# The relationship of house price and transportation improvements: A general case for Iceland, a large but thinly populated European country.

Vífill Karlsson[1]

*The Faculty of Social Science, Bifröst School of Business, Bifröst, 311 Borgarnes, Iceland.*
*&*
*Regional Development Office of West-Iceland, Bjarnarbraut 8, 310 Borgarnes, Iceland.*

**Abstract**

In this paper, I examine the relationship between house price and transportation improvements. Due to a consumer preference for access over amenity value, there is a relationship between distance and house prices. Thus, it is reasonable to believe that transportation improvements tend to influence house prices. It has been documented that this relationship is negative for a densely populated area with one central business district (CBD). I will examine whether this relationship holds for a thinly populated area with one CBD, and will test whether this relationship converges with respect to distance. A macro panel data set from Iceland, which provides several essential variables for 19 counties in Iceland from 1981 through 2004, will be used.

*Keywords:* House prices, Transportation improvments, Distance gradient, Local

*JEL Classifications:* R40; R21; R41; C23

## 1 Introduction

Does travel distance have an impact on housing prices in a thinly populated country? Iceland is an interesting subject for this question because it is large but thinly populated, a geographically isolated, it has one single central business distirct (CBD), and a data sample for the entire country is available for a long period of time. This paper examines this relationship in order to capture the effect of transportation improvements in a thinly populated country and test whether its location makes any marginal difference to the results.

Iceland is a large but thinly populated country in Northern Europe, and is a 103,000 km$^2$ island in the North-Atlantic Ocean. A large part of Iceland is not suitable for people to live in due to a bad climate in the highlands, especially during the winter. Thus, relatively few inhabitants live more than 200 metres above sea level. Only 24,700 km$^2$ of Iceland is below 200 metres above sea level[2], and the highland is located in the center of the island (Figure 1). Thus, residence was evenly spread along the coastline until the beginning of the 20$^{th}$ century, when a relatively large and persistent migration flow to the capital area in the southwest corner of Iceland began. Today, almost 70% of the total population lives in the capital and adjacent municipalities, including Reykjavík,

[1] Tel.: +354-4372328; fax: +354-4371494; *E-mail address*: vifill@vesturland.is
[2] 43,100 km$^2$ of Iceland is below 400 metres

the largest town of Iceland, with 113,000 inhabitants, Kópavogur, the second largest, with 25,800 civilians, and Hafnarfjörður, the third largest, with 22,000 residents. The fourth largest town in Iceland, Akureyri, has 16,300 inhabitants and is located on the North coast.

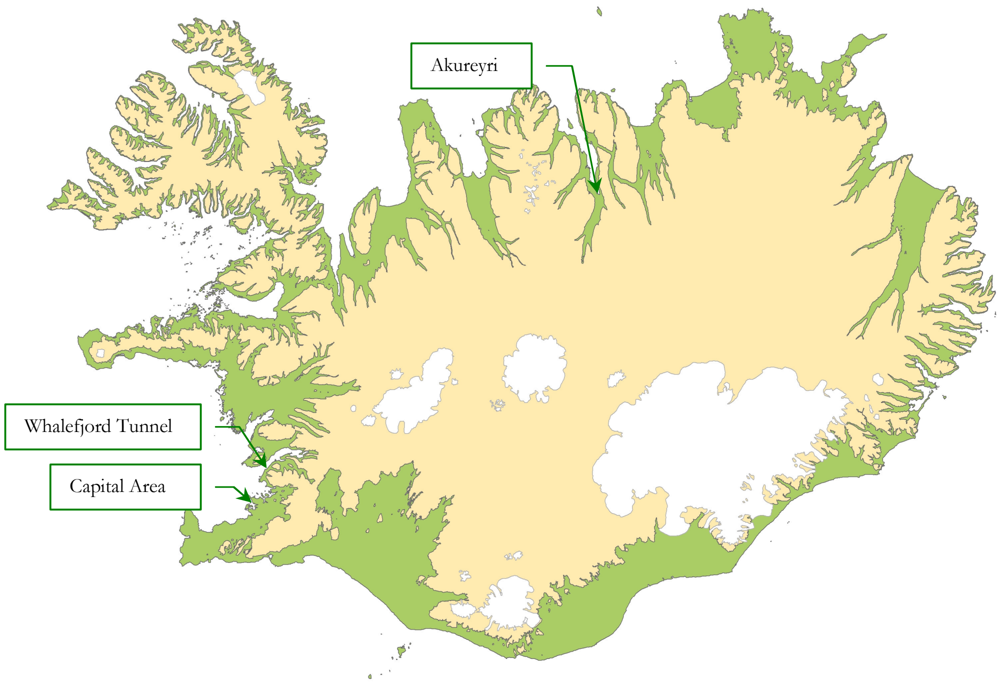


**Figure 1: Lowland of Iceland**

Lowland defined as area from 0-200 metres above sea level (green shaded area). Source: National Land Survey of Iceland

The towns and villages outside of the capital area are still evenly spread around the coastline, but have fewer inhabitants than the four largest towns of Iceland (Table 1). 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 fairly spread along the coastline. There were 293,291 inhabitants in Iceland in December 2004 (reaching 300,000 in January 2006). Though this analysis concentrates on the lowland, where population is denser relative to other areas, Iceland is a very thinly populated country compared to other European countries.

**Table 1: Size and location of towns in Iceland - December 2004.**

Source: Statistics Iceland.

| Number of towns | Iceland | South-coast | West-coast | North-coast | East-coast |
|---|---|---|---|---|---|
| Population of 0-500 inhabitants | 60 | 14 | 19 | 18 | 9 |
| Population 500-1,000 inhabitants | 17 | 5 | 3 | 4 | 5 |
| Population 1,000-10,000 inhabitants | 25 | 13 | 5 | 4 | 3 |
| Population >10,000 inhabitants | 4 | 3 | 0 | 1 | 0 |
| Total | 106 | 35 | 27 | 27 | 17 |

Approximately 100 towns and villages are spread around the lowland in Iceland (Table 1). Due to low population, the capital area is the only business center that has been able to offer a wide variety of goods and services. Therefore, access to the capital area brings benefits to the local population in rural Iceland. Since there is a very limited supply of collective transport in rural Iceland, inhabitants rely on their own vehicles and driving skills. Several types of export industries are evenly spread along the coastline and are dependent on fast and accurate transportation, with the fish industry, tourism, and agriculture being the largest industries. Furthermore, travel has also proved to be very hazardous in Iceland. A harsh climate, high mountains, deep fjords, and bad roads influence the driving conditions in Iceland. Thus, the transportation system seems to be extremely important for the Icelandic economy, especially in order to improve local scale economies. Therefore, it is very interesting to investigate how valuable access to the capital area is to the residents of rural Iceland, due to transportation improvements, which have been considerable over the last 25 years (Table 3).

