Transportation improvement and interregional migration

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Háskólaprent ehf.

In memory of my father

Abstract

Iceland's population of approximately fifty thousand inhabitants did not change appreciably from the end of the settlement period in the late twelfth century until the mid-nineteenth century because of the climate and limited technology in agriculture and fisheries. In fact, periodic decreases resulted from climatic fluctuations, natural disasters and epidemics, since this was a primitive rural community of farmers and fishermen. The weakness of the urban community was so apparent that when the royal monopoly on domestic trade was abolished by law in 1788, new migrants from selected villages to urban communities[1] were offered public subsidies, such as free lots and tax dispensation for twenty years. Despite this government intervention, the growth of the urban population, especially in the capital city, did not manifest until early in the twentieth century following technological developments, such as the advent of motor vessels, banks, and certain infrastructure investments. That is probably because the Danish authorities and Icelanders were not unanimous in their policies and actions. The growth of the urban population was followed by a decline in the rural population. This trend increased after World War II, and at the beginning of the 1980s, the population of the urban areas outside the capital area[2] began to decline as well, especially those populations that were farthest away from Reykjavík and Akureyri, the second-largest urban community outside the capital area.

The present research's objective is to investigate whether transportation improvements affect inter-regional migration in Iceland. This thesis is divided into three main parts. First, a brief introduction describes the development of the transportation system in Iceland, especially the road network, and geographic population patterns in the twentieth century. The second part covers fundamental theories of transportation economics and spatial economics, especially regarding transport demand, the geographic pattern of housing prices, theories of industrial location, and interregional migration. The third part reports on an empirical investigation that is in line with the objective of the thesis.

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[1] Definition: the term urban communities covers urban communities in both the rural and the capital area.

[2] Definition: the capital area is the capital city and adjacent municipalities: the definition is identical to that of Statistics Iceland.

Many factors motivate migration. Geographic differentials in labour market conditions were among the first factors addressed by economic theory in the context of spatial economics and were still among the central factors when amenities, local factors of value offered free or relatively inexpensively to the local population, were included several years ago. Amenities include natural resources, public services and social activities, while negative amenities or dis-amenities include local phenomena, attributes, incidents or threats, including crime and pollution that decrease the welfare of the local population without compensation. One theory has suggested amenities compensate for lower wages; since people tend to like places with good weather conditions, beautiful scenery, and other amenities, these places tend to generate an excess supply of labour, and wages decrease, while wages are higher where amenities are more limited. The New Economic Geography is the most recent theory covering interregional migration, where the core-periphery model is central. According to the model, the agglomeration economies are among the main reasons for rural-to-urban migration, through higher real wages. Moreover, lifetime earnings instead of present wages are addressed as more relevant. Uncertainty is included as well. One version of the core-periphery model includes social capital and traffic congestion.

Transportation economics is a large field within economics. Here, transport demand is relevant to the study topic so the theoretical presentation of transportation economics will be devoted to that only. Unlike many others types of demand, transportation demand is a derived demand since it is the demand for any other goods – that is, people travel to work, trade, and go shopping. Otherwise, transportation demand is comparable to demand for other values or goods where price, income, and the price of supplementary and complementary goods play a central role.

The dissertation’s empirical contribution will be divided into three parts and therefore classified into three separate chapters. First, we investigate the relationship between transportation improvements and local housing prices because housing prices reflect the value of locations. Second, we measure whether and to what degree rural residents value agglomeration and access to a central business district

(CBD)[3]. Finally, we examine whether transportation improvements affect interregional migration.

The empirical part of the study is based on data from Iceland that covers annual averages for Iceland's 79 municipalities for nearly two decades – the period from 1981-2006. Many municipalities were merged during this period with the result that the relevant data for all the years were classified according to the number of municipalities in the year 2006 in order to maintain comparability of data. Panel data models are implemented for analysis. They combine the analysis of cross section and time series simultaneously – that is an analysis of number of individuals or municipalities over time. One can choose between fixed and random effect in the analysis of panel data, where the coefficients of the fixed effect model include a variation within municipalities, while coefficients of random effect include both within and between variations.

The estimation of the relationship between transportation improvements and housing prices is based on a relatively new interpretation of Johan Heinrich von Thünen's (1783-1850) theory regarding land rent: housing prices tend to be highest in the centre of a CBD because of the significance of the market, and they decrease for every unit of distance from the centre. However, the theory also suggests that transportation improvements between a CBD and a rural area increase housing prices in the rural areas because of easier access to the CBD. Where the variation of transportation improvements is to be found between all municipalities and Reykjavík, a model of fixed effect was found to be relevant. The analysis of Iceland confirms that the relationship between transportation improvements and housing prices is non-linear—that is, the marginal impact, which is largest in the municipalities adjacent to the CBD, decreases as the distance between the municipality and the CBD increases. This result shows that the impact of transportation improvements on local housing prices increases marginally as the distance between a district and a CBD decreases. Several other known factors, such as the supply of housing, had an expected negative impact on housing prices, while the number of rooms, balconies, garages, and parking had positive impacts. Until the present study, an analysis of this theory had not been implemented on an entire

[3]Definition: a rural area is the area outside the capital area: both farm and urban communities outside the capital area are included.

country. Along with heterogeneous marginal impact, these were the major contributions of this particular empirical study.

The value of access was estimated by testing whether the spatial disparity of housing prices in Iceland, especially the difference between CBDs and rural areas, had changed during the past two decades. If it had changed, we tested whether the change was a result of increased agglomeration of economies or a result of changing preferences for access over amenity values. Again, the analysis is based on a modern version of von Thünen's theory concerning the forces behind the spatial disparity of housing prices, along with theories of agglomeration economies. Now, a model of random effect, returning coefficients including both within and between variations, was relevant since local amenities have to be considered in an evaluation of access and agglomeration economies. The results suggest that the spatial disparity of housing prices changed in favour of CBDs in Iceland and that changed preferences in favour of access over amenities were responsible—that is, access became relatively more valuable. These changes were also due to increased agglomeration economies, but further inspection shows that the differences in housing prices between Reykjavík and the closest neighbouring municipalities decreased, despite previous findings. Weak evidence suggests that this decreased difference could be due to counter-urbanisation, a relatively new phenomenon in which certain types of urban citizens move from urban areas to rural areas within a 120-kilometre radius. This phenomenon has been detected both in North America and Europe. The many reasons for this phenomenon can generally be classified into economic factors and changed preferences such as proximity to wild nature (absence of pollution) and traditional farming. In the present study, as in the previous one, several other known factors have had an expected impact on housing prices. These factors include labour income, supply of housing, housing age, dwelling size, number of rooms per dwelling, balconies, garages, parking, and number of dwellings in the same house.

Finally, the impact of transportation improvements on interregional migration was tested. The empirical model is based on the neo-classical Harris-Todaro model. The results suggest that geographic differentials in labour market conditions, such as wages and unemployment, play a leading role in explaining interregional migration, but the supply of housing and transportation improvements also affects interregional migration. While the supply of housing seemed to have had a positive impact on interregional migration, transportation improvements between the rural and urban areas did not have a homogeneous impact on interregional migration in the relevant regions, where it was negative towards its closest regions of the rural area and positive towards regions farther away. The first result is in line with the theory of the New Economic Geography (or the Core-Periphery Model), suggesting that a transportation improvement between two different regions would result in a net flow of residents from the smaller to the larger region, due to better market access and agglomeration economies. Certain types of industries (firms in monopolistic competition) will disappear from the smaller region and grow in the larger region. The latter is in line with the Disequilibrium and Harris-Todaro models, suggesting that transportation improvements lead to positive net inflows of migrants because of higher real wages following lower transport costs.

Since the overall results indicate that selected factors are missing in the model, the analysis was repeated for men and women separately. The results then showed that the model was better in explaining the migration behaviour of women rather than men. The condition of the labour market seemed to matter more to women than men. This is a logical result to some extent, since it has been shown in other studies that the gender wage gap is larger in rural areas of Iceland than in urban areas. The supply of housing was affecting the migration patterns of both genders, while travel time, surprisingly, did not show any significance.

Weak results for the migration pattern of men fuelled the idea that it should be tested against the migration pattern of women. Thus, if women would leave for better income, according to Gary Becker's results that show singles are generally less well off than married people and other couples, the expected future welfare of single men would be lowered. With this in mind, the most logical response by single men would be to follow single women, since men are indifferent regarding other potential factors affecting migration. A new variable for reflecting changes in the local gender ratio (number of women divided by number of men) in the previous period was added to the model and confirmed the hypothesis. Moreover, travel time also became significant for men, and the overall robustness of the model increased. Therefore, travel time seems to impact the interregional pattern of men but not women.

Ágrip

Hin mikla fjölgun íbúa á höfuðborgarsvæðinu og fækkun til sveita á Íslandi var tilefni þessarar rannsóknar. Þjóðinni fjölgaði lítið fram á miðja 19. öld, en íbúafjöldi sveiflaðist öldum saman í kringum 50.000. Miðað við ríkjandi tæknistig virðast landbúnaður og sjávarútvegur ekki hafa geta brauðfætt fleiri íbúa og sveiflur í veðurfari, náttúruhamfarir og farsóttir lögðu grunninn að sveiflum í fjölda íbúa þannig að ekki var stór munur á íbúafjölda frá lokum landnámsaldarinnar fram á miðja 19. öld, eftir því sem komist verður næst. Þetta var frumstætt sveitasamfélag og mikill meirihluti bjó í strjálbýli. Myndun þéttbýlis var svo veik á Íslandi að sett voru lög árið 1788, þegar verslun var gefin frjálsari[4], um styrki til þeirra sem settust að í völdum kaupstöðum – þ.e. Reykjavík, Grundarfirði, Ísafirði, Akureyri, Eskifirði og Vestmannaeyjum. Styrkirnir fólust í ókeypis lóðum og 20 ára undanþágu frá sköttum svo eitthvað sé nefnt. Það var samt ekki fyrr en snemma á 20. öldinni eftir vélvæðinguna, fjárfestingu í innviðum, stofnun banka og annarra stofnana, að fólki fer að fækka til sveita og fjölga í þéttbýli um land allt en mest á höfuðborgarsvæðinu. Það kann að vera vegna þess að framan af voru ráðandi öfl ekki einhuga um eflingu þéttbýlis. Vöxtur þess varð síðan mjög ör eftir lok seinni heimstyrjaldarinnar og í upphafi 9. áratugarins fór íbúum að fækka í þéttbýlum utan höfuðborgarsvæðisins, einkum þeim sem fjærst voru Reykjavík og Akureyri.

Rannsóknin er í þremur megin hlutum. Fyrst er stuttur inngangur sem varpar ljósi á hvernig samgöngukerfið, þó aðallega vegakerfið, íbúaþróun einstakra landsvæða og búferlaflutningar á Íslandi þróuðust á 20. öldinni. Þar á eftir kemur stór kafli um helstu kenningar og líkön innan samgönguhagfræði og svæðahagfræði. Innan svæðahagfræði er einkum horft til landfræðilegs breytileika á fasteignaverði, staðsetningar fyrirtækja og búferlaflutninga. Að lokum kemur hluti sem segir frá þremur mismunandi reynslurannsóknum (e. empirical studies).

Samkvæmt kenningum hagfræðinnar hefur margt áhrif á búferlaflutninga. Oftast eru aðstæður á vinnumarkaði nefndar en

[4] Verslun var ekki gefin frjáls í hefðbundinni merkingu þess orðs, heldur var hverjum þegni Danmerkur frjálst að hefja verslun.

[5] Definition: Rural (small) urban communities are urban communities outside the

skynvirði verður áberandi á síðari tímum. Skynvirði (e. amenity value) felst í staðbundnum gæðum sem auka velferð almennings án þess að hann borgi fyrir það markaðsvirði. Ýmis náttúrugæði, niðurgreidd og endurgjaldslaus þjónusta eða hreinlega félagsstarf hefur verið flokkað undir skynvirði. Þá hafa fræðimenn talað um neikvætt skynvirði (e. dis-amenity). Það eru staðbundnir þættir sem draga úr velferð íbúanna án þess að þeir fái fyrir það bætur. Glæpir og mengun hafa verið taldir þar á meðal. Athyglisverðar eru kenningar sem gengið hafa út á að laun séu almennt lægri á stöðum þar sem skynvirði er hátt. Það er útskýrt þannig að fólk laðist að stöðum sem bjóða upp á gott veðurfar eða önnur endurgjaldslaus gæði. Það eykur framboð vinnuafls og laun lækka. Að sama skapi eru laun óvenju há þar sem skynvirði er lágt. Nýjastar eru kenningar nýju- svæðahagfræðinnar (e. New Economic Geography), en þaðan er kjarna- jaðarlíkanið ættað. Þar á borgarhagræði stóran þátt í að laða íbúa úr sveit til borgar með hærri launum. Þá er einnig lögð meiri áhersla á ævitekjur fremur en laun á hverjum tíma. Einnig er svigrúm fyrir áhættu. Öll óvissa um afkomu dregur íbúa til svæða þar sem afkomuöryggi er meira. Í einu þessara líkana er félagsauði og umferðarþunga fundinn staður.

Samgönguhagfræði er stórt svið. Hér er það eftirspurn eftir samgöngum sem tengdist viðfangsefni ritgerðarinnar og fræðilegum bakgrunni hennar því gerð skil. Það sem einkennir eftirspurn eftir samgöngum er að hún er afleidd – þ.e. hún er afleiðing af eftirspurn eftir öðrum gæðum. Fólk ferðast í þeim tilgangi að versla og sækja vinnu og afþreyingu svo eitthvað sé nefnt. Að öðru leyti lýtur eftirspurn eftir samgöngum sömu lögmálum og eftirspurn eftir öðrum gæðum þar sem eigið verð, verð stuðnings- og staðkvæmdarvara og tekjur neytenda spila stórt hlutverk.

Í þessari rannsókn var ætlunin að mæla hvort samgöngubætur hefðu áhrif á búferlaflutninga og hvernig. Þetta var gert í þremur skrefum. Fyrst með því að skoða áhrif samgöngubóta á fasteignaverð, þar sem fasteignaverð endurspeglar virði staða og staðsetninga. Í öðru lagi að meta þróun landfræðilegs breytileika fasteingaverðs og hvort í því fælist þróun á borgarhagræði og virði aðgengis að höfuðborginni. Að lokum meta áhrif samgöngubóta á búferlaflutninga með beinum hætti.

Reynslurannsóknir ritgerðarinnar byggðu á gögnum frá Íslandi yfir öll sveitarfélög á landinu (79) í nærri tvo áratugi. Reiknuð voru ársmeðaltöl fyrir öll sveitarfélögin. Mörg sveitarfélög voru sameinuð á þessu tímabili en til að gæta samræmis voru allar tölur reiknaðar upp fyrir 79 sveitarfélög líkt og á síðasta ári í gagnasafninu, árið 2006. Líkönum fyrir tvívíð gögn (e. panel data) var beitt við greiningarnar. Þau greina líkön með þversniðs- og tímaraðagögn samtímis – þ.e. yfir fjölda einstaklinga eða sveitarfélaga í mörg ár. Í greiningum tvívíðra gagna er í megin atriðum hægt að velja á milli líkans með föstum áhrifum annars vegar og tilviljunarkenndum áhrifum hins vegar. Líkan með föstum áhrifum skilar stuðlum sem endurspegla breytileika innan sveitarfélaga eingöngu, meðan líkan með tilviljunarkenndum áhrifum skilar breytileika innan sveitarfélaga og milli þeirra samtímis.

Við mat á áhrifum samgöngubóta á fasteignaverð var stuðst við kenningu og líkan þýsks hagfræðings, Johan Heinrich von-Thünen (1783-1850), um landfræðilegt mynstur fasteignaverðs, þar sem það hefur tilhneigingu til að lækka út frá borgarmiðju vegna mikilvægis markaðarins. Þar sem breytileika á samgöngubótum var að finna á milli allra sveitarfélaga og Reykjavíkur skilaði líkan með föstum áhrifum niðurstöðum sem svöruðu rannsóknarspurningunni. Niðurstaða greiningarinnar staðfesti að samgöngubætur milli landsbyggðarinnar og höfuðborgarinnar hafa áhrif á fasteignaverð á landsbyggðinni til hækkunar. Sérstaða rannsóknarinnar fólst einkum í tvennu: Þessari greiningu hefur aldrei verið beitt á heilt land með þessum hætti og sýnt var fram á að áhrifin væru ekki einsleit. Þau voru mest næst höfuðborginni en fjara síðan smám saman út eftir því sem fjær dregur. Það gefur til kynna að áhrif samgöngubóta eru líklegastar til hafa mest áhrif á fasteignaverð ef þær eru sem næst höfuðborgarsvæðinu. Ýmsir aðrir vel þekktir þættir höfðu áhrif á fasteignaverð eins og búist var við. Þeir helstu voru að framboð íbúða hafði neikvæð áhrif á verð íbúða á meðan stærð þeirra, fjöldi herbergja, svalir, bílskúr og bílastæði höfðu marktæk jákvæð áhrif á verð þeirra.

Þá var aðgengi dreifbýlis að borgum metið. Það var gert með því að kanna hvort munur á fasteignaverði í Reykjavík og annarra landsvæða hafi aukist á síðastliðnum 20 árum. Ef það var tilfellið, var ætlunin að meta hvort það fælist í auknu virði á aðgengi vegna breyttra óska almennings um aukið aðgengi að fjölbreyttu úrvali þjónustu og atvinnu eða aukins þéttbýlishagræðis (e. agglomeration economies) vegna aukinnar almennrar hægræðingar af nábýli við annað fólk og fyrirtæki. Að þessu sinni var stuðst við nútíma útfærslu á kenningum von-Thünens um drifkrafta á landfræðilegum breytileika fasteignaverðs og kenninga um þéttbýlishagræði. Nú var líkan með tilviljunarkenndum áhrifum viðeigandi, þar sem aðgengi togast á við skynvirði en slík verðmæti mælast aðallega með breytileika gagnanna milli sveitarfélaga og breytileiki innan þeirra er síðan nauðsynlegur til að gefa fullnægjandi mynd af virði borgarhagræðis. Í greiningunni kom fram að munurinn á fasteignaverði í Reykjavík og Akureyri gagnvart öðrum sveitarfélögum hafði aukist á síðustu árum. Sýnt var fram á að óskir almennings um búsetukosti höfðu verið undirliggjandi þáttur og breyst stóru þjónustukjörnunum tveimur í hag – þ.e. aðgengi sem borgir veita hefur orðið hlutfallsega verðmætara heldur en skynvirði sem dreifbýlið hefur í ríkara mæli. Þá kom fram vísbending um að þéttbýlishagræði hafði átt sinn þátt í þróuninni. Við nánari skoðun kom í ljós að munurinn á fasteignaverði í Reykjavík og nálægum sveitarfélögum hafði verið að minnka á sama tíma, þrátt fyrir áðurnefnda þróun. Vísbendingar komu fram um að búferlaflutningar úr borg í sveit hafi verið undirliggjandi áhrifaþáttur þess. Það er almenn tilhneiging til flutnings borgarbúa aftur til sveitar eða smærri bæja í nágrenni borganna, eða í u.þ.b. 120 kílómetra radius frá miðju hennar sem orðið hefur vart bæði annars staðar í Evrópu og einnig í Bandaríkjunum. Ástæður hennar eru ýmist af efnhagslegum hvötum eða af breyttri forgangsröðun í lífi fólks eins og óskir um meiri nálægð við náttúruna eða nánari tengsl við lífið í sveitinni. Í þessari rannsókn komu fram ýmsir aðrir áhrifaþættir fasteingaverðs, margir þeir sömu og í fyrri rannsókninni. Þar má nefna atvinnutekjur, framboð íbúða, aldur og stærð þeirra, fjöldi herbergja, svalir, bílastæði og bílskúr, fjöldi íbúa.

