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Modern industrial structure and development of house price spatial disparity

A general case for Iceland — a large but thinly populated European country

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Ágrip

Þróun á landfræðilegum breytileika íbúðaverðs er til skoðunar í þessari grein. Þessi breytileiki myndast vegna óska og forgangsröðunar neytenda á aðgengi sem borgir veita og náttúrugæða sem dreifbýli veitir. Samkvæmt útvíkkun Alonso's á kenningum von Thünen's, lýtur íbúðaverð í borgum og í dreifbýli ákveðnum lögmálum. Það er oftast hæst í borgum og lækkar eftir því sem fjær dregur og myndar þar með feril neikvæðs sambands á milli íbúðaverðs og fjarlægðar frá borg. Sýnt hefur verið fram á að þetta gildir fyrir Ísland sem og víða annars staðar í heiminum. Í þessari grein verður gerð tilraun til að sýna fram á að halli þessa ferils verði sífellt brattari, vegna mikils vaxtar þekkingarfrekra atvinnugreina og þar með vaxandi breiddar- og lengdarhagræðis. Gagnagrunnur yfir Ísland frá 1981-2004 verður notaður til að sannreyna þetta. Um er að ræða ársmeðaltöl þar sem Íslandi hefur verið skipt upp í 19 svæði.

Lykilorð: Húsnæðisverð, Bid-rent kúrfan, fjarlægðarstigull, Local, Localization and urbanization economies.

Abstract

In this paper, I examine the development of the spatial structure of house prices. Due to consumer preferences for access over amenity value, there is a spatial disparity of house prices. According to Alonso's extension of von Thünen's theory, the relationship between house prices in urban and rural areas tends to follow certain principles. This relationship is more often negative than positive, i.e. the price of a standardized unit of housing declines with increasing distance from a central business district (CBD). It has been documented that this relationship is negative for Iceland, as well as in many other regions. I will argue that this relationship has become increasingly marked in Iceland, most likely due to the more rapid growth of the knowledge-based industry and, thus, the increased significance of localization and urbanization economies. A macro panel data set from Iceland will be used, representing several essential variables of the residential housing market for 19 counties in Iceland from 1981 to 2004.

Keywords: House prices, Bid-rent curve, Distance gradient, Local, Localization and urbanization economies.

Introduction

Many have argued that the spatial disparity of house prices tends to follow a certain structure (Fujita, 1989; Fujita & Thisse, 2002, pp. 78-91; McCann, 2001). The pattern is generally a negative distance gradient – that is, price declines with distance from a central business district (CBD). This relationship is presented by the slope of the so-called bid-rent curve or the distance gradient. The existence and shape of the bid-rent curve is dependent on consumers' preferences for access over amenity value, according to Alonso's extension of von Tünen's theory (Fujita, 1989; Fujita & Thisse, 2002, pp. 78-91; McCann, 2001) or industry productivity, as argued in the core-periphery model (Baldwin, 2001; Baldwin et al., 2003). Researchers have documented that the slope is negative for Iceland (Karlsson, 2007) as well as in many other places (Archer et al., 1996; Haurin & Brasington, 1996; McMillen, 2003; Plaut & Plaut, 1998, p. 213; Tyrväinen & Miettinen, 2000). The current paper examines the development of the bid-rent curve. If the distance gradient has become increasingly steep, it is either because of relative productivity or increased preferences for access over amenity value, both in favour of the CBD.

In order to explain relative productivity, it should be emphasized that the main assumption of the core-periphery model is an economy of scale, which is a characteristic of a monopolistic firm (Baldwin et al., 2003; Fujita et al., 1999; McCann, 2001). To minimize the average cost and maximize profit, it is always profitable for a firm of monopolistic competition to increase production due to economies of scale. This is one type out of three possible economies of scale for industries which are stressed in spatial economics. This one is the traditional one, called an internal economy of scale. The other two capture economies of scale due to geographical concentration: localization and urbanization economies (Henderson, 2003, p. 1). According to Henderson (2003, pp. 1-2), these two effects are called Marshall, Arrow, Romer (MAR) and Jacobs economies in a dynamic context. The former refers to decreasing average costs due to an increased number of firms in the same industry. The second presents decreasing average costs following an increased number of firms in any other type of industry. The average cost becomes lower following improved proximity of similar or dissimilar firms, because it stimulates a firm's specialization, generating spillover effects. According to this, the productivity of industry located in the CBD's improves due to the economies of scale: Proximity becomes attractive, and the demand for land and real estate increases, leading to an upward pressure on real estate prices in the CBD. Thus, the bid-rent curve becomes steeper following increased economies of localization or urbanization. It is interesting that Henderson's (2003) results were almost as expected. An effect of localization economies existed among high-tech industries but not among mechanized industries. Furthermore, smaller firms have tended to benefit more from localization economies than larger ones.

In order to explain consumer preferences for access relative to amenity value, the urban area offers its residents access to a wide variety of services and employment opportunities. The non-urban districts, however, offer residents better natural recreational endowment, scenery, and less urban disadvantages such as traffic congestion, high crime rates, and pollution. Consumer preferences for access over amenity value tend to be reflected by the spatial structure of house prices, which often decline with distance from the CBD, due to higher value of access than amenity value.

Even though the core-periphery and von Thünen models are two separate theories, they are actually two sides of the same coin – that is, geographical economies of scale can affect migration through consumers' residential preferences. Localization and urbanization economies stimulate agglomeration, and thus the variety of services and employment opportunities. Furthermore, larger communities nurture market niches due to an enlarged local market and thus increase access to various supplies of goods and services. Therefore, localization and urbanization economies are necessary to create various supplies of services and employment opportunities, and improved preferences for access over amenity value leads to improved localization and urbanization economies.

If consumers prefer access over amenity value, they will migrate to the CBD following improved localization and urbanization economies, and the entire real estate market will be affected. When the urban residence becomes more attractive, the demand for both residential and industrial premises will increase, and the distance gradient will become steeper, ceteris paribus.

The present research will be implemented using data from Iceland, a country in Northern Europe with a relatively low population. Iceland is an island of 103,000 km2 in the North Atlantic Ocean, but a large part of the island is not suitable for human habitation due to its bad climate and particularly cold and windy winters. Relatively few inhabitants live in areas that are 200 or more metres above sea level, with only 24,700 km2 of Iceland being lower than 200 metres above sea level (43,100 km2 of Iceland is below 400 metres). The higher land is located in the centre of the island, so residential areas were evenly spread along the coastline until the beginning of the twentieth century. Then, a relatively large and persistent migration flow began to the urban area of the capital city in the south-west corner of Iceland ('the capital area') from the rural areas ('district areas'). Today, almost 70% of the population lives in the capital area and adjacent municipalities. The villages outside of the capital area are still evenly spread around the coastline, but have much lower populations. Furthermore, many farms have been completely or partly abandoned, so the population in the countryside of Iceland (i.e. areas other than in the capital area) is thinly distributed, although it is still spread along the coastline. The population of Iceland was 293,291 in December 2004 (reaching 300,000 in January 2006). Iceland is a very thinly populated country compared to other European countries, with the population concentrated in the lowlands, which is the area the subject of the current study.

The rapid growth of knowledge-based and high-tech industries is one of the major characteristics of Iceland's recent economic expansion, which started in 1996 and had a minor recession in 2001. In the past, economic expansion was driven by primary industry (i.e. fisheries), which has had geographical implications. The fishing industry is fairly evenly spread along the coastline of Iceland, while the knowledge-based industry is primarily located in the capital area. Thus, it is reasonable to believe that the effect of economic expansion in the past was more spatially distributed than at present (especially when the economic relationship between the capital area towards other districts of Iceland is weaker than the other way around) and thus the present economic growth generates more geographical economies of scale, as mentioned above.

Table 1: Employment in Iceland by occupational groups and areas, from 1991 to 2004.

Area	Labour skills	1991	2004	StDev	Trend	%Trend
Iceland						
	Total employment	136,900	156,100	8,900	2,011	2.6%
	Highly skilled occupations	43,000	61,800	6,148	1,440	3.3%
	Skilled occupations	82,100	80,000	3,779	331	0.4%
	Unskilled occupations	11,800	14,300	1,321	243	2.1%
Capital area						
	Total employment	77,900	100,200	8,347	1,954	3.3%
	Highly skilled occupations	30,400	45,500	5,356	1,263	4.2%
	Skilled occupations	41,000	46,700	2,996	550	1.3%
	Unskilled occupations	6,400	8,000	789	139	2.2%
District areas						
	Total employment	59,000	55,900	1,503	57	0.1%
	Highly skilled occupations	17,100	19,700	820	142	0.8%
	Skilled occupations	41,100	33,200	2,119	-223	-0.5%
	Unskilled occupations	5,400	6,400	612	106	2.0%

Occupational groups: Highly skilled occupations include legislators, managers, professionals, and associated professionals. Skilled occupations include clerks, service, and sales workers, agricultural and fishery workers, craft and related trades workers, and plant and machinery operators. Unskilled includes elementary occupations.