According to Fujita and Thisse (2002, p. 78-91), McCann (2001), and Fujita (1989), the price of land and real estate is highest in the city centers and decreases with every mile of distance from the city center. Thus, when some areas are pulled closer to the city center through an improvement in transportation, the land value in these areas increases. These researchers based their analyses on the newest extension of von Thünen's theory, the model of land rent or the bid-rent curve. The essence of the bid-rent curve reflects the fact that consumers prefer the accessibility of cities rather than the amenity value of rural districts. The formation of the bid-rent curve is sometimes called the distance gradient.

According to Baldwin et al. (2003, 2001), transportation improvements lead to higher local real house prices in the concerned peripheries due to an increased demand following lower transportation costs, which improve access to the labor market and the markets of goods and services. Baldwin et al. (2003, 2001) used the core-periphery model in their analyses, which Krugman (as cited in Baldwin et al., 2003) has called the core of the new geographical economics. However, the relationship between a transportation improvement and real house prices will be investigated in this article based on the von-Thünen theory. A hedonic price model will be implemented to estimate the distance gradient.

The distance gradient based on von-Thünen's theory has been estimated in several studies. McMillen (2003), McDonald and Osuji (1995), and Cunningham (2006) did so for large American cities and their suburbs. Tyrväinen and Miettinen (2000), estimated the distance gradient for Salo district in Finland and De Bruyne and Van Hove (2006) for Belgium. These studies did not have the same focus, and only one was related to improvements in transportation. In addition, these studies cover rather densely populated countries or areas. Thus, it becomes very interesting to test whether this relationship holds for a thinly populated country such as Iceland.

The hypothesis of this article is as follows: *The distance gradient exists in Iceland and, thus, transportation improvements between conurbation and periphery areas and the capital area result in local house real price increases.* This could also be phrased as follows: Do district areas benefit from better access to relatively large urban areas due to an improved transportation system? It is also interesting to investigate whether there are different impacts between regions regarding proximity to a central business district, due to potential access. Thus, I try to answer the question of whether there is a marginal difference between the impact of transportation improvement on local housing prices in the conurbation and periphery areas of Iceland.

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

## 2 Literature review

Many studies have documented the relationship between local house prices and travel distance between the houses and some preferable or undesireable phenomenon, such as CBD, attractive view or source of pollution. A large number of studies have been devoted to the relationship between property value and distance from a new railway station or access to similar additional transportation possibilities. Gibbons and Machin (2005) evaluated the benefit of railway access in London by looking at house prices. Their general findings were that house prices rose by 9.3% following transportation improvements of this kind. A comparable result was presented in a very similar study by Bae et al. (2003) regarding Seoul's subway line 5. Smersh and Smith (2000, p. 195) estimated the effect of a new bridge in Jacksonville, Florida on property values. Jacksonville lies on both sides of the river and the effect was larger on the north side, due to the location of the city center. Bowes and Ihlanfeldt (2001) studied the impacts of railway transit stations on residential property values and the results were very differential between stations due to better access to assorted positive and negative externalities, such as retail service and criminal activity.

Several empirical studies have documented the impact of the CBD travel distance on local house prices. Empirical studies devoted to researching the effects of improvements of access from district areas to a relatively strong CBD were not easily found for large areas. However, the study of Archer et al. (1996) explored such a topic using data from Dade County in Miami Florida. According to Archer et al. (1996, p. 334), house price appreciation has spatial aspects. The result suggests that price appreciation depends on municipalities' distance from the CBD, housing units, local changes in population, and ethnic mix. Sheppard and Stover (1995) discussed a suitable method for economic impact estimation of inner city transportation improvements. The method emphasizes changes in the price level of real estate following a transportation improvement, and reflects the total benefit of transportation improvements. According to Sheppard and Stover (1995), this method is applicable and practical, though several economists doubt its reliability. McDonald and Osuji (1995) presented results from a similar study based on an 11-mile long freeway between Chicago center and its airport, which was finished in 1993. The results indicated that the land value started to increase before the freeway opened, and rose a total of 17% in real terms. Haurin and Brasington (1996, p. 351) used this theoretical framework to test whether school quality has a positive influence on real house prices. The study was based on primary source data from the six largest metro areas in Ohio (Haurin & Brasington, 1996, p. 356). School quality was found to positively influence real house prices, along with arts, and recreational opportunities and crime rate negatively (Haurin & Brasington, 1996, p. 351). Cunningham (2006, p. 27) applied a similar approach in his investigation of real options in the Seattle house market. Allowing parameter estimates to vary by distance from the CBD, his results suggest that real-options in the real estate markets appear only in the vicinity of the urban-rural frontier, i.e. within the distance radius of 12 to 20 miles from the city center. My study seems to be most comparable to McMillen's (2003) study, in which the researcher evaluated the return of centralization in Chicago by a repeat sales model and concluded that house prices decline by more than 8% for every mile from the CBD. In a similar study, Case and Mayer (1996) analyzed house price dynamics in the

Boston metropolitan area using data from 1982 to 1994 and found that the spatial disparity of house prices can be explained by differences in new constructions, demographic variables, manufacturing employment, proximity to the downtown, and aggregate school enrolment. An investigation of spatial variation of housing prices was implemented by De Bruyne and Van Hove (2006), in which the data sample represented every municipality in Belgium. An increase in travel distance by 1 kilometer was found to lower the housing price by 0.001 to 0.002% (De Bruyne & Van Hove, 2006, p. 11).

As mentioned earlier, empirical studies devoted to the relationship of house prices and travel distances for a large area around a relatively strong CBD were not as easily found as expected. Such studies have been described above. My study differentiates from the previous studies in five ways. Firstly, none of the previous studies has focused on the distance gradient for one country in order to make a general interpretation of the impact of transportation improvement on local house prices and estimate whether its location will influence the results. Secondly, no study has compared the marginal impact of distance on local house prices in areas close to the CBD and areas a great distance away. Thirdly, none have focused on a thinly populated country such as Iceland and whether this relationship will be significant, given the circumstances. Fourthly, Iceland is an unusually geographically isolated island. Finally, the data sample represents an extraordinary long period, from 1981 through 2004.