Að lokum voru áhrif samgöngubóta á búferlaflutninga metin með beinum hætti. Stuðst var við klassískt búferlaflutningalíkan. Niðurstaða rannsóknarinnar benti til að aðstæður á vinnumarkaði, atvinnutekjur og atvinnuleysi, skiptu mestu máli varðandi búferlaflutninga milli sveitarfélaga á Íslandi. Einnig sást að framboð íbúða laðaði fólk að. Þá skipti aðgengi að sterkum þjónustukjörnum nokkru máli og þess vegna geta samgöngubætur milli höfuðborgarsvæðsins og landsbyggðar hægt á eða jafnvel snúið óhagstæðri íbúaþróun við. Það gæti líka magnað óhagstæða íbúaþróun vegna þess að áhrifin voru þau sömu allsstaðar; því nær sem samgöngubótin var Reykjavík því líklegri var hún til að valda óhagstæðum búferlaflutningum í nærliggjandi sveitarfélagi. Í ákveðinni fjarlægð snérist þetta við þannig að samgöngubætur milli Reykjavíkur og fjarlægari sveitarfélaga stuðluðu að hagstæðum búferlaflutningum til þeirra. Fyrra samhengið er í samræmi við kenningar nýju- svæðahagfræðinnar (kjarna-jaðarslíkansins) og kveður á um að samgöngubótin leiði til þess að ákveðin framleiðsla og þjónusta leggist af vegna nálægðar við sterkan kjarna. Hið seinna í samræmi við ójafnvægislíkanið þar sem samgöngubótin hefur tilhneigingu til að auka kaupmátt launa (raunlaun) utan borgarinnar vegna lækkandi verðlags í kjölfar lægri flutningskostnaðar og draga þannig úr brottflutningi eða jafnvel draga fólk að vegna hærri launa.

Þar sem niðurstöðurnar gáfu til kynna að ennþá vantaði mikilvæga áhrifaþætti inn í líkanið var gerð tilraun til að meta það á ný og skipta gagnasafninu upp á milli karla og kvenna. Þá kom í ljós að líkanið skýrði miklu betur út búferlaflutninga kvenna heldur en karla. Aðstæður á vinnumarkaði virtust skipta konur miklu meira máli en karla. Það er á vissan hátt rökrétt niðurstaða þar sem sýnt hefur verið fram á að launamunur kynja er minni á höfuðborgarsvæðinu en utan þess. Framboð á íbúðum hafði áhrif á bæði kynin, en ferðatími engin áhrif. Þar sem þetta líkan virtist vera óvenju lélegt í að skýra búferlaflutninga karla vaknaði sú hugmynd að kanna hvort brottflutningar kvenna hefðu áhrif á brottflutning karla. Sú tilgáta vaknaði á grundvelli kenninga Gary Beckers um að hagsæld fólks í sambúð eða hjónabandi sé meiri heldur en einhleypra; þar með ef konur flyttu brott þá dragi úr líkum karla á að komast í sambúð. Það var gert með því að kanna hvort karlar flyttu í kjölfar kvenna til þess að auka líkurnar á sambúð/hjónabandi. Það var staðfest þegar líkanið var keyrt aftur með viðeigandi breytingum. Við þetta hafði ferðatími marktæk áhrif á búferlaflutninga karla og niðurstaðan almennt áreiðanlegri. Það virðist því vera þannig að samgöngubætur hafi frekar áhrif á búferlaflutninga karla en ekki kvenna.

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At the beginning of the new millennium, I was eager to seek further education and academic training, but it took me five years to find my field of interest. At first, I was occupied with my previous field of resource and environmental economics, but spatial economics gradually became my focus. Based on previous study as a consultant on the impact of a large sub-sea tunnel in Iceland on its adjacent region, I constructed a research plan for a general study of the impact of transportation improvements on interregional migration in Iceland and delivered it to Gylfi Magnússon, my supervisor. Eventually, Sveinn Agnarsson and Frank Goetzke became supervisors as well. I thank them for their supervision, guidance, and encouragement, which added to my motivation, eagerness, and ambition to excel in this field.

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1 Introduction

The movement of residents from rural areas to cities is a well-recognized pattern worldwide. The primary reasons for this population migration include labour market issues, such as wages and employment, and the spatial disparity of amenities (a non-priced local value). Due to agglomeration economies, wages are higher and employment opportunities are better in cities and because of the proximity of wild nature, amenities are greater in rural areas. Migration is also motivated by other factors. Uncertainty is one of them and access is another. Cities inhabitants' have better access to wide variety of goods, service and leisure opportunities than those who live in rural areas. Narrow employment opportunities in rural areas have motivated families to send members for work in the cities in different branches to stabilize their income fluctuations, especially in the developing countries. Since migration is more likely to be affected by life time earnings than current wages uncertainty is also significant factor for interregional migration among developed countries. Since isolation reduces the spatial flexibility of production factors, goods services and other local valuables, it is reasonable to assume that interregional migration could be affected by improvements in transportation. Flexibility reduces risk, increases household expected income and improves access. Therefore, the purpose of this dissertation is to address the following research question: *Do transportation improvements that increase access to urban areas from rural areas affect migration from rural to urban areas?*

The dissertation is divided into two main subjects. Instead of moving directly to estimating the interregional migration, the dissertation starts by addressing conditions for residence captured by local housing prices since housing prices tend to reflect the value of the location of a household residence. Therefore, the dissertation begins with investigating the impact of transportation improvements on local housing prices and then on interregional migration.

Data of almost two decades from Iceland is analyzed in the empirical section of the dissertation. Iceland is an appropriate case for this study because it is a large, sparsely populated country that has experienced a significant and persistent flow of residents from rural to urban areas during a time of extensive transportation improvements. The development for other possible factors such as real wages, level of culture, public service, local taxes and infrastructure have not followed an identical pattern of development.

Iceland is a 103.000 km^2 island in the north-antlantic ocean of approximately 315.000 inhabitants where two third lives in the capital area on the south-west coast. However, there are approximately 100 small urban communities[5] scattered relatively evenly along the coast. The population has been growing relatively fast compared to other European countries where birth rate, good health and recently foreign immigrants are mostly responsible.

Overall, the population of Iceland is homogeneous in terms of ethnic origin, culture, and language. In addition, the country is geographically isolated in northern Europe, so it is a good representative for all countries or communities in the northern periphery, since it is comparable to them when it comes to characteristics like population density, climate, industrial structure, distance from large export markets, and access to natural resources.

The results of this study have several policy implications. The development of rural-to-urban migration has concerned policymakers in several countries, many of whom have recommended government intervention in response to market failures in the form of lack of information, immobility factors, and externalities (Bartik, 1990; Weiler, 2000). For instance, as suggested by a new study (Rodríguez et al., 2011), better information affects people's choices regarding residential location. Others (Minford & Stoney, 1991) have suggested that the market mechanism would solve many regional problems and that development should involve less government intervention. However, Tiebout (1956, p. 418) said that communities should be many and varied in order to satisfy all individuals, because people's preferences for location vary as well. Furthermore, since Iceland is an island with active volcanoes, dispersed residents could be a sensible public risk management. For Iceland, the geographic dispersion of residents has historically been determined by the economics of harvesting and

[5] Definition: Rural (small) urban communities are urban communities outside the capital area; the rural area apart from the countryside; communities of farms are not included.

processing natural resources. Government intervention have also had several impacts: Earlier by rigid laws to prevent the growth of fisheries to protect the agriculture and thus hindering urban development and later by direct and indirect public grants for selected industries located in the rural area of Iceland.

The rest of this dissertation is organised in following manner. Chapter two discusses the historical development of the Icelandic transportation system, with a special focus on important transportation improvements, as well as changes in the level and spatial distribution of the population. The next chapter, “Theories and Models,” introduces the theoretical background and the models of the spatial structure of housing prices and interregional migration. There is also an overview over location theories in the chapter, since they are related to the analysis of migration. Finally, three empirical papers are presented in successive chapters. The first paper addresses whether improvements in transportation between the urban and the rural areas make the rural areas more attractive and increase housing prices there. The second paper investigates whether agglomeration economies, or changed values, as they relate to access to employment, goods, and services, affect the spatial disparity of housing prices. Thirdly, if either access is valued or agglomeration economies are present, the relationship between transportation improvements and the flow of rural-urban migration can be significant. Therefore the third paper tests the significance of the relationship between interregional migration and transportation improvements. The dissertation is finished by an extensive chapter for conclusions.

2 Development of the population and transportation system in Iceland

2.1 Population development

Most scholars assume that the first settlers came to Iceland close to the year 870 AD (Karlsson, 2011) and that the population in 930 was approximately ten thousand (Teitsson & Stefánsson, 1972, p. 156). According to the Icelandic Sagas, ocean fish and the livestock the inhabitants brought with them were the main sources of food (Sigurðsson et al., 2005, p. 40), although the fisheries were more significant in the first years of the settlement when the number of livestock was limited (Sigurðsson et al., 2005, p. 120). Because of a higher average temperature that affected the growth of vegetation needed to feed the livestock and the health of the birchwood forests as material for fuel, the estimated population at the end of colonization period in the eleventh century was greater than that in the eighteenth century, which we know from our first national census in 1703 was around fifty thousand (Karlsson, 2000, p. 45). One estimation even suggests that the population in the eleventh century was close to seventy thousand (Steffensen, 1963, pp. 143-146). Some (Snævarr, 1993, p. 12) claim that Iceland was not able to feed more than fifty thousand people prior to the modernisation of its economy in the late nineteenth century. Apart from the population in 930 and 1703, knowledge concerning population figures is limited and is often based on weak evidence (Teitsson & Stefánsson, 1972). However, it is certain that the population was occasionally affected by disease, epidemics, and natural disasters: the Black Death came twice to Iceland, killing 50-60 percent of the population when it came in 1402 and 30-50 percent when it returned in 1494 (Karlsson, 2000, p. 115); a smallpox epidemic in 1707 took 26 percent of the population; and the consequences of the eruption of Laki crater in 1783 killed approximately 20 percent of the population (Karlsson, 2000, pp. 177-181). In short, the prosperity of the agriculture and fisheries, along with diseases and epidemics, were the major determinants of population development in Iceland for centuries (Snævarr, 1993, pp. 9-15).

It is most likely that settlement began by the coast at the very first years of the settlement (Jóhannesson, 1965, pp. 38-45; Valsson, 2002, p. 59; Þór, 2002, pp. 32-34). Since agriculture focused on animal husbandry rather than planting (Karlsson, 2000, pp. 46-47), and since the number of livestock was limited, it was safer to rely on fisheries parallel to farming. Soon the population was dominated by inland[6] settlements (Karlsson, 2000, pp. 46-47) since the livestock increased in numbers because of breeding and foreign merchants that offered it for sale to the settlers (Jóhannesson, 1965, p. 42). Moreover, because of the favourable climate at the time, a much larger share of the country was covered with grass and birchwood than is the case today (Þórarinsson, 1974a, p. 53). Old ruins of houses from the settlement period have been found 400-500 metres above sea level in places that have never been settled again, but when the weather got colder (the "little ice age") and the highland vegetation became over-exploited, the highest part of inland population had to move closer to the coast (Þórarinsson, 1974b, pp. 41-42). According to Jóhannesson (1965, p. 48), Iceland was dominated by inland residence by the eleventh century, and it reached its maximum late that century. Some evidence suggests that more farms appeared closer to the coast than inland in the period 1100-1400 (Teitsson & Stefánsson, 1972, p. 173).

It is likely, then, that the relative significance of seafood and agricultural products for the household welfare influenced the population's geographic dispersion and proximity to the inland or coast (Teitsson & Stefánsson, 1972, p. 169). Agricultural products (mainly wool) dominated the exports until the fourteenth century when fish (stockfish) took their place, remaining significant exports until the beginning of the seventeenth century (Jóhannesson, 1965, pp. 39-56; Snævarr, 1993, pp. 17-18; Þorláksson, 1991, p. 8). From the first settlements until the late nineteenth century, when urbanisation took off (Gunnlaugsson, 1993, p. 107), there were some adjustments in the spatial disparity of the residents, although it was generally dominated by settlements in the countryside[7]. Some have even suggested that the national population growth influenced structural changes and, thus, the geographic dispersal of the population, that is, that labour-intensive industries like cattle farming and fishing were dominant when the country

[6] Definition: the inland is urban communities and countryside not along the coast where a high share of incomes come from agriculture.

[7] Definition: the countryside is relating to the country or agriculture; communities of farms; the area outside the capital area where no urban communities are included.

was overpopulated, and less labour-intensive industries like sheep farming were dominant when the population was low (Júlíusson, 1990). If this is true, epidemics and natural disasters affected the geographical dispersion of the population as well, such as when eruptions like Hekla in 1103, Öræfajökull in 1362, and Laki in 1784 covered or spoiled the soil so farming was impossible and large areas were not populated thereafter (Teitsson & Stefánsson, 1972, pp. 150-152).

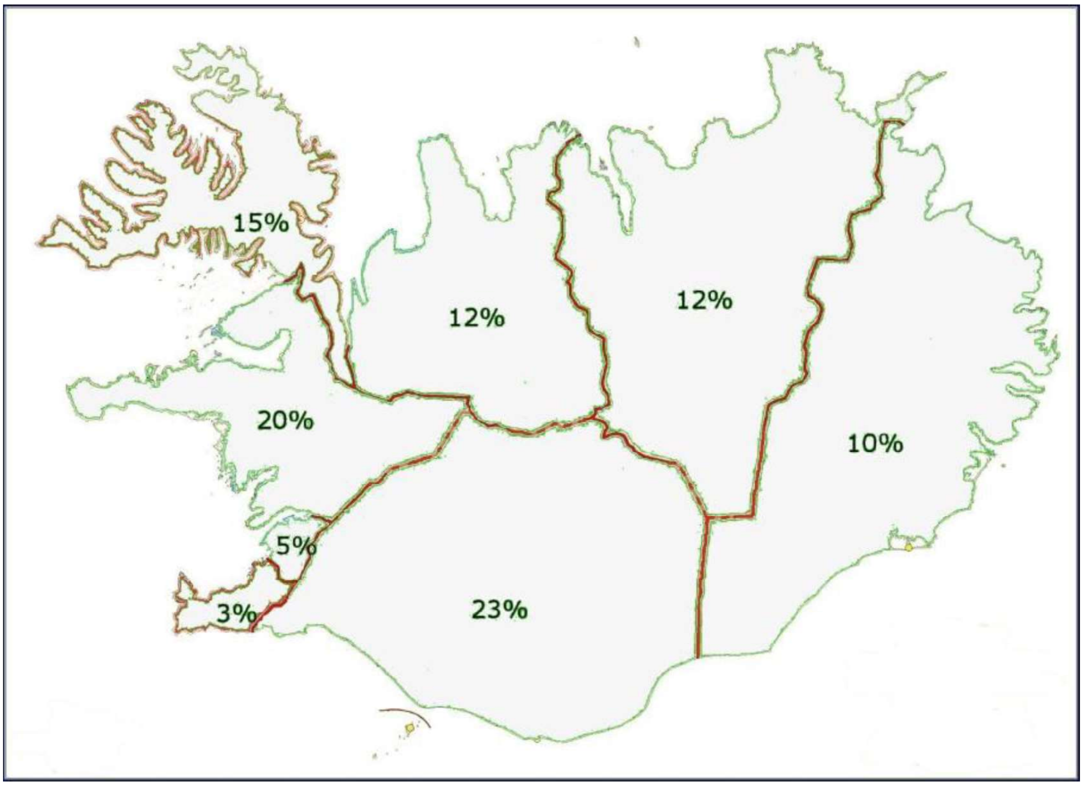

Figure 2-1. Population regional dispersion in 1703.

Population of Iceland was 50,358 in 1703. Source: Statistics Iceland.

The country has always been sparsely populated. The farms were situated throughout the entire lowland (and sometimes the lowest part of the adjacent highlands), but on average there was a relatively long distance to the next farm, at least compared to continental Europe at the same time. The reason for this is that the primary type of farming in Iceland in recent centuries, sheep farming, is very land-intensive (Jóhannesson, 1965, p. 57). In addition, the main fish stocks are distributed along the coasts of the Iceland. It can be added that the south and the west coasts are richer in some of the most valuable fish stocks, such as cod and haddock, than the north and east coasts. Barley was also cultivated until the mid-sixteenth century, but it is also land-intensive (Þórarinsson, 1974b, pp. 38-40). However, this single-farm pattern was dominant in the northern part of Europe—that is, the Nordic countries, at that time (Sigurðsson, 2010).

Even though there were farms throughout the lowlands, the south and the west coasts were more attractive than the rest of the country. Winter is the high season for the fisheries on the south and the west coasts of Iceland, and summer is the high season for agriculture, so there was a favourable match in terms of labour-sharing between agriculture and the fisheries, especially on the south and the west coasts (Jónsson, 1984, p. 267; Valsson, 2002, pp. 59-62). The south and the west coasts of the country afforded favourable circumstances for human habitation, which is partly in line with the regional dispersion of the population in Iceland in 1703 (Figure 2-1), when there were more inhabitants in Westfjords than in the northwest, the northeast, or the east, even though these areas have more lowlands than the Westfjords do (Figure 4-1). In 1703, 15 percent of the population lived on both agriculture and fisheries in Iceland, and 16 percent lived solely on fisheries (i. þurrabúðarfólk). Half of the latter group lived in two municipalities on Snæfellsnes peninsula in West Iceland (Teitsson & Stefánsson, 1972, p. 136), an area relatively poor in lowlands (Figure 4-1). At the same time, 65 percent of the population lived in the south and west part of the country, which is not much different from what was the case in the year 1240 (Sigurðsson, 1999, pp. 67, 80), while agriculture was still benefitting from the climate prior to the coldest period of the little ice age. Note that in both periods, fisheries were not significant in terms of exports.

However, urban communities in Iceland did not develop as they did in other countries of Europe. In Iceland, they were few and small and based on agriculture and fishing (Gunnlaugsson, 1993, p. 107). Therefore, Iceland was a simple economy of farmers and fishermen, and almost everyone lived in rural areas until the late nineteenth century. The government (then Danish) prevented urban development by laws and regulation, such as by social legislation like labour bondage (i. vistarband) and regulation of occupation and settlement, thus slowing down the development of fisheries (Jónsson, 1995, pp. 192-194). According to Jónsson (1993, pp. 65-66) there were two possible reasons for legal limits on complete freedom in choosing occupation and residence: Firstly, there was a fear of increased social expenditures in municipalities because of increased poverty among civilians since urban communities were based on fisheries. Because of the fish stock's (cod and other demersal fish) travel pattern and small and poor boats, fisheries were highly seasonal and offered uncertain income. Secondly, the legal limits were intended to prevent other competition so agricultural labour would remain cheap. This suggestion is in line with Snævarr (1993, pp. 18-19), but he adds a third reason, which was also mentioned by Gunnarsson (1987, p. 250): that Icelanders feared risk and social change. Eggertsson (1996) also mentioned the second reason of cheap labour and that Danish authorities were willing to keep the fisheries weak in order to prevent competition in international trade since Iceland had earlier been trading fish to both Britain and Germany. However, Gunnarsson (1987, p. 76) doubted that the Danish authorities had to work to keep other countries from trading with Iceland. Not all scholars (Stefánsson, 1995, pp. 187-191) agree with Jónsson and Snævarr regarding negative impact of the legal limits on choosing occupation and residence on the development of fisheries and urban development. Regardless of the reason, the urban communities were small, and fishermen were mainly farmers and their workers who travelled to the coast, living in primitive accommodations during the fishing season and bring processed fish back to the farm when the season was over (Valsson, 2002, pp. 59-61).