Source: Statistic Iceland.

The statistics support this statement, as employment increased in Iceland from 1990 to 2004 (i.e. 2014 annually or by 2.6%; Table 1), and increased the most among highly skilled occupations (i.e. 1382 or almost 75% of the total annual increase). The vast majority of this increase has been in the capital area (i.e. 1221 annually). While the absolute trend in highly skilled and skilled occupations is higher than among the unskilled in the capital area, it is lower (and actually decreasing) in the district areas.

Table 2: Population 16–74 years by labour force education levels 1991–2004.

Area	Labour skills	1991	2004	StDev	Trend	%Trend
Iceland						
	Total labour force of Iceland	140,500	161,100	8,100	-440	-0.3%
	Basic education, ISCED 1,2	59,700	59,500	3,854	-2,960	-5.0%
	Secondary education, ISCED 3,4	65,600	66,400	2,018	-750	-1.1%
	University education, ISCED 5,6	15,200	35,200	6,300	3,270	21.5%

Source: Statistic Iceland.

Educated workers presumably have higher preferences for access over amenity value compared with less educated workers, ceteris paribus. Access brings them a higher probability of suitable employment. In that sense, educated workers behave like a monopolistic firm, benefiting from proximity. Recent statistics related to the skill of the labour force in Iceland are interesting. While the total labour force has been fairly stable, the skill level of workers has been rapidly increasing. The proportion of the labour force with a university education increased by 21.5% annually from 1991 to 2004 (Table 2).

The hypothesis of this study is as follows: The Icelandic bid-rent curve has become increasingly steep over the last 25 years. If the hypothesis is true, evidence of increased localization or urbanization economies in Iceland will be found. This must be true if in-migration still occurs and there is not a decreased number of firms in a certain CBD while the relative price of its real estate is increasing, which confirms increased value of proximity, ceteris paribus. Furthermore, if the hypothesis will not be rejected, it confirms improved localization and urbanization economies in the capital area of Iceland. This is in line with the theory of the core-periphery model. The hypothesis of the present paper will be tested by comparing the slope of Iceland's bid-rent curve for the period 1981–2004 against the bid-rent curve for the period of the recent expansion and the prior recession: the period from 1993 to 2004. The estimation will be based on my former analyses (Karlsson, 2007).

McMillen (2003) implemented a similar study for the city of Chicago, and had positive results. The distance gradient exists today, but did not a couple of decades ago. McMillen (2003) concluded that this is strong evidence of the return of centralization in Chicago. His methods and data sample are reasonably different from those of the present study.

The organization of the study is as follows. Section 1 presents the introduction and a description of the paper's purpose, as well as its relation toward the recent spatial economics literature and a construction of the research question. Section 2 is the literature review and provides a short overview of the recent literature, with an emphasis on empirical studies, their methods, and main conclusions. Section 3 is a theoretical discussion of the model and several other possible approaches, while Section 4 stresses the data origin, definition, construction, and transformation. Section 5 contains the analysis and results, and Section 6 includes a summary and concluding remarks.

Literature review

The spatial disparity of house prices has been a topic in a variety of theoretical and empirical studies Frame (2004), Turnbull (1998), and Capozza and Helsley (1989) are among those which are pure theoretical studies. Regression analysis is the most common method used in empirical house price spatial disparity studies among economists, including Cunningham (2006), McMillen (2003), Tyrväinen and Miettinen (2000), Plaut and Plaut (1998), Archer et al. (1996), Haurin and Brasington (1996), Kiel and Zabel (1996), and Kiel and McClain (1995A; 1995B). A pooled regression model implemented on micro data is the most common approach in the literature, such as in Cunningham (2006), McMillen (2003), Tyrväinen and Miettinen (2000), Plaut and Plaut (1998), Archer et al. (1996), Kiel and Zabel (1996), Haurin and Brasington (1996), and Kiel and McClain (1995A; 1995B), with several interesting differentiations, such as those of Cunningham (2006) and Plaut and Plaut (1998), who used GIS tools, as well as Tyrväinen and Miettinen (2000), who implemented a Box-Cox regression.

The content of studies on the spatial disparity in house prices varies greatly. Archer et al. (1996, p. 334) argued that house price appreciation has spatial aspects, and seems to be dependent on distance from the CBD, housing units, local changes in population, and the ethnic mix. The study was implemented using data from Dade County in Miami, Florida. Sheppard and Stover (1995) discussed a suitable method for the economic impact estimation of inner city transportation improvements. The method emphasizes changes in the price level of real estate following an improvement in transportation. According to Sheppard and Stover (1995), changes in the price level reflect the social surplus of transportation improvement. This method has been applied in several studies, and according to Sheppard and Stover (1995), it is applicable and practical, although several scientists doubt its reliability. McDonald and Osuji (1995) presented results from a similar study, focusing on an 11-mile freeway between the centre of Chicago and its airport, which was finished in 1993. According to the results, land values started to increase before the end of the freeway construction, and rose a total of 17% in real terms.

Haurin and Brasington (1996, p. 351) used the framework of the bid-rent curve to test whether quality of schools has a positive influence on real house prices, testing the hypothesis using primary data from the six largest metropolitan areas in Ohio (Haurin & Brasington, 1996, p. 356). The results were as expected – school quality had a significant influence on real house prices, along with the crime rate, arts, and recreational opportunities (Haurin & Brasington, 1996, p. 351). Cunningham (2006, p. 27) applied this approach to his study for a different purpose, to search for evidence of real options in the Seattle housing market.

The current study seems to be most comparable to McMillen's (2003) study, in which the researcher evaluated the return of centralization to Chicago using a repeat sales model, and concluded that house prices decline by more than 8% for every mile from the CBD. Case and Mayer (1996) analysed house price dynamics in the Boston metropolitan area in another similar study, using data from 1982 through 1994. According to Case and Mayer (1996, p. 387), the spatial disparity of house prices can be explained by differences in new construction, demographics, manufacturing employment, proximity to downtown, and aggregate school enrolment. Tyrväinen and Miettinen (2000) investigated the influence of urban forest amenities on property prices using data from the district of Salo in Finland, and concluded that houses become more valuable if they are close to, or have a view of, a forested area. Plaut and Plaut (1998) confronted an interesting methodological challenge in their study of identifying and ranking the multiple 'centres' of a metropolitan area. In order to capture the complexity of multiple centres in metropolitan areas, they developed a new framework for analysis, based on gravity models, which is readily applicable to GIS tools and data. Kiel and Zabel (1996) found that house prices tend to capture racial effects, and

Kiel and McClain (1995A; 1995B) examined the impact of undesirable land use on real estate prices and, not surprisingly, found it to have significant and negative influence.

As mentioned before, empirical studies devoted to the spatial disparity of house prices were not found as easily as expected. Those that were most relevant have been described above. The current study is different from this previous work in five ways. Firstly, none of the previous researchers tried to find evidence of geographical economies of scale. Secondly, none focused on a community as densely populated as Iceland. Thirdly, the data sample of the present study represents an extraordinarily long period, from 1981 to 2004, and the data sample covers one country in total. Finally, the country studied in the current research is unusual geographically as an isolated island.

