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Agglomeration dynamics of business services

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Abstract An important characteristic of the economic development in Europe and North America during the last few decades is a fast expansion of the business-service sector. The present paper aims at modeling the location dynamics of three categories of firms: (i) knowledge-intensive business-service firms, (ii) ordinary business-service firms and other firms, where the latter form the rest of the economy. In the theoretical framework, business-service firms have random-choice preferences and respond in a non-linear way to time distances in their contact efforts to customer firms. Business-service firms make their location decisions in response to local, intra-regional and extra-regional access to market demand. The econometric analysis makes use of information about time distances between zones in urban areas as well as between urban areas in the same agglomeration and between urban areas in different agglomerations. The empirical analysis shows how the number of jobs in the different sectors change in response to accessibility to purchasing power. The estimation results show that the change processes feature non-linear dependencies with varying spatial reach.

JEL Classification C23 · L84 · R11 · R12 · R30

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1 Introduction

Economic growth takes place in a spatially selective manner, and technological, social and life-style innovations are clustered in space, bringing about geographic concentrations of economic renewal.

The focus in this study is firms supplying business or producer services, and for these firms and their customer firms, the issue of interaction with direct face-to-face contacts seems to be a clear case where interaction externalities will prevail. A common hypothesis is that firms benefit and become more productive from interaction with each other, due to interaction and communication externalities as phrased in Fujita and Thisse (2002). From another perspective, one may argue that individual firms can benefit from upstream and downstream externalities which bring about co-location advantages.

Location properties of this kind can, at least partly, explain the existence of urban regions (urban agglomerations), which consist of interlinked urban areas, which in turn can be decomposed into zones. For each of these levels, co-location advantages exist so that spatial concentrations can be observed at different levels of spatial resolution. This suggests that a system of urban agglomerations has a fractal property, with major centers, centers of urban areas as well as sub centre concentrations (Anas et al. 1998). An appropriate approach to analyze such a system is to develop accessibility measures to characterize urban agglomerations and their surroundings.

Given the above, we introduce a model in which firms supplying producer services make their location decisions as a response to the accessibility to customer demand (customer contacts) that each possible location offers. The accessibility measures introduced refer back to Weibull (1976). In this paper, we follow Mattsson (1984) and Johansson and Klaesson (2007) when deriving the accessibility measure from a random-choice preference function of decision-making firms.

The present study contributes to the modeling and the analysis of urban regions in several respects. For the explanation of supply in each urban location, we apply a model which identifies many demand concentrations in a spatial landscape—consisting of urban areas, with zones, other urban areas belonging to the same region, and other urban regions. The model specifies the time distance from a supply location to all demand concentrations. For each supply location, we derive the market access for producer-service suppliers from a random-choice decision model. Based on each location's market access, we calculate the attractiveness of each possible supply location. These processes imply that the supply expand and shrink in different urban areas as well as in each urban region as a whole.

The major focus in this paper is to understand urban locations as places for communication externalities and interaction. We have chosen to focus on selling activities of business-service suppliers as major example of interaction between firms as buyers and firms as customers. The reason for this is (i) that producer-service suppliers have all firms as potential customers, and (ii) that the pertinent transactions can be classified as distance sensitive.

Considering economic life in an urban region across all sectors, it can be depicted as a complex of transactions between buyers and sellers. Some of these transactions are distance sensitive in the sense that their probability (or frequency) declines fast as the time distance between supplier and customer increases, whereas other transactions are less sensitive.

The suppliers of producer services are assumed to supply distance-sensitive, differentiated product varieties subject to increasing returns to scale. The demand for a suppliers output depends positively on the market access that obtains in the location of the firm, while the firm perceives its "own" negatively sloping demand schedule. This creates a market with properties resembling monopolistic competition, where the number of differentiated varieties will expand if the market access (accessibility to customer demand) expands (Fujita and Thisse 2002; Forslund and Johansson 2008). New varieties can be introduced only as the market size increases, because each supplier needs sufficiently large sales to cover fixed costs. The described features set the stage for the model of how market access stimulates the growth and decline of jobs in firms supplying business services as well as for firms in the rest of the economy.

The rest of this paper is organized as follows. Section 2 introduces the basic results from a standard monopolistic competition model. Section 3 outlines the theoretical framework used presenting a map of the spatial organization as viewed from each urban area, deriving the accessibility measures from a random-choice model. Section 4 specifies an empirical model that depicts job dynamics as dependent on three types of market accessibilities and presents hypotheses for the job dynamics. Section 5 gives descriptive background to the area studied. In Sect. 6, the hypotheses are tested. Concluding remarks are given in Sect. 7.

2 Agglomeration economies and market access

What can be expected if the share of business services increase? According to Fujita and Thisse (2002) what happens is that when the diversity of business services increases then the productivity of the firms that can benefit from increased diversity will become more productive. Large urban agglomerations thereby get an advantage that stimulate further, cumulative, growth.

Already two decades ago, Coffey and Polèse (1989) came to the conclusion that the potential for high-order producer services to locate outside of major metropolitan areas was limited. Their research was motivated by the attention producer services received as policy-levers for developing lagging regions.

In an investigation of co-location between manufacturing and producer services, Andersson (2006) utilizes an approach of simultaneously determining location patterns of manufacturing and producer services. This approach was motivated by the assumed supplier–customer relation between the two sectors. The conclusion, using Swedish data, is that producer services is a location factor for manufacturing but that the reverse is not supported by the analysis. The result points to that producer services in many cases is produced for other service firms.