## 3 The model

The empirical model is based on von Thünen's theory of land rent, extended by Alonso (1964), Mills(1969; 1970), Muth(1969), and Evans (1973) for the house market, as mentioned before. Since distance between localities is the essence of this theory, its model becomes an appropriate tool for the estimation of transportation improvements, which is the main purpose of this paper. A theoretical derivation of this model is included in the Appendix. According to Fujita (1989, pp. 16, 26) and Kiel and McClain (1995b, pp. 314-315), the general context from the basic model in Eq. 9 (see Appendix) can be derived through a log linear utility function into an equation of the following form:

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

where $h$ is the land value, $r$ 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

$$\ln h(r) = \ln A - br. \tag{2}$$

This equation has been frequently used in various versions in house price research. Furthermore, it is the most common form in comparable and related studies, e.g. 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 (1995, 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,

$$\ln h_{it} = \alpha + r_{it}\beta_1 + \varepsilon_{it},$$

economists frequently implement an extended model,

$$\ln h_{it} = \alpha + r_{it}\beta_1 + cx'_{it} + \varepsilon_{it},$$

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

Indicators for house quality are relevant explanatory variables in hedonic price models, such as lot size (Cunningham, 2006; McMillen, 2003; Kiel & McClain, 1995), house age (De Bruyne & Van Hove, 2006; McMillen, 2004; McMillen, 2003; Tyrväinen and Miettinen, 2000; Archer et al., 1996; Kiel & McClain, 1995), indicators for house building material 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 supply of houses (De Bruyne & Van Hove, 2006; Archer et al., 1996; Case & Mayer, 1996), 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. presence of a lake or an attractive view (Cunningham, 2006; De Bruyne & Van Hove, 2006; Tyrväinen & Miettinen, 2000; Kiel & McClain, 1995), 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,

$$\ln h_{it} = \alpha + r_{it}\beta_1 + x'_{it}\beta_2 + d'_{it}\beta_3 + \varepsilon_{it}, \qquad (3)$$

where the natural logarithm of 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, $\varepsilon$, of every county, $i$, in every single period, $t$. Total household income, age of the house buildings, 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 Whalefjord Tunnel is actually 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, $z$, lot size, $s$, and mortgage interest rates.

This model is suitable for the evaluation of the relationship between house prices and transportation improvements, because the distance parameter, $r$, captures the relative influence of the respective factors on real house prices and the data for distance is the length of roads between the centers of counties and the center of the capital area measured in kilometres (further description of the data is in the next chapter). Thus, the distance parameter reflects the relative influence of single unit road contraction on the real unit price of houses, *ceteris paribus*. Furthermore, note that this evaluation is limited to transportation improvements implied only by a reduction of distance.

## 4 Data

The data for this analysis comes from Iceland, a large but thinly populated European country. Iceland is divided into 19 counties[3] 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.

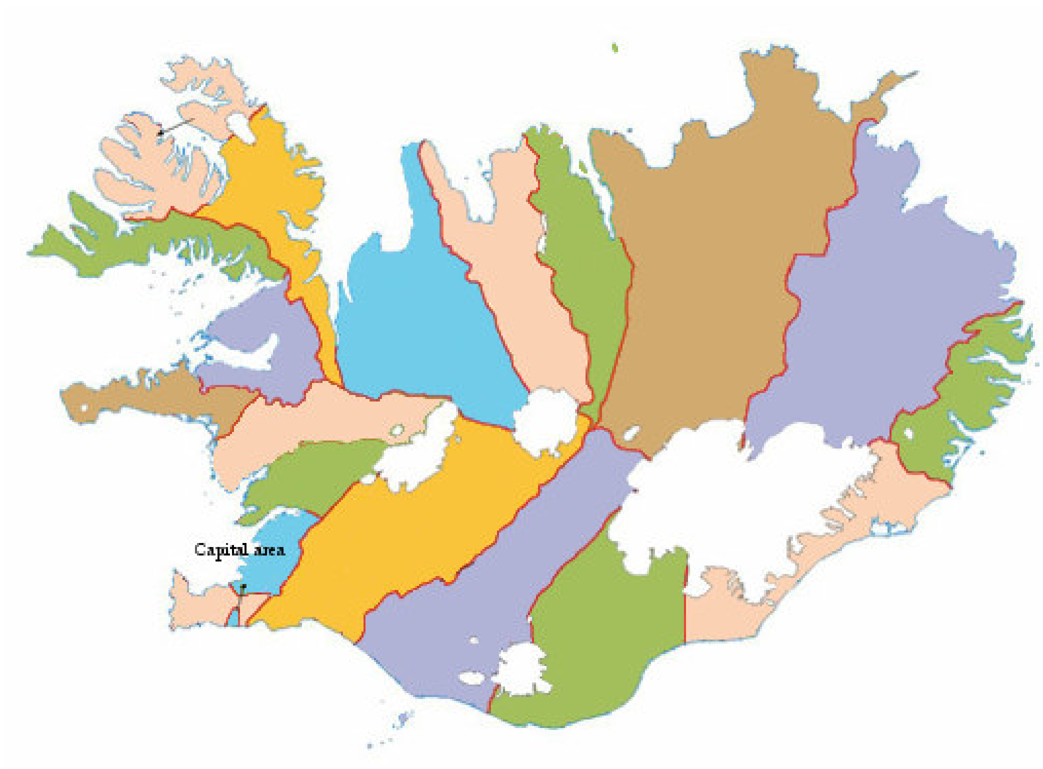


**Figure 2: Counties of Iceland.**

[3] There is a two-tier system in Iceland, the central and local level, i.e. central goverment and municipalities. Counties are not a part of it. 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 text of this paper.

The data on house prices[4] in this study come from the Land Registry of Iceland. The data sample covers the monthly average numbers of all Icelandic municipalities from 1981 to 2004. The sample was transformed into counties with annual average numbers, both due to comparability and lack of the house market's turnover in several municipalities. In order to do that, monthly average cash prices were transformed into annual average cash prices by the weight of the contract's number in each month.

$$\overline{h_y} = \sum_{m=1}^{12} \overline{h_m} \left( \frac{c_m}{\sum_{m=1}^{12} c_m} \right) \tag{4}$$

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. 110m$^2$ to 210m$^2$, which is the most common type of house in other regions.

**Table 2: Real house prices of Icelandic counties from 1981 through 2004.**

Annual average house prices 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. (4).