The model

The hedonic price model is the most frequently used approach in research on the spatial disparity of house prices within the economic literature (Archer et al., 1996; Cunningham, 2006; Gibbons & Machin, 2005; Haurin & Brasington, 1996; Kiel & Zabel, 1996; McMillen, 2003, p. 289-290; Plaut & Plaut, 1998, p. 213; Tyrväinen & Miettinen, 2000). A hedonic price model contributes house and lot characteristics to the standard analysis (Cunningham, 2006, p. 6; Tyrväinen & Miettinen, 2000, p. 206). Special explanatory variables are then added to the model to capture house characteristics such as house age, size of garden, number of rooms, building materials, and location amenity values. Other alternative approaches are the standard repeat sales (McMillen, 2003, p. 290) and Fourier repeat sales approaches (McMillen, 2003, p. 291). The standard repeat sales approach is similar to the hedonic model but only includes data on houses that have been sold more than once in the relevant period (Kiel & McClain, 1995A, p. 315; McMillen, 2003, p. 290). The difference is then calculated for each house in order to capture the appreciation of its price. According to McMillen (2003, p. 290), the repeat sales approach was developed to avoid missing variable bias, which tends to vary over time, but this approach also has disadvantages. It reduces the available data sample considerably and can create a sample selection bias, as argued by Kiel and McClain (1995, pp. 315-316). There are several studies using the pure hedonic price approach, such as those of Cunningham (2006), Eshet et al. (2006), Kong et al. (2006), Haurin and Brasington (1996), Kiel and Zabel (1996), as well as studies using the pure repeat sales model, such as that of Archer et al. (1996). There are also studies using mixed hedonic and repeat sales model approaches, including those of Gibbons and Machin (2005), McMillen (2003) and Kiel and McClain (1995).

The approach of the present paper will follow a pure hedonic model. Other alternative approaches, such as the standard repeat sales (McMillen, 2003, p. 290) and Fourier repeat sales approaches (McMillen, 2003, p. 291) could have been implemented if the data sample was suitable. Many counties of Iceland have such a low population that a repeat sales model approach would cancel them out from the analysis. Furthermore, since this study is based on aggregated data (macro data sample), the repeat sales model is not as relevant as it would be in the case of a micro data sample.

According to Fujita (1989, p. 16; p. 6), Kiel and McClain (1995B, pp. 314-315), and Karlsson (2007) the general context from the basic model, $h(Y,T,r,z,s)$, can be derived a log linear utility function into an equation of the following form in its simplest version,

$$h(r) = Ae^{-br}, \qquad (1)$$

where h is the house price, r is the distance between the land location and the CBD, and A and b are positive constants. By taking the natural logarithm of both sides, Eq. 1 becomes

$$\ln h(r) = \ln A - br \,. \qquad (2)$$

This equation has been used in many versions of house price research in the case of the hedonic price model approach. Furthermore, it is the most common form in the field of house price research regarding relevant dependent variables which can be seen, for example, in the papers of Cunningham (2006, p. 6), Gibbons and Machin (2005, p. 152), McMillen (2003, pp. 289, 293), Haurin and Brasington (1996, p. 356), Kiel and Zabel (1996, p. 148) and Kiel and McClain (1995A, p. 248; 1995B, p. 319). The equation is a non-linear relationship of the semi-logarithmic type. Instead of estimating a simple model as follows,

$$\ln h_{it} = \alpha + r_{it}\beta_1 + \varepsilon_{it} \,, \qquad (3)$$

economists frequently implement an extended model,

$$\ln h_{it} = \alpha + r_{it}\beta_1 + x'_{it}\beta_2 + d'_{it}\beta_3 + \varepsilon_{it} \quad , \qquad (4)$$

where x'_{it} is a vector of relevant additional explanatory variables and c is a vector of coefficients. Additional explanatory variables from former studies include several local demographic factors, such as population or a change in it (Archer et al., 1996; De Bruyne & Van Hove, 2006; Cunningham, 2006), demographics (Case & Mayer, 1996), population density (De Bruyne & Van Hove, 2006; McDonald & Osuji, 1995), presence of a park or school nearby (McDonald & Osuji, 1995), and ethnic mix (Archer et al., 1996; De Bruyne & van Hove, 2006; McDonald & Osuji, 1995).

Indicators for house quality are relevant explanatory variables in hedonic price models, such as plot size (Cunningham, 2006; Kiel & McClain, 1995; McMillen, 2003), house age (Archer et al., 1996; De Bruyne & Van Hove, 2006; Kiel & McClain, 1995; McMillen, 2004; McMillen, 2003; Tyrväinen & Miettinen, 2000), house building materials and type of construction (McMillen, 2004; Tyrväinen & Miettinen, 2000), number of rooms (Kiel & McClain, 1995), number of bathrooms (Kiel & McClain, 1995), number of storage areas (McMillen, 2003; McMillen, 2004), existence of a garage, attic, basement, central air conditioning, fireplace, or land area (McMillen, 2004), and the existence of a building area (McMillen, 2003; McMillen, 2004).

Furthermore, local economic factors can be among the relevant explanatory variables, such as the supply of houses (Archer et al., 1996; Case & Mayer, 1996; De Bruyne & Van Hove, 2006), manufacturing employment (Case & Mayer, 1996), importance of agriculture (De Bruyne & Van Hove, 2006), household income (De Bruyne & Van Hove, 2006; McDonald & Osuji, 1995), unemployment rate (De Bruyne & Van Hove, 2006), municipal tax rate (De Bruyne & Van Hove, 2006), aggregate school enrolment (Case & Mayer, 1996), school quality (Haurin & Brasington, 1996, p. 351), and interest rate (Cunningham, 2006).

Finally, indicators for some kind of amenity value reflect a significant aspect of the distance gradient, e.g. the presence of a lake or an attractive view (Cunningham, 2006; De Bruyne & Van Hove, 2006; Kiel & McClain, 1995; Tyrväinen & Miettinen, 2000), arts and recreational opportunities (Haurin & Brasington, 1996, p. 351), any kind of local dangers (Cunningham, 2006), and crime rate (Haurin & Brasington, 1996).

Thus, it is reasonable to apply the following empirical model,

$$\ln h_{it} = \alpha + r_{it}\beta_1 + x'_{it}\beta_2 + d'_{it}\beta_3 + \varepsilon_{it} \;, \qquad (5)$$

where the natural logarithm of the house price, h, is dependent on the distance, r, to the capital area, or CBD, several other explanatory variables, x', dummy variables, d', and relevant residuals, ε, of every county, i, in every single period, t. Total household income, age of the houses, and population are other explanatory variables. There are two dummy variables; one for the Eyjafjarðar County and another for the Whalefjord Tunnel. The dummy variable for the Whalefjord Tunnel should capture the effect of a transportation improvement financed by a road toll, as the Whalefjord Tunnel is the only such transportation improvement in Iceland between 1981 and 2004. The dummy variable for Eyjafjarðar County should reflect the fact that it contains the largest town in rural Iceland. Furthermore, its population is large in number compared to other towns in rural Iceland. Unfortunately, limitations of the data prevented any possible estimation of the compensated good, z, plot size, s, and mortgage interest rates.

This model is suitable for the evaluation of the development of localization and urbanization economies because the distance parameter, r, reflects the spatial disparity of the local real price of houses and if there is a significant difference between two known regions, the rural and the urban area, when everything else has been accounted for, the difference is most likely due to proximity to the CBD, which is their largest difference. Thus, the development of the distance parameter reflects changes in localization and urbanization economies on the real unit price of houses, ceteris paribus. There are few variables available for hedonic estimation in the present study, which is a shortcoming in other studies as well (McMillen, 2003, p. 292).

Data

The data for this analysis come from Iceland, a large European country with a relatively small population. Iceland is divided into 19 counties[1] in this paper (Figure 2), all of which are real counties, except for the capital area. The capital area is not a clearly defined selection of municipalities with a definition by Statistics Iceland, as are the other counties in this study.

Figure 1: Counties of Iceland.

1 There is a two-tier system in Iceland: the central and local levels (i.e. central goverment and municipalities). Counties are not a part of this system. The role of counties was more important historically but is now mainly used to determine jurisdictions for Iceland's courts and police. Counties, rather than municipalities, were selected as the domestic areas of Iceland in this paper due to a lack of a reliable data sample for the vast majority of the smallest municipalities, as mentioned in the body of this paper.

The data on house prices[2] in this study come from the Land Registry of Iceland. The data sample covers the monthly average figures of all Icelandic municipalities from 1981 to 2004. The sample was transformed into counties with annual average figures, both due to comparability and lack of the housing market's turnover in several municipalities. In order to do so, monthly average cash prices were transformed into annual average cash prices by the weight of the number of contracts in each month.

$$\overline{h_y} = \sum_{m=1}^{12} \overline{h_m} \left(\frac{c_m}{\sum_{m=1}^{12} c_m} \right) \qquad (6)$$

The annual average cash price, $\overline{h_y}$, is the sum of the weighted monthly average cash price, $\overline{h_m}$, defined by the notation above. The weight is calculated by the number of contracts in each month, c , divided by the total number of contracts each year. To improve the comparability between regions, data for the capital area were only for single apartment houses of a selected size, i.e. 110m2 to 210m2, which is the most common type of house in other regions.