Concerning producer service location and growth in the Swedish context, Hermelin (2007) observes that 54% of the employees in Sweden in these sectors are employed in the Stockholm region. Also, during the period 1993–2002 producer services accounted for 50% of total employment growth in the Stockholm region.

Table 1 Monopolistic competition, market access and feasible locations

Formula	Interpretation
(i) $x_{ir} = \delta_i G_i(A_r) p_i^{-\theta}$	Demand function of firms, where $G_i(A_r)$ depicts firm i's access to the purchasing power when located in area r, and where θ_i is the price elasticity
(ii) $p_i = \theta/(\theta - 1)v_i$	The optimal price selected by firm i in an environment of monopolistic competition, where v_i represents marginal cost
(iii) $p_i \geq v_i + F_i/x_{ir} + \rho_r$	This is the condition for a feasible location in r, which requires that x_{ir} is large enough to make F_i/x_{ir} small enough, where F_i represents fixed costs

There is a vast literature concerned with the modeling of markets characterized by monopolistic competition and increasing returns. Overviews of this literature can be found in, e.g. Fujita et al. (1999), Fujita and Thisse (2002), and Brakman et al. (2009).

The modeling of increasing returns in the final goods sector as a consequence of increasing diversity in the intermediate goods sector is a part of this literature. Examples in this tradition are Abdel-Rahman (1988), Fujita (1988a,b), and Rivera-Batiz (1988).

In the results from these models concerning the economics of agglomeration (Fujita and Thisse 2002), the size of the accessible market determines whether a certain location is feasible for a firm that supplies a differentiated, distance-sensitive product under conditions of monopolistic competition, and subject to fixed costs. A simple model of this type is presented in Forslund and Johansson (2008) for the case where each firm i supplies a differentiated variety i, and Andersson and Johansson (2008) for the case where a firm may supply several varieties.

Table 1 presents the basic results for the simple model version, for which every firm supplies its own differentiated product variety. In the Table 1, x_{ir} denotes demand for product variety i when r is the supply region, $G_i(A_r)$ is an increasing function of the market-access A_r for suppliers in r, p_i denotes price, v_i the variable cost, F_i the fixed cost, δ_i a coefficient that reflects the market structure and shrinks as the number of varieties increases, and θ is the price elasticity.

Given these definitions this means that formula (i) and (ii) in Table 1 corresponds to a standard description of monopolistic competition in the New Economic Geography tradition. In formula (iii), an extra (compared to the standard model) variable is added, $\rho_r = \rho(A_r)$ which stand for the land rent per unit output, where ρ is increasing in A_r. The location condition is given by formula (iii), which shows how the average cost shrinks if the realized sales increase, recognizing that the firm's sales depend on its market access, given optimal price setting.

According to (ii) $p_i > v_i$. Thus, condition (iii) will be satisfied as soon as x_{ir} is large enough to make the quotient F_i/x_{ir} small enough. Moreover, for a given set of supplying firms, x_{ir} grows as A_r grows. At the same time, δ_i shrinks as more firms enter the set of differentiated suppliers. As a consequence, the size of the market access vector stimulates firms to locate in r while a growth in $\rho_r = \rho(A_r)$, as A_r increases, counteracts the demand-expansion effect of a growing market access. As the size of the market access of an urban area increases, this implies that the demand for more varieties increases, and hence more suppliers can establish themselves in the urban area. The principle temporal mechanism in this stylized model is then that the size of the market access A_r stimulates the entry of a greater supply, and the expanded supply, in turn, adds to the size of the market access A_r.

There are two growth dampening forces. One works via increased land rents. The second (implicit in the above framework) works via possible congestions of various types and diminish market access. If congestion increases time distances, increases in density and time delays in contact efforts may obtain (to be established in the derivation of our accessibility variables below).

3 Spatial organization and measures of accessibility

An urban area with a high market potential (accessibility) is large in itself and/or is an integral part of a large urban agglomeration. Previous research tend to show that the size of urban regions affect their growth (e.g. Henderson 1988; Glaeser et al. 1992; Glaeser 2000; Forslund-J 1998). In the present approach, not only the size but also the structure and spatial layout of the urban agglomerations are taken into account. Growth in urban areas is modeled as dependent on the structure of market access, and these dependencies are expected to be different for different groups of economic activities.

A fundamental basis of the spatial economy is a set of nodes (or areas) where activities are concentrated. In order to identify these nodes space has to be observed via zones of some size, some zones will contain dense concentrations and others not. Using large zones when observing an urban agglomeration, few nodes will be identified, whereas using small zonal areas will result in the identification of an increased number of nodes. In recent decades this phenomenon has been referred to as a fractal property of the urban landscape (Anas et al. 1998).

In view of the above, this paper describes urban agglomerations as a set of nodes connected by a corresponding set of links, which form a network. We consider three different layers of nodes. The medium layer consists of urban areas. These are towns or cities, depending on the size. The lower layer consists of zones within an urban area, and the upper layer consists of functional urban regions (FUR) consisting of functionally interdependent urban areas. In the limiting case, when the urban region is small, the region consists of only one urban area. In general, an urban region is a set of interconnected urban areas, between which the interaction is more intense than it is between urban areas belonging to different urban regions.