However, the government seemed to be worried about urban population as well, since they offered public subsidies in 1788 for those who moved to chartered towns[8] to support the development of service centres and domestic trade (Ingólfsson et al., 1987, p. 37). A free housing lot and no tax payments for twenty years were among the subsidies offered urban citizens. Despite this sign of understanding, notable growth of urban communities did not accelerate until in the late nineteenth century, when the legal limits for choosing occupation and residence were dissolved because of emigration to North America and movement to domestic urban communities for jobs in fast-growing fisheries (Gunnlaugsson, 1993, pp. 102, 107).

The total population of Iceland was close to fifty thousand at the beginning of the eighteenth century (Figure 2-2), but it took off in the late

[8] Only six towns: Reykjavík, Grundarfjörður, Ísafjörður, Akureyri, Eskifjörður, and Vestmannaeyjar.

nineteenth and early twentieth century (Figure 2-2), which was the beginning of a period of urbanisation in Iceland (Gunnlaugsson, 1987, p. 107) and part of the modernisation of the Icelandic economy (Jónsson, 2002; Snævarr, 1993). Jónsson (2002, pp. 9-15) described this period:

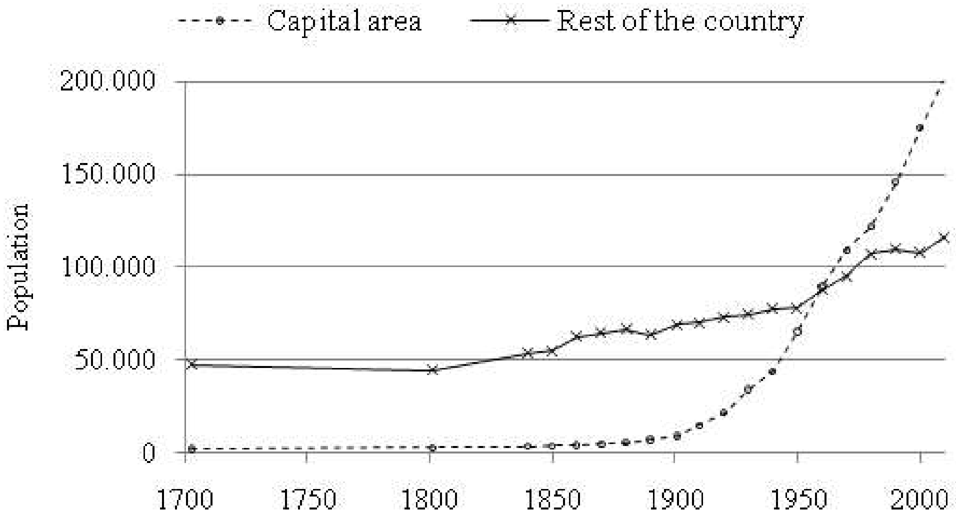

Figure 2-2. Population development in the capital area of Iceland and the rest of Iceland 1703-2010.

Source: Statistics Iceland.

> The development of a modern economy in Iceland began in the late 1800s and the beginning of the 1900s. Then changes regarding the economy and general conditions for both households and the industries occurred almost simultaneously: 1) capitalism, marketisation, urbanisation, and new class division; 2) industrialisation, structural change, economic growth, and new technology. The population and the economic growth on the European continent following the industrial revolution increased the demand for food, amongst other goods, and transportation became better and cheaper. Iceland had exported both agricultural goods and fish products to Northern Europe for centuries, but it grew gradually in the late nineteenth century and accelerated necessary imports to the country, such as new and better fishing gear and vessels. It improved Iceland's technology and labour productivity and rendered the economy capable of increasing the supply of export goods to meet the demands of the foreign markets and of bringing back valuable goods. It fuelled population growth through improving the general health conditions in

> Iceland, primarily because of the availability of better food (especially imported corn for the poor), better houses made of imported timber, and improved health care. With free trade, the earlier developments allowed for new investments that were necessary to maintain the economic growth. Economic growth was present in Iceland prior to this development, but the modern economy made it persistent in the long run.

Therefore, the population growth in Iceland increased following the modernisation of the Icelandic economy. The reasons are traced back to the increased life expectancy (Gunnlaugsson, 1993, p. 110) that was due to better health care and general standards of living (Jónsson, 2002, p. 10).

An efficient labour market was part of the modernisation. The complete freedom for people to choose their occupations was secured when laws limiting the choice of occupation and residence were abolished (Jónsson, 2002, p. 13). Recall that urban communities offered unstable household income because of fluctuations in the fisheries. Technology improvements increased the stability of the fisheries because the new vessels were faster and safer in bad weather, increasing the number of fishing days and increasing the size of the fishing grounds. Therefore, it is reasonable to say that the stagnation in agriculture (Jónsson, 1999, p. 164), new technology, and the end of legal constraints on the freedom of the poorer part of the population were probably the most significant factors for the urbanisation in Iceland that began in the 1870s and 1880s. The industrialisation in the fisheries took off in Iceland in steps: Some of the first steps were bigger row boats in the 1870s (Gunnlaugsson, 1987, p. 214), decked fishing vessels in the 1880s (Gunnlaugsson, 1993, p. 85), motor boats in 1902, and the first trawler in 1905 (Jónsson, 1999, p. 171). Hand in hand with under-exploited fish stocks at that time and growing foreign demand, the fisheries' new technology was the leading factor in the 500 percent increase in export income in Iceland in the first three decades of the twentieth century (Jónsson, 1984), the 200 percent increase in the volume of exports (exports at constant prices) (see Statistics Iceland), and its long-run prosperity through most of the twentieth century. Despite growth in other export industries and short-run fluctuations in the prosperity of fisheries and total catches, fisheries dominated in terms of share of export income throughout the twentieth century. In the early stages of this development, the demand for labour increased, so agriculture was forced either to increase wages or to employ new technology to curtail labour-intensive production. Both happened because urbanisation and higher wages in fisheries increased the domestic demand for agricultural products (Magnússon, 1993; Snævarr, 1993, p. 23) and, thus, prices. However, the technology improvements in agriculture were much slower than those in fisheries: they developed first by replacing small tools (Snævarr, 1993, p. 23) and much later by installing new machines (Jónsson, 2002, p. 14).

The total population of Iceland reached seventy-eight thousand at the beginning of the twentieth century, and in the century since, the population has increased fourfold. The population increase was most rapid in urban areas, especially in the capital area, which counted ten thousand inhabitants in 1900 but more than two hundred thousand in 2010 (Figure 2-2). During the same period, the population outside the capital area did not even double, growing from 69,000 to 116,000.

The majority of the population of Iceland still lived outside the capital area at the beginning of the twentieth century (Figure 2-3), but the population development was gradually moving in its favour so that, by the beginning of World War II, 36 percent of the population lived in the capital area. The capital area's population has increased rapidly ever since, while the population in the countryside has decreased since the 1870s, migrating first to North America and then to small fishery communities at the coast because of overpopulation and limited agricultural productivity (Gunnlaugsson, 1993, p. 85; Jónsson, 2002, p. 10). However, the overall population in small urban areas outside the capital area increased throughout the twentieth century, and it continues to increase (Figure 2-3). Almost all towns and villages are situated by the coast, and the majority (59%) are or were based on fisheries at the beginning of the urbanisation of Iceland: only ten towns and villages can be counted as pure agriculture service centres[9]. Therefore, we can conclude that the migration flow that began around 1870 in Iceland was from the inland to the coastal areas[10].

[9] Borgarnes, Búðardalur, Blönduós, Svalbarðseyri, Fellabær, Egilsstaðir, Vík, Kirkjubæjarklaustur, Hella, Hvolsvöllur, Flúðir, and Selfoss.

[10] Definition: the coastal areas are urban communities and countryside along the coast where a high share of incomes comes from fisheries.

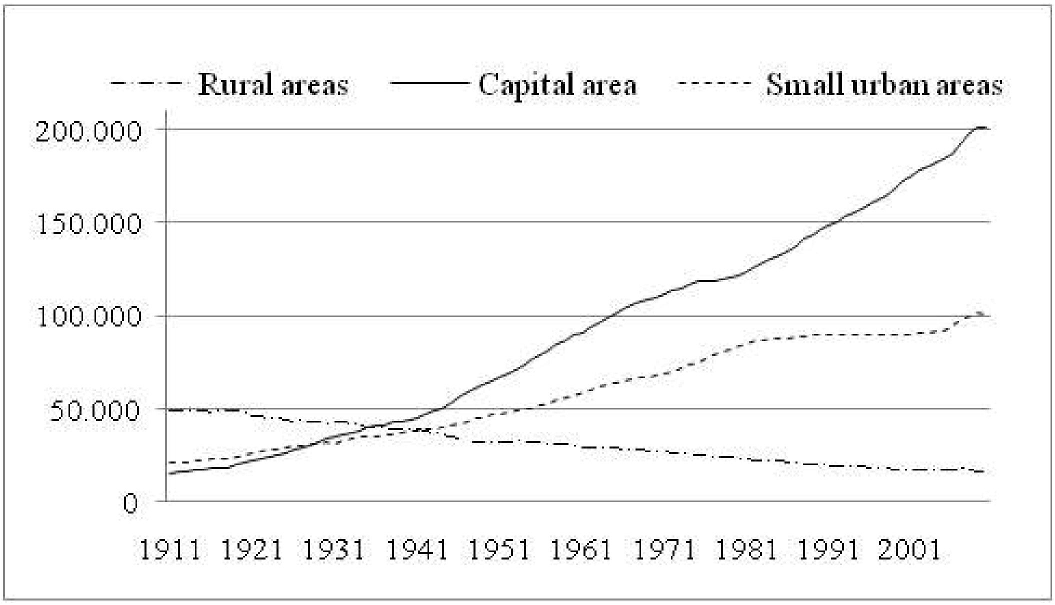

Figure 2-3. Population of Iceland 1911-2010.

Numbers for 1991–1997 are simulated. Source: Statistics Iceland.

According to Gunnlaugsson (1993, p. 108), two things are peculiar about the urbanisation in Iceland: many people resided in the capital area, and while the number of other urban communities is high, they are small in terms of population. There are several reasons for the rapid population growth in the capital area. During the 18th century, Reykjavík was transformed from a cluster of farms to Iceland's leading urban community, first with the establishment of country's first textile workshop and then as the location of many of Iceland's public institutions, including the representative of the Danish king, the bishop of the state church, the surgeon general, jail and the highest court in the country (Óskarsson, 2002a, pp. 123, 236, 259). As one of the six communities designated as trade ports in 1786, Reykjavík also became an increasingly more important centre of trade and commerce. In 1844 the process of centralization took another significant step forward when the parliament, Alþingi, was re-established and seated in Reykjavík (Óskarsson, 2002b, pp. 176-177). Reykjavík was after that usually the default choice for the location of additional public institutions. The government's share of total employment increased from that time from under 1 percent in 1870 to 5.5 percent in 1940 (Jónsson, 1999, p. 38) and, according to Statistics Iceland, 20 percent in 1997. In 1846 Reykjavík became the centre of education when a school for priests in

Bessastaðir was closed and rebuilt in Reykjavík as the first formal secondary school in Iceland (Óskarsson, 2002b, pp. 171-172). The first university was opened in 1911 (Jónsson, 1961, p. 15). Jónsson's (1984, pp. 267-268) description of the regional development in Iceland in the period 1905-1939 suggests that industrialisation and public planning were responsible:

> Led by the fisheries, the growth was not identical between regions. Even though fishery towns grew in population all over Iceland (Figure 2-4 and 4.3), growth was fastest in the southwest corner of the country, especially the capital area (Figure 2-3), where Reykjavík played a leading role as the capital city, capital of trade and services, and the largest fishery town in Iceland, where trawlers were greatest in number. Good conditions for a harbour in Reykjavík, proximity to good fishing grounds, and the decision to direct all foreign trade through Reykjavík were the primary reasons for its prosperity. The conditions for the harbour were not as good elsewhere in the area. Gradually, Reykjavík became the centre for most new industries, enterprises, and institutions, such as banks and telecommunications. This was the pattern of regional development in Iceland until World War II, led by the rapid growth of fisheries, and thus, the export industry.

Jónsson's view is partly in line with Gunnlaugsson (1993, p. 85), who suggests that larger fishing boats benefitted only the larger towns in Iceland, at least when the boats were new technology. Jónsson (1984, pp. 279-281) continued his analysis for the post-war period (the period 1945-1980) based on the staple theory (discussed later, chapter 3.4.4.) and pointed out that the growth in the primary industry (fisheries) was somewhat slower, while manufacturing (meat, milk, wool, wood and especially fish processing) grew faster.

> Unlike its development in the first phase of the century, the service industry's share of GDP increased rapidly after the Second World War, and fisheries became less important, although fisheries were still leading in share of exports. Since the demand for services and some manufactured goods are more income-elastic than that for the products of the primary industries, especially agriculture, the service and manufactured goods sectors grew faster than the primary industry did. However, new technology developed faster

> in the primary industries of fishing and farming than in service and manufacturing, so employment in manufacturing and service grew relatively faster than in primary industries. It fuelled the population growth of smaller urban communities outside the capital area (Figure 2-4), decreased the population in rural areas, and thus modified the massive spatial disparity in population development (Figure 2-3).

This view is recalled in Jónsson (1999, pp. 162-166), where he shows that the growth moves from agriculture to fisheries and from fisheries to manufacturing and services even prior to the Second World War. Jónsson (1984, pp. 281-285) offers an additional explanation for the same period, based on the centre-periphery theory, which shows how the capital area supported the growth in other regions and partly the role of the government:

> According to the centre-periphery theory [explained in the next chapter], however, the interregional migration in Iceland for the period 1945-1980 can also be explained by the outstanding growth of Reykjavík and Hafnarfjörður[11], both of which are in the capital area (Figure 2-2), as absolute leaders in Icelandic trawl fisheries and the fastest-growing business centre of the community. The capital area attracted inhabitants from other regions because of the "back wash effect," the attracting forces of higher wages and greater local services on the inhabitants of the periphery. Sooner or later, the periphery will gain from the "spread effect," the increased demand in the periphery that is due to the growth in the business centre (the capital area). The back wash effect dominated the spread effect in Iceland until the 1970s, when the spread effect became larger because of government interventions, such as the establishment of a special bank for rural investments, the extension of the exclusive economic zone (EEZ), and infrastructure investments like harbours, airports, telecommunications, road networks, and power masts.

[11] Reykjavík and Hafnarfjörður were among the largest fishery communities in Iceland, but they moved gradually toward service- and knowledge-based industries during the twentieth century. Therefore, the recent growth in the capital area is not as directly connected to the prosperity of fisheries as the growth of Kópavogur suggests: Kópavogur, which is between Reykjavík and Hafnarfjörður, has negligible connection to the fisheries and the fish processing industry.

The back wash effect still dominates in the regions of Westfjords and Northwest, while all other regions demonstrated population growth in small urban communities during the period of 1945-1980, despite a significant setback in the1980s (Figure 2-4).

An explanation for the high number of small urban communities was not found in the literature. However, the geographical dispersion of valuable natural resources, such as fish, farmland, water, energy, and beautiful landscapes for tourists to enjoy, along with the low population in Iceland, are probably among the most significant explanations.

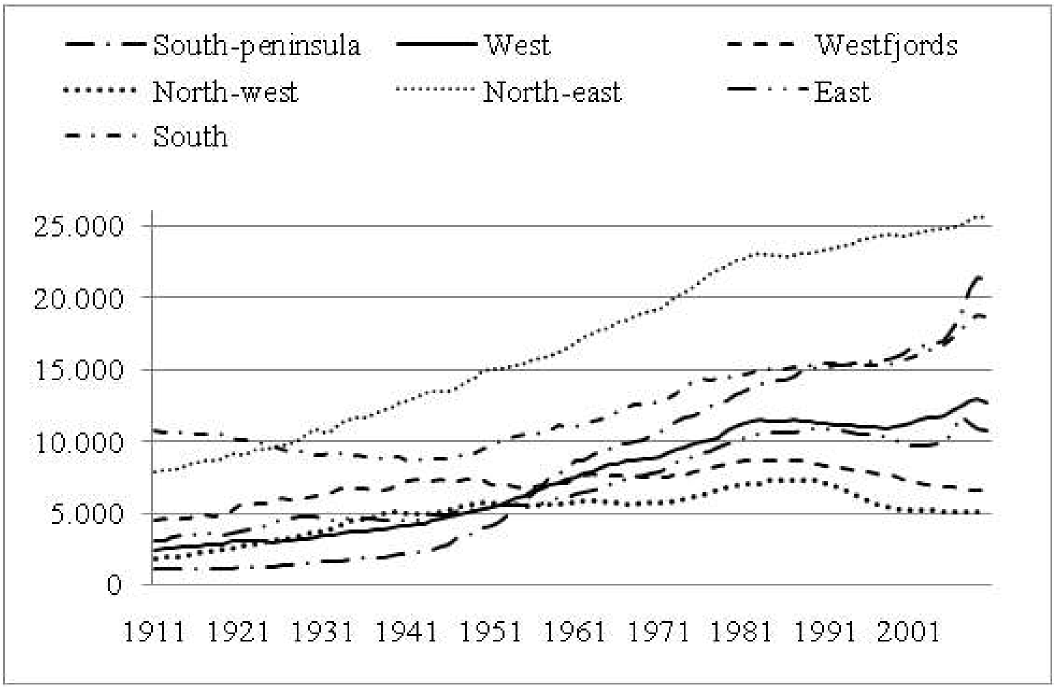

Figure 2-4. Population of small urban areas in Iceland 1911-2010.

Divided into regions according to former constituencies. Numbers for 1991–1997 are simulated. Source: Statistics Iceland.

From 1911 to 2010, the population in small urban communities increased in four of the seven regions outside the capital area (Figure 2-4). Three of these four regions are adjacent to the capital area, and the fourth region, which is far away from the capital area, includes Akureyri, the largest town outside the capital area, on the north coast. In two regions (Westfjords and Northwest), the population has decreased continuously since the early 1980s. In two other regions (West and East), the population decreased from its level in the early 1980s but increased again in the beginning of the twenty-first century. Population development was negative in only one of the regions, the

South, in the first half of the twentieth century (Figure 2-3), although no reasonable explanation has yet been identified for the decrease.

The turning point in the population development for many small urban communities outside the capital area in the 1980s and 1990s (Figure 2-4) could be related to the changes in the business environment in fisheries and agriculture when the government changed the public policy in both industries, which led to their restructuring. It is likely that the public policy accelerated the industrial restructuring that was part of the industry's natural long-term development. An overproduction of agricultural products and an over-exploitation of fish stocks (Magnússon, 1993, pp. 146, 162) motivated the change in the public policy.