Table 3: Real house prices in Icelandic counties from 1981 to 2004.
Annual average house prices in Icelandic kronur based on the total sample. Source: Land Registry of Iceland.

County	Average	Max	Min	StDev	Years	Trend
Capital area	104,605	144,012	83,336	14,628	24	1,018.1
Gullbringu County	72,021	93,386	62,096	8,757	24	418.0
Borgarfjarðar County	64,713	93,707	45,851	12,532	24	1,200.5
Mýra County	66,458	95,608	49,964	12,320	24	45.9
Snæfellsnes County	51,024	66,797	38,768	6,837	24	320.8
Dala County	37,558	58,254	25,163	10,118	14	477.7
Barðastrandar County	39,370	61,010	26,235	9,280	24	-991.5
Ísafjarðar County	57,350	78,787	41,963	9,272	24	-1,110.1
Stranda County	43,703	64,074	28,679	11,374	14	-314.8
Húnavatns County	41,797	48,570	31,972	4,817	22	-64.7
Skagafjarðar County	49,774	63,566	17,898	9,541	23	10.5
Eyjafjarðar County	76,599	96,376	59,116	8,104	24	793.6
Þingeyjar County	56,938	105,582	44,696	12,673	24	-1,110.5
N- Múla County	42,106	62,101	29,813	8,356	19	-520.6
S- Múla County	58,410	98,695	28,030	14,100	24	-281.1
A- Skaftafells County	69,027	94,844	33,289	14,088	19	-168.7
V- Skaftafells County	38,139	55,238	23,975	9,328	14	15.5
Rangárvallar County	53,748	66,270	43,822	4,781	24	474.1
Árnes County	67,397	91,274	53,060	10,251	24	575.3

The figures of this table, i.e. average, max, min, standard deviation, and trend, are based on transformed data of the annual average, according to Eq. (6).

House prices vary substantially both within and between counties in Iceland. The average house price from 1981 to 2004 was highest in the capital area and lowest in Dala County, while among every annual average, the price was lowest in Skagafjarðar County, but was still highest in the capital area. The development of the house prices during the period of 1981-2004 was dissimilar among counties. The

2 The Land Registry of Iceland collected these data from the original source: written contracts between the house sellers and buyers. The data were available both in terms of contract prices and cash prices. The contract price is the total house price according to the written contract between a seller and buyer. However, it is common for the contract price to be paid in several payments during a certain period. Both the duration and number of payments vary substantially between contracts. In order to make the house prices more comparable, the Land Registry of Iceland calculates a so-called cash price for every contract, which is the present value of the contract price. The dependent variable in this paper is the cash price divided by the house size in square metres.

most marked changes were in Borgarfjarðar, Ísafjarðar, and Þingeyjar Counties. House prices increased in real terms by 1,200.5 kronur per m2 in Borgarfjarðar County annually during that period, at 2004 price levels. House prices, however, decreased in real terms by 1,110 kronur per m2 annually during the period in both Ísafjarðar and Þingeyjar County. Note that the data are missing in seven out of nineteen counties during the relevant period (Table 3).

The explanatory variables included in Eq. 5 are drawn from various sources, including the Commissioner of the Inland Revenue, Statistics Iceland, and the Icelandic Road Administration. Information on house age was received from the Land Registry of Iceland, along with house prices, as mentioned before. Data on road distances came from Fjölvís Publishing Company, originally collected by the Icelandic Road Administration, and the data on population and total income were received from Statistics Iceland. The Commissioner of Inland Revenue was the primary source for total income. The data series were annual averages, except for population and road distance, which were static. Data on population is based on 1 December every year and the data on road distance is based on 1 January every year. The data series were spatially classified by municipalities, except for the data on road distance, which were classified by localities. The data series were transformed from municipalities and localities into counties.

Table 4: Variable description and sample statistics.

Variable (acronym)	Description	Mean	Standard deviation
House price (HPRI)	Real price per m^2, in Icelandic kronur	58,233.0	17,820.4
Road distance (RDIS)	Average distance in kilometres of each county from the capital area, in absolute terms	302.5	212.3
Total income (TINC)	Total income per capita, in ,000 Icelandic kronur	1,803.7	374.4
House age (HAGE)	Average age of houses sold, in absolute terms	30.3	10.2
Population (POPU)	County population, in absolute terms	13,809.1	33,557.3
Interest rate (INBA)	The average interest rate for residential mortgages in Iceland during the period 1994-2004	0.0614	0.0082
Eyjafjarðar County (EYJA)	Dummy variable for a county outside the capital area with a large centre: 1 for Eyjafjarðar-county and 0 for any other county	0.0614	0.0082
Tunnel (TUNN)	Dummy variable of large transportation improvement: 1 for Whalefjord Tunnel	0.052632	0.2235

The figures of this table, i.e. mean, standard deviation, and trend, are based on transformed data of annual average, according to a similar calculation as in Eq. (6).

In many previous studies, the analyses were based on a model of repeat sales estimators due to a problem with missing variable bias toward the estimated price index (McMillen, 2003, p. 290). This method will not be utilized in this study in order to maximize the consistency of the data sample. A sample of repeat sales estimators would have increased the number of missing years for many counties.

Estimating the result

As argued in the discussion of the model in Chapter 3, the empirical model for testing the hypothesis is as follows:

$$\ln h_{it} = \alpha + r_{it}\beta_1 + x'_{it}\beta_2 + d'_{it}\beta_3 + \varepsilon_{it} \ . \qquad (7)$$

The natural logarithm of the local real price of houses is dependent on the distance to the capital area, r_{it}, and a vector of other significant explanatory variables, x'_{it}, such as total income, house age, population, and interest rate. Furthermore, the local real price of houses will most likely be affected by an exceptional transportation improvement and a local business centre outside the capital area, represented by a vector of two dummy variables, d'_{it}.

The estimation of the results will be divided into two sections. The first section will stress the results for all counties, while the second section covers the analysis for the capital area and adjacent counties.

Estimating the result for all counties in Iceland

To estimate the development of the bid-rent curve, the relationship of road distance to the local real price of houses among other relevant variables, as in Eq. (7), is estimated by a pooled least squares model. The results are presented in Table 5, including parameter coefficients, t-values, number of observations, adjusted R2, F-values, Durbin-Watson values, and t-statistics for a special test of serial correlation recommended by Wooldridge (2002, pp. 176-177).

The analysis is divided into several parts in order to emphasize the development of the distance gradient. First, I analyse the whole period from 1981 to 2004 and then analyse the period of the last business cycle or the second half of the data sample, 1993-2004. Furthermore, I repeat the test several times with longer and shorter periods in order to test the robustness of the results.

When I estimated and compared the slope of Iceland's bid-rent curve for the 1981-2004 period, based on my former analysis (Karlsson, 2007), against the bid-rent curve for the period of the most recent business cycle, the period from 1993-2004, the results were as expected. The latter bid-rent curve was steeper, changing from $-0.0013+0.000003RDIS$ in the 1981-2004 period to $-0.0021+0.000005RDIS$ in the period of 1993-2004 (Model 1 compared with Model 4 in Table 5 and Figure 2).

Initially, both estimations suffered from serial correlation, which was sufficiently eliminated by a lagged variable of the residual, which is a method recommended by Wooldridge (2002, pp. 176-177). Furthermore, multicollinearity (Table 11) and heteroscedasticity (Tables 5-10) were not observable in the final results.

Since Capozza and Helsley (1989) have argued that the mortgage interest rate tends to influence the slope of the bid-rent curve, I added the relevant variable to my former models in order to improve the results. As mentioned before, reliable data for the mortgage interest rate were only available for the period of 1994–2004. To amplify the comparison, the analysis was first implemented without including data on the mortgage interest rate. When adding the data for the interest rate to the model, the slope of the bid-rent curve was still larger for the model of the most recent business cycle than for the entire period, and the distance gradient became increasingly larger when it came closer to the present time (see Table 5 and appendix for the semi-logarithm version of the model). This means that the local prices of houses are more sensitive to distance from the CBD than in the past. It should be noted that an identical model was tested for the period of 1981-1992 and showed no significant relationship between the local prices of houses and distance from the CBD (see appendix, Table 10), which does not undermine former findings.

Table 5: Relationship between house price and distance in the entire country of Iceland: A comparison of short and long periods of a quadratic distance model.

