 1993). It is important to note that market *potential* is not necessarily the actual market, and that the summed up measure has a certain degree of overlap. E.g., since a person cannot make the same purchase at two different locations, there is an element of a zero-sum game included in a market potential measure (cf. Andersson & Klaesson, 2009).

In the Swedish setting a number of studies have used variants of the above set-up to analyze a multitude of phenomena dependent on access to markets or different types of resources. Here we will reference some of them in order to shed light on the multitude of questions that can be addressed using accessibility measures.

Andersson and Klaesson, (2006) show that the above outlined methodology lends itself to model spatial hierarchies of municipalities and how this facilitates the understanding of the development of ICT-service sectors. Andersson and Karlsson (2007) analyze the growth performance in regional value added per capita explained by accessibility to knowledge as measured by accessibility to R&D in firms and universities. The result of their analysis indicate that knowledge flows cross municipal borders, but that they tend to be bound within functional regions. Johansson and Karlsson (2007) studies the effects of accessibility to R&D resources on the diversity international exports from Swedish regions. Andersson and Hellerstedt (2009) use accessibility to wage-sums in order to explain start-up activity of knowledge-intensive business-service (KIBS) firms in Swedish municipalities. The find that it is the intra-municipal accessibility that is the principal explanatory variable in their modeling set-up.

Andersson and Gråsjö (2009) use the methodology outlined above and show that a representation of geography that reflects the possibility of interaction between municipalities by means of accessibility is a simple but effective alternative to spatial lag and spatial error models and that it captures spatial dependence.

Johansson and Klaesson (2011) model the growth of jobs in different sectors and analyze how job growth responds to changes in market access. They show that the relevant market may not only be the local market in each urban region, but also the surroundings markets, given that they are close enough in terms of time distance. The estimation results show that the change processes feature non-linear dependencies with varying spatial reach.

Karlsson & Backman (2011) examine the influence of accessibility to human capital on new firm formation. Accessibility-based measures to explain new firm formation are also used by Grek, Karlsson and Klaesson (2011). Karlsson & Nyström (2011) investigate the role of accessibility to university and company R&D for new firm formation.

Nilsson and Johansson (2013) analyze the determinants of agricultural land prices. One of the main conclusions is that accessibility to population reflecting urbanity is shown to be the main explanatory factor.

Karlsson and Gråsjö (2013) provide a further and more in-depth overview of the literature of this line of research, primarily considering Swedish studies.

The principal conclusion that is illustrated by these studies is that spatial patterns matter and that location choices of firms depend on the inner structure of each urban area, the intra-regional accessibility as well as accessibility to other regions.

8 Conclusion and Summary

Over the last decades we have seen a downward trend of transportation costs of people, goods and information. Intuitively, this should imply that firms and people become less restricted in their locational choices, which in turn should lead to a greater homogeneity across regions. However, there are still great variations across geographical space in terms of incomes, cost of living, regional structure of production, and so on. Accessibility and market potential analysis are two theoretical concepts that assist us in understanding the patterns of spatial location of individuals and establishments and the linkages between the locations.

The chapter has given an overview of the concepts accessibility and market potential. The measurement and modeling of these concepts in geographical space have been evaluated in different economic contexts, while considering the advances in the field. We have shown how accessibility and market potential indicators can be used to measure regional development and to assess locational choices of firms or people.

There is a general consensus among authors that accessibility is important for regional economic development and that spatial patterns matter. Measurements have improved over time as the quality and geographical precision of data has become more refined. In this chapter, we have introduced measures and showed how they can be used when estimating relationships in systems of regions.

References

Åberg, P. (2000), Three Essays on Flows – Trade, commuting and foreign direct investments, Licentiate Thesis, Division of Regional Planning, Royal Institute of Technology.

Alonso, W., 1964. Location and Land Use. Harvard University Press, Cambridge, Mass.

Andersson, J. (1979), ”A Theoretical Foundation for the Gravity Equation”, American Economic Review, 69(1), pp. 106-116.

Andersson, M., & Gråsjö, U. (2009). Spatial dependence and the representation of space in empirical models. The annals of regional science, 43(1), 159-180.

Andersson, M., & Hellerstedt, K. (2009). Location Attributes and Start-ups in Knowledge-Intensive Business Services. Industry and Innovation, 16(1), 103-121.