Each link connecting two urban areas, r and s, is characterized by the time distance, t_{rs}, between the two areas. For an individual urban area r we can also identify the average time distance, t_{rr}, between any pair of zones within the area. This reflects the spatial extent of the urban area and the quality of the intraurban infrastructure.

In the analysis, we consider the change in three groups of activities: KP-firms supplying knowledge-intensive producer services, OP-firms supplying other (ordinary) producer services, and O-firms comprising the rest of the economy. Change is measured in terms of jobs in each time period, sector and location. For each urban area, the model specifies how change processes (for each sector) are influenced by (i) local market access in the specific urban area, (ii) intra-regional market access, and (iii) extra-regional market access. Market access in a location reflects the space-discounted value of the economic activity (customer budget) in each of the three categories of markets (i)–(iii).

The size of economic activities in an urban area r, is reflected by the total wage sum, W_r, in area r, generated by all firms in the area. For area r, we identify the number of jobs in the KP-firms, L_r^{KP}, in the OP-firms, L_r^{OP}, and in the other (rest of the economy) firms, L_r^{O}. The total number of jobs in r, is given by $L_r = L_r^{\mathrm{KP}} + L_r^{\mathrm{OP}} + L_r^{\mathrm{O}}$.

Consider now a firm located in urban area r. Given this location, in the modeling framework three categories of related locations are considered. The first is area r itself (consisting of zones), the second consists of urban areas $s \in R(r)$, which belong to the same urban region (FUR) as r, and the third consists of all other urban areas $k \in E(r)$, which belong to other urban regions. The analysis is focused on the location decisions of suppliers of producer services and how these decisions depend on the location advantage of each area r.

The advantage of a location in area r will be measured by

- intra-urban market access, reflecting the accessibility to customer demand inside area r;
- intra-regional market access, reflecting the accessibility to customer demand in other areas belonging to the same urban region;
- extra-regional market access, reflecting the accessibility to customer demand in other areas belonging to other urban regions.

Once these measures are established, we assume that the supply of producer services in an urban area expands or contracts in response to the size of the accessible demand in that area. Using this information we can formulate a model for the location dynamics across urban areas.

We will use a measure of a supplier's access to customer demand that is based on the assumption that suppliers make the effort to contact its potential customers. It is likely that both suppliers and customers make contact efforts in many markets. However, for simplicity, we shall use a decision model in which suppliers make the contact efforts.

Following the modeling in Johansson et al. (2002, 2003), we assume that the supplier has a random-choice preference function $\tilde{V}_{rs} = V_{rs} + \varepsilon_{rs}$, which consists of a systematic part V_{rs} and an extreme-value distributed random part, denoted by ε_{rs}. The systematic part is specified as follows:

$$V_{rs} = \phi_{rs} - \lambda_{rs} t_{rs} \tag{3.1}$$

where t_{rs} is the time distance between r and s, ϕ_{rs} reflects spatial preferences of customers in area r with regard to area s, and λ_{rs} is a time-sensitivity coefficient, where the parameters are specified in (3.2).

$$\phi_{rs} = \begin{cases} \hat{\phi}_1 \text{ as } r = s \\ \hat{\phi}_2 \text{ as s} \in R(r) \\ \hat{\phi}_3 \text{ as s} \in E(r) \end{cases} \quad \lambda_{rs} = \begin{cases} \lambda_1 \text{ as } r = s \\ \lambda_2 \text{ as s} \in R(r) \\ \lambda_3 \text{ as s} \in E(r) \end{cases} \tag{3.2}$$

Established results for a random-choice model of the type introduced here tell us that the probability, P_{rs}, of suppliers in area r to contact customers in area s equals (Mattsson 1984; Johansson and Klaesson 2008):

$$P_{rs} = W_s \exp\{V_{rs}\} / \sum_s W_s \exp\{V_{rs}\} \tag{3.3}$$

where W_s is the total wage sum in urban area s, which represents the total purchasing capacity in area s, which we assume is positively related to the demand for producer services. The variable P_{rs} reflects the share of demand from customers in s. In view of this, the denominator of (3.3) can be used as an indicator of the demand potential of supply firms in urban area r. Because of this, the expression in the denominator is interpreted as area r's accessibility to customer demand, signified by $\sum_s W_s \exp\{V_{rs}\} = A_{rr} \exp\{\phi_1\} + A_{R(r)} \exp\{\phi_2\} + A_{E(r)} \exp\{\phi_3\}$, in accordance with the specification in (3.3), where

$$\begin{aligned} \hat{A}_{rr} &= W_r \exp\{\phi_1 - \lambda_1 t_{rr}\} = A_{rr} \exp\{\phi_1\} \\ \hat{A}_{R(r)} &= \sum_{s \in R(r)} W_s \exp\{\phi_2 - \lambda_2 t_{rs}\} = A_{R(r)} \exp\{\phi_2\} \\ \hat{A}_{E(r)} &= \sum_{s \in E(r)} W_s \exp\{\phi_3 - \lambda_3 t_{rs}\} = A_{E(r)} \exp\{\phi_3\} \end{aligned} \tag{3.4}$$

Following from formula (3.4), we shall refer to the triplet $A_r = (A_{rr}, A_{R(r)}, A_{E(r)})$ as the market access vector of location r. It can be translated to the overall market demand accessibility, $\hat{A}_r = (\hat{A}_{rr}, \hat{A}_{R(r)}, \hat{A}_{E(r)})$ by means of the three coefficients, $\exp\{\phi_1\}$, $\exp\{\phi_2\}$ and $\exp\{\phi_3\}$.