	Model 1 The period 1981-2004	Model 2 The period 1990-2004	Model 3 The period 1993-2004	Model 4 The period 1993-2004	Model 5 The period 1996-2004
α	10.84815 (156.77)	10.93213 (134.09)	11.39270 (71.03)	10.95717 (109.90)	11.24311 (47.93)
RDIS	-0.001326 (-7.08)	-0.001864 (-10.95)	-0.002143 (-11.27)	-0.002134 (-10.82)	-0.002530 (-10.75)
RDIS^2	1.52E-06 (5.52)	2.12E-06 (8.86)	2.46E-06 (9.00)	2.45E-06 (8.67)	2.93E-06 (8.56)
TINC	0.000326 (8.98)	0.000325 (8.14)	0.000302 (7.88)	0.000319 (7.36)	0.000344 (5.67)

HAGE	-0.011754 (-9.18)	-0.011505 (-6.99)	-0.010852 (-6.00)	-0.010995 (-5.94)	-0.009583 (-4.33)
TUNN	-0.102555 (-4.68)	-0.107702 (-4.77)	-0.101221 (-4.62)	-0.099453 (-4.19)	-0.065313 (-2.50)
EYJA	0.417676 (17.38)	0.553356 (26.65)	0.598279 (29.92)	0.596893 (26.32)	0.648268 (28.96)
POPU	1.62E-06 (9.28)	9.16E-07 (5.69)	7.52E-07 (4.26)	7.14E-07 (3.94)	6.42E-07 (2.95)
INBA			-6.416690 (-3.46)		-6.051492 (-3.00)
ε(-1)	0.603739 (10.37)	0.740504 (14,45)	0.734676 (13.17)	0.723625 (12.58)	0.757459 (11.48)
n	385	255	206	206	152
R2	0.74	0.83	0.85	0.84	0.87
Adjusted R2	0.73	0.83	0.84	0.83	0.86
F-value	133	156	123	126	106
Durbin Watson	1.91	1.98	2.14	1.99	1.89
Log-likelihood	176				
Serial correlation (t-statistics)	-1.05	-1.34	-1.81	-1.31	-1.20

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroscedasticity-Consistent Standard Errors & Covariance. Cross sections without valid observations dropped. Values in parentheses are t-statistics.

The relationships between house prices and total income, house age, and population, are also significant. The results indicate that house prices will increase by 3.0% for an increase of 100,000 Icelandic kronur in total income per capita, ceteris paribus (Table 5). Furthermore, the age of a house influences its real price. As the house gets older, the house price reduces by 1.1% in real terms for every year, ceteris paribus. County population has a positive relation with house prices. When county population increases by 1,000 inhabitants, the house prices increase by 0.1%, ceteris paribus. The house prices in Eyjafjarðar County are significantly higher than in other counties, by about 60%, due to the existence of Akureyri, which is an extraordinarily large local centre in district Iceland (Model 3 in Table 5). This is in line with my previous results (Karlsson, 2007).

According to the analysis, the distance gradient of the bid-rent curve is much steeper today than it was for at least the last three decades. Since the analyses were able to include the spatial diversity of other relevant economic factors such as income, distance, population, and house age, it is reasonable to believe that this is evidence for either improved spatial scale economies due to rapid industrial structural change over the last decade or changed consumer preferences in Iceland, for access over amenity value. As argued before, the results will be interpreted as clear evidence for increased localization or urbanization economies in the capital area of Iceland. These results are in line with the theory of the core-periphery model.

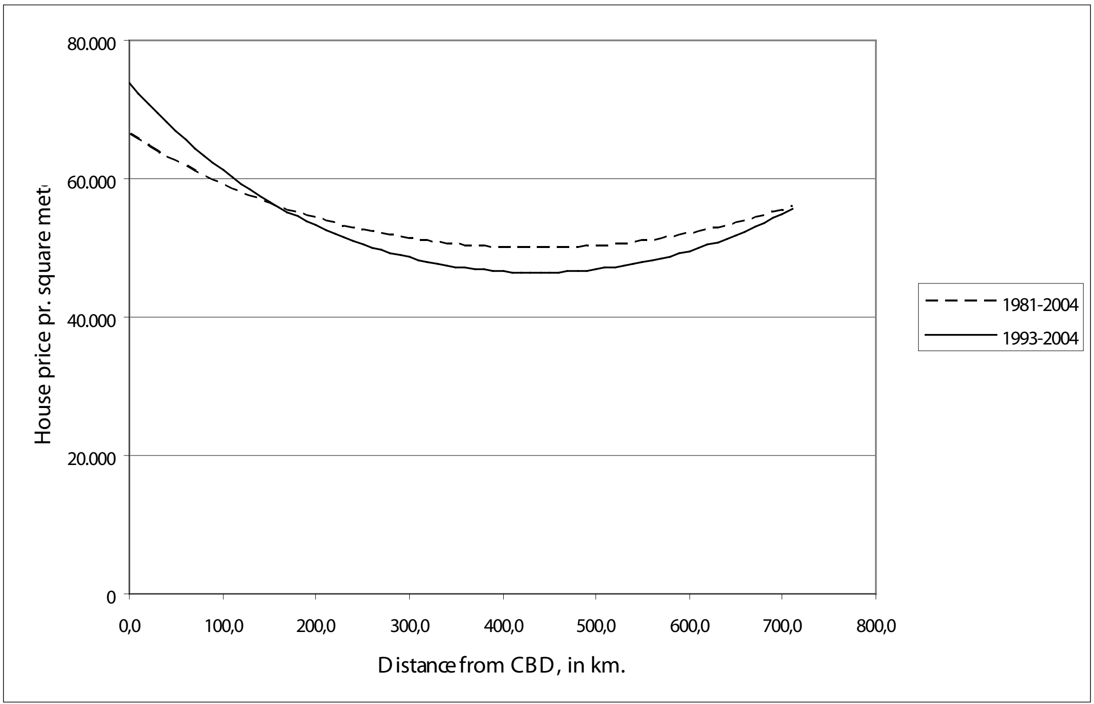

Figure 2: The development of the Icelandic distance gradient.
A simulation of the results for Model 1, the period 1981-2004, and Model 4, 1993-2004. The models are quadratic distance models.

These results have two shortcomings that should be stressed. Firstly, there is no explanatory variable for the development of industrial structure in domestic Iceland. Secondly, improved economic wealth among households in Iceland could be another explanation for this result, since there is a larger market for goods and services of higher income elasticity in urban, rather than rural, areas. The impact of the development of industrial structure has, to some extent, been accounted for, since the population is presumably correlated with employment. The relationship between local house prices and population is positively significant. The impact of improved economic wealth, however, has been clarified implicitly, since the model includes an explanatory variable for the total local income. The relationship between local house prices and total income is positively significant, as mentioned before.

Estimating the result for the conurbation area

The analysis is divided into several parts, as in the former analysis, in order to emphasize the development of distance gradient. First, I analyse the whole period from 1981 to 2004 and then analyse the period of the last business cycle. Furthermore, the test is repeated several times with shorter and longer periods in order to test the robustness of the results.

When I estimate and compare the slope of the conurbation area's distance gradient for the period 1981–2004, based on my former analysis (Karlsson, 2007), against the bid-rent curve for the period of the recent expansion and the recession before, the period from 1993 through 2004, the results were not as expected. The latter bid-rent curve was flatter, changing from $-0.0182+0.000199RDIS$ in the 1981–2004 period to $-0.0179+0.000210RDIS$ during the 1993–2004 period (Model 5 compared to Model 9 in Table 5 and Figure 3). The analyses suffered from autocorrelation, which was sufficiently eliminated by a lagged variable of the same type as before. Thereafter, autocorrelation, multicollinearity (Table 11), and heteroscedasticity (notations in tables) were not observable in the results.

Table 6: Relationship between house prices and distance in the capital area and adjacent counties: A comparison of short and long periods of a quadratic distance model.