[4] 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 payed in several payments during a certain period. Both the duration and number of payments vary substantially between contracts. In order to make the house price more comparable, the Land Registry of Iceland calculates a so-called cash price for every contract. It is, actually, the present value of the the contract price. The dependent variable in this paper is the cash price divided by the house size in square metres.

House prices vary substantially both within and between counties. 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 most marked changes were in Borgarfjarðar, Ísafjarðar and Þingeyjar Counties. House prices increased in real terms by 1,200.5 kronur per $m^2$ in Borgarfjarðar County annually during the period, at the price level of 2004. House prices, however, decreased in real terms by 1,110 kronur per $m^2$ annually during the period in both Ísafjarðar and Þingeyjar County. Note that the data are missing in seven counties out of nineteen during the relevant period (Table 2).

Table 3 gives an exact overview of the transportation improvements implied by distance reduction from 1981 through 2004. The distance between counties and the capital area varies substantially, from 49.3 to 703.0 kilometres. The distance, however, has been reduced in almost every county. The reduction has been relatively small on the south coast of Iceland, primarily due to the absence of deep fjords and high mountains, which have offered opportunities to decrease road distance in the past. In other regions, distance has been reduced by two to four kilometres annually. Ísafjarðar County had the most reductions in travel distances during the period, with a reduction of 4.2 kilometres annually (Table 3).

**Table 3: Distance between the capital area and Icelandic counties and its changes due to transportation improvements during the period from 1981 through 2004.**

Source: Fjölvís and Icelandic Road Administration.

| County | Average | 1981 | 2004 | StDev | Trend |
|---|---|---|---|---|---|
| Capital area | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gullbringu County | 49.3 | 49.7 | 49.2 | 0.1 | 0.0 |
| Borgarfjarðar County | 94.6 | 108.8 | 50.6 | 26.0 | -2.8 |
| Mýra County | 105.7 | 117.0 | 74.0 | 18.7 | -2.0 |
| Snæfellsnes County | 220.2 | 235.9 | 186.4 | 20.1 | -2.3 |
| Dala County | 186.3 | 198.0 | 154.0 | 19.1 | -2.1 |
| Barðastrandar County | 432.6 | 457.5 | 384.6 | 28.8 | -3.5 |
| Ísafjarðar County | 512.6 | 543.3 | 457.7 | 33.8 | -4.2 |
| Stranda County | 315.5 | 332.7 | 281.3 | 19.9 | -2.4 |
| Húnavatns County | 268.5 | 284.2 | 235.0 | 19.6 | -2.2 |
| Skagafjarðar County | 353.6 | 371.0 | 319.8 | 20.1 | -2.3 |
| Eyjafjarðar County | 427.1 | 445.8 | 393.0 | 20.1 | -2.3 |
| Þingeyjar County | 539.6 | 562.8 | 499.5 | 23.0 | -2.8 |
| N- Múla County | 699.3 | 723.1 | 657.8 | 25.0 | -3.1 |
| S- Múla County | 703.0 | 727.5 | 674.0 | 28.9 | -3.2 |
| A- Skaftafells County | 466.9 | 474.5 | 458.6 | 7.4 | -1.0 |
| V- Skaftafells County | 212.8 | 213.0 | 209.7 | 2.7 | -0.3 |
| Rangárvallar County | 102.1 | 103.0 | 100.7 | 0.7 | -0.1 |
| Árnes County | 57.8 | 58.6 | 57.5 | 0.6 | -0.1 |

Figures of this table, i.e. average, maximum, minimum and standard deviation are based on transformed data of the annual average, according to a similar calculation as in Eq. (4).

The explanatory variables included in Eq. (3) are drawn from various sources, including the *Commissioner of the Inland Revenue*, *Statistics Iceland,* and the *Icelandic Road Administration*. Information for house age was received from the Land Registry of Iceland, along with house price, as mentioned before. Data on road distances were received from Fjölvís Publishing Company, originally collected by the Icelandic Road Administration. The data on population and total income were received from Statistics Iceland. The Commissioner of Inland Revenue is 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 1. December every year and the data on road distance is 1. January every year. The data series were spatially classified by municipalities, except for road distance. Data on road distance 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 m², 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 thousands of 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 |
| Eyjafjarðar County (EYJA) | Dummy variable for a county outside the capital area of extraordinary large center: 1 for Eyjafjarðar-county and 0 for any other county. | 0.0614 | 0.0082 |
| Tunnel (TUNN) | Dummy variable of large transportation improvement. 1 for Whale fjord tunnel. | 0.052632 | 0.2235 |

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. (4).

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.

## 5 Estimating the result

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

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

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

To estimate the impact of transportation improvements on house prices, I estimate a pooled least square model. The results are presented in Table 5, including parameter coefficients, t-value, number of observations, $n$, R square, adjusted R square, F-value, the Durbin-Watson parameter, log likelihood, and special t-statistics for testing serial correlation in panel data, as recommended by Wooldridge (2002, pp. 176-177).

**Table 5: Relationship between house price and transportation improvement. A semi-logarithm model**

| | Model 1 Every county of Iceland included | Model 2 Every county of Iceland included | Model 3 Only capital area and adjacent counties included | Model 4 Only capital area and adjacent counties included |
|---|---|---|---|---|
| α | 10.66011 | 10.72482 | 11.06112 | 10.95951 |
| | (122.02) | (160.40) | (159.87) | (190.33) |
| RDIS | -0.000217 | -0.000229 | -0.002028 | -0.001832 |
| | (-4.28) | (-5.08) | (-3.53) | (-3.84) |
| TINC | 0.000366 | 0.000338 | 0.000186 | 0.000218 |
| | (7.67) | (9.07) | (4.58) | (7.29) |
| HAGE | -0.012414 | -0.012672 | -0.007250 | -0.006339 |
| | (-8.06) | (-9.71) | (-2.78) | (-2.63) |
| TUNN | -0.127147 | -0.110433 | 0.151404 | 0.130946 |
| | (-3.61) | (-4.89) | (4.71) | (4.54) |
| EYJA | 0.329011 | 0.338363 | | 1.34E-06 |
| | (10.49) | (16.28) | | (5.61) |
| POPU | 2.50E-06 | 2.45E-06 | 1.26E-06 | |
| | (10.50) | (14.62) | (3.94) | |
| ε(-1) | | 0.623875 | | 0.590800 |
| | | (10.89) | | (5.24) |
| n | 413 | 385 | 144 | 138 |
| $R^2$ | 0.52 | 0.73 | 0.65 | 0.80 |
| Adjusted $R^2$ | 0.51 | 0.73 | 0.64 | 0.79 |
| F-value | 74 | 149 | 52 | 87 |
| Durbin Watson | 0.65 | 1.93 | 0.76 | 1.77 |
| Log-likelihood | 49 | 149 | 90 | 125 |
| Serial correlation (t-statistics) | 10.98 | -1.08 | 5.08 | 0.06 |

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroskedasticity-Consistent Standard Errors & Covariance. Values in parentheses are t-statistics.