A recent difference in the development of the Westfjords and the Northwest, as opposed to that of the West and East, can be related to several large-scale investments. In 1998, a new aluminium smelter and a large subsea tunnel (Hvalfjörður tunnel) were constructed in the West that improved the access of the West (especially the southern part of the West) to the capital area. The tunnel stimulated growth in the construction industries and tourism and improved the inhabitants of the southern part of the West's access to the labour market in the capital area. The labour market in the capital area had a higher wage level and wider variety of jobs, and at the same time, two colleges (universities) in the West began to grow. A large aluminium smelter was constructed in 2004-2007 in the East, and in the same period, a hydro-electric power plant was constructed in the region to provide electricity for the smelter. No comparable investments were made in Westfjords or the Northwest (Jóhannesson, 2010a; Jóhannesson & Árnason, 2008; Karlsson, 2004).

Before the subsea tunnel (i. Hvalfjarðargöng) was constructed, the South and the South-peninsula (i. Suðurnes) were the regions that were closest to the capital area in terms of travel time. The subsea tunnel changed this, as the presence of the subsea tunnel made the West as proximate to the capital area as the South and the South-peninsula had been before. The presence of Akureyri renders the Northeast much better off than other regions farther from the capital area because it offers a variety of job opportunities, services, and leisure activities. The facts that have been presented in this chapter support the idea that a strong labour market and good access to the markets for goods and services are the forces that lead to a favourable local population and, thus, interregional migration in Iceland.

2.2 The transportation system

A difficult terrain (Valsson, 2002, p. 65) and dynamic weather has made travel in Iceland hazardous, whether on land or sea. For centuries, people in Iceland travelled almost entirely by foot or on horseback on trails or paths since there were no proper roads[12] and rivers and brooks were not bridged. Therefore, it was often easier to travel by sea, so the ocean around Iceland has sometimes been called Iceland's highway. The Icelandic fleet was primarily composed of relatively small open boats that were used mainly for offshore fishing. There were three proper man-made harbours[13] in Iceland in the beginning of the twentieth century located in Flatey in Breiðafjörður, Hafnarjförður and Ísafjörður – so in many hamlets by the coast, large foreign vessels had to dock off land and use small boats to ferry cargo to and from the ships.

Table 2-1. Iceland transportation network 1900–2006.
Source: Statistics Iceland, Icelandic Road Administration, Icelandic Maritime Administration, Aeronautical Information Publication Iceland.

Year	1900	1925	1950	1990	2006
Total length of roads, in kilometres *a)*	-	612	6,742*b)*	11,381	11,178 *c)*
Paved roads, in kilometres	0	0	5	2,136	4,397
Tunnels, in kilometres	0	0	0	5	27
Tunnels, in number	0	0	1	4	8
Bridges, in number	29*d)*	-	446	1,468	1,250
Harbours, in number	3	4*e)*	68*f)*	71	73
Airports, in number	0	0	14	147*g)*	101*h)*
Harbour lighthouses, in number *i)*	6	17	65	228	-
Navigation aids, in number *j)*	3	17	85	151	-

a) Non-urban roads for vehicles: defined as national roads and county roads from 1937 to 1993 and as major, collector and county roads after 1994. *b*) In 1947. *c*) Estimated value based on the classification from 1937. The number is 10,461, according to the 1994 classification. *d*) Only bridges passing large rivers between villages (Þórðarson, 2007). *e*) Estimated number based on (Sveinsson, 2009). *f*) The year 1958. *g*) The date of this number is an estimate. Forty-one airports have been closed down over the last few decades. *h)* The year 2011, both registered and unregistered airports. *i*) Harbour lighthouses, pier headlights, leading lights, and harbour light buoys *j*) Lighthouses, sound signals, radio beacons, light and whistle buoys.

At the beginning of the twentieth century the road network was primitive where most roads and bridges were used only by pedestrians and horse riders, although a few were for horses and carriages (Karlsson, 2004; Valsson, 2002, p. 88). Back then, roads were only gravel trails. Twenty-nine bridges had been constructed to cross arduous

[12] Roads are mainly non-urban roads in present discussion due to the purpose of the study.

[13] A harbour is a protected inlet for anchoring ships; any place for refuge. In Iceland it was most commonly a couple of man-made piers protected by berm breakwater.

rivers, but few were adequate for a heavy load (Karlsson, 2004; Þórðarson, 2007). For seafarers, piers had been constructed in many ports, and six lighthouses had been built. In addition, three navigational aids had been erected (Table 2-1).

Despite the disbelief such as on the part of Danish experts in the idea that Iceland could be covered with an efficient transportation network (Þórðarson, 2007), Iceland expanded its transportation network quickly during the twentieth century. As for other developed countries, the development of the transportation system in Iceland included cars, airplanes, and motorized ships replacing horses and boats. New transportation technology demanded new or improved transportation systems—first, harbours and new roads and then airports and better roads. In the first half of the twentieth century an emphasis was therefore laid on building new harbours and gravel roads, but in the latter half of the century the emphasis was on constructing new airports and on laying asphalt on the gravel roads (Table 2-1). The first harbour was built in Reykjavík in 1917 (Sveinsson, 2009). In 1925, only four harbours and seventeen man-made piers were in Iceland (Sveinsson, 2009).

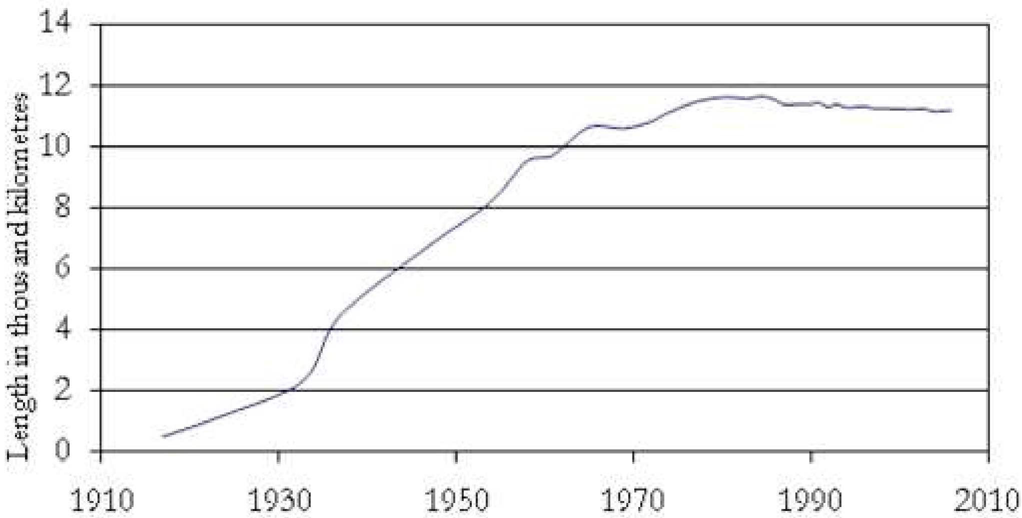

Figure 2-5. Total length of roads in kilometres in Iceland 1913–2006.

National and county roads in rural areas. The values from 1995-2006 are estimated with respect to 1937 road classifications. Source: Statistics Iceland.

Scheduled domestic flights were first offered in Iceland in 1937. As no airports had then been constructed, seaplanes made up most of the fleet, but they were taken out of service as aviation developed further after the Second World War (Valsson, 2002).

The road network expanded rapidly during the 20th century, especially between World War II and the late 1960s. Almost every region of the country was connected by roads (for cars) by 1935, but several villages were still quite isolated (Valsson, 2002). Back then the government laid a great emphasis on establishing a road connection between the towns and the villages on the one hand and the rural areas on the other. New roads were therefore constructed throughout the land. The total length of the highway system increased from approximately five thousand to about ten thousand kilometres in the first two decades after World War II (Figure 2-5).

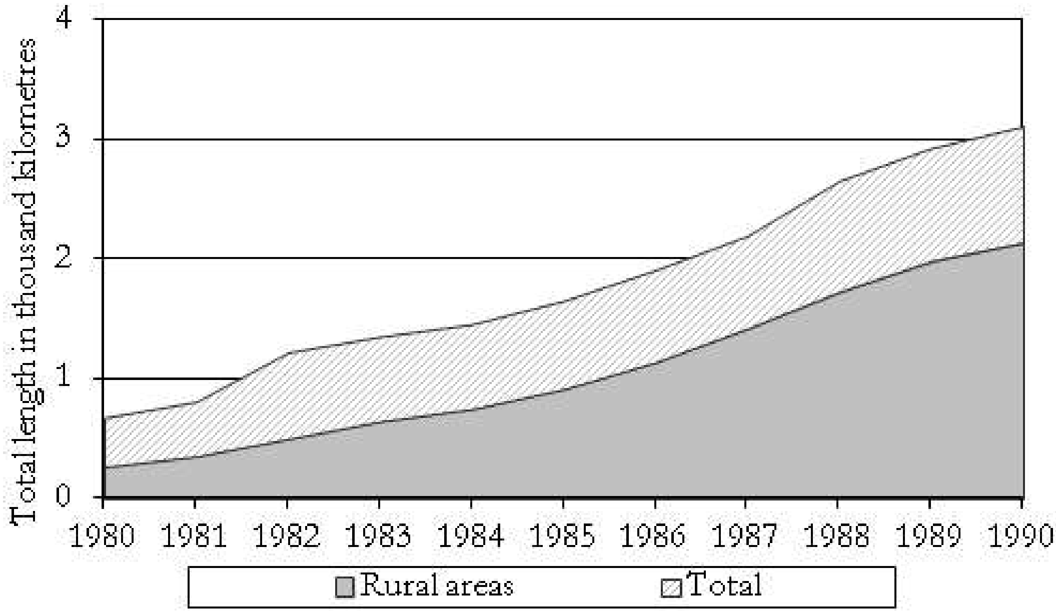

Figure 2-6. Total length of paved roads in urban and rural Iceland 1980-1990.
The top line represents the total length of paved roads in the entire country, the lower those in rural areas. Source: Statistics Iceland.

The emphasis of the authorities concerning the highway system took gradual changes. In the beginning the emphasis was on constructing new roads, but later the emphasis was on improving the older ones. The change was from road quantity to road quality. The improvements were primarily in the form of paving gravel roads, replacing poorly constructed roads, and building new tunnels and bridges. The objective of the improvement programme was to reduce travel time and increase travel safety and comfort. Road improvements began in urban areas, and the first road in rural Iceland was not paved until 1965 (Valsson, 2002). By the beginning of the 1980s, there were approximately 300 hundred kilometres of paved roads, but the total length of these roads had increased to 2,100 kilometres in 1990 (17 % of the entire road network), and further to 4,400 kilometres in 2006 (34%) (Table 2-1). Although the early emphasis was on paving roads in urban areas, the majority of paved roads were located in rural Iceland by the end of the 1980s, (Figure 2-6). In 1990, the road system included four road traffic tunnels in 1990, but by 2006 the number of tunnels had doubled.

Because of the new, better, and more direct roads, distance and travel time between urbanities has been reduced considerably almost all over the country. The reduction was relatively small in the southern part of Iceland, primarily because of the absence of deep fjords and high mountains. In other regions, distance to the capital area was on average reduced by 2-4 kilometres annually during 1981-2004 (Table 2-2).

Table 2-2. Distance between the capital area and Icelandic shires 1981-2004.

Distance in kilometres. Source: Fjölvís and Icelandic Road Administration.

Shire	1981	2004	Total change	Annual change
Capital area	0	0	0	0
Gullbringu-sýsla	49.7	49.2	0.5	0
Borgarfjarðar-sýsla	109.7	50.4	59.3	-2.8
Mýra-sýsla	117	74	43	-2
Snæfellsnes-sýsla	236	186.1	49.9	-2.3
Dala-sýsla	198	154	44	-2.1
Barðastrandar-sýsla	457.7	384.5	73.2	-3.5
Ísafjarðar-sýsla	543.4	457.6	85.8	-4.2
Stranda-sýsla	333.9	281.3	52.6	-2.4
Húnavatns-sýsla	284.2	235	49.2	-2.2
Skagafjarðar-sýsla	371	319.6	51.4	-2.3
Eyjafjarðar-sýsla	447.1	393.8	53.3	-2.3
Þingeyjar-sýsla	559.8	496.3	63.5	-2.8
N- Múla-sýsla	723.1	657.7	65.4	-3.1
S- Múla-sýsla	727.5	604.6	122.9	-3.2
A- Skaftafells-sýsla	475.5	458.5	17	-1
V- Skaftafells-sýsla	216.7	208.7	8	-0.3
Rangárvallar-sýsla	103	100.7	2.3	-0.1
Árnes-sýsla	58.8	57.1	1.7	-0.1

Sýsla is an Icelandic word for “county” or “shire”.

The road network in Iceland is quite unique. The difficult terrain of the highlands in the middle of the island, together with a harsh climate, makes it difficult to build roads that satisfy modern demands across the country. Instead, the primary road is a circle along the coast of the island that extends out onto three peninsulas on the west coast. Therefore, it is not practical to drive directly across the country[14]. However, even the ring-road is jagged as it traces many long fjords and valleys.

The number of airports and bridges has been declining, as can be seen by comparing their numbers in 1990 and 2006 (Table 2-1): the number of bridges has declined because of the new technology of installing large tubes instead of small bridges over rivers, and the number of airports has declined because of road improvements that reduce the demand for flight transportation from localities in less than four hours driving distance from the capital (Valsson, 2000).

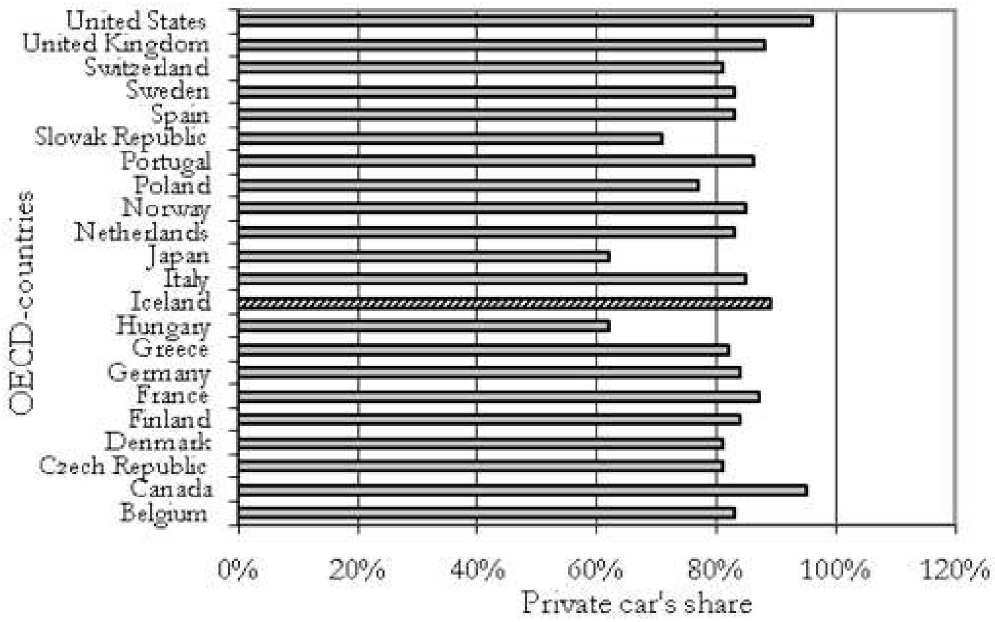

Figure 2-7. The share of the average private car in use for passenger transportation in 2003.

International comparison amongst OECD countries. Based on figures of billion passenger-kilometres. Source: Trends in the Transportation Sector, ECMT, Paris 2005.

The Icelandic Road Administration has in recent decades replaced one lane bridges by double lane bridges. Previously, all bridges had only one lane with the result that only one car could cross the river at a time, and when the traffic volume increased, these bridges became dangerous and created traffic bottlenecks. Therefore, the social return of this project became positive.

[14] There are primitive highland roads across the country that were significant for transportation (mainly for pedestrians and hourses) before the construction of bridges.

This gradual shift from the construction of navigation and aviation networks to road networks occurred because of changes in transportation demand as the major transportation mode in Iceland moved from ships and airplanes to private cars. Sufficient facilities for the navigation and aviation networks were already installed when this shift towards the use of private cars happened. This means that total traffic has moved from public to private transportation. According to recent statistics from 2003 the Organisation for Economic Co-operation and Development's (OECD), 89 percent of passenger transportation in Iceland is done by private cars. Among OECD countries, this share is higher only in the United States and Canada (Figure 2-7).

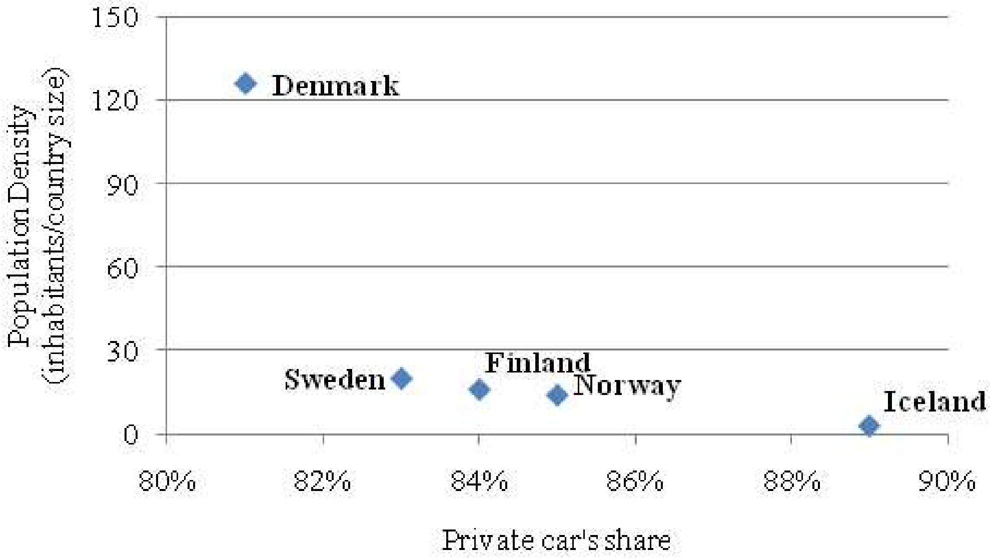

Figure 2-8. Population density and proportion of private cars in use for passenger transportation in the Nordic countries in 2005.

Source: OECD.

This heavy dependence on private vehicles is probably related to the population density. Public transportation becomes more efficient in densely populated communities, a notion supported by the correlation coefficient between population density and private car's share in use for passenger transportation in the Nordic countries which is -0.73 and -0.99 if Denmark is dropped out (Figure 2-8). Of course, other factors also have an impact, such as income, transportation cost, and government policies, but the Nordic countries are similar in this regard.

All other Nordic countries (Norway, Sweden, Finland and Denmark) have a higher population density than Iceland.

2.3 Empirical research on interregional migration in Iceland

Many research papers and reports have been written on interregional migration in Iceland. Some are consultant reports for public institutions and others are academic research papers. In this chapter the result of this research will be described. Many of the reports deal with the causes for the flow of migrants between regions while others are more policy oriented. The Icelandic authorities have traditionally been very averse to this trend of migrancy from the rural area to the capital area. In spite of this, migration studies have only recently been initiated in Iceland and they mostly cover only the period 2000 – up to the present. We have already seen how both Jónsson (1984) and Valsson (2002) connected regional population development to the prosperity of industries, both early 1900s and 1950s. Arnbjörnsson (1989) investigated the spatial development of industrial locations in Iceland, its causes, and its impacts on interregional migration. Arnbjörnsson founds that industries moved from the centres (i.e. from towns and Reykjavík) to the peripheries (i.e. to small villages), especially during the period 1972-1980. Notably, the fisheries did not seem to be responsible for this development. Arnbjörnsson traced this development to the manufacturing of textiles, clothing, and furniture and other wood products. The growth of these industries was based on the relatively low wages and cheap industrial housing lots in the peripheral areas. However, as he said, industrial employment did not fully compensate for decreased employment in agriculture and services in the peripheries, so the increase of total employment and population in the peripheral areas was less than the national average. Therefore, Arnbjörnsson's primary finding was that the increased geographical dispersion of manufacturing in Iceland had a limited impact on rural-to-urban migration.