Andersson, M., & Karlsson, C. (2007). Knowledge in regional economic growth—the role of knowledge accessibility. Industry and Innovation, 14(2), 129-149.

Andersson, M., & Klaesson, J. (2006). Growth Dynamics in a Municipal Market-Accessibility Hierarchy. In The Emerging Digital Economy (pp. 187-212). Springer Berlin Heidelberg.

Andersson, M., & Klaesson, J. (2009). Regional interaction and economic diversity: exploring the role of geographically overlapping markets for a municipality's diversity in retail and durables. In C. Karlsson, B. Johansson & R. R. Stough (Eds.), Innovation, Agglomeration and Regional Competition. Cheltenham, UK: Edward Elgar.

Annals of the Association of American Geographers 44, 315-348.

Aschauer, D. A. 1989. Is public expenditure productive? Journal of Monetary Economics, 23, 177-200.

Batten, D. (1981), Entropy, Information Theory and Spatial Input-output Analysis, Umeå Economic Studies, No. 92.

Batten, D. F. Boyce, D. E. (1986), “Spatial Interaction, Transportation, and Interregional Commodity Flow Models”, in Handbook of Regional and Urban Economics, Volume I, Regional Economics, Elsevier, Amsterdam, pp. 357-406.

Batten, D. F. Karlsson, C. (1996), Infrastructure and the Complexity of Economic Development, Springer-Verlag, Berlin.

Beckmann, M. J. (1999), Lectures on Location Theory, Springer-Verlag, Berlin.

Ben-Akiva, M. Lerman, S. R. (1985), Discrete Choice Analysis – Theory and Application to Travel Demand, Cambridge, MA: MIT Press.

Bergman, E. M. Sun, D. (1996), "Infrastructure and Manufacturing Productivity: Regional Accessibility and Development Level Effects", in Batten and Karlsson.

Bergstrand, J. H. (1985), "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence", Review of Economics and Statistics, 67, 474-81.

Berman, B. Evans, J. R. (1998), Retail Management – A Strategic Approach, Prentice Hall, New Jersey.

Bjurklo, L-G. (1995), Assessing Methods to Estimate Delivery Flows and the ERG Model, Department of Infrastructure and Planning, Royal Institute of Technology, Sweden.

Brakman, S., Garretsen, H. and Marrewijk, C. (2009). Economic Geography Within And Between European Nations: The Role Of Market Potential And Density Across Space And Time. Journal of Regional Science, Wiley Blackwell, 49(4), pages 777-800.

Burns, L. D. (1979), Transportation, temporal, and spatial components of accessibility, Lexington, Mass.: Heath.

Button, K. Nijkamp, P. Priemus, H. (1998), Transport Networks in Europe – Concepts, Analysis and Policies, Edward Elgar, USA.

Carrothers, G. A. P. (1956), "A Historical Review of the Gravity and Potential Concepts in Human Interaction, Journal of the American Institute of Planners, 22, pp. 94-102.

Coccossis, H. Nijkamp, P. (Eds.), (1995), Overcoming Isolation – Information and Transportation Networks in Development Strategies for Peripheral Areas, Springer-Verlag, Berlin.

Combes, P. P., Mayer, T., Thisse, J.T. (2008). Economic Geography: The Integration of Regions and Nations. Princeton: Princeton University Press

Crozet, M. (2004). Do migrants follow market potentials? An estimation of a new economic geography model. Journal of Economic Geography, 4(4), 439-458.

De Jong, G., M. Pieters, A. Daly, I. Graafland, E. Kroes and C. Koopmans (2005), Using the Logsum as an Evaluation Measure: Literature and Case Study. Leiden: RAND Europe/SEO

Deichmann, U., M. Fay, J. Koo and S. Lall (2004), ‘Economic Structure, Productivity, and Infrastructure Quality in

Dicken, P. Lloyd, P. E. (1990), Location in Space: Theoretical Perspectives in Economic Geography, HarperCollinsPublishers, New York.

Erlander, S. (1980), Optimal spatial interaction and the gravity model, Berlin, New York, Springer.

Evenett, S. J. Keller, W. (1998), “On Theories Explaining the Success of the Gravity Equation”, NBER Working Paper, No. 6529, Massachusetts.

Fallah, B. N., Partridge, M. D., & Olfert, M. R. (2011). New economic geography and US metropolitan wage inequality. Journal of Economic Geography, 11(5), 865-895.