The analysis is divided into two separate parts in order to demonstrate the different effect of road distance on the adjacent counties and the rest of the country and, thus, emphasize the diminishing marginal return of the tranportation improment's benefit with respect to distance. This could be rephrased by claiming that the relationship between an urban area and its adjacent areas is different than its relationship with areas further away. First, I analyze the relationship between the capital area and all of the counties of Iceland, where a special dummy variable is created for Eyjafjarðar County because its local center, Akureyri, is very large in comparison to other local centers of rural Iceland. I then analyse the relationship between the capital area and the nearest counties because any city tends to have more interactions with its adjacent areas than with areas farther away. If the initial model suffers from insignificant variables or another kind of inaccuracy, the model is revaluated until sufficient robustness is reached (see Model 2 replacing Model 1 and Model 4 replacing Model 3 in Table 5).

Initially, both analyses were suffering from serial correlation, which was sufficiently eliminated by a lagged variable of the residual. Though Bae et al. (2003, p. 88) argued that one should not worry too much about spatial autocorrelation, spatial multicollinearity, and heteroscedasticity in studies of this type, by referring to Oliver

Blanchard (1987, p. 449), it was confirmed that none of these problems were observable in the final results.

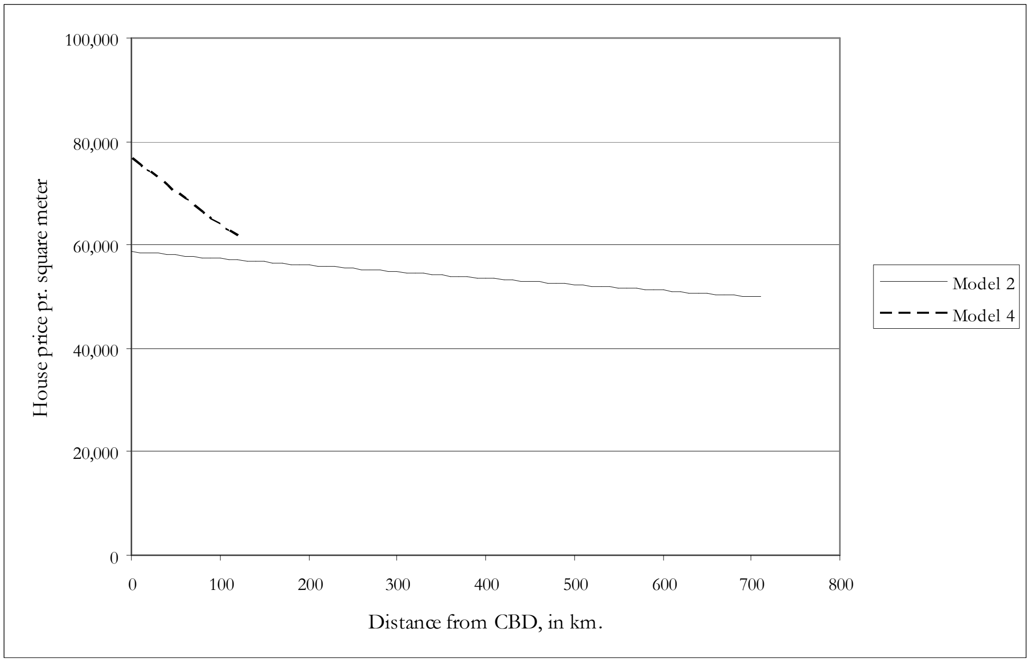


**Figure 3: The distance gradients of Iceland and the conurbation of Iceland according to a semi-logarithm model.**

A simulation of the result of Model 2 for all counties and Model 4 for the conurbation area.

The result of the analysis based on data from all counties shows a significant negative relationship between house price and the distance from the capital area. According to the results, house price declines by 0.02% with each additional kilometre of distance from the center of the capital area, *ceteris paribus* (Model 2 in Table 5). This means that transportation improvements that reduce the distance of municipalities in rural district of Iceland from the capital area tend to increase local real estate prices in real terms.

The relationships between house prices on the one hand and on the other total income, house age, and population are also significant. The results indicate that house prices will increase by 3.4% for every 100 thousand Icelandic kronur in total income per capita, *ceteris paribus* (Model 2 in Table 5). This is an interesting result because the spatial disparity of average income is large due to the various combinations of industry and productivity in the different counties. The wages tend to be lower in primary industries compared to knowledge-based industries due to differences in the actual and potential growth of labor productivity. Traditional primary industries tend to dominate in district Iceland, while knowledge-based industries tend to dominate in the capital area.

Furthermore, the age of a house influences its real price. As the house gets older, the house price decreases by 1.3% in real terms for every year, *ceteris paribus*. County population also influences the local real price of houses. When county population increases by 1,000 inhabitants, the house prices increase by 0.25%, *ceteris paribus*. The house prices in Eyjafjarðar County are significantly higher than in other counties, about 34%. The relationship between house prices and the dummy variable for the Whalefjord tunnel is significant. The dummy variable for the Whalefjord tunnel confirms an 11% lower house price among the affected counties due to the presence of the tunnel's road toll (Model 2 in Table 5).

Now, it is interesting to stress the result of my second analysis, based only on the data of the capital area and its adjacent counties, and investigate whether the relationship between house price and distance became stronger, as argued by Fujita (1989, p. 26). The results were as expected (Model 4 in Table 5). The relationship shifted from -0.02% for every kilometre away from the center of the capital area, to -0.18%. Every other parameter became weaker. A weaker relationship between local housing prices and population within the conurbation area is explainable. The conurbation area is dominated by distant and double residences, due to the geographical extension of the labor market and increased household desire for amenity values, without being registered as such in public statistics. Unexpectedly, the relationship between house prices and the Whalefjord tunnel became positive, instead of negative. The average price of houses is 13% higher in the affected counties. This can be explained by an outstanding growth of several local industries simultaneously in the relevant region.