A policy-oriented article (Kristinsson, 1963) discussed developing areas in Iceland in order to preserve the geographically dispersed population as it was in 1963. Kristinsson argued that the urbanisation had brought Iceland into modern times that it was one of the main conditions for increased welfare, and that sustainable dispersed population should go hand in hand with urbanisation. Based on the population forecast for the entire country, an estimated 360-380 thousand inhabitants by the year 2000, Kristinsson defined three layers of urban communities: two cities, four micro areas with one centre, and several growth villages and suggested that the cities should be Reykjavík on the south-west coast, Akureyri on the north coast, and the micro-areas: Egilsstaðir on the east coast, Ísafjörður in the Westfjords, Vestmannaeyjar at the South coast, and Stykkishólmur for Snæfellsnes peninsula on the West coast. Ten years later, in 1973, Kristinsson repeated his suggestions based on new population forecasts for Iceland of between 310-330 thousand inhabitants and concluded that three cities should be developed: one in Reykjavík, another in Akureyri, and the third in Egilssaðir on the east coast. According to Kristinsson, this would be possible by building a ring-road around the island, building a power-intensive industry, stimulating growth of enterprises within small manufacturing and craft, and by increasing jobs of public administration outside the capital area. Much later, Kistinsson (1988) was even more pessimistic regarding the future population development, and he came down to the model of one city, Reykjavík, and massive improvements of the road network around the island to improve rural communities' access to Reykjavík. He also discussed the significance of the regional internal road network, providing a suggestion for a highland road network as one of his most novel suggestions. Kristinsson (1995) then suggested that the urban development in the capital area would be diverted to the north and away from the location of the Atlantic ridge and volcanic activity. He said that the farmland between Akranes and Borgarnes would be suitable for a city, which he called Akraborg, of eighty thousand inhabitants—close to a good harbour, able to provide enough hot and cold water, and with stratum suitable for buildings. He also saw possibilities for urban development on the east coast, in Reyðarfjörður. Kristinsson also discussed the possibility of increasing the variety of industries in rural Iceland and suggested opportunities in international collaboration, especially with the neighbouring countries of Norway, Greenland, and the Faroe Islands.

Ólafsson's (1997) study, based on a national survey, asked respondents how satisfied they were with 24 factors concerning quality of residence. This data was compared to the local population development to detect possible reasons for interregional migration in Iceland. According to the results, migration is a decision related to the overall estimation of the quality of life provided locally: employment level, variety of employment, culture, leisure opportunities, access to services and shopping, housing, and efficient transportation. Furthermore, many mid-sized communities are doing better than the capital area in these matters, while the smallest urban communities seem to do worse in providing of these important household needs. Ólafsson mentioned the reconstruction in the primary industry as another significant explanation for rural-to-urban migration. Moreover, other familiar patterns were among the results, such as that younger people, educated people, and unmarried people are more likely to migrate than older people, uneducated people, and married people, respectively.

Magnússon (1998) observed that the restructuring of the fisheries and agriculture is partly responsible for rural-to-urban migration in Iceland. Furthermore, better access to a wide variety of leisure opportunities in the capital area also fuels rural-urban migration. He also pointed out that since many of the cultural and educational institutions of higher order are publically owned, the central government also affects rural migration since economies of scale are mainly responsible for the central location of these institutions. According to Magnússon's simulation, taxes and subsidies, which are likely to affect interregional migration, should be considered among the instruments available to correct for geographical bias in the distribution of public resources.

Haraldsson (2001) analysed how changes in fisheries management have affected interregional migration in Iceland, especially after the fishing quotas were made transferable in 1989. According to his view, quota transactions have increased the debt level of many firms, forcing them to lower relative wage and thus damaging the comparative advantage of the rural areas. Haraldsson's conclusion was only based on this argument. Runólfsson (2000) and Agnarsson (2001; 2007) do not share Haraldsson view. Runólfsson claims that there does not exist a clear-cut general relationship between the introduction of the individually transferable quota system, that the current management system is based upon, and interregional migration in Iceland, while Agnarsson argued that the present policy was necessary to maintain the competitiveness and efficiency of the harvesting and fish-processing industries as whole. Similar arguments can be found in Hagfræðistofnun and Byggðarannsóknastofnun (2003) and Hall et al. (2002).

Valsson (2002), who investigated several decades of public planning, migration, and transportation, argued that the residency and construction of communities, is not static but is infinitely dynamic, a process of changes affected by the development of the community, such as the industrial structure, transportation network, and new technology. He said that for Iceland, the community is moving from primary industries toward service- and knowledge-based industries. Valsson pointed out that the mindset of the inhabitants is the strongest force in moulding the community and that Iceland is in the phase of changing from a collection of rural communities to an urban settlement community, however, scattered residences will exist in some parts of the country, but the youth seem to desire an urban lifestyle.

Hall, Jónsson, and Agnarsson's (2002) extensive analysis of the regional development of Iceland was based on descriptive analysis and statistical analysis. They pointed out that the population of Reykjavík has not grown relative to the rest of the country since the 1950s, while population has grown in the adjacent municipalities because of transportation improvements and relatively low travel costs. These are improvements of access to Reykjavík and its industrial prosperity, extensive service level, and labour market. They also argued that major change in transportation can have significant regional impact as when the primary transportation mode shifted from ships to vehicles, the domestic highway moved from the ocean to the roads, and previously "central" destinations, especially many fishery communities, became part of the outer peripheries (Hall et al., 2002, pp. 183-184). They suggested that because of the significance of access to larger CBDs, the government should have improvements in transportation as a priority, i.e. transportation improvements involving improved access to larger CBDs, within the capital area, between other regions and the capital area, and for other much smaller CBDs outside the capital area. Also, that public planning for the development of rural communities should be in line with the local comparative advantages based on endogenous growth where local immobile factors are the central keys (Hall et al., 2002, p. 17).

The geographical dispersion of residence in Iceland, which is characterized by the tendency of Icelanders to live close to the coast rather than inland, somewhat reflect the geographical dispersion of the natural resources of Iceland, which are chiefly fish, land for farming, and energy sources. These natural resources have been the sources of the comparative advantage of the rural area. The rural area tends to have comparative advantage in the primary industries rather than the manufacturing or the service sector.

Hall, Jónsson, and Agnarsson (2002, p. 18) described unfortunate geographical educational layers, where low-skilled individuals tend to live in the rural areas, high-skilled workers tend to live in the capital area, and the urban communities outside the capital area have a mixture of both. This is an unfavourable development. They suggested that the main emphasis of the regional development policy should be on education. The emphasis should be on strengthening or developing educational institutions in the rural areas and on motivating the rural people to attend the educational institutions.

According to Zoega and Skúladóttir (2002), neither wages, employment nor transferable fish quotas, affect interregional migration in Iceland. They implemented a regression analysis on panel data that included annual averages for the entire country of Iceland in the period 1993-2000, divided into eight regions. The result indicates that urban quality of life and agglomeration economies, which are of course most prevalent in the regions of Reykjavík and Akureyri, have a significant impact on migration. Moreover, the population of local central business districts fuels interregional migration as well, as people are attracted to populous locations. High housing prices de-motivate in-migration since housing carries the largest share of the migration cost. Amenity values were also estimated and found to be highest in the Westfjords and on the east coast of Iceland. These findings are in line with the theory of New Economic Geography, in which agglomeration economies and spillover effects play a central role (Baldwin et al., 2003).

A group of economists and sociologists (Hagfræðistofnun & Byggðarannsóknastofnun, 2003) used quantitative and qualitative methods to analyse spatial differentials of local prosperity in Iceland. They found evidence that both agglomeration economies and access to a wide variety of shopping and services, especially education and health care fuel rural-to-urban migration in Iceland. Furthermore, varied and specialized services in urban areas create jobs for educated employees; while homogeneous low-skill jobs in the rural areas are not attractive to most skilled people. Noteworthy, the industrial leaders in the rural areas confessed to them that their business networks are much slower because of the distance between partners, despite the implementation of new technologies, such as internet connections and efficient telecommunication. However, according to the result, transportation improvements improve the level of commercial services, despite local businesses have been closed down following such improvements, the local populace claim to be better off because of the improved proximity of the nearest CBD. The analysis, suggests that regions outside the capital area are able to compete with the capital area if they have access to a strong CBD, such as Akureyri on the north coast of Iceland and therefore improvement in the regional internal transportation network is likely to support the rural area of Iceland. They point out that while the variety of jobs and other amenities in the rural areas will never equal that of the metropolitan areas, it will be sufficient for the inhabitants who have different preferences from those of most metropolitan dwellers.

Hagfræðistofnun and Byggðarannsóknastofnun (2003) suggested government interventions in transport, transportation networks, and education to stimulate the growth of three CBDs in Iceland: Reykjavík on the southwest corner, Akureyri on the north coast, and Egilsstaðir on the east coast. These suggestions were more or less in line with the propositions of Hall, Jónsson, and Agnarsson (2002).

The Icelandic Regional Development Institute (2004) conducted an extensive study on the various communities in Iceland and published a policy oriented report on the results. The results were based on a survey and indicated that the causes of interregional migration were highly related to both changes in industrial structures and in household preferences.

Aradóttir and Ólafsson (2004) studied the relationship between optimism and migration in several surveys and found a significant relationship between these factors. According to them, inhabitants who view the future of the home region with optimistic eyes; those who live in the midst of a successful business environment, those who live in general in optimistic atmospheres, and those with mental vitality and a happy disposition, amongst other things, tend to be less likely to move away than those who do not. This empirical study, then, documented the role of expectations in the pattern of interregional migration of Iceland.

Karlsson (2004) investigated the impact of a large transportation improvement in western Iceland (Hvalfjörður tunnel) on the conditions for residence and interregional migration in western Iceland, that shortened the distance to the capital area by 42 kilometres and bypassed a dangerous road. Both qualitative and quantitative methods were implemented in the study, which found that the tunnel had significant impacts on quality of residence, as suggested by increased housing prices, lower price levels, and a wider variety of goods and services. The impact on interregional migration was mixed.

Ólafsson and Gíslason (2006) studied the gendered pattern of interregional migration in Iceland using a descriptive analysis. Their primary findings were that the gender imbalance reached a peak in the mid-twentieth century and that the imbalance has been slowly diminishing ever since, even though it has not disappeared. They argued that gender imbalance is not a problem in itself, but it is a reflection of other problems: for example, the gender wage difference is smaller in the capital area than elsewhere in Iceland, so a woman from the rural area could expect a 20-23 percent increase in salary if she moved to the capital area, while men could expect a 9-15 percent increase.

According to Bjarnason and Thorlindsson (2006), based on national surveys taken in 1992 and 2003, most of the rural adolescents in Iceland expect to live somewhere else in the future. The interest in working in Iceland primary industry was negatively related to the likelihood of migrating. However, the authors concluded that occupational opportunities are by far the strongest factors in the intention to migrate. Other significant factors on youth migration were parental education, well being in school, and parental participation in the primary industry.

Benediktsson and Nielsen (2008) studied the impact of local services on interregional migration, based on cross sectional data from a survey and census tract. They implemented a quantitative study of municipalities in a more than two hundred kilometres distance from Reykjavík. They focused on the municipalities that suffered the greatest loss of inhabitants. The result suggested that the level of service, but not the proximity to the capital city, affects interregional migration. The result also suggested that the size of the local population has an impact on the local service level.

Based on a survey from selected regions in Iceland, Karlsson and Eythorsson (2009) investigated which local qualities affect migrants when they choose new places to live. Factors concerning family welfare, such as quality of schools and general conditions for raising children, were more important than factors concerning amenities and household economics, although amenities were more important than household economics. However, the results could have been coloured by the generally exceptional economic situation in Iceland when the survey was fielded in 2006; the respondents' priorities would probably be affected by the present economic crisis.

Karlsson and Jóhannesdóttir (2010) studied women's migration in Iceland using the same survey as Karlsson and Eythorsson used (2009) and found a significant gender difference when it came to family welfare and household economies. Notably, women were more concerned about factors related to children, family issues, and household economies, but no gender difference was found regarding amenities. In a separate study, Gunnarsdóttir (2009) concluded that education, wages, and the variety of employment drives women from the rural to the capital area of Iceland.

Bjarnason (2010) investigated youth migration in Fjallabyggð municipality prior to the opening of a new tunnel, along with one of the adjacent and less isolated municipalities, Dalvíkurbyggð, for comparison. An unexpected result suggested that a third of the youth in each municipality intended to migrate, although men were less likely to migrate than women were.

Ólafsson and Bjarnason (2010) investigated full-time and divided residence, also in Fjallabyggð municipality prior to the opening of a new tunnel. The result showed that 88 percent of registered inhabitants had a full-time residence in Fjallabyggð, and 12 percent lived both in Fjallabyggð and in another municipality. Most of those with dual residences were people in the 18-25 and 26-45 age ranges.

The Icelandic Regional Development Institute publishes, participates in, and supports research on interregional migration and related issues, issuing annual reports since 1986 and providing research on regional growth several times in collaboration with the Institute of Economic Study (IoES). The difference in accumulated growth by region varied from -6 percent to 44 percent when the country was divided into eight regions in the period 2003-2008 (Jóhannesson, 2010b). The growth was the greatest per capita in the capital and adjacent areas and negative in Westfjords and the

Northwest region of Iceland. These results correlate roughly with internal migration during the period.

According to Karlsson (2010a) spatial disparity of employment is sensitive to GDP, mainly because of the exchange rate of the Icelandic krónur and its impact on the export industry. The currency tends to appreciate during the expansion of the economy and depreciate in recessions. Since employment in the export industry is higher in the rural areas than the capital area because of fisheries and tourism, the local impact of Iceland's overall business cycle varies. Because of the rigid economic and institutional environment of the agricultural sector, the decrease in the net returns of agriculture in economic downturns tends to be above the national average. In economic downturns the demand for the more income elastic agricultural products decreases since the most of the products are sold on the domestic market, whereas the fisheries and the tourism focus on export markets.

Sigursteinsdóttir (2002) analysed the locations of firms specializing in supporting and servicing the fisheries and found that 71 percent of the man-years working in this industry worked in the capital area, despite relatively favourable conditions elsewhere, outside the capital area.

Domestic transportation cost increased relatively more than the national price index over the 1994-2002 period following a new regulation that ended government intervention in price setting in the transportation industries (Hall et al., 2002; Sigursteinsdóttir & Jakobsson, 1999).

This survey of migration studies in Iceland illustrates that the reasons for migration trace back to the prosperity of industries, demand for labour, agglomeration economies, and access to the markets of goods and services. Prior to 1900s the population of Iceland lived mainly on the countryside and was more evenly scattered all over the island than today, when urbanisation began, and the literature suggests that it was triggered by stagnation in agriculture and investment in fisheries and the level of industrial technology. Moreover, construction of infrastructure such as roads and harbours, the location of public institutions, laws and regulations, and other public interventions seem to have had a significant role in affecting the direction of migration flow as well. After the World War II migration flow seem to be dominated by, first by the growth of manufacturing and later by the limits and fluctuations in the harvest of natural resources, agglomeration economies, changed preferences and level of service. Notably, there are differentials between the demographic factors of age and gender: as in other countries young icelanders are more likely to migrate than older and Icelandic women are more likely to move than men.

3 Theories and models

3.1 Introduction

This chapter discusses the theoretical background of the thesis, focusing on the relationship between the transportation improvements and interregional migration, as well as the housing market. The chapter shows that transportation costs affects housing prices and that housing prices not only are significant factors in residential relocation but that they also reflect amenity values.

The chapter begins with a discussion of transportation demand before moving on to an explanation of the relationship between transportation and the housing market. Next, the impact of transportation improvements on interregional migration is addressed. Finally, the relationship between the housing market and interregional migration is explained.

3.2 Transportation costs and labour market

Consider first, a simple neoclassical model of a single labour market where supply of labour is dependent on the labour utility of consuming goods and leisure time, while demand, which is determined by the industry, reflects the labour productivity.

If wages increase, the supply of labour increases and demand decreases. If, for instance wages equal w^H, households will be willing to offer N^S quantity of labour, but the industry will only demand N^D. The market would, in this case, suffer from an excess supply of labour as $N^S > N^D$ (Figure 3-1, left), resulting in unemployment. Workers who are willing to accept lower wages will on the other hand find employment. If wages equal w^L, the market will have an excess demand of labour as $N^S < N^D$. Wages would therefore have to rise in order to attract more supply. Finally, if wages equal w^* demand of labour will equal supply of labour.

Generally, regions differ in their resources and ability to produce goods and services, and some are not able to offer some of the necessity goods. As Ricardo's (1817) theory concerning comparative advantages indicates, countries and regions gain from trade, and this is also true for the labour market. Therefore, communities become dependent on trade

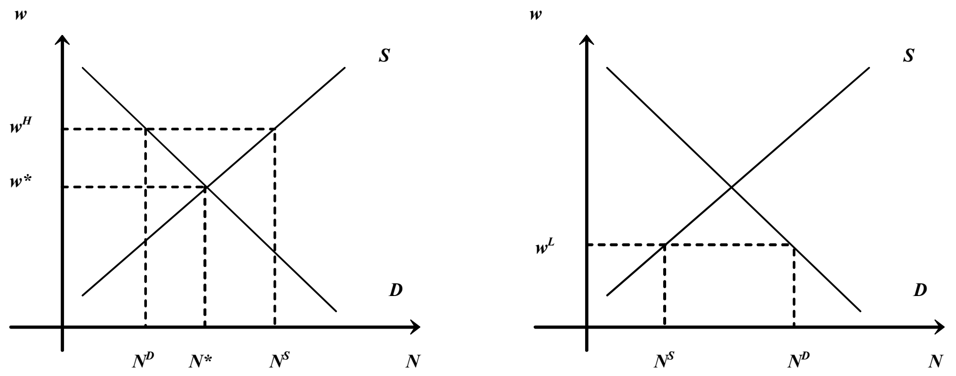

Figure 3-1. A labour market.

and transportation to move valuables between sellers and buyers, and transportation becomes a necessary service to make transaction between distant partners possible. Thus the demand for transportation is a derived demand. Transportation is in itself not the primary reason for its demand, but rather the need for goods, services, or employment.