	Model 6 The period 1981-2004	Model 7 The period 1990-2004	Model 8 The period 1993-2004	Model 9 The period 1993-2004	Model 10 The period 1996-2004
α	11.48954 (83.87)	11.48267 (81.59)	11.90202 (44.92)	11.64942 (51.11)	11.24955 (72.77)
RDIS	-0.018214 (-4.63)	-0.015395 (-4.03)	-0.017858 (-3.35)	-0.017897 (-3.17)	-0.005582 (-5.76)
RDIS^2	9.97E-05 (3.98)	8.79E-05 (3.71)	0.000105 (3.12)	0.000106 (2.95)	2.01E-05 (2.43)
TINC	0.000269 (7.70)	0.000327 (13.36)	0.000315 (10.91)	0.000336 (10.25)	0.000297 (5.23)
HAGE	-0.005954 (-2.56)	-0.012963 (-5.95)	-0.015294 (-4.71)	-0.015851 (-4.32)	-0.009222 (-2.17)
TUNN	0.110204 (3.82)	0.110935 (3.78)	0.118510 (3.90)	0.120988 (3.89)	0.113244 (3.24)
EYJA					
POPU	-2.77E-06 (-2.94)	-2.22E-06 (-2.45)	-2.80E-06 (-2.29)	-2.84E-06 (-2.19)	
INBA			-3.612770 (-2.16)		-2.876993 (-1.83)
(-1)	0.552411 (4.74)	0.678470 (9.06)	0.569222 (4.41)	0.580219 (4.36)	0.602962 (3.59)
N	138	84	66	66	48
R^2	0.80	0.92	0.90	0.89	0.91
Adjusted R^2	0.79	0.91	0.89	0.87	0.89
F-value	77	120	68	64	55
Durbin Watson	1.73	2.01	2.18	1.94	2.20
Log-likelihood	127	118	89	83	62
Serial correlation (t-statistics)	0.35	0.12	-0.37	0.09	-0.64

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroscedasticity-Consistent Standard Errors & Covariance. Cross-sections without valid observations dropped. Values in parentheses are t-statistics.

As in the former analysis, I add an explanatory variable for mortgage interest rate. To improve the comparison, the analysis was first implemented without including data on the mortgage interest rate for the 1993–2004 period, and the distance gradients were increasingly smaller.

The results of the short period analysis based on every county in Iceland show a significant negative relationship between local price of houses and the distance from the capital area. According to the results, house prices initially decline by 1.79% with each additional kilometre of distance from the centre of the capital area, ceteris paribus. This marginal effect reduces by 0.02% for every kilometre in distance away from the CBD (Model 3 in Table 6). This means that the slope of the distance gradient becomes positive when the distance exceeds 85 kilometres from the CBD. Furthermore, according to the analyses, the distance gradient of the bid-rent curve within the conurbation area is flatter today than it was for at least the past three decades.

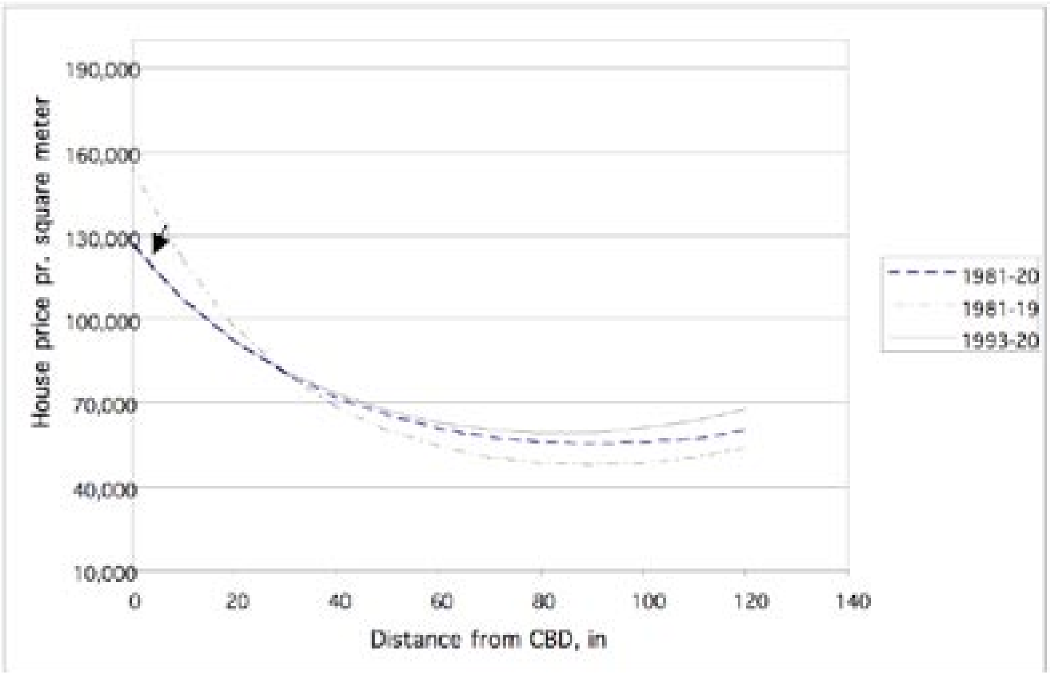

Figure 3: The development of the Icelandic conurbation distance gradient.
A simulation of the results for Model 6 in 1981-2004, and Model 12 in 1993-2004. The models are quadratic distance models.

According to the results, the distance gradient is becoming increasingly steep for the entire country but increasingly flatter for the conurbation area. Is there any logical explanation? It is possible that, even though the value of access has been increasing, relatively more inhabitants of the CBD appreciate amenity values and tend to combine those two qualities. This could be evidence of a mutual increase in access and amenity values where the local price of houses in counties farthest away from the CBD, called rural areas, are decreasing compared to the capital and the conurbation area. The rural area is only capable of serving amenity value, while the conurbation area serves both access and amenity value. This explains a relatively new trend in interregional migration, counterurbanization, which is characterized by an out-migration from the urban areas to the adjacent rural areas (Dahms & McComb, 1999; Mitchell, 2004; Stockdale et al., 2000). Counterurbanization has been perceptible within a 120-kilometre radius from a city centre (Dahms & McComb, 1999) and tends to magnify many kinds of interactions between the relevant areas. The geographical enlargement of the labour and recreation markets is among the symptoms of counterurbanization (Dahms & McComb, 1999; Mitchell, 2004; Stockdale et al., 2000).

Conclusion

The relationship between house prices and the distance from the capital area in Iceland, a thinly populated country with one large CBD, is statistically significant. I have shown that this relationship has become increasingly large in recent times, most likely due to improved localization and urbanization economies, where the present economic expansion in Iceland has been more intensively driven by the knowledge-based industry than former expansions, and it has been documented that the knowledge-based industry seems to have higher localization economies than manufacturing. These are the results when correcting for a regional disparity in total income, interest rate, population, and house age.

Evidence was found of so-called counterurbanization in Iceland. Although the spatial disparity of local house prices has become larger in the entire country, it is decreasing within the conurbation area.

These results are considerably robust, as they are based on a large data series of all 19 counties of Iceland from 1981 to 2004, which covers several business cycles of different origin. Sensitivity analysis supports its substantiality.

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Appendix

This appendix contains several short analyses to support my main arguments.

Estimating the result of the semi-logarithmic model

The results of the distance gradient for a semi-logarithmic model will be presented in this section. The periods, areas, and explanatory variables are completely comparable to the analyses of the former model type. The results for all counties of Iceland are the first semi-logarithm estimation (Table 7).

Table 7: Relationship between house prices and distance in the entire country of Iceland: A comparison of short and long periods of a semi-logarithmic model.

	Model 11 The period 1981-2004	Model 12 The period 1990-2004	Model 13 The period 1993-2004	Model 14 The period 1993-2004	Model 15 The period 1996-2004
α	10.72482 (160.40)	10.74425 (124.05)	11.15306 (64.45)	10.72457 (100.90)	10.94219 (43.38)
RDIS	-0.000229 (-5.08)	-0.000343 (-8.64)	-0.000392 (-8.37)	-0.000395 (-8.26)	-0.000481 (-8.23)
TINC	0.000338 (9.07)	0.000344 (7.98)	0.000331 (7.69)	0.000347 (7.29)	0.000385 (5.69)
HAGE	-0.012672 (-9.71)	-0.012240 (-7.02)	-0.011482 (-5.77)	-0.011622 (-5.77)	-0.010070 (-4.41)
TUNN	-0.110433 (-4.81)	-0.123131 (-5.18)	-0.119065 (-5.10)	-0.117207 (-4.67)	-0.084975 (-3.28)
EYJA	0.338363 (16.28)	0.449295 (26.46)	0.481250 (29.15)	0.480682 (25.20)	0.511846 (27.25)
POPU	2.45E-06 (14.62)	1.98E-06 (10.35)	1.91E-06 (9.16)	1.86E-06 (8.44)	1.88E-06 (6.61)
INBA			-6.338808 (-3.22)		-5.974195 (-2.75)
ε(-1)	0.623875 (10.89)	0.773480 (15.89)	0.774579 (14.80)	0.764597 (14.02)	0.806658 (13.34)
n	385	255	206	188	152
R^2	0.73	0.82	0.84	0.82	0.86
Adjusted R^2	0.73	0.82	0.83	0.82	0.85
F-value	149	165	125	132	109
Durbin Watson	1.93	2.00	2.16	2.02	1.96
Log-likelihood	172				
Serial correlation (t-statistics)	-1.08	-1.50	-2.01	-149	-1.35

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroscedasticity-Consistent Standard Errors & Covariance. Cross-sections without valid observations dropped. Values in parentheses are t-statistics.