This result is in line with many other studies. McMillen (2003, p. 287) 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 away from the CBD. That is approximately 5% in terms of kilometres. This is an unusually large distance gradient and not a robust one, since the same author (McMillen, 2004) presented the opposite results for the same area one year later. In many other studies, the distance gradient is generally closer to my result. McDonald and Osuji (1995, p. 261) found it to be approximately 1% for the city of Chicago. A 0.7% distance gradient was among Cunningham´s (2006, p. 18) results for the CBD of Seattle. Tyrväinen and Miettinen (2000, p. 215) concluded that house value reduces by 0.11% for every 1% distance in kilometres away from center of the Salo district in Finland. De Bruyne and Van Hove (2006) reached a rather different result, where the gradient became somewhere between 0.001 and 0.002% for Belgium. The present result, 0.2% for the conurbation area in Iceland and 0.02% for the whole country, is among the lowest.

An underlying skepticism regarding the rather weak relationship between house price and distance, both due to a comparison with other studies and a pre-observation of house price spatial variation in Iceland, leads me towards a similar type of nonlinear model, a quadratic distance model. The new model reflects a different relationship between house price and distance. The initial model, Model 1, is estimated in a new version as follows:

$$\ln h_{it} = \alpha + r_{it}\beta_1 + r_{it}^2\beta_2 + x'_{it}\beta_3 + d'_{it}\beta_4 + \varepsilon_{it} \,. \tag{5}$$

Quadratic distance models of this type are rather unusual in studies of the distance gradient, but were found in three studies by Tyrväinen and Miettinen (2000), Archer et al. (1996), and McDonald and Osuji (1995). Only McDonald and Osuji (1995) use the same form as in Eq. (5).

According to the t-statistics, serial correlation was observable in the model (see Model 5 in Table 6). Appropriate adjustment eliminated the problem and the result was, thereafter, completely free from serial correlation, heteroskedasticity, and multicollinearity. The result suggests that there is a significant relationship between the local real price of houses and distance from the CBD. This relationship is strictly convex. The real price of houses reveals a clear sign of a marginal rate of diminishing return with respect to decentralized location. This could be rephrased by claiming that the value of central location in Iceland has an increasing marginal rate of return.

**Table 6: Relationship between house price and transportation improvement. A quadratic distance model.**

| | Model 5 Every county of Iceland included | Model 6 Every county of Iceland included | Model 7 Only capital area and adjacent counties included | Model 8 Only capital area and adjacent counties included |
|---|---|---|---|---|
| α | 10.80005 | 10.84815 | 11.54349 | 11.48954 |
| | (131.35) | (156.77) | (72.22) | (83.87) |
| RDIS | -0.001424 | -0.001326 | -0.017315 | -0.018214 |
| | (-6.31) | (-7.08) | (-4.05) | (-4.63) |
| RDIS^2 | 1.66E-06 | 1.52E-06 | 9.29E-05 | 9.97E-05 |
| | (5.46) | (5.52) | (3.49) | (3.98) |
| TINC | 0.000344 | 0.000326 | 0.000239 | 0.000269 |
| | (8.04) | (8.98) | (5.48) | (7.70) |
| HAGE | -0.011054 | -0.011754 | -0.006673 | -0.005954 |
| | (-7.17) | (-9.18) | (-2.72) | (-2.56) |
| TUNN | -0.117642 | -0.102555 | 0.123741 | 0.110204 |
| | (-3.66) | (-4.68) | (3.84) | (3.82) |
| EYJA | 0.418132 | 0.417676 | | |
| | (11.80) | (17.38) | | |
| POPU | 1.59E-06 | 1.62E-06 | -2.63E-06 | -2.77E-06 |
| | (6.74) | (9.28) | (-2.37) | (-2.94) |
| ε(-1) | | 0.603739 | | 0.552411 |
| | | (10.37) | | (4.74) |
| Average marginal propensity to distance………………… | | -0.000219 | | -0.006549 |
| n | 413 | 385 | 144 | 138 |
| $R^2$ | 0.56 | 0.74 | 0.68 | 0.80 |
| Adjusted $R^2$ | 0.55 | 0.73 | 0.67 | 0.79 |
| F-value | 73 | 133 | 49 | 77 |
| Durbin Watson | 0.70 | 1.91 | 0.81 | 1.73 |
| Log-likelihood | 65 | 176 | 96 | 127 |
| Serial correlation (t-statistics) | 10.53 | -1.05 | 4.62 | 0.35 |

Dependent Variable: LOG (HPRI). Method: Pooled least squares. White Heteroskedasticity-Consistent Standard Errors & Covariance. Values in parentheses are t-statistics.

Furthermore, the results suggest that total household income has a significant positive impact on the local real price of houses, as before. It increases by 3.3% for every 100,000 kronur increase of local annual total income per capita, *ceteris paribus*. The influence of house age is negative on house prices, it decreases by 1.2% per year. The presence of the road toll in the Whalefjord tunnel seems to have a significant, 10% negative impact on the real house prices in relevant counties, *ceteris paribus*. The local real price of houses is 41% higher in Eyjafjarðar County than other counties, *ceteris paribus*, due to the relatively strong position of Akureyri as a local business center. Finally, the real house prices increase by approximately 0.2% if the local population increases by 1,000 inhabitants, *ceteris paribus*.

It is interesting to compare these results to the results of the proper semi-logarithm model (Model 2 in Table 5). The marginal porpensity to distance were -0.000219 in the semi-logaritm model compared to -0.000229 on the average in the quadratic distance model. Furthermore, the coefficient of income were 0.00034 in the semi-logarithm model instead of 0.00033 for the quadratic distance model, houseage -0.012 instead of -0.013 population 0.0000025 instead of 0.0000016. The coefficients for the dummy variables were 0.34 instead of 0.42 for Eyjafjarðar County and -0.11 instead of -0.10 for Whalefjord Tunnel. According to this, the results are remarkably similar.

When the model was estimated for the conurbation area, similar problems were observed and solved as before (Model 8 in Table 6). It is interesting to compare these results to the results of the proper semi-logarithm model (Model 2 in Table 5). The marginal porpensity to distance were -0.00181 in the semi-logaritm model compared to -0.00646 on the average in the quadratic distance model. Furthermore, the coefficient of income were 0.00022 in the semi-logarithm model instead of 0.00027 for the quadratic distance model, houseage -0.0067 instead of -0.0063, population 0.0000015 instead of 0.0000026. The coefficients for the dummy variable were -0.11 instead of -0.10 for Whalefjord Tunnel. According to this, the results are reasonably similar except for the effect of road distance.