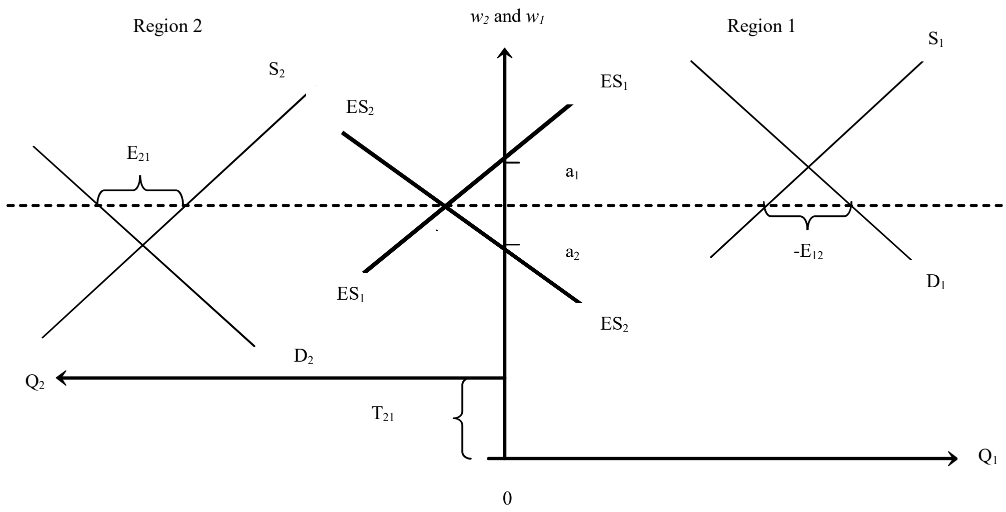

Figure 3-2. Labour market of two regions: Regions' supply, demand and excess supply.

Imagine two completely separate labour markets in Regions 1 and 2 (Figure 3-2). Initially, residents in both regions work at home. The market equilibrium for identical workers is based on the respective supply, S_1 and S_2, and the demand curves, D_1 and D_2, where the demand reflects the workers' productivity and the supply reflects the workers' utility from consumption of goods and leisure time. The markets are perfectly competitive. While separated, the local wages are different, $w_1 = a_1$ and $w_2 = a_2$ (Figure 3-2); wages in Region 1 are higher than those in Region 2, $a_1 > a_2$. If the isolation is broken because of new transport technology, workers in Region 2 will be willing to travel in order to obtain higher wages if the wage differential compensates for the transportation cost, T, i.e. provided $(w_1 - w_2) > T_{21}$. Provided this is the case, workers in Region 2 will migrate to Region 1. Thus, demand for transportation is derived from labour market opportunities and a market of goods and services, as explained in Samuelson (1952).

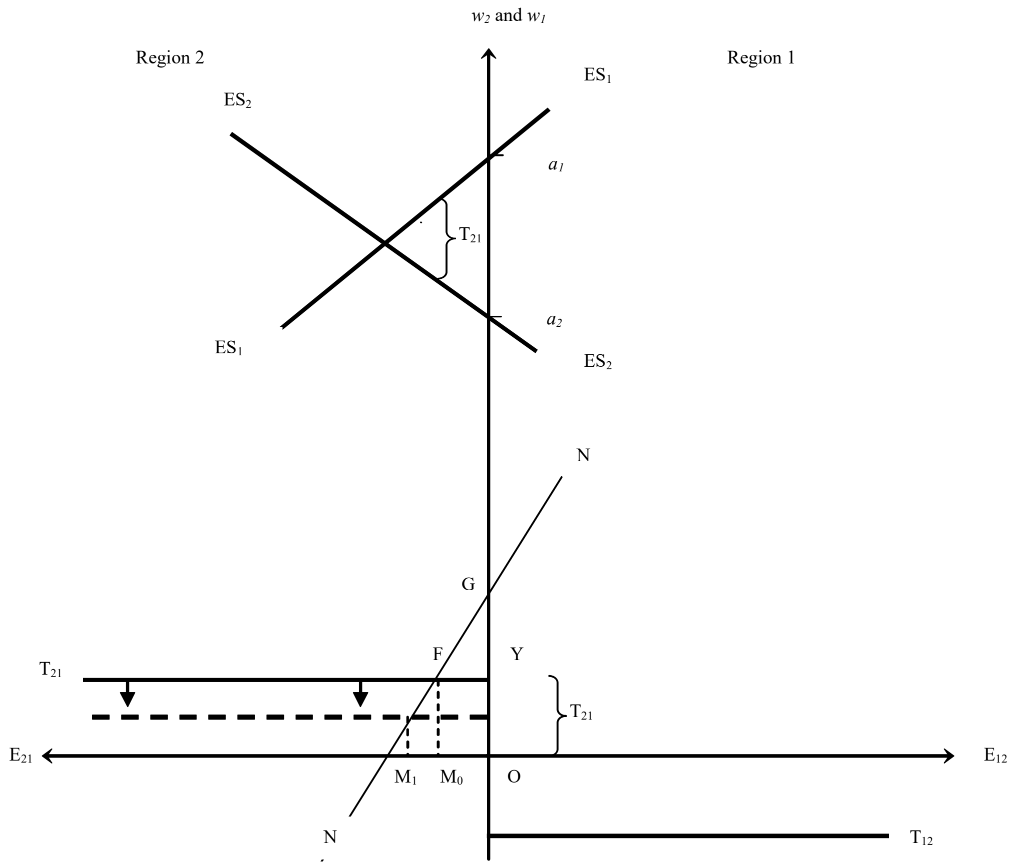

Figure 3-3. Labour market in two regions: Regions' excess supply and joint net excess supply (the N-N line).

In Figure 3-3, we of analyse the impact of transportation cost on the social benefit (here, net social pay-off) of the free flow of labour. The local supply and demand curves are not included in the graph, but transportation cost curves, T_{21} and T_{12}, are included explicitly along with a new curve, the net-excess supply curve. The net-excess supply curve is the sum of both excess supply curves. Figure suggests that both markets gain from the free flow of labour, despite the transportation cost, since the net social payoff (NSP) which is equal to the triangle GYF, becomes positive. The impact of changes in transportation cost on NSP can now be seen more clearly. If the travel cost, T_{21}, drops by 50 percent (the dashed line moves down), the number of commuters from Region 2 to Region 1 increases from M_0 to M_1, and the NSP increases since the triangle becomes larger. Increased travel cost reduces the flow of labour and, thus, the NSP. The travel cost can eliminate the labour flow between the regions if it exceeds a certain limit, here $T_{21} = G$.

It is appropriate to derive the demand curve for transportation formally in order to discuss its impact factors, especially transportation price (cost) and income. The model is a standard model for transportation demand, and the analysis is based on McCarthy (2001). Assume two desirable and perfectly divisible goods: transportation, d, and the composite good, x. The composite good is a bundle of several consumer goods, where their internal weight is fixed; if the number of composite goods increases, all goods included increase relatively identically. Since transportation is a perfectly divisible good, it is measured in kilometres. In this way, the consumer's utility is entirely based on consumption, stated formally as

$$U(d, x)$$

As there are only two goods in the utility function, they must be substitutes, and the utility follows the standard assumption, of diminishing marginal utility: $\partial U/\partial d > 0, \partial U^2/\partial d^2 < 0, \partial U/\partial x > 0, \partial U^2/\partial x^2 < 0$. The consumer's budget constraint is defined as

$$I = \tau d + px$$

Total income, I, has to be spent on transportation and the composite good, where τ is the unit price for the transportation, and p represents the price of the composite good. The Marshallian demand function for transportation and the composite good can be derived by solving the consumer's maximum utility problem, subject to the budget constraint.

In the simple case where the utility function is defined as $U(d, x) = dx$, the demand function for transportation can be written as

$$d = \frac{I}{2\tau}$$

This is the transportation demand curve for a single consumer. Thus, if there are N consumers at the transportation market, the demand curve for the entire market becomes

Eq. 3.1 $$d = \frac{\sum_{i=1}^{N} I}{2\tau}$$

The equation (Eq. 3.1) suggests that the demand for transportation increases when household income increases, $\partial d/\partial I > 0$. Hence, a drop in the level of transportation can be expected during economic depressions, *ceteris paribus*. Moreover, the demand for transportation decreases following an increase in the unit price of transportation — flights, bus tickets — or the unit cost of any other transportation mode. Therefore, for instance the demand for transportation will decrease in the future if new technology based on non-fossil fuels is developed in response to the scarcity of oil, *ceteris paribus*. Because of the simplicity of the utility curve, the price of the composite good is not included. Generally, prices of supplementary or complementary goods are included in an explicit demand function. If the price of any supplementary good to transportation, such as hotels, increases, it will have a negative impact on demand for transportation and a price increase of any complementary good would have the opposite impact (Button, 1982).

3.3 Housing market

3.3.1 The von Thünen Model

Johan Heinrich von Thünen's theory of land rent, established in 1826, is in the tradition of Ricardo (1821). Von Thünen's theory explained the relationship between the price of land and transportation cost in the nineteenth century, when the economy of most countries was still dominated by agriculture. Farmers used land for various kinds of farming and cultivation and then transported their products to markets in urban areas where they were sold.

In Von Thünen's pioneering model in 1842 (Thunen, 1966), farms were the only land intensive business in an economy, where only agricultural goods were produced. The model assumed a fixed supply of land, and farmers maximised their profits, so the land rent was determined by the agricultural productivity and the accessibility of the land to the market centres. He also assumed that the farms within each type of agriculture were all alike, except for their location, so that the distance, d, to the centralised market differed, $d > 0$. Farmers produced rye and used horses to deliver the crop to the market. A share of the harvest was, however, needed to feed the horse, which generated the transportation cost. Thus, the harvest, q, measured in bushel crops per unit of area, was dependent on the distance between the farm and the market in d kilometres. Von Thünen created a general model for land rent, Λ, in the following terms:

Eq. 3.2 $$\Lambda = \frac{pq}{\varpi} - \left(\frac{\eta + \xi(1-\delta) + p\varphi q(1-\delta)}{\varpi}\right) - \delta(p\varphi q + \xi)$$

The first factor, pq/ϖ, is the farmer's total revenue, and the other two reflect the cost. The first bracket, $\left(\left(\eta + \xi(1-\delta) + p\varphi q(1-\delta)\right)/\varpi\right)$, is the cost counted in bushels of rye and the second, $\delta(p\varphi q + \xi)$, is the cost counted in thalers, which was the currency used in 19th century Germany. This is an unusual way of presenting a model in economics, but according to von Thünen, the reason was that there are geographical differentials in prices and technological conditions in agriculture so, as von Thünen put it: "*there is not a single country where the costs may be given wholly in money or wholly in grain*" (Thunen, 1966, p. 29). Thus, von Thünen chose to present the model in that unusual way in order to preserve its generality.

The total revenue (or total product, as von Thünen called it) was equal to pq thalers, and the value, or the unit price of rye on the farm itself, was ϖ thalers. Thus, the total revenue pq/ϖ was expressed in bushels of rye, which the farmer could either sell or consume. ϖ is the unit price of bushels on the farm itself, reflecting opportunity costs. Thus, p/ϖ measures the contribution from bringing the harvest to the market instead of consuming it. Since p/ϖ is the relative market price of rye, it indicates that, when the price at the market is equal to the price at home, p/ϖ is equal to unity. When the market price is higher, then $p/\varpi > 1$; if it is lower, then $p/\varpi < 1$. Therefore, if the farm benefits from sending the products to the market, the relative price is higher than unity and the index scales the price accordingly. If the farmer produces 100 units of rye and sells it for a lower price on the market than it is worth on the farm itself, the index returns a number smaller than 100; if the market price is higher, the index returns a number larger than 100.

The cost is divided into three categories: sowing, cultivation, and harvesting and general farming cost. η is the sowing cost and ξ is the cultivation cost, both measured in thalers. The harvesting and general farming cost is equal to the φ share of the gross production, where $0 \leq \varphi \leq 1$. Accordingly, the cost of harvesting and general farming is equal to $pq\varphi$ thalers. Since the quantity refers to the unit of area, only harvesting and the general farming cost is dependent on quantity, q, while the sowing and cultivation cost is fixed with respect to the unit of the area.

Von Thünen presented the cost in units of rye and in monetary terms. The cost expressed in units of rye is cost paid in grain, and the rest is paid in thalers. The sowing cost, which is equal to η/ϖ bushels of rye, consists only of grain so it must be transformed into units of rye so the sowing cost can be presented entirely in terms of rye. The cultivation, harvesting, and general farming cost is paid partly in grain $(1-\delta)$, and partly in thalers, δ, where $0 \leq \delta \leq 1$. The cultivation cost is equal to $\xi(1-\delta)/\varpi$ bushels of rye plus $\delta\xi$ thalers. Finally, the harvest and general farming costs are equal to $p\varphi q(1-\delta)/\varpi$ bushels of rye plus $p\delta\varphi q$ thalers.

Since distance is implicitly represented by production quantity, the impact of distance is determined by taking the first derivative of the land rent in Eq. 3.2 with respect to the production quantity:

$$\text{Eq. 3.3} \qquad \frac{\partial \Lambda}{\partial q} = \frac{p}{\varpi} - \left(\frac{p\varphi(1-\delta)}{\varpi}\right) - \delta p\varphi$$

If the first term on the right hand side of Eq. 3.3 is larger than the next two, Eq. 3.3 must be positive. Here, it becomes clear that a presentation in both thalers and units of rye is incomplete. Why von Thünen solves the problem of geographical differences in prices in this way is puzzling, as today a vector of different prices, p_i, would be implemented. However, the derivation here continues using von

Thünen's original model. It is known that, in the long run, the farm will exist only if

$$\frac{pq}{\varpi} \geq \left(\frac{\eta + \xi(1-\delta) + p\varphi q(1-\delta)}{\varpi}\right) + \delta(p\varphi q + \xi)$$

This equation can be rewritten as:

$$\frac{p}{\varpi} \geq \left(\frac{\eta + \xi(1-\delta)}{\varpi q}\right) + \frac{p\varphi(1-\delta)}{\varpi} + \delta p\varphi + \frac{\xi}{q}$$

If this is true, then Eq. 3.3 must be positive, or $\partial\Lambda/\partial \mathrm{q} > 0$. Since the farmer uses part of the production as feed for horses used for transporting the harvest, the longer the distance between the farm and the market, the lower the percentage of the production is left to sell, or $\partial \mathrm{q}/\partial \mathrm{d} < 0$. Since $\partial\Lambda/\partial \mathrm{q} > 0$, then $\partial\Lambda/\partial \mathrm{d} < 0$: the land rent is lower the farther the land is from the central market.

So far this discussion has focused on only one agricultural product, but it can easily be extended to include different kind of farms. Suppose for instance that there are many farmers scattered around one city, each producing one of three different agricultural products: flower, milk and meat. Each product has different transportation costs, so the product with the highest transportation cost per mile gains the most from proximity to the market. If farmers are randomly distributed through space around the city, they may start to trade land so the product with the highest transportation cost will be produced closest to the market. The land closest to the city centre contributes with the lowest transportation cost, and brings the farmers the highest return. One simple model for the land-rent curve based on von Thünen's model is given by Lloyd and Dicken (1977) as

Eq. 3.4 $$\Lambda = (p-c)q - d\tau q$$

where Λ is the rent per unit of land, p is the price of the goods produced per acre, c is production cost per acre, q is production quantity per acre, τ is transportation cost per mile, and d is the distance of the unit of land from the market.

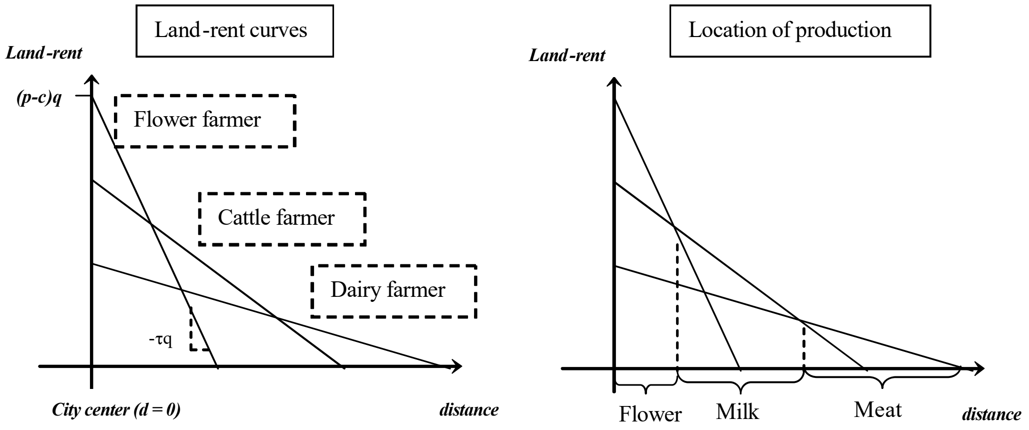

Figure 3-4. A geographical representation of land rent and location of agricultural production.

Land-rent curves of three farmers—a flower farmer, a dairy farmer, and a cattle farmer—are drawn in Figure 3-4. The city is at the origin, while farmers are located along the x-axis on this two-dimensional graph. The land-rent curves represent both profits per acre, $(p-c)q$, which is shown on the y-axis, and marginal transportation costs, $-\tau q$, the slope of each curve. Generally speaking, the ability of farmers to absorb transportation costs depends on profits per acre. Thus, farmers with high profits can tolerate high transportation costs and vice versa. In Figure 3-4, it is assumed that flower production yields the highest profits per acre, but that costs associated with transporting the harvest are also larger than costs of transporting meat and milk. Thus, the land-rent curve for flowers becomes the steepest (Figure 3-4, right), and the farmer can consequently offer the highest price for a unit of land, while the farmer with the lowest profit per acre and lowest marginal transportation cost offers the lowest price. If we assume that the cattle farmer has the lowest profit per acre and the dairy farmer is in between the other two, it follows that the production of flowers would be closest to the city, the production of meat farthest away, and milk in the middle. The spatial distribution of different kind of farmers is further determined by the intersection of the land-rent curves. The distribution of farms around the city can be illustrated better in a three-dimensional graph (Figure 3-5) (Lloyd & Dicken, 1977; McCann, 2001).

Von Thünen's classical theory has been extended by neoclassical economics by introducing a Cobb-Douglas production function and allowing factor substitution instead of a fixed amount of land per unit. The latest version of von Thünen's model is called the bid-rent model. In this model, transportation costs are not the only component that influences the optimal location, and land can be substituted with other production factors. In addition, the supply of land is no longer fixed. As the distance from the market centre, d, increases the industry in question will substitute other production factors for land, just as it will substitute land for other production factors as it gets closer to the market centre. The result of the latest version of von Thünen's theory is more general than the former version.

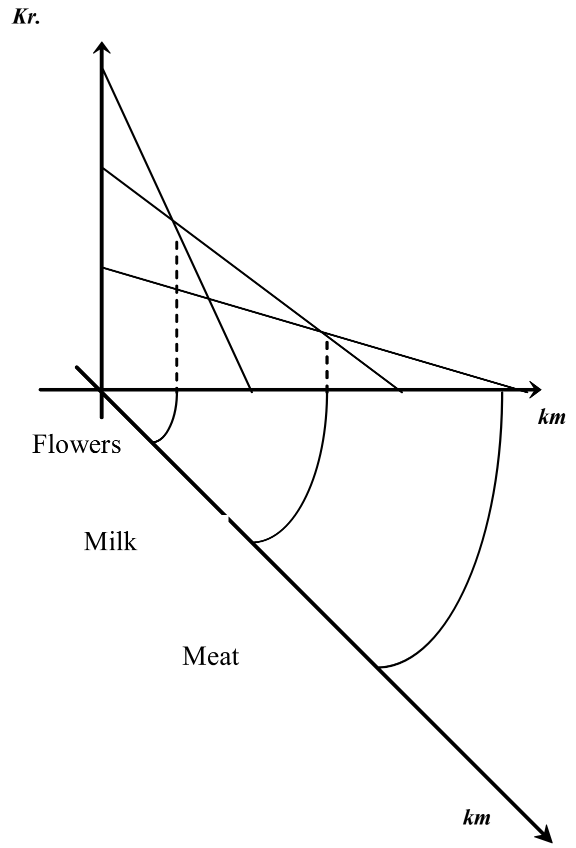

Figure 3-5. Geographical representation of land rent and farmers' location.