The parameters in (3.4) have been estimated in a previous study from a data set on trip making inside and between 288 Swedish urban areas by means of a multi-constrained trip-making model, with an objective function of entropy type (Johansson et al. 2003). From that study a series of empirical estimations were made for different types of trip makers. All these results reveal that the following pattern applies:

$$\phi_1 > \phi_2 > \phi_3 \quad \text{and} \quad \lambda_2 > \lambda_3 > \lambda_1 \tag{3.5}$$

which implies that the valuation of location advantages is governed by preferences that give priority to local proximity over intra-regional proximity, while the latter is preferred over extra-regional proximity. The other implication is that the time sensitivity is largest for medium-length intra-regional distances and smallest for very short local distances. We may refer to this as a property of non-linear travel time responses among decision makers. In particular, the constellation of the six parameters in (3.5) that preferences for contact making are highly non-linear, and these non-linearities are used when calculating the accessibility measures in the present context.

Consider the basic conditions of any firm, i.e., of firms in any of the three sectors KP, OP and O. On the one hand, the firm makes use of markets for buying inputs, and on the other, it makes use of markets for selling its output. In both cases, the firm's full market is decomposed into urban, regional, and extra-regional market. Firms with distance-sensitive inputs benefit from having a large supply inside its own urban region. For urban area r this would be reflected by large values of A_{rr} and $A_{R(r)}$. These two market-access measures show the size of the opportunities of input suppliers to contact input-buying firms. Indirectly, A_{rr} and $A_{R(r)}$ will also indicate the advantage for input buyers, the supply of inputs will be larger in an area r where the market access variables are large.

The mirror case comprises suppliers of distance-sensitive producer services. In particular, these firms benefit from large values of A_{rr} and $A_{R(r)}$. These conclusions should imply that the location of producer services reflects the size of the intra-urban and intra-regional market access. In the present study, we extend this idea, by assuming that the growth of producer services in a region is influenced by the market access vector, $A_r = (A_{rr}, A_{R(r)}, A_{E(r)})$ which corresponds to the idea that firms adjust their location and the size of their supply from a given location in response to the A_r-vector, and while doing that they also influence the A_r-vector in a cumulative way.

It is evident that the A_r-vector is especially important for suppliers of producer services, since service supply is considered distance sensitive in a pronounced way. However, market access is relevant for all suppliers (firms). For firms with moderate and low distance sensitivity, the extra-regional market access may be relatively more important than for suppliers of producer services.

4 A model of job location dynamics

Given the specifications of market conditions in Sect. 3, we want to study in a discrete-time setting how the size of producer-service supply changes between time t and $t + \tau$. This change can be observed as an increase in (i) the value of the supply of services, (ii) the number of firms supplying producer services, and (iii) the number of jobs in firms supplying producer services. In the subsequent analysis we will study the process as a change in number of jobs.

Referring to urban area r, we define L_r^j as the number of jobs in sector j, where j = KP refers to knowledge-intensive producer services, j = OP refers to other producer services and j = O refers to all other sectors, representing the rest of the economy.

The change in L_r^j is specified as $\Delta L_r^j = L_r^j(t+\tau) - L_r^j(t)$, and it is assumed to be a function of the A_r-vector, where each component has its own influence on the change process. Why should L_r^j change? One way of thinking is to assume that the market access, as given by A_r allows for a supply size, L_r^{j*}, that exceeds $L_r^j(t)$, and hence the change can be characterized as an adjustment process. Thus, it is assumed that at any given time the job location pattern is not in equilibrium. This can be the case if the market access vector itself changes over time. The reasons for these changes can basically be broken down into two parts (i) relocation of people (migration) and (ii) changes in the infrastructure that changes the time–distance network. In the "Mills-Carlino" literature, it is often found that "jobs-follow-people" and not the other way around (Carlino and Mills 1987; Hoogstra and Florax 2005).

Given that adjustments cannot be considered instantaneous, the time interval τ should be long enough to allow responses to take place.

When studying the change process of each sector's supply size, we will consider two different specifications, one linear and one quadratic. The linear specification can be written as follows:

$$\Delta L_r^j = \alpha_0 + \alpha_1 A_r + \alpha_2 A_{R(r)} + \alpha_3 A_{E(r)} \tag{4.1}$$

Equation 4.1 shows how change in number of jobs is dependent on urban, intra-regional and extra-regional market access. This may be seen as a direct application of formula (3.4), given that

$$\begin{aligned} \hat{A}_{rr} &= k_1 A_{rr} \exp\{\phi_1\} = \alpha_1 A_{rr} \\ \hat{A}_{R(r)} &= k_2 A_{R(r)} \exp\{\phi_2\} = \alpha_2 A_{R(r)} \\ \hat{A}_{E(r)} &= k_3 A_{E(r)} \exp\{\phi_3\} = \alpha_3 A_{E(r)} \end{aligned} \tag{4.2}$$

where k_1, k_2, and $k_3$are three response parameters. Interpreting formula (4.1), we can see that if there is a lowest level for the compound market access, below which no supply is possible from urban area r, then this means that $\alpha_0 < 0$. A second observation is that demand in locations r and $s \in R(r)$ represent the "home-market" areas for suppliers in r. Thus, $\alpha_1 > 0,\ \ \alpha_2 > 0$, and $\alpha_3 < 0$ will express that large extra-regional market access provides incentives to locate outside the region to which r belongs.