As mentioned before, reliable data for mortgage interest rates were available only for 1994 through 2004. To amplify the comparison, the analysis was first implemented without data on mortgage interest rates for the period of 1994-2004, resulting in an increasingly larger value of the coefficient to the road distance, or -0.000395 (Model 11 compared to Model 14 in Table 7). When the data for the interest rate were added to the model, the slope of the bid-rent curve was still larger than for the entire period, -0.000402 (Model 11 compared to Model 13 in Table 7). Finally, the analysis was implemented again for an even shorter period (i.e. 1996-2004), and the bid-rent curve turned out to be increasingly steeper, i.e. -0.000481 (Model 13 compared to Model 15 inTable 7).

The second semi-logarithm estimation represents the bid-rent curve for the conurbation of Iceland (Table 8).

Table 8: Relationship between house prices and distance in the conurbation area of Iceland: A comparison of short and long periods of a semi-logarithm model.

	Model 16 The period 1981–2004	Model 17 The period 1990–2004	Model 18 The period 1993–2004	Model 19 The period 1993–2004	Model 20 The period 1996–2004
α	10.95951 (190.33)	10.98898 (233.50)	11.25908 (85.94)	11.03452 (157.64)	11.12201 (78.07)
RDIS	-0.001832 (-3.84)	-0.001120 (-2.45)	-0.001030 (-1.66)	-0.000943 (-1.29)	-0.002461 (-3.35)
TINC	0.000218 (7.29)	0.000282 (12.80)	0.000265 (10.13)	0.000284 (9.69)	0.000292 (5.25)
HAGE	-0.006339 (-2.63)	-0.011838 (-5.18)	-0.012991 (3.78)	-0.013482 (-3.59)	-0.008798 (-2.08)
TUNN	0.130946 (4.54)	0.115330 (3.76)	0.116887 (3.55)	0.119243 (3.58)	0.109363 (2.94)
POPU	1.34E-06 (5.61)	1.14E-06 (5.68)	1.07E-06 (4.38)	1.06E-06 (3.91)	6.51E-07 (2.44)
INBA			-3.093772 (-1.92)		-2.709958 (-1.76)
ε(-1)	0.590800 (5.24)	0.713857 (9.88)	0.659137 (5.83)	0.665428 (6.06)	0.616357 (3.72)
n	138	84	66	66	48
R^2	0.80	0.91	0.89	0.88	0.91
Adjusted R^2	0.79	0.91	0.90	0.87	0.89
F-value	87	136	75	75	56
Durbin Watson	1.77	1.98	2.21	1.99	2.23
Log-likelihood	125	117	87		63
Serial correlation (t-statistics)	0.06	0.29	-0.53	-0.11	-0.68

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroscedasticity-Consistent Standard Errors & Covariance. Cross-sections without valid observations dropped. Values in parentheses are t-statistics.

An opposite development seems to be the case for the conurbation area, with one exception. The slope of the bid rent curve decreases when the entire period, 1981-2004, is compared with 1994-2004, shifting from -0.001832 to -0.000943, but shows an increase to -0.002461 when the period 1996-2004 is chosen for comparison.

Estimating the results of the first and the second half of the data sample

This section contains two tables where the results of the exact first and the second half of the data samples, i.e. 1981-1992 and 1993-2004, are compared for both versions of the bid-rent curve models (i.e. quadratic distance and semi-logarithm versions). The insignificant results of the coefficients on road distance undermined the comparison between those periods in several cases.

Table 9: Relationship between house prices and distance: A comparison of the first and second halves of the sample. A quadratic distance model.

	Model 21 Conurbation 1981–1992	Model 22 Conurbation 1993–2004	Model 23 Iceland 1981–1992	Model 24 Iceland 1993–2004
α	12.18334 (37.02)	11.64942 (51.11)	10.79518 (82.44)	10.95717 (109.90)
RDIS	-0.026104 (-3.16)	-0.017897 (-3.17)	-0.000166 (-0.52)	-0.002134 (-10.82)
RDIS^2	0.000144 (2.88)	0.000106 (2.95)	1.64E-07 (0.35)	2.45E-06 (8.67)
TINC	4.07E-05 (0.57)	0.000336 (10.25)	0.000289 (3.79)	0.000319 (7.36)
HAGE	-0.006573 (-1.50)	-0.015851 (-4.32)	-0.014184 (-6.39)	-0.010995 (-5.94)
TUNN		0.120988 (3.89)		-0.099453 (-4.19)
EYJA			0.188496 (4.27)	0.596893 (26.32)
POPU	-4.96E-06 (-2.16)	-2.84E-06 (-2.19)	3.26E-06 (9.60)	7.14E-07 (3.94)
INBA				
ε(-1)	0.312685 (2.10)	0.580219 (4.36)	0.385834 (4.12)	0.723625 (12.58)
N	66	66	163	206
	0.73	0.89	0.61	
Adjusted R^2	0.70	0.87	0.60	0.83
F-value	26	64	35	126
Durbin Watson	1.76	1.94	1.89	1.99
Log-likelihood	51	83		
Serial correlation (t-statistics)	0.15	0.09	-0.08	-1.31

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroscedasticity-Consistent Standard Errors & Covariance. Cross-sections without valid observations dropped. Values in parentheses are t-statistics.

The results seem to be generally weaker for the former period, 1981-1992. However, a weak relationship does, to some extent, support the former results. The relationship can be significantly weaker when there is no relationship at all. Therefore, when a relationship between two variables develops from nothing to something, it supports the conclusion that the bid-rent curve has becoming increasingly steep for the entire country (both Models 25 and 26 and Models 29 and 30).

Table 10: Relationship between house prices and distance: A comparison of the first and second halves of the sample. A semi-logarithmic model.

	Model 25 Conurbation 1981–1992	Model 26 Conurbation 1993–2004	Model 27 Iceland 1981–1992	Model 28 Iceland 1993–2004
α	11.30613 (88.32)	11.03452 (157.64)	10.77998 (86.10)	10.72457 (100.90)
RDIS	-0.001583 (-2.21)	-0.000943 (-1.29)	-4.50E-05 (-0.59)	-0.000395 (-8.26)
TINC	1.40E-05 (0.20)	0.000284 (9.69)	0.000288 (3.84)	0.000347 (7.29)
HAGE	-0.009696 (-2.22)	-0.013482 (-3.59)	-0.014099 (-6.54)	-0.011622 (-5.77)
TUNN		0.119243 (3.58)		-0.117207 (-4.67)
EYJA			0.180052 (4.81)	0.480682 (25.20)

POPU	2.21E-06 (4.40)	1.06E-06 (3.91)	3.37E-06 (11.74)	1.86E-06 (8.44)
INBA				
ε(-1)	0.339834 (2.35)	0.665428 (6.06)	0.384827 (4.11)	0.764597 (14.02)
n	66	66	163	188
R^2	0.70	0.88	0.61	0.82
Adjusted R^2	0.68	0.87	0.60	0.82
F-value	28	75	41	132
Durbin Watson	1.72	1.99	1.88	2.02
Log-likelihood	48			
Serial correlation (t-statistics)	0.13	-0.11	-0.05	-149

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroscedasticity-Consistent Standard Errors & Covariance. Cross-sections without valid observations dropped. Values in parentheses are t-statistics.

Furthermore, when a relationship develops from something to nothing, it supports the conclusion that the bid-rent curve has become increasingly flat for the conurbation area (comparison of Models 27 and 28).