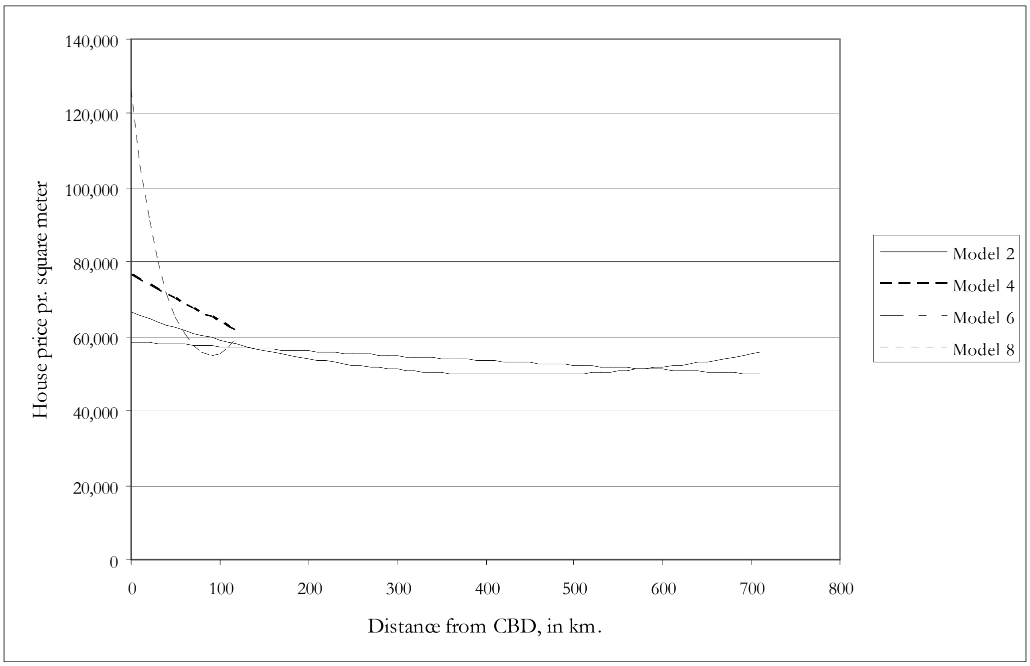


**Figure 4: The distance gradients of Iceland and the conurbation of Iceland according to quadratic distance along with a semi-logarithm model.**

A simulation of the results of Model 6 for all counties and Model 8 for the conurbation area, compared to Models 2 and 4.

When the results is compared to the entire country (Model 6 and 8), it is obvious that the distance has a stronger effect in the conurbation area than for all of the counties (Table 6 and Figure 4), and other factors have a much weaker effect. The relationship of the local population and house prices became negative, instead of positive. This is not easy to explain. It can, however, be explained by the ever less significance of the local populations within the conurbation area, as mentioned for the analysis of the semi-logarithm model results.

It is interesting to observe a slight change in the relationship between local house price and distance when it moves from being negative to positive in the far end of the distance gradient in both models. This is hard to explain. It is, however, possible to argue that the negative relationship reflects a population dominated by individuals with a higher preference for access over amenity value. When the distance exceeds a certain limit, the population becomes dominated by individuals with a preference for amenity value over access. Thus, the distance gradient becomes gradually positive beyond the limit. This limit is located at a distance of 100 kilometres from the CBD in the model of the conurbation area and approximately 450 kilometres in the model for all counties within Iceland. This distinction will not be easily explained and is beyond the purpose of this paper (Figure 4).

The results are presented in Figure 4 along with the results of the semi-logarithm model. Apart from distance (from the CBD), local population, and the dummy variable for Eyjafjarðar County, the results are comparable for both types of models. The qudratic distance model is, to some extent, more robust and appropriate than the semi-logarithm model, with respect to distance and the dummy variable of Eyjafjarðar County. The impact of distance is closer to the results of the studies mentioned above and also closer to the known difference of housing prices between regions in Iceland. Thus, it is tempting to choose the quadratic distance model, as in Models 6 and 8, as the most appropriate for Iceland. This is, however, not unambiguous.

The distance gradient is steeper for the conurbation area than for all of the counties of Iceland in both types of models, i.e. Eq. 3 and 4. Is there any logical explanation? One likely explanation is that when the sample covers only an urban population, the preference of the selected individuals will be biased in favour of access over amenity values. When the sample, on the other hand, represents inhabitants of both urban and rural areas, the result will be more likely to reflect a true estimation of preference for access over amenity for the total community. This is in line with the mentioned results of McMillen (2003), McDonald and Osuji (1995), and Cunningham (2006), who analyzed the data of large American cities and their suburbs. Tyrväinen and Miettinen (2000), however, explored the data for one district of Finland, and De Bruyne and Van Hove (2006) explored one country, i.e. Belgium. The distance gradient is generally steeper in studies representing only cities and their suburbs, such as in McMillen (2003), McDonald and Osuji (1995), and Cunningham (2006), compared to studies covering larger areas, such as Tyrväinen and Miettinen's (2000) study of a large district in Finland, and De Bruyne and Van Hove's (2006) study of one country.

This result suggests that transportation improvements, i.e. including an abbreviation of distance, have an impact on the local real prices of houses. Furthermore, such improvements have a generally greater marginal impact on the local price of houses close to the CBDs than those which are farther away. This means that two identical transport investment opportunities of different locations would have different returns, *ceteris paribus*. The return would be higher for the one which is closer to the CBD. This is logical where the inhabitants of areas adjacent to the CBDs have higher preferences for access over amenity values compared to inhabitants of more distant areas.

## 6 Conclusion

The aim of this study was to measure the influence of transportation improvements on the local real price of houses. The analysis was based on the annual average numbers of the house prices, distance from the CBD, total household income, and several other relevant explanatory variables for all counties in Iceland from 1981 through 2004. The data were analyzed with a pooled least squares model. The result clearly shows that the relationship between the local real house prices in Iceland and the distance from the CBD, i.e. the capital area, is statistically significant and negative. According to the semi-logarithmic model, a decrease of one kilometre between counties and the CBD increased the real price of houses by 0.02% when the model was tested for all counties. When the model was tested only for the capital area and its adjacent counties, the result was 0.18%. A quadratic distance model, which seemed to be more appropriate than the former, was also tested. The result confirms the former results, along with suggesting a greater impact of distance on the local real price of houses. Furthermore, a comparison of the results for every county of Iceland and the capital area along with its adjacent counties implies that the relationship converges with respect to distance. This means that transportation improvements close to CBDs generally have a greater marginal impact on the local real price of houses compared to those which are farther away. This is logical where the inhabitants of the areas adjacent to the capital area have higher preferences for access over amenity values compared to inhabitants of more distant areas.