The change process can come to rest only if at least one of the α-coefficients is negative. Such an equilibrium is obviously never stable, but we may contemplate grouping A_r-vectors into domains in which L_r^j invariantly remains positive or negative. As the paper aims at showing that Eq. (4.1) is not sufficient for revealing the basic properties of the agglomeration change processes, we turn to an a equation system in quadratic form in (4.3):

$$\begin{aligned} \Delta L_r^j = \alpha_0 + \alpha_1 A_r + \alpha_2 A_{R(r)} + \alpha_3 A_{E(r)} \\ + \beta_1 (A_r)^2 + \beta_2 (A_{R(r)})^2 + \beta_3 (A_{E(r)})^2 \end{aligned} \tag{4.3}$$

In this formulation we cannot establish the direct relation between ϕ-parameters and α-parameters. The reason for this is that (4.3) assumes that the response mechanism are not linear in the market-access vector. In this context we especially observe that the constellation of parameters will have to reflect the net effect of (i) expanding market access and (ii) increased land rents for each urban area.

When leaving the linear specification, we attempt to model response mechanisms which can reflect our basic market-access hypotheses. These hypotheses are summarized in Table 2.

Table 2 Hypotheses concerning job change as result of market access constellations

	Producer service sectors		Sectors in the rest of the economy
A	$\alpha_0 < 0$: Reflecting a threshold level of the market access vector, below which an urban area will not experience job growth	E	$\alpha_0 < 0$: For the same reasons as those given producer service sectors
B	$\alpha_1 > 0$: Reflecting that the local market access generates a positive stimulus to expansion of producer services. If, in addition, $\beta_1 > 0$: the growth response is accelerating in local market access	F	$\alpha_1 > 0$: Reflecting that local market access is important also for O-firms. If the local market access is a weaker stimulus, this implies that [$\alpha_1 > 0$; $\beta_1 < 0$], meaning that the growth response is positive for urban areas of moderate size
C	[$\alpha_2 < 0$; $\beta_2 > 0$]: Reflecting that there is a positive growth stimulus as $A_{R(r)}$ is sufficiently large	G	[$\alpha_2 > 0$; $\beta_2 < 0$]: Reflecting that a large intra-regional market access is important, but beyond a certain size, the stimulus to growth disappears
D	$\alpha_3 < 0$: Reflecting a negative growth response to "intervening opportunities" in neighboring urban agglomerations. If, $\beta_3 > 0$, this reflects that growth stimulus may obtain if sufficiently large extra-regional market access is present	H	$\alpha_3 > 0$: Reflecting a benefit from extra-regional market access. If $\beta_3 > 0$ the influence is very pronounced

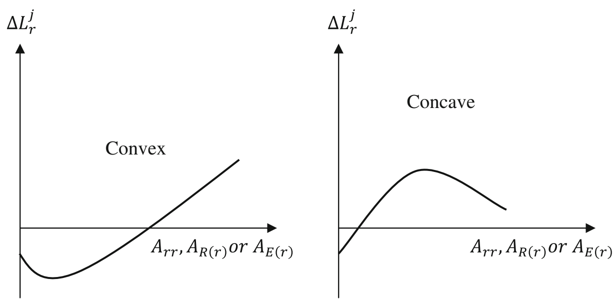

Fig. 1 Response to market access components

Referring to Table 2 hypotheses A and B are self-explanatory. Hypothesis C is referred to as a convex response mechanism: for low values of $A_{R(r)}$ the impact is negative and turns positive as $\beta_2(A_{R(r)})^2 > -\alpha_2 A_{R(r)}$, and the derivative $\partial \Delta L_r^j / \partial A_{R(r)} > 0$ as $2\beta_2 A_{R(r)} > -\alpha_2$. The convex response is illustrated to the left in Fig. 1.

Just focusing on producer services will provide only a partial description of the total job dynamics for an urban area. Thus, besides firms in the KP- and OP-sectors, we also must account for the change of jobs in the rest of the economy.

The main reason for treating the O-sector firms separately is that on average these firms are less contact intensive and engaged in less distance-sensitive interactions. Important parts of the O-sector are manufacturing firms, and many of these firms have

Table 3 The wage sum (W) in Swedish urban regions 1999 and 2006

Urban region	1999 (billion SEK)	2006 (billion SEK)	Absolute growth	Percentage growth
Stockholm	244	301	57	23
Göteborg	90	117	27	30
Malmö	80	101	21	26
Medium-sized regions	293	351	57	20
Small regions	99	116	16	17

Figures in fixed 1999 SEK; source: statistics Sweden

a major part of their customers outside their own urban agglomeration. However, the O-sector also contains household service suppliers that can be expected to follow a similar response pattern as producer service firms. Large parts of the household service firms may be serving even more local markets e.g. food and clothing retail. This means that the change pattern may be expected to be more blurred by the grouping of diverse sectors into one.