Mortgage interest rates

Relevant data for mortgage interest rates were not easily found for the period 1981–2004. Due to very complex market rules, especially regarding supply and the terms of mortgage loans, is was only possible to construct a reliable set of data for the period of 1994–2004. The construction of the dataset was based on the market's rules and traditions. The largest supplier of the most favourable mortgages in the relevant period was a public institution, the Housing Financing Fund[3], simply called 'government house-bonds' in the current study. Government house-bonds were only issued for the residential market. Afterwards, they became viable in the capital market. In each trade, the issued government house-bond's total amount was limited to 65-90% of the asset's value. This value was estimated by another public institution, the Land Registry of Iceland. The difference was commonly financed by either a commercial bank using less favourable terms or the household's own capital. Data regarding the annual average interest rate are based on information from the Central Bank of Iceland. The government house-bond was issued by a fixed real interest rate. When the sale took place, the seller received government house-bonds from the buyer, which he could sell in the capital market. The difference between the issued and market interest rates generated a gain or loss, which was commonly divided between the seller and buyer. According to this description, a basket of interest rates for the relevant buyer of any residence during the relevant period will be constructed in the following manner:

$$i = 0{,}3\left(0{,}15 i_d + 0{,}2 i_{sb} + 0{,}65 i_{lb}\right) + 0{,}35 i_{ib} + 0{,}35 i_{mb} \quad (8)$$

The weight of the government house-bond is assumed to be 70%, on average, of residence financing. The weight of the government house-bond is evenly divided between issued interest rate, i_{ib}, and market interest rate, i_{mb}, since the market terms of government house-bonds are evenly divided between seller and buyer. The rest of the basket, 30%, is based on the commercial banks' loan terms. I use the average terms of the three most common types of loans: drafts, i_d, short term bonds, i_{sb}, and long term bonds, i_{lb}.

3 This institution has had several names during the period; the Housing Financing Fund is its present name.

Multicollinearity

The following table contains the correlation coefficients between the explanatory variables of the present data sample.

Table 11: Correlation tests between variables.

	rdis	tinc	hage	popu	Inba	akur	tunn
rdis	1.0000						
tinc	-0.0633	1.0000					
hage	0.1108	0.2698	1.0000				
popu	-0.3515	0.2166	-0.1019	1.0000			
inba	-0.0223	0.0812	0.2070	-0.0034	1.0000		
akur	0.1375	0.0215	-0.0061	0.0355	-0.0060	1.0000	
tunn	0.1479	0.4269	0.3607	-0.1839	0.1399	0.0704	1.0000

The correlation coefficients confirm that there are negligible internal correlations and there is no serious threat of multicollinearity (Table 11).

References

Alonso, W. (1964). *Location and land use.* Cambridge, MA: Harvard University Press.

Archer, W. R., Gatzlaff, D. H., & Ling, D.C. (1996). Measuring the importance of location in house price appreciation. *Journal of Urban Economics, 40*, 334-353.

Bae, C.-H. C., Myung-Jin, J., & Park, H. (2003). The impact of Seoul's subway Line 5 on residential property values. *Transport Policy, 10*, 85-94.

Baldwin, R., Rikard, F., Martin, P., Ottaviano, G., & Robert-Nicoud, F. (2003). *Economic geography and public policy.* Oxford: Princeton University Press.

Baldwin, R.E. (2001). Core-periphery model with forward-looking expectations. *Regional Science and Urban Economics, 31*, 21-49.

Banister, D., & Berechman, J. (2000). *Transport investment and economic development.* London: Routledge.

Bowes, D. R., & Ihlanfeldt, K. R. (2001). Identifying the impacts of rail transit stations on residential property values. *Journal of Urban Economics, 50,* 1-25.

Capozza, D.R., & Helsey, R. W. (1989). The fundamentals of land prices and urban growth. *Journal of Urban Economics, 26*, 295-306.

Case, K. E., & Mayer, C. J. (1996). Housing price dynamics within a metropolitan area. *Regional Science and Urban Economics, 26*, 387-407.

Cunningham, C. R. (2006). House price uncertainty, timing of development, and vacant land prices: Evidence for real options in Seattle. *Journal of Urban Economics, 59,* 1-31.

Dahms, F., & McComb, J. (1999). 'Counterurbanization', interaction, and functional change in a rural amenity area: A Canadian example. *Journal of Rural Studies, 15*, 129-146.

De Bruyne, C., & Van Hove, J. (2006). Explaining the spatial variation in housing prices: An economic geographic approach. Paper presented to the ECOMOD Urban & Regional Modeling Conference, June 1-2, Brussels, Belgium.

Eckey, H.F., & Stock, W. (2000). *Verkehrsökonomie – eine emprisch orientierte Eiführung in de Verkehrswissenschaften.* Wiesbaden: Betriebswirtshaft-licher Verlag Dr. Th. Gabler GmbH.

Eshet, T., Baron, M. G., Shechter, M., & Ayalon, O. (2006). Measuring externalities of waste transfer stations in Israel using hedonic pricing. *Waste Management, 15*, 614-625.

Frame, D.E. (2004). Equilibrium and migration in dynamic models of housing markets. *Journal of Urban Economics, 55,* 93-112.

Fujita, M. (1989). *Urban economic theory: Land use and city size.* Cambridge: Cambridge University Press.

Fujita, M., & Thisse, J.-F. (2002). *Economics of agglomeration: Cities, industrial location, and regional growth.* Cambridge: Cambridge University Press.

Fujita, M., Krugman, P., & Venables, A. J. (1999). *The spatial economy: Cities, regions, and international trade.* Cambridge, MA: The MIT Press.

Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics, 57*, 148-169.

Haurin, D. R., & Brasington, D. (1996). School quality and real house prices: Inter- and intrametropolitan effects. *Journal of Housing Economics, 5*, 351-368.

Henderson, J. V. (2003). Marshall's scale economies. *Journal of Urban Economics, 53*, 1-28.

Karlsson, V. (2007). The relationship of house price and transportation improvements: A general case for Iceland, a large but thinly populated European country. Paper presented to the ECOMOD Urban & Regional Modeling Conference, June 1-2, Brussels, Belgium.

Kiel, K. A., & McClain, K. T. (1995A). The effect of an incinerator siting on housing appreciation rates. *Journal of Urban Economics, 37*, 1995, 311-323.

Kiel, K. A., & McClain, K. T. (1995B). House prices during siting decision stages: The case of an incinerator from rumor through operation. *Journal of Environmental Economics and Management, 28*, 241-255.

Kiel, K.A., & Williams, M. (2007). The impact of Superfund sites on local property values: Are all sites the same? *Journal of Urban Economics, 61*, 170-192.

Kiel, K.A., & Zabel, J. E. (1996). House price differentials in U.S. cities: Household and neighborhood racial effects. *Journal of Housing Economics, 5*, 143-165.

Kong, F., Yin, H., & Nakagoshi, N. (2006). Using GIS and landscape metrics in the hedonic price modeling of the amenity value of urban green space: A case study in Jinan City, China. *Landscape and Urban Planning*, In Press, Corrected Proof, Available online May 2, 2006.

Mackie, P. J., Jara-Díaz, S., & Fowkes, A. S. (2001). The value of travel time savings in evaluation. *Transportation Research Part E: Logistics and Transportation Review, 37*, 91-106.

McCann, P. (2001). *Urban and regional economics.* Oxford: Oxford University Press.

McDonald, J.F., & Osuji, C.I. (1995). The effect of anticipated transportation improvement on residential land values. *Regional Science and Urban Economics, 25*, 261-279.

McMillen, D. P. (2003). The return of centralization to Chicago: Using repeat sales to identify changes in house price distance gradients. *Regional Science and Urban Economics, 33*, 287-304.

McMillen, D. P. (2004). Airport expansion and property values: the case of Chicago O'Hare Airport. *Journal of Urban Economics, 55*, 627-640.

Mitchell, C.J.A. (2004). Making sense of counterurbanisation. *Journal of Rural Studies, 20*, 15-34.

Plaut, P.O., & Plaut, S. E. (1998). Endogenous identification of multiple housing price centers in metropolitan areas. *Journal of Housing Economics, 7*, 193-217.

Schwartz, A. E., Ellen, I. G., Voicu, I., & Schill, M. H. (2006). The external effects of place-based subsidized housing. *Regional Science and Urban Economics*, 36, 679-707.

Sheppard, S., & Stover, M.E. (1995). The benefits of transport improvements in a city with efficient development control. *Regional Science and Urban Economics, 25*, 211-222.

Smersh, G. T., & Smith, M. T. (2000). Accessibility changes and urban house price appreciation: A constrained optimization approach to determining distance effects. *Journal of Housing Economics, 9*, 187-196.

Stockdale, A., Findlay, A., & Short, D., (2000). The repopulation of rural Scotland: Opportunity and threat. *Journal of Rural Studies, 16*, 243-257.

Turnbull, G. K. (1998). Housing prices and residential land use under job site uncertainty. *Journal of Housing Economics, 7*, 1-20.

Tyrväinen, L., & Miettinen, A. (2000). Property prices and urban forest amenities. *Journal of Environmental Economics and Management, 39*, 205-223.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data.* Cambridge, MA: The MIT Press.