Fingleton, B. (2006). The new economic geography versus urban economics: an evaluation using local wage rates in Great Britain. Oxford Economic Papers, 58(3), 501-530.

Fotheringham, A. S. (1983), ”A new set of spatial-interaction models: the theory of competing destinations”, Environment and Planning, A15, pp.15-36.

Fotheringham, A. S. O’Kelly, M. E. (1988), Spatial Interaction Models: Formulations and Applications, Dordrecht, Netherlands: Kluwer Academic Publishers.

Fujita, M., Krugman, P. & Venables, A.J. (1999). The Spatial Economy. Cities, Regions and International Trade. MIT Press, Cambridge, MA.

Geurs, K.T. and van Eck, J.R.R. 2003. Evaluation of accessibility impacts of land-use scenarios: the implications of job competition, land-use, and infrastructure developments for the Netherlands. *Environment and Planning B: Planning and Design,* 30(1), 69–87. doi:10.1068/b12940.

Geurs, K.T., van Wee, B., 2004. Accessibility evaluation of land-use and transport strategies: Review and research directions, Journal of Transport Geography, 12(2), 127-140.

Geurs, K.T., Wee, B., van Rietveld, P., 2006. Accessibility appraisal of integrated land-use/transport strategies: methodology and case study for the Netherlands Randstad area. Environment and Planning B: Planning and Design 33, 639–660.

Geurs, K.T., Zondag, B., de Jong, G.C., de Bok, M., 2010. Accessibility appraisal of landuse/transport policy strategies: More than just adding up travel-time savings. Transportation Research Part D, 15(7), 382-393

Glaeser, E. L. (1999). Learning in Cities. Journal of Urban Economics, 46(2), 254-277.

Glaeser, E. L., & Maré, D. C. (2001). Cities and Skills. Journal of Labor Economics, 19(2), 316-342.

Grek, J., C. Karlsson & J. Klaesson (2011), Determinants of Entry and Exit: The Sig-nificance of Demand and Supply Conditions at the Regional Level, in Kourtit, K., P. Nijkamp & R.R. Stough (Eds.), Drivers of Innovation, Entrepreneurship and Regional Dynamics, Springer, Berlin, 121-141

Guldmann, J-M. (1999),"Competing destinations and intervening opportunities interaction models of inter-city telecommunication flows", Papers in Regional Science, 78, pp. 179-194.

Gutiérrez, J. Urbano, P. (1996), "Accessibility in the European Union: the Impact of the Trans-European Road Network", Journal of Transport Geography, vol. 4, no. 1, pp. 15-25.

Hansen, W. (1959). How Accessibility Shapes Land Use. Journal of the American Institute of Planners, 25, 73-76.

Harris, C.D. (1954). The market as a factor in the localization of industry in the United States.

Head, K. and Mayer, T. (2005). Regional Wage and Employment Responses to Market Potential in the EU. Bruges European Economic Research Papers, 3.

Head, K., & Mayer, T. (2011). Gravity, market potential and economic development. Journal of Economic Geography, 11(2), 281-294.

Holl, A. (2007). "20 years of accessibility improvements. The case of the Spanish motorway building programme", Journal of Transport Geography 15: 286-297.

Hsieh, C-Y. Ye, M-H. (1991), Economics, Philosophy, and Physics, M. E. Sharpe, New York.

Ingram, D. R. (1971), "The Concept of Accessibility: a Search for an Operational Form", Regional Studies, 5, 101-107.

Isard, W. (1960), Methods of Regional Analysis: an Introduction to Regional Science, John Wiley and Sons, Inc., New York.

Isard, W. (1999), "Regional Science: Parallels from physics and chemistry", Papers in Regional Science, 78, pp. 5-20.

Isard, W. Azis, I. J. Drennan, M. P. Miller, R. E. Saltzman, S. Thorbecke, E. (1998), Methods of Interregional and Regional Analysis, Ashgate, England.

Johansson, B. (1993), “Infrastructure, Accessibility and Economic Growth”, International Journal of Transport Economics, Vol. XX, No. 2, pp. 131-156.

Johansson, B. (1998), “Infrastructure and Economic Milieu: Swedish Contributions 1960-1995”, in Lundqvist et. al.