Hypotheses A–H expresses what we expect from the theoretical arguments and all these hypotheses will be tested in the empirical analysis of Sect. 6. We may observe that we assume more similarities than differences between O-sector firms and producer-service suppliers. One should also add that the differences between the three types of sectors are reflected both by sign and size of parameters.

Observe also that Property C and D differ from Property F and G. The former are assumed to be concave, whereas the latter are assumed to be convex.

5 Descriptives for regions in Sweden

Producer service firms find their customers in all sectors of the economy. In the subsequent empirical analysis the purchasing power of those customers is reflected by the proxy variable total wage sum in each urban region. Thus, total wage sum is used as a proxy for the size of the economic activity in each region. Gross regional product (GRP) might seem to be a better choice in this respect, however at the fine geographical level we are studying there are several drawbacks inherent in using GRP. The two main drawbacks are: (i) the capital stock varies much more than actual economic activity (especially for some northern areas with hydro-power plants), (ii) GRP are mostly allocated to company headquarters. As a background to the econometric analysis, Table 3 presents the wage sum in the three largest regions in Sweden, a group of medium-sized regions, and a group of smaller regions. The medium sized regions have a population of at least 100,000 inhabitants. The small regions have >100,000 inhabitants.

From Table 3, we can see that the three largest regions stand for more than 50% of the wage sums in the whole country in both years. In terms of absolute growth, there is a falling tendency from Stockholm down to the small regions, with the exception of the medium-sized regions. In terms of relative (percentage) growth the pattern is the same, now with exception of Stockholm. In any case, the overall patterns is quite clear, there is a positive connection between size and growth.

Table 4 Share of producer services in urban regions 1999 and 2006

Urban region	Knowledge-intensive producer services 1999	Knowledge-intensive producer services 2006	Other producer services 1999	Other producer services 2006
Stockholm	8.56	11.07	27.51	30.46
Göteborg	6.82	8.45	21.56	24.03
Malmö	5.46	8.02	19.15	22.77
Medium-sized regions	3.76	4.32	14.97	16.55
Small regions	2.42	2.73	12.19	12.96

Share of employment in producer service sectors. Source: statistics Sweden

Table 5 Growth of employment in sectors 1999–2006 in percent

Urban region	KP-services	OP-services	Other sectors	All sectors
Stockholm	39.89	19.71	−1.14	8.11
Göteborg	41.15	27.13	7.52	14.04
Malmö	65.81	34.16	3.58	12.83
Medium-sized regions	24.65	19.94	5.68	8.53
Small regions	17.75	11.00	3.12	4.44

Source: statistics Sweden

The present study divides the economy into three parts (1) knowledge intensive producer services, (2) other producer services and (3) the rest of the economy. The division into these groups has been accomplished in the following manner. First, we use a more or less standard classification of producer services using two-digit SIC-codes (given in the appendix). Second, we use employment and education data at the five-digit for the producer services. At the five-digit level sectors where more than 30% of the employed have a university education of at least three years are considered *knowledge-intensive producer services*. The rest of the producer services at the five digit level are called *other producer services*. All other sectors are grouped as the *other sectors*.

If we believe that size and growth of producer services are particularly dependent on regional size, then we should expect exactly the pattern that is presented in Table 4. The table reveals that the share of knowledge intensive producer service jobs attains the highest value in the largest urban region (Stockholm), the second highest in the second largest region (Göteborg), and continues to fall with the size of the regions. The smallest share (in small regions) is less than one-third of that in the Stockholm region for the year 2006. This pattern holds for both knowledge-intensive producer services and other producer services.

Table 4 tells us that the share of producer services is growing between 1999 and 2006. The table also shows that the growth of knowledge-intensive producer services is much faster in the three metropolitan regions than in either medium-sized or small regions. This is further illuminated in Table 5. The growth rate for other producer services is more evenly spread across regions that are medium-sized or larger. The

Table 6 Descriptive statistics for jobs, changes in jobs and accessibility measures in Swedish Urban areas

	Min	Max	Mean	SD
Employment				
Total	794	537,449	14,579.07	37,633.82
Knowledge intensive producer services	0	81,165	916.34	5,134.84
Other producer services	84	202,934	2,945.88	12,951.97
Other sectors	695	253,350	10,716.86	20,307.19
Employment change				
Total	−6,182	25,093	598.64	1, 746.9
Knowledge intensive producer services	−1,621	20,983	203.62	1,199.77
Other producer services	−2,889	22,004	341.01	1,543.47
Other sectors	−42,058	8,084	54.02	2,358.12
Wage sums				
Total wage sum	0.12	155.88	3.29	10.2
Total accessibility to wage sum	0.06	32.11	3.26	4.78
Intra-urban accessibility to wage sum	0.03	24.3	0.62	1.69
Intra-regional accessibility to wage sum	0	26.39	2.31	4.28
Extra-regional accessibility to wage sum	0	2.84	0.33	0.32

Figures refer to urban areas over the time period 1999–2001; employment change refer to three periods, 1999–2004, 2000–2005, 2001–2006

Table 7 Correlations among the accessibility variables

	Accessibility to wage sum		
	Total	Intra-urban	Intra-regional
Intra-urban	0.488**		
Intra-regional	0.934**	0.150**	
Extra-regional	−0.119**	−0.024	−0.198**

* Significant at 10%; ** significant at 5%; *** significant at 1%

table also indicates that total urban employment growth is higher for those regions which have a high growth rate in producer services.