The general conclusion from this analysis is that transportation improvements implied by a reduction of the distance from a county to the CBD tend to increase the local house prices in the former in a thinly populated country with only one CBD, such as Iceland. The results are stronger for counties close to the CBD than those which are farther away.

# 7 Appendix

## *7.1 Theoretical model*

According to Fujita (1989), the consumer maximizes his utility by choosing the best combination of lot size, $s$, and compensated goods, $z$, with respect to distance, $r$, when it comes to the choice of residence.

$$\max_{r,z,s} U(z,s),$$

The consumer maximizes his utility with respect to his budget constraint. The total expenditures are divided between the house price, $h$, compensated goods, $z$, and transport cost, $T$. Furthermore, house prices are dependent on the lot size, $s$, and distance, $r$, and the transport cost is obviously dependent on distances. Thus, the maximum problem becomes subject to the following constraint,

$$z + h(r)s = Y - T(r).$$

The bid-rent curve will be found by solving the following maximization problem, defined by the following Lagrange function,

$$L = U(z,s) - \lambda(Y - T(r) - z - h(r)s).$$

Thus, the first order condition becomes:

$$\frac{\partial L}{\partial z} = \frac{\partial U}{\partial z} + \lambda = 0 \tag{6}$$

$$\frac{\partial L}{\partial s} = \frac{\partial U}{\partial s} + \lambda\big(h(r)\big) = 0 \tag{7}$$

$$\frac{\partial L}{\partial \lambda} = Y - T(r) - z - h(r)s = 0. \tag{8}$$

Eq. 6 can be rewritten as:

$$\frac{\partial U}{\partial z} = -\lambda .$$

Furthermore, Eq. 7 can be rearranged as follows,

$$h(s) = -\frac{\frac{\partial U}{\partial s}}{\lambda} .$$

Thus, by embedding (6) into (7)

$$h(s) = \frac{\frac{\partial U}{\partial s}}{\frac{\partial U}{\partial z}} ,$$

Eq. 8 can be rewritten as

$$h(s) = \frac{Y - T(r) - z}{s} .$$

The following definition is helpful at this point: "*the bid rent* $\psi(r,u)$ *is the maximum rent per unit of land that a household can pay for residing at distance* $r$ *while enjoying a fixed utility level,* $u$." (Fujita, 1989) and thus the relationship for the bid-rent curve becomes,

$$\psi(r,u) = \max_{z,s}\left\{\frac{Y - T(r) - z}{s} \middle| U(z,s) = u\right\} \qquad (9)$$

It can be confirmed, and should be rather obvious, that the maximum rent per unit of land is positively related to income, $Y$, and negatively related to distance, $r$, transport cost, $T$, compensated goods, $z$, and lot size, $s$.

According to Fujita (1989, pp. 16, 26) and Kiel and McClain (1995b, pp. 314-315), the general context from the basic model in Eq. 9 can be derived through a log linear utility function into an equation of the following form:

$$h(r) = Ae^{-br} , \qquad (10)$$

where $h$ is the land value and $A$ and $b$ are positive constants. By taking the natural logarithm of both sides, Eq. 10 becomes

$$\ln h(r) = \ln A - br . \qquad (11)$$

This equation is commonly known in this field of research, as argued before.

### 7.2 Multicollinearity

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

**Table 7: Correlation test between variables.**

| | *hpri* | *hage* | *popu* | *tinc* | *rdis* | *akur* | *tunn* |
|---|---|---|---|---|---|---|---|
| *hpri* | 1.00 | | | | | | |
| *hage* | -0.30 | 1.00 | | | | | |
| *popu* | 0.58 | -0.05 | 1.00 | | | | |
| *tinc* | 0.26 | 0.41 | 0.18 | 1.00 | | | |
| *rdis* | -0.29 | 0.02 | -0.35 | -0.05 | 1.00 | | |
| *akur* | 0.26 | -0.06 | 0.03 | 0.00 | 0.15 | 1.00 | |
| *tunn* | -0.17 | 0.40 | -0.15 | 0.48 | 0.10 | 0.04 | 1.00 |

The correlation coefficients confirms that there are negligible internal correlations and there is no serious threat of multicollinearity (Table 7), as the estimation of Eviews confirms.

## 8 Acknowledgements

The author is grateful for the supervision of Gylfi Magnússon and Sveinn Agnarsson. Furthermore, the author is thankful for general comments from Ívar Jónsson, Lilja Mósesdóttir, and Þorbergur Þórsson. Financial support of Regional Development Office of West-Iceland, Bifröst School of Business, the Icelandic Regional Development Institute, and the Icelandic Road Administration.

## 9 References

Alonso, W. (1964). *Location and Land Use*. Cambridge: 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. E. (2001). Core-periphery model with forward-looking expectations. *Regional Science and Urban Economics*, *31*, 21-49.

Baldwin, R., Rikard, F., Martin, P., Ottaviano, G., & Robert-Nicoud, F. (2003). *Economic Geography and Public Policy*. Oxfordshire: Princeton University Press.

Banister, D. & Berechman, J. (2000). *Transport Investment and Economic Development*. London: Routledge.

Blanchard, O. J. (1987). Comment. *Journal of Business and Economic Statistics*, *5*, 449-451.

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.

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.

Evans, A. W. (1973). *The Economics of Residential Location*. London: MacMillan.

Fujita, M. (1989). *Urban Economic Theory: Land Use and City Size*. Cambridge: Cambridge University Press.

Fujita, M., & Thisse, J.-F. (2002). *Economic 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: 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.
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., & 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., & Zabel, J. E. (1996). House Price Differentials in U.S. Cities: Household and Neighborhood Racial Effects. *Journal of Housing Economics*, *5*, 143-165.
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.
Mills, E. S. (1969). *The Value of Urban Land,in H. Perloff (ed.). The Quality of the Urban Environment, Resources for the Future*. Washington, DC.
Mills, E. S. (1970). *Urban Economics*. Glenview, Ill: Scott, Foresman & Co.
Muth, R. (1969). *Cities and Housing: The Spatial Pattern of Urban Residential Land Use*. Chicago: University of Chicago Press.
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.
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: The MIT Press.