Johansson, B. and Klaesson, J. (2007). Infrastructure, labour market accessibility and economic development. In C. Karlsson, W. P. Andersson, B. Johansson & K. Kobayashi (Eds.), The management and measurement of infrastructure - performance efficiency and innovation (pp. 69-98). Cheltenham, UK.: Edward Elgar.

Johansson, B., & Klaesson, J. (2011). Agglomeration dynamics of business services. The Annals of Regional Science, 47(2), 373-391.

Johansson, B., Karlsson, C., & Stough, R. (2006). The Emerging Digital Economy. Springer-Verlag Berlin Heidelberg.

Johansson, B., Klaesson, J. & Olsson, M. 2002. Time distances and labour market integration. Regional Science, 81, 305-327.

Johansson, B., Klaesson, J., & Olsson, M. (2003). Commuters’ non-linear response to time distances. Journal of Geographical Systems, 5(3), 315-329.

Johansson, S., & Karlsson, C. (2007). R&D accessibility and regional export diversity. The annals of regional science, 41(3), 501-523.

Karlsson, C. & B. Backman (2011), Accessibility to Human Capital and New Firm Formation, International Journal of Foresight and Innovation Policy 7, 7-22

Karlsson, C. & K. Nyström (2011), Knowledge Accessibility and New Firm For-mation, in Desai, S., P. Nijkamp & R.R. Stough (Eds.), New Directions in Re-gional Economic Development. The Role of Entrepreneurship Theory and Methods, Practice and Policy, Edward Elgar, Cheltenham, 174-197

Karlsson, C., & Gråsjö, U. (2013). Accessibility: a useful analytical and empirical tool in spatial economics–experiences from Sweden (No. 314). Royal Institute of Technology, CESIS-Centre of Excellence for Science and Innovation Studies.

Klaassen, L. H. (1988), Exercises in Spatial Thinking, Avebury, England.

Klein, A., & Crafts, N. (2012). Making sense of the manufacturing belt: determinants of US industrial location, 1880–1920. Journal of Economic Geography, 12(4), 775-807.

Krugman, P. (1991). Increasing returns and economic geography. Journal of Political Economy 99(3), 483–499.

Krugman, P. (1993). On the Relationship Between Trade Theory and Location Theory. Review of International Economics, 1(2), 110-122.

Krugman, P. R. (1991). Geography and trade. MIT press.

Lall, S.V., H.G. Wang and U. Deichmann (2008), 'Infrastructure and City Competitiveness in India', in Jo Beall, Basudeb Guha-Khasnobis and Ravi Kanbur (eds), Beyond the Tipping Point: Benefi ts and Challenges of Urbanization. UN WIDER, London School of Economics.

Lall, S.V., Z. Shalizi and U. Deichmann (2004), 'Agglomeration Economies and Productivity in Indian Industry', Journal of Development Economics, 73(2): 643–73.

López-Rodríguez, J., Medin, J., & Rodríguez, J. L. (2011). New Economic Geography and educational attainment levels in the European Union. International Business & Economics Research Journal (IBER), 4(8).

Lundqvist, L. Mattsson, L-G. Kim, T. J. (Eds.), (1998), Network Infrastructure and the Urban Environment – Advances in Spatial Systems Modelling, Springer-Verlag, Berlin.

Manaugh, K. and El-Geneidy, A.M. (2012). What makes travel 'local': Defining and understanding local travel behavior. The Journal of Transport and Land Use, 5(3), 15-27.

Martellato, D. Nijkamp, P. (1998), "The Concept of Accessibility Revisited", in Reggiani, A.

Martellato, D. Nijkamp, P. Reggiani, A. (1998), "Measurement and Measures of Network Accessibility: Economic Perspectives", in Button et. al.

McDonald, J. F. (1997), Fundamentals of Urban Economics, Prentice Hall, New Jersey.

Mikkonen, K. Louma, M. (1999), "The parameters of the gravity model are changing – how and why?", Journal of Transport Geography, 7, pp. 277-283.

Mirowski, P. (1989), More heat than light – Economics as social physics: Physics as nature's economics, Cambridge University Press, Cambridge.

Munnell, A. H. 1990. Why Has Productivity Growth Declined? Productivity and Public Investment. New England Economic Review, January/Februray, 4-22.

Neuburger, H. (1971). User benefit in the evaluation of transport and land use plans, Journal of Transport Economics and Policy, vol 5, pp 52-75

Niebuhr, A. (2006). Market Access and Regional Disparities: New Economic Geography in Europe. Annals of Regional Science 40, 313–334.