It is not only the industry with the lowest marginal transportation cost that is located far away from the market centre as in the earlier example for the agriculture, but also land-intensive industries[15] (Fujita

[15] McCann (2001) divides the industry between large-scale engineering and small-scale workshop activities, with respect to the intensity of land use. According to this classification, the shopping industry is divided between shopping malls that have large floor space and distribution activities against more specialized shops. The latter type of shopping industry is located in the market centre of the city, and the former is somewhere farther away.

& Thisse, 2002, pp. 76-78; McCann, 2001, pp. 100-101). Thus, non-linear demand for land depends not only on transportation costs, but also on the land-intensity of the industry in question. Assume a city of three industries. Based on von Thünen's arguments, the centre would be dominated by a specialized service industry that requires little land but has high transportation costs, the manufacturing and distribution industry that requires large lots but has low transportation costs would be positioned farthest away from the centre and the retail industry in between (McCann, 2001).

According to this model, the price of land and real estate becomes highest in the city centre and decreases with every kilometre of distance away from the centre (Fujita, 1989; Fujita & Thisse, 2002, pp. 78-91; McCann, 2001). One could argue that land areas would be "pulled closer" to the city centre following a transportation improvement, so the land values would increase.

3.3.2 The Monocentric City Model

The theory of von Thünen was extended by Alonso (1964), Mills (1972), Muth (1969), and Evans (1973) for the housing market by developing the notion of a bid-rent curve which reflects the spatial disparity of housing prices. In order to address the possible impacts of transportation improvements through distance and transportation cost on housing prices we first discuss the case of a monocentric city. Here, land is assumed to be homogeneous and constant in supply. There is a single owner of the land and it will be rented to the highest bidder. The model assumed just one city, one service centre, and some rural area. Consumer's utility depends on ordinary goods and services, plus land and non-land inputs; these goods are perfect substitutes. The consumer spends all his income on these goods. Finally, it is assumed that every inhabitant travels to the city centre for work (McCann, 2001).

The consumer maximizes his/her utility by choosing the best place of residence based on a combination of lot size, l, and composite consumer goods, x, with respect to distance, d (Fujita, 1989, p. 22).

$$\max_{d,x,l} U(x,l)$$

The consumer's budget constraint is given by

Housing market

$$I = T(d) + x + h(d)l,$$

where $T(d)$ denotes transportation cost, x the consumer composite goods, $h(d)$ denotes housing price, and l lot size. The price of the composite good is set at unity, $p_x = 1$. Housing prices and transportation costs depend on distance, d. Household income, I, must be equal to total household expenditure, nothing is saved (or dissaved).

From the first-order conditions we have:

$$h(d) = \frac{\frac{\partial U}{\partial l}}{\frac{\partial U}{\partial x}}$$

For the utility function $U(x, l)$, the marginal rate of substitution is $\partial x/\partial l = -\partial u/\partial l/\partial u/\partial x$. Therefore, $h(d)$ is equal to $-MRS(l, x)$.

The third first-order condition can be rewritten as:

$$h(d) = \frac{I - T(d) - x}{l}$$

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

Eq. 3.5 $$\psi(d, u) = \max_{x,l} \left\{ \frac{I - T(d) - x}{l} \middle| U(x, l) = u \right\}$$

Here, the consumer chooses the optimal bundle of land for residence and a composite good to maximize his/her utility with respect to the constraints that income and prices provide. The bid-rent curve reveals the consumer's willingness to pay for the land with respect to its distance from the CBD. The model suggests that the maximum rent per unit of land is positively related to income, I, and negatively related to distance, d, transportation cost, T, composite goods, x, and lot size, l.

The essence of the bid-rent curve reflects a tension between access and space (Fujita, 1989; Fujita & Thisse, 2002, pp. 78-91; McCann, 2001). Access reflects a proximity to the labour market and the market of goods and services. Urban areas are generally better in terms of access than rural areas. According to McCann (2001), space reflects the values of rural areas—that is, space, scenic views, stillness and other amenities—which tend be more available in the countryside than in urban areas.

The impact of transportation improvements on housing prices may be based on improved access and lower transportation costs since transportation improvements make it possible to travel larger distances per unit of time and for workers to live farther away from their workplaces (Fujita, 1989; Fujita & Thisse, 2002, pp. 78-91; McCann, 2001). Thus, lower transportation costs expand the labour market geographically, as the market of goods and services and even amenities become more accessible, and the housing market expands geographically since labour becomes more mobile. Thus, the demand for land in distant areas rises and its price increases, given that the supply is fixed, so the fringe of the city is extended geographically, moving farther away from a city centre, beyond the impact area of the relevant transportation improvement, and toward the adjacent regions so the conurbation covers a larger area.

Distance and transportation cost influence the bid rent in the following manner. Differentiation of the bid rent, ψ, in Eq. 3.5 with respect to transportation cost, T, yields:

$$\textit{Eq. 3.6} \qquad \frac{\partial \psi(d,u)}{\partial T} = -\frac{1}{l} < 0$$

Further, differentiating the bid rent, ψ, in Eq. 3.5 with respect to distance, d, yields (Eq. 3.7) that reflects the relationship between the consumers' willingness to buy land for housing and distance:

$$\textit{Eq. 3.7} \qquad \frac{\partial \psi(d,u)}{\partial T}\frac{\partial T}{\partial d} = -\frac{1}{l}\frac{\partial T}{\partial d} < 0$$

According to Fujita (1989, p. 14), $\partial T/\partial d > 0$, so $(\partial \psi(d,u)/\partial T)(\partial T/\partial d) < 0$, as stated in Eq. 3.7. Thus, the shape of the bid-rent curve for the monocentric city is negative, non-linear and convex (Figure 3-6), meaning that housing prices are highest in the CBD and decrease the farther the dwelling is from the centre. The margin of decrease is largest for housing closest to the CBD and decreases gradually the farther the house is from the centre.

Assume a community of one city (CBD) and two adjacent villages, A and B, both outside the conurbation area[16] (noted by the dotted area in Figure 3-6), and located at a_0 and b_0. When a new transportation improvement takes place between the CBD and A, both A and B are shifted closer to the city, because the travel time is shortened. A is now located at a_1 and B at b_1 (Figure 3-6, to the right). According to the bid-rent curve, following the transportation improvement the housing price will increase from h_{A0} to h_{A1} in village A and from h_{B0} to h_{B1} in B. In addition, A becomes a part of the conurbation area.

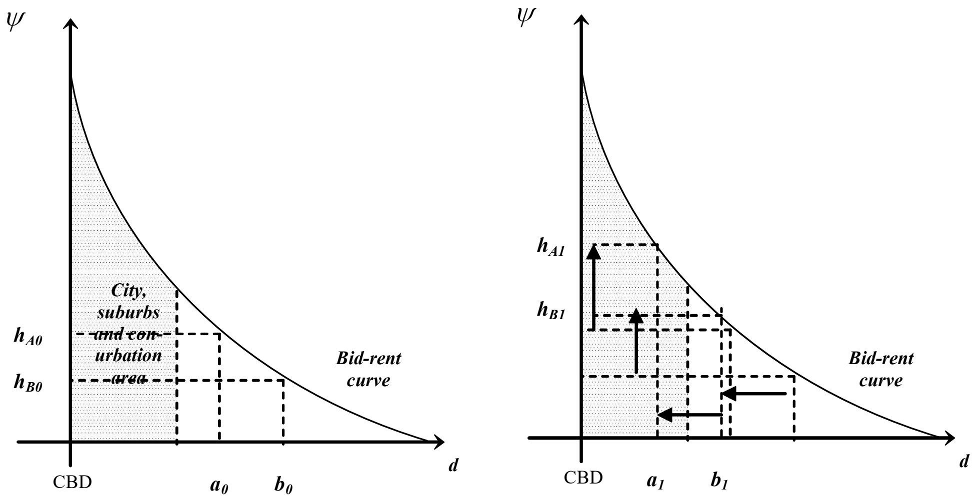

Figure 3-6. Changes in rural housing-prices following a transportation improvement, road quantity.

Demand for housing and land for residence can be dependent on a household's income (McCann, 2001, pp. 109-113). Consumers' income tends to shift the bid-rent curve back and forth because income affects the constant term of the curve (Eq. 3.5). Since the bid-rent curve reflects the tension between access and amenities, the shape, or the slope, of the bid-rent curve is dependent on the consumer's preferences for access over amenities. If the consumers' preferences change in favour of access, the bid-rent curve becomes steeper, *ceteris paribus*, meaning that the consumers prefer labour and service market proximity to the quiet and beautiful nature. The consumer therefore becomes willing to

[16] Definition: the conurbation area is the capital area and other municipalities within 120 km from the capital city.

pay higher prices for access. Hence, centralized housing becomes relatively more expensive than housing farther away. If the consumers' preference turns in favour of amenities, the bid-rent curve becomes flatter. Thus, if consumers are identical, apart from the income and preference of access over amenities, the bid-rent curve becomes a conglomeration of numerous individual bid-rent curves, resulting in the bold sections of the household bid-rent curves of three different income levels in Figure 3-7. In the figure, the low-income households are assumed to be willing to pay the highest price for the dwelling closest to the CBD, and the high-income household is assumed to be willing to pay the highest price for dwellings farthest away from the CBD. The middle-income households live in the area in between. Thus, the uppermost part of figure 3-7 represents the demand curve for low-income households, the middle part represents that for the middle-income households, and the lowest part represents that for the high-income households.

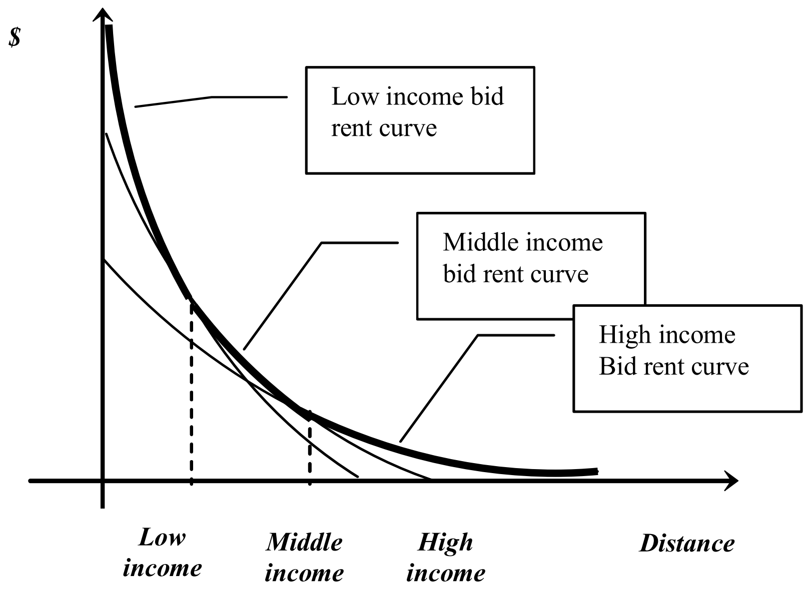

Figure 3-7. The geographical aspect of land rent.

According to McCann (2001), a low-income household tends to keep its transportation cost low, even close to zero, while the middle-income household spends more on transportation and lives in the suburbs. High-income households have the highest transportation expenses and are most likely to live in rural areas with a wide variety of amenities, but still a comfortable travel distance to the city (Figure 3-7). Transportation can be by car, by cheaper mass transportation, by cycling, or even by foot. This pattern can reverse if the income elasticity toward land begins to favour accessibility over amenities. In that case, high-income households will outbid low-income households and invade the city centre, while low-income households move to the city's periphery, and the middle-income group remains in between. In this case, the city will become more densely populated, since the low-income households, preferring access to amenities, try to keep the transportation cost as low as possible.

Factors other than income can also have an impact on the bid-rent curve. In the standard theory, the composite good includes all goods (Eq. 3.5). Empirical studies include amenities and income, which are sets of demographic variables, variables for the level of infrastructure, and variables for housing characteristics. A detailed list is presented in the theoretical background of the empirical section of this dissertation.

Other factors are also preferred by consumers with respect to the accessibility and amenities that form the slope of the bid-rent curve and that represent the distance gradient of the housing prices. These include an increased number of service centres in or near the cities, a dispersion of the labour market, reduced travel time, the mortgage interest rate, and inhabitants' expectations (Capozza & Helsley, 1989; McCann, 2001). The standard theory reflects a model of a monocentric city, where there is only one centre in each city. The model of the polycentric city was developed for cities with many service centres; if a city develops many centres, as in many European and U.S. cities, the marginal influence of distance on housing prices will be lower. A polycentric city reduces a consumer's need for travel to shop and work, and increased dispersion of the industry would also reduce the impact of distance on housing prices. If a traveller can spend less time for each mile of distance without higher travel hazards, his or her travel cost would decline and the value of the real estate would increase. Improved transportation technology, cars, and roads are general conditions for this development.

Capozza and Helsley (1989) mention two other significant factors of development: expectations and changes in the mortgage interest rate. Rapidly growing cities tend to support consumers' positive expectations, so the expected future rent (growth premium) increases and the slope of the bid-rent curve steepens. The mortgage interest rate also influences the slope of the bid-rent curve: if the interest rate decreases, the price of the land becomes relatively cheaper against the travel cost, the demand for a centrally located residence increases, and the bid-rent curve steepens.

3.4 Urban and rural growth – location theories

Marshall, Weber and von Thünen argued that the development of cities is based on the service industry and manufacturing, while primary industries are located in rural areas because of the need for land as an input factor. Population growth has been faster in urban areas than rural areas for many reasons, including the faster growth of the manufacturing and service industry than primary industries because of their differences in income elasticity. Another reason is the localization and urbanisation of economies (Fujita, 1989).

Several theories are related directly or indirectly to interregional migration. International economics is, to some extent, part of spatial economics. There have always been two smaller spatial fields called regional and urban economics, where the former refers to the development of the countryside and the latter to towns and cities. Regions and distances have often been neglected by assuming the economy as one single period of location, even in the case of two or more economies, such as those of nations. Krugman (1995) argued that globalization moved the attention of economists from the national level to the regional level. When it comes to migration, the prime theories always focused on the industries' location, presuming a direct connection to migration based on the commonly accepted assumption of the perfectly mobile input factors of labour and capital. This section is devoted to theories of urban and rural growth (location theories), while the theories and models of interregional migration are presented in the next section.

3.4.1 Agglomeration

The present chapter is based on the work by O′Sullivan's (2009, pp. 235-240) unless otherwise specified. In all cities, certain tensions occurred between the benefit from agglomeration economies and diseconomies, such as transportation costs (Abdel-Rahman & Anas, 2004; Fujita et al., 1999; Henderson, 1974; O'Sullivan, 2009). Agglomeration economies include

Marshall Arrow Romer (MAR) economies, Jacobs economies, localization economies, and urbanisation economies. Localization economies occur when a firm's average cost decreases because of the presence of other firms in the same industry, while urbanisation economies occur when a firm benefits from lower average costs because of its proximity to firms in other industries. Localization economies are based on sharing intermediate inputs and labour pools, labour matching, and knowledge spillover. Lower average costs that result from localization economies include lower training and transaction costs and higher quality of specialized input factors. Urbanisation economies have similar effects arising from companies in other industries.

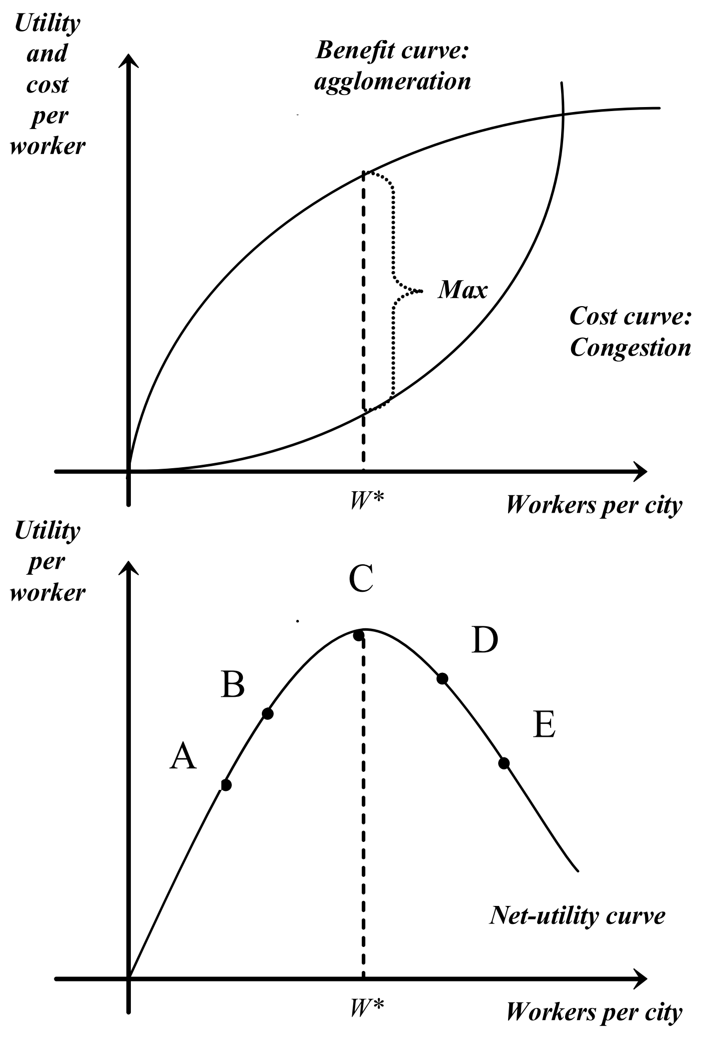

Figure 3-8. Urban growth and utility.

MAR economies occur when the average cost decreases only because of knowledge spillovers between companies in the same industry. Jacob's economies occur when spillovers between firms in different industries lower their average costs. MAR and Jacob's economies are commonly counted as part of the localization and urbanisation economies, where MAR economies are the dynamic aspect of localization economies and Jacob's economies are the dynamic aspect of urbanisation economies (Henderson, 2003; O'Sullivan, 2009). If agglomeration economies are present, these benefits contribute to higher wages in the relevant location (Henderson, 1985; O'Sullivan, 2009).

Recall that the benefit curve reflects the agglomeration economies and the cost curve traffic congestion (Figure 3-8, top). Since there are competitive markets, agglomeration economies increase their citizens' wages. While cities are small, the local social benefit of an additional worker (inhabitant) tends to be higher than the local social cost, and the utility increases. The size of cities is measured by the number of workers. Comparable to workers' productivity in the standard microeconomic theory, the agglomeration economies increase regressively with respect to the city size and number of workers; thus, the benefit curve is increasing and concave (Figure 3-8, top) because of the cities and the industrial construction, where they impose limits on the agglomeration economies. The social cost increases progressively because each minute of traffic delay has a multiplied impact on the community; a tiny impact of one additional citizen on congestion affects thousands of travellers. Thus, the cost curve is positive and convex (Figure 3-8, top).

Urban utility is based on the difference between local social benefits and costs (Figure 3-8, bottom), so urban utility becomes a strictly concave function with one local maximum, and the utility is maximized at a given urban size (point C in Figure 3-8, bottom). The utility per worker decreases with an additional worker when the population exceeds the optimal city size, W^*(point D and E in Figure 3-8, bottom) and increases when the city is smaller than W^* (points A and B in Figure 3-8, bottom).