In Table 6, descriptives are given for the dataset that are used in the empirical analysis. Observation units are urban areas. There are 288 such areas in Sweden and the entire population is used in our analysis. Three time periods are used, thus the number of observations is 864. The employment figures are measured in number of jobs. The wage sum and accessibility to wage sum is measured in 1000's of billions fixed 1999 SEK.

Concerning the accessibility measures it may be observed that the minimum value for intra-regional and extra-regional accessibility to wage sum is zero, this is a rounding error. It signifies that some isolated areas are very far from other areas so that these accessibility measures approach zero.

In Table 7, the bivariate correlations between the three accessibility measures and the total measures are given. There is a high correlation between the total and the

Table 8 Correlations between the location and change in number of jobs in the three sectors

	Other producer services	Knowledge intensive producer services	Other sectors	Change in other producer services	Change in knowledge intensive producer services
Knowledge intensive producer services	0.991**				
Other sectors	0.929**	0.899**			
Change in other producer services	0.943**	0.940**	0.922**		
Change in knowledge intensive producer services	0.965**	0.972**	0.895**	0.967**	
Change in other sectors	−0.819**	−0.843**	−0.606**	−0.722**	−0.823**

* Significant at 10%; ** significant at 5%; *** significant at 1%

intra-regional accessibility. This means that areas with a high total accessibility are generally those located in large regions. The extra-regional accessibility correlates negatively to the other measures. Thus, areas with high extra-regional accessibility tend to be small and situated in small regions.

In Table 8, the bivariate correlations between the location and change in numbers of jobs are presented. In the two-shaded areas of the table, the correlations of the location variables and change variables are given, respectively. Concerning the location of jobs, all correlations are very high reflection that in larger urban areas there is more employment in all sectors. The lowest of these correlations is the one between knowledge-intensive business services and other sectors.

For the change variables, the correlation is very high between change in knowledge-intensive producer services and other producer services. This means that they tend to grow in the same areas. The correlation between the other sectors and the two producer services sectors is negative. Thus, growth and decline seem to occur in different areas. The most negative is the correlation coefficient between knowledge-intensive producer services and the other sectors.

6 Job dynamics in the Swedish regions

At this point, we may observe that he inclusion of accessibility variables means that the models capture characteristics in terms of market-size in each urban area as well as its regional and extra-regional surroundings. Probably, the pertinent market most sectors is not only the urban area market, but also the market in neighbouring urban areas within some time–distance space. This is precisely what we aim at modelling, but a feature that potentially can cause biases. Normally, this kind of potential problem is dealt with using traditional spatial econometrics since it implies the existence of spatial dependencies in the sense that employment in one urban area is partly a function of characteristics in other urban areas. From an econometric viewpoint, the models in Eqs. (4.1) and (4.3) account for such spatial dependencies by using spatially lagged independent variables (Andersson and Gråsjö 2008), and are a forms of a spatial

Table 9 Change in number of jobs as dependent on market accessibility (linear specification)

	ΔKP	ΔOP	ΔO
Intercept	−160.31 (5.49)***	−187.47 (5.39)***	493.45 (3.23)***
Intra-urban, A_{rr}	673.63 (63.72)***	867.92 (68.97)***	−1,011.84 (18.32)***
Intra-regional, $A_{R(r)}$	3.23 (0.76)	13.18 (2.60)***	18.830 (0.85)
Extra-regional, $A_{E(r)}$	−179.68 (3.20)***	−115.00 (1.72)*	427.74 (1.46)
R^2 (overall)	0.90	0.92	0.52
No. obs	864	864	864

Between effects estimation. Absolute value of t statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%

cross-regressive model (Rey and Montouri 1999). The possible spatial interdependencies are modelled in the construction of the independent accessibility variables.

In the estimations of both the linear and the quadratic specifications, we use the 288 urban areas in Sweden and three time periods. The estimation method applied is the between effects estimator using STATA. The reason for this is that the fixed-effects estimator is very problematic when the explanatory variables change very slowly and we only have few time periods. The between effects estimator gives the same result as averaging our variables over time and use OLS. The reason for not using OLS for a single time period is to avoid chance occurrences, that is, major employment shifts that are a one-time occurrence, for instance the close-down of a large establishment in a small area. Using more than one time period, we believe is more proper as we wish to model systematic changes over time.

Thus, we model the change over three overlapping five year periods as dependent on the market in the applicable starting year.

We begin with the linear model of sector growth, where the change of jobs in a sector has the form specified in Eq. (4.1), which means that the sector change is a linear function of intra-urban, intra-regional and extra-regional market access.

In line with our previous theory discussion, Table 9 presents results, where producer-service jobs respond positively and with significant parameters to the size of intra-urban or local market access, whereas the growth coefficients for intra-regional market access is positive but with less clear significance.

The major result from Table 9 is that with the linear specification, the sign as well as size of each parameter are similar for the KP-sector and OP-sector. For these two categories of producer-service supply, we can conclude the following with regard the growth of the supply:

(i) There is a threshold level for growth, indicated by $\alpha_0 < 0$.
(ii) The size of the local market access parameter $\alpha_1 > 0$ shows that the local market access has a large and significant impact on the growth of producer-service supply.
(iii) The response parameter $\alpha_2 > 0$, representing the growth impact of intra-regional market access, is positive, small, and not significant for KP-services.