Niedercorn, J. H. Bechdolt, B. V. (1969), ”An Economic Derivation of the Gravity Law of Spatial Interaction”, Journal of Regional Science, 9, pp. 273-282.

Nijkamp, P. (Ed.), (1986), Handbook of Regional and Urban Economics, Volume I, Regional Economics, Elsevier, Amsterdam.

Nijkamp, P. and Reggiani, A. (1988). Dynamic Spatial Interaction Models: New Directions: Environment and Planning A, Pion Ltd, London, 20(11), 1449-1460.

Nijkamp, P. Reggiani, A. (1992), Interaction, Evolution and Chaos in Space, Springer-Verlag, Berlin.

Nijkamp, P. Vleugel, J. Maggi, R. Masser, I. (1994), Missing transport networks in Europe, Avebury, Aldershot.

Nilsson, P., & Johansson, S. (2013). Location determinants of agricultural land prices. Jahrbuch für Regionalwissenschaft, 33(1), 1-21.

Ortúzar, J. Willumsen, L. G. (1995), Modelling Transport, John Wiley and Sons, New York.

Puu, T. (1997), Mathematical Location and Land Use Theory: An Introduction, Springer-Verlag, Berlin.

Reggiani, A. (Ed.), (1998), Accessibility, Trade and Locational Behaviour, Ashgate Publishing Ltd, England.

Richardson, H. W. (1978), Regional and Urban Economics, Penguin Books, England.

Rietveld, P. and Bruinsma, F. (1998), Is transport infrastructure effective?: transport infrastructure and accessibility: impacts on the space economy, Berlin, New York, Springer.

Sen, A. Smith, T. E. (1995), Gravity Models of Spatial Interaction Behavior, Springer-Verlag, Berlin.

Song, S. (1996), “Some Tests of Alternative Accessibility Measures: A Population Density Approach”, Land Economics, 72 (4), pp. 474-482.

Southern Mexico’, Annals of Regional Science, 38(3): 361–85.

Spiekermann and Wegener (2007), ‘Update of Selected Potential Accessibility Indicators—Final Report’, Urban and Regional Research (S&W), RRG Spatial Planning and Geoinformation, ESPON. Available online at http://www.espon.eu/mmp/online/website/content/projects/947/1297/file_2724/espon_accessibility_update_2006_fr_070207.pdf, accessed on 1 July 2009.

Stewart, J. Q. (1948), ”Demographic gravitation: evidence and applications”, Sociometry, 11, pp. 31-58.

Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. Journal of Economic Geography, 4(4), 351-370.

Tipler, P. A. (1999), Physics for scientists and engineers, W. H. Freeman and Company, New York.

Tressider, J.O., Meyers, D.A., Burrell, J.E., Powell, T.J. (1968). The London transportation study. Proceedings of the Institute of Civil Engineers 39, 433–464.

Vickerman, R. (1995), “Accessibility and Peripheral Regions”, in Coccossis and Nijkamp.

Vickerman, R. (1996), “Location, accessibility and regional development: the appraisal of trans-European networks”, *Transport Policy*, Vol. 2, No. 4, pp. 225-234.

Vickerman, R. Spiekermann, K. Wegener, M. (1999), “Accessibility and Economic Development in Europe”, *Regional Studies*, Vol. 33.1, pp. 1-15.

Weibull, J. W. (1976), “An Axiomatic Approach to the Measurement of Accessibility”, *Regional Science and Urban Economics*, 6, pp. 357-379.

Weibull, J. W. (1980), “On the numerical measurement of accessibility”, *Environment and Planning A*, vol. 12, pp. 53-67.

Wilson, A. G. (1967), ”A Statistical Theory of Spatial Distribution Models”, *Transportation Research*, vol. 1, 253-269.

Wilson, A. G. (1971). A family of spatial interaction models and associated developments. *Environment and Planning A,* 3(1), 1–32.

Yoshida, N & Diechmann, U. (2009), “Measurement of Accessibility and Its Applications”, *Journal of Infrastructure Development*, vol. 1(1), 1-16.

Zipf, G. K. (1949), Human behaviour and the principle of least effort, Reading Mass.: Addison-Wesley.

RESEARCH NETWORK DEBATE
SWEDISH ENTREPRENEURSHIP FORUM

WWW.ENTREPRENORSKAPSFORUM.SE