Table 10 Change in number of jobs as dependent on market accessibility (quadratic specification)

	ΔKP	ΔOP	ΔO
Intercept	−34.394 (1.24)	−111.070 (2.55)**	−180.537 (1.69)*
Intra-urban, A_{rr}	392.583 (19.62)***	802.878 (25.49)***	825.279 (10.68)***
Intra-regional, $A_{R(r)}$	−9.070 (1.00)	−32.396 (2.27)**	85.074 (2.43)**
Extra-regional, $A_{E(r)}$	−216.322 (2.63)***	−154.495 (1.19)	−5.847 (0.02)
Intra-urban, $(A_{rr})^2$	15.325 (15.31)***	3.791 (2.41)**	−100.114 (25.91)***
Intra-regional, $(A_{R(r)})^2$	1.132 (2.29)**	2.739 (3.52)***	−6.727 (3.53)***
Extra-regional, $(A_{E(r)})^2$	56.262 (1.24)	24.625 (0.35)	60.239 (0.35)
R^2 (overall)	0.93	0.92	0.82
No. obs	864	864	864

Between effects estimation. Absolute value of t statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%

(iv) For the KP-services, the response to extra-regional market access is significantly negative, expressed by $\alpha_3 < 0$.

In previous studies we have interpreted $\alpha_3 < 0$ as a "Christaller effect" showing that when a given urban area is close to one or several large extra-regional markets, then this could imply that jobs will rather grow in these extra-regional locations (Johansson and Klaesson 2007). This may be labeled as an inter-regional competition effect. However, when employing a quadratic specification, the understanding of the extra-regional market influences is improved considerably.

Table 9 also show that the group other sectors has a different change pattern, such that there is a negative response to intra-urban (local) market access, while the response to intra-regional and extra regional market access is not significant. A particular feature of the O-sector in Table 9 is that threshold parameter, α_0, seems to imply that there is no size effect for the rest of the economy. However, as a quadratic specification is introduced, the econometrics will detect a threshold effect also for the O-sector.

The result from the quadratic specification is given in Table 10. The overall impression from the table is that the quadratic specification generates parameter values that reflect a higher degree of similarity between the change processes of the three economic sectors. This also allows for conjectures of a general response pattern, where sectors differ in the strength of the response rather than in the sign of parameter values. Moreover, the nature of the differences between the sectors are better understood with the quadratic specification.

We discuss the parameter values in groups, referring to (i) threshold level, (ii) local market access, (iii) intra-regional market access, and (iv) extra-regional market access.

(i) *Threshold level*: All three sectors are similar in having $\alpha_0 < 0$ although the size of the parameter is small for the KP-sector. Thus there is a threshold level for growth.

(ii) *Local market access*: The growth response to the size of local market access has the same structure for the KP-sector and OP-sector, reflected by [$\alpha_1 > 0$; $\beta_1 > 0$] which corresponds to an exponentially increasing response to the size of A_{rr}.

For the O-sector, the response is given by the pair $[\alpha_1 > 0;\ \beta_1 < 0]$, showing that for O-activities (as a group), the response remains positive as long as the local market access is not too large, and it turns negative as A_{rr} exceeds a given size level, i.e., when $A_{rr} > -\alpha_1/\beta_1$. This could indicate that O-sector firms do not benefit enough from a large local market to compensate for the higher land rents that are associated with a large value of A_{rr}.

(iii) *Intra-regional market access*: For the producer-service sectors, KP and OP, we observe $[\alpha_2 < 0;\ \beta_2 > 0]$, signifying a positive growth response that is initiated when $A_{R(r)}$ passes the threshold level $A_{R(r)} > -\alpha_2/\beta_2$. Thus, a large intra-regional market stimulates growth of producer-service supply. On the other hand, as the intra-regional market access becomes larger, the stimulus to growth of the O-sector is weakened, because in this case we have $[\alpha_2 > 0;\ \beta_2 < 0]$.

(iv) *Extra-regional market access*: The overall result is that across the three sectors, there is only one parameter estimate that is significantly different from zero. The significant parameter is $\alpha_3 < 0$ for the KP-sector, indicating competition between regions with regard to knowledge-intensive producer services.

7 Concluding remarks

A major result from the empirical exercise in this paper is that the macro patterns of firms' location choices in a temporal setting evolve in response to the inner structure of each urban area, to each urban area's intra-regional accessibility to the other urban areas of the relevant region, and to each urban area's accessibility to other regions.

A conclusion of the empirical estimations is that spatial pattern matters, and that producer services are associated with more distance-sensitive transactions than the urban economy as a whole. Regressions where carried through with linear and a quadratic specifications, demonstrating that the linear system leads to misinterpretations of the dynamics.

The estimation results for the producer-service change process follow to a large extent the theoretical motivations. However, one empirical result is a clear surprise. The hypothesis that the extra-regional influence has a negative influence on the growth has to be rejected for the OP-sector. Thus, extra-regional features come out as not being important.

A second observation is that the local market access is very important for the producer-service sectors. With regard intra-regional market access, it is the quadratic term that governs the growth process.

Appendix

See Table 11.

Table 11 Definition of business services (Swedish standard industry classification)

SIC	Type of activity
60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications
65	Financial intermediation, except insurance and pension funding
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation
70	Real estate activities
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computer and related activities
73	Research and development
74	Other business activities

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