However, some argue that cities can be too large (point D in Figure 3-8) but never too small (point A in Figure 3-8). If there are two cities with identical utility curves, A and B, the residents will increase their utility by moving from A to B, which will move the position of A and B further apart along the utility curve, increase the benefit of migration, and continue the process until A is wiped out and B is closer to the utilities maximum. However, when the cities are larger than a city of optimal size, such as D and E, the motivation for migration is from the larger city, E, to the smaller one, D. The two cities will obtain stable equilibrium, where both are larger than a city of optimal size. Thus, cities can be “too” large, but not “too” small.

Specialized and diversified cities return different utility maximums; a specialized city tends to reach its utility maximum with smaller populations than diversified cities do (Figure 3-9) because of the potential benefit of agglomeration economies that are greater in a diversified city, while the transportation cost is identical. That is, diversity accumulates and fuels urban economies, making diversified cities richer in agglomeration economies than specialised ones are. Cities are of various sizes because small cities are more specialized than larger ones, even though they cannot be counted as diversified cities, and the largest cities tend to be diversified.

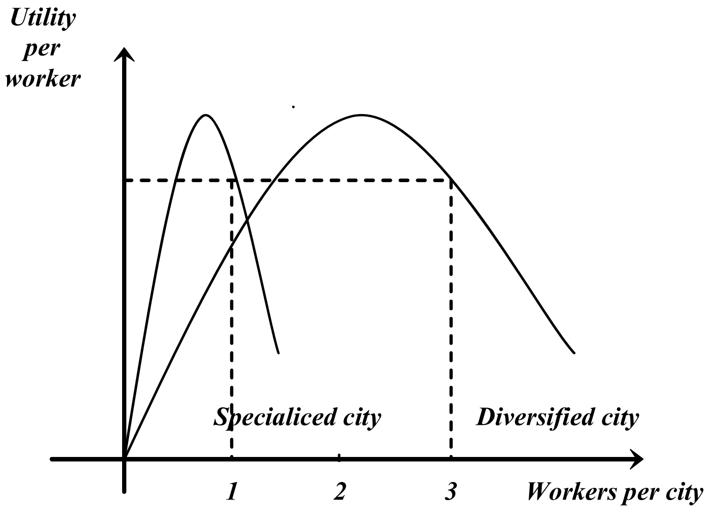

Figure 3-9. Urban growth and urban size.

A city’s population can reach stable equilibrium. A country with two cities that have different utility curves, where the total population is 4 million, will reach stable equilibrium when the smaller city has a total population of 1 million and the larger city has a population of 3 million if the utility curves are comparable to those in Figure 3-9. The equilibrium will not necessarily form two cities if the country's total population is closer to 2 million. In that case, the equilibrium position would move to the left of the maximum point on both utility curves, given that the same utility level is kept, and the citizens of the smaller city would gain by moving to the larger city. At the same time, citizens of the larger city would not benefit from moving to the smaller one. Therefore, the equilibrium would be unstable. To attain a stable equilibrium in a country of two or more cities, the country's total population must exceed the maximum point of the country's two or more largest cities.

Part of this theory is traced back to Marshall (1920), who explained the development of cities. According to Marshall, there are three reasons for the geographical clustering of industry. Firstly, proximity decreases transportation cost and increases the accuracy in the supply of raw materials in terms of suitability and delivery time. Secondly, the labour market becomes larger and eventually more specialized where there is more than one company in each industry. Thus, well-qualified labour is more likely, and it is easier to recruit when the demand increases, as people are less likely to move away from an area with a large labour market during a recession. Thus, the local skills are better preserved in such a way that the regional learning curve steepens. Thirdly, knowledge spillover between firms tends to increase with proximity (Fujita et al., 1999; Krugman, 1995).

3.4.2 Central place theories

According to the central place theory, the role of cities is to host the central service for the agricultural or any other non-footloose activity (Fujita et al., 1999; Krugman, 1995). Furthermore, "cities are the engines of long run economic growth" (Abdel-Rahman & Anas, 2004, p. 2), and the location of cities develops according to industries' transportation cost. The number of cities tends to increase with respect to the geographical size of the country and the population.

Christaller (1933), one of the primary scholars of the central place theory, argued for a system of cities, called central places, that could be classified as a hierarchy of N different market area levels. The largest city (in population) and the capital of commerce represent the top level (Level 3 in Figure 3-10). All available goods are delivered at the top level, while the variety of goods decreases slightly on the second level, since a highly specialized service with a small market is profitable only in the largest market. Accordingly, the variety of goods and services continues to decrease with the level of cities; the variety will be widest at Level 3, narrower at Level 2, and narrowest at Level 1 (Figure 3-10).

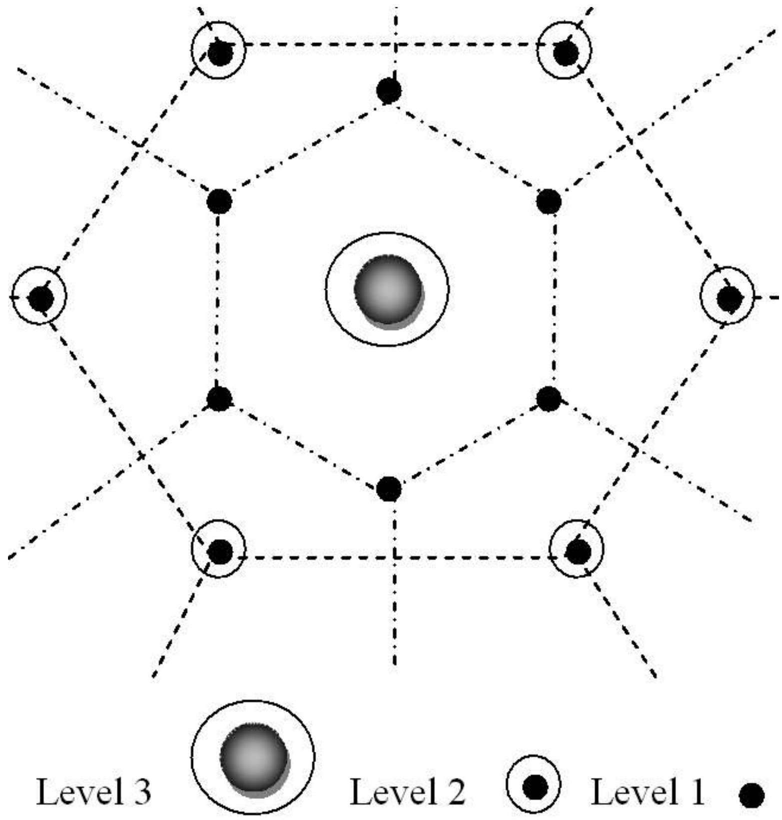

Figure 3-10. The Central Place Theory: Walter Christaller. Source: McCann (2001).

The number of levels, N, is determined by the population and population density, amongst other considerations, so more populous and denser communities tend to have more levels than communities that have smaller populations and that are more scattered (Lloyd & Dicken, 1977, pp. 29-32; McCann, 2001, pp. 72-72). Household income and transportation cost affect the numbers of the levels, even though these factors are not mentioned in relation to Christaller's theory.

Losch's (1954) theory is similar to that of Christaller. Losch made several assumptions for the model: consumers are evenly spread across the space, land is identical in all locations, transportation service is identical, and the demand is price elastic.

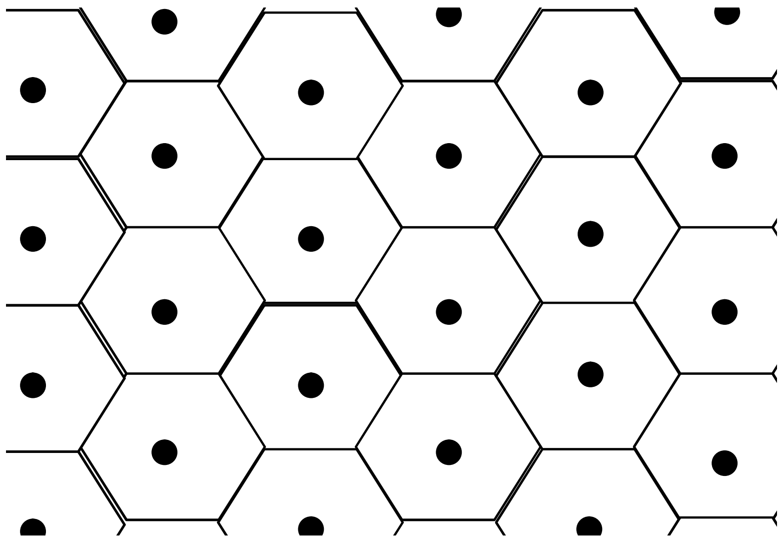

Figure 3-11. The Central Place Theory: August Losch. Source: McCann (2001).

Accordingly, firm markets will be determined by a circle around its location, noted by πd^2, where d is distance. Because of transportation cost and price elasticity, firms' turnover drops for every kilometre of additional distance of transport required from the firm's location. Since the population is scattered evenly throughout the space, firms are evenly spread, and the consumers meet the demand. The market's geographical size for each company depends on the distance to the neighbouring company; the market is divided between adjacent companies, demonstrated graphically by a straight line between their borders' intersection. Thus, there will be many different markets throughout the space, with one for each firm, generating a honeycomb pattern (Figure 3-11). The dots represent each firm's location.

The rank-size rule, or Zipf's law (Overman & Ioannides, 2000), represents a system of cities that ranks cities according to the following model:

$$M_i = \frac{k}{R_i^b}$$

where there is a relationship between the population, M, of city i, and its rank, R. When the equation is transformed by a logarithm on both sides, it returns a simple linear model, where k and b are the estimators returned by a standard OLS regression (O'Sullivan, 2009). This very successful empirical model suggests that a city's size tends to follow an inverse logarithm form, where the largest city is progressively larger than the second largest one, and so on. More precisely, "*Rank times population is constant across cities…. If the largest city (rank 1) has a population of 24 million, the second largest city will have a population of 12 million (12*2=24), while the third largest will have a population of 8 million (8*3=24), and so on*" (O'Sullivan, 2009, p. 79). The rank size rule is one of the strongest empirical models for explaining the distribution of a city's size. It is taken from physics and has not yet been properly explained by economic theory (Krugman, 1995).

Another related model was presented by Harris (1954), who addressed the attractiveness of market size toward industries and presented a market-potential function:

$$\Omega_i = \sum_j \alpha \frac{I_j}{d_{ij}^{\beta}}$$

where the market potential, Ω, in location i, is dependent on the household income, I, of a particular market, j, and on the distance between the location and the market. Income increases the market potential, and distance reduces it, although the impact of distance is not necessarily linear when its power is kept variable, β. α is an unspecified coefficient. Accordingly, the firms locate where the access to the markets is best. This model has been successful in explaining the location of the industry in the US (Krugman, 1995).

Theories of agglomeration economies are based on minimizing travel cost and, to some extent, scale economies. Firms cluster and form a city to lower a cost by sharing the labour pool, intermediate products, and the like, and central place theories are, to some extent, based on the same principle. In Lösch's theory, transportation cost determines firms' market borders, while in Christaller's theory, transportation cost and scale economies decrease the size of the sufficient market for specialized services in small communities. Thus, specialized services are profitable only in large markets, making cities attractive in terms of their ability to offer a vast variety of goods and services. Zipf's law is in line with Christaller's theory, even though the arguments are not as obvious. The function of the market potential is similar to Zipf's law.

3.4.3 Theories of non-competitive models

According to Hotelling's (1929) theory, firms (all in retailing) choose a location that is most likely to bring them customers. The theory describes the optimal behaviour of one firm in a world of many customers and one other comparable firm. The demand is perfectly inelastic; that is, each consumer consumes a fixed quantity in each period of time. The consumers are evenly distributed in space. Hotelling assumed fixed production prices, covering production and the transportation costs, and the good is probably homogeneous since *"No customer has any preference for either seller except on the ground of price plus transportation cost"*(Hotelling, 1929, p. 45). The analytical tool is based on game theory, where each company makes its optimal choice by selecting a location assuming that the other company will not react. The result suggests that the companies will cluster and create a centre. The consumers will be worse off following a clustering since consumers are spatially evenly distributed, so the average price of goods will increase (McCann, 2001).

Palander (1935) studied the work of Hotelling and came to an opposite conclusion: that competition would motivate two oligopolistic firms to keep their distance in order to gain monopolistic power and would not agglomerate as Hotelling suggested. Palander made the same assumptions as Hotelling, except for the type of game, which, according to Fujita (2010, p. 11), was an informal two-staged game (McCann, 2001).

According to McCann (2001), Hotelling's solution holds only if there is some kind of solid non-price competition, which is possible, either by agreement or in markets of heterogeneous goods. Therefore, McCann concluded that companies that supply homogeneous goods will disperse spatially and that firms that offer heterogeneous goods will cluster.

According to Fujita (2010), Launhardt (1993) implemented models similar to those of Hotelling 45 years previously. Launhardt, who primarily analysed market areas, also investigated the spatial price policy, but Hotelling's analysis was much more general than Launhardt's. Launhardt did not study the firm's joint determination of price and location, but all of these models assumed oligopolistic firms.

A similar result was presented in what Krugman (1998) called the "racetrack economy". The difference between Krugman and Palander and Hotelling is primarily in Krugman's assumption of an industrial location along a circle instead of a line. Krugman divided the circle into twelve regions, such that Region 1 was next to Region 2 and Region 12. The model concluded that companies would locate in only two regions as far as possible from each other. Krugman's results may help to unite the results of Palander and Hotelling, since Krugman returns two clusters (cities) of firms where the maximum distance is kept between them. Although a circle is an unrealistic assumption for many economies because of their geographical formation, it is quite appropriate in the case of Iceland which is a relatively round island. Further, the interior of the country is a hinterland without residents. Most notably, the distance between Reykjavík and Akureyri is closely in line with the "racetrack economy".

The core-periphery model belongs to this category, but it is addressed later in the thesis.

As for theories of agglomeration economies and central place, transportation cost plays a central role in the decision of location and local growth in the theories of non-competitive models. By minimizing transportation cost, Hotelling and Palander claim that the market is divided among firms that choose their locations with respect to the available market in order to maximize profits.

3.4.4 Theories including rural and urban areas

The theories described in the previous sections of the thesis generally avoided the discussion of rural areas and small villages. The von Thünen model refers to industrial location (then farmers) with respect to the distance from the central market and explains the existence and the relationship of urban and rural areas. Explanations for the existence and prosperity of both urban and rural areas can also be found in theories of the Ricardo, Weber, and Heckscher and Ohlin.

Almost two centuries ago, Ricardo (1817) developed a theory of the comparative advantages of nations and regions that explained how two countries/regions could both gain in trade based on comparative advantage—or the comparative opportunity cost—even though one region was more productive in the production of all goods. A world that consists of two countries, A and B, and two tradable goods, 1 and 2, where A is more productive in both goods, especially good 1, is better off by trading since both countries would gain. It may seem obvious for

Country B, but Country A would gain by exporting good 1 and importing good 2 at a price closer to that of good 1 than that of good 2.

Swedish economists Heckscher and Ohlin (1967) extended this theory with the so-called Heckscher-Ohlin theorem, to show that the development of industries within each region or country are dependent on the region/country's access to resources. A region's most prosperous industry (-ies) would be intensive in factors relatively easily provided locally, and they would export that good and import goods intensive of locally scarce factors. Thus, the world's largest region (in km^2) would have comparative advantages in agriculture, and the most populated region would have a comparative advantage in labour-intensive industries, if everything else is identical.

Weber presented a theory of industrial location (Lloyd & Dicken, 1977; McCann, 2001; Weber, 1909) in which firms choose location according to production input-output density, input prices, and access to new output markets in order to maximise profits. The density, which refers to the input-output weight or volume[17], increases if the overall volume shrinks during the production process in terms of weight or volume. The input-output density can either increase or decrease in the production process. For example, in forestry, the input-output density increases in the process from a tree to a plank because only 70-80 percent of the original tree is transformed into a plank, while the rest becomes waste. However, the input-output density probably decreases when a chair (or any other compounded furniture) is made from the plank because the chair's volume exceeds the volume of its raw material. The transportation cost depends on the product's weight or volume, either of which can be favourable to the transporters. Thus, the industry's location is close to the resource if the input-output density increases during its production process and is close to the market when it decreases, *ceteris paribus* (Lloyd & Dicken, 1977, pp. 120-122). The former fuels the growth of rural areas and the latter the growth of urban areas. This example becomes particularly interesting when we think of IKEA, a manufacturer that leaves the assembly of the furniture to the customer.

According to a more recent version of Weber's theory, relative prices of immobile factors also influence the optimal industrial location.

[17] Input-output density (or the material index) is y/q, where y is the weight of localized materials used in the industry and q is the weight of the product (Lloyd & Dicken, 1977).

In the original theory, there was only one input factor and one output factor, but the theory has been extended to include many input factors from different locations, including labour, several types of raw materials, and land. No substitution is assumed to be available for the input factors. If the factor prices are equal between regions, the optimal location is still dependent on input-output density, but when the factor prices differentiate, the optimal location can change in favour of the lowest-priced region (McCann, 2001). Later, Isard (1956) made an improved analytical tool for the model.

Another recent version of the theory, called the Weber-Moses triangle, allows for factor substitution. In that case, the determinants of location will simultaneously affect the mixture of the input factors when those factors change. Furthermore, the expansion of the industry in terms of output change can lead to a shift in the input mix and, therefore, the optimal location (McCann, 2001, pp. 24-25; Moses, 1958).

Myrdal founded a theory called the centre-periphery theory. According to Fujita, Krugman and Venables (1999) and Guild (2000), Myrdal was the founder of the so-called cumulative causations theories. In Myrdal's theory, migration changes a region's competitive advantage and increases the regional disparity of economic growth and welfare. Myrdal imagined a regional equilibrium and then introduced a sudden incident that changes the local competitive advantages, such as a new local entrant or innovation in a prosperous industry that increases the local aggregate demand. The gross area product will increase so the real wages and local taxes can be lowered, and new migrants will show up. These migrants are partly domestic, meaning that population growth can be negative in other regions. Local aggregate demand and real wages will decline in these regions, so local taxes must be increased to preserve the level of public service. This triggers a "vicious cycle" of continuous negative migration from those regions, which Myrdal called the "back wash effect". Myrdal (1957, p. 31) argued that the expansion of the growing region will create a centrifugal effect, called the "spread effect". The neighbouring region, as the sole supplier of agricultural goods and an alternative supplier of raw materials for the growing region, can gain from the expansion, which will also have its local multiplier effect.

Myrdal (1957, pp. 33-34) made it clear that the magnitude of the "spread effect" would rise if an effective transportation and telecommunication system, amongst other factors, is present: *"a high average level of development is accompanied by improved* ***transportation*** *and* ***communications****, higher levels of education, and a more dynamic communion of ideas and values"*. Later, Myrdal presented empirical evidence for a smaller regional disparity of real wages in countries where these conditions are met and classified regions into expanding, stagnating and regressing localities.

In von Thünen's theory, farmers' optimal behaviour creates certain layers of industries around the CBD, where the most transportation-intensive industry is closest to the CBD and the less intensive is farthest away. According to Weber's theory and the theory of the Weber-Moses triangle, the firm's decision in terms of proximity to the market or resources is dependent on several factors, but the transportation cost is one of the most significant. Transportation cost also affects the "spread effect" in Myrdal's theory; local growth benefits inhabitants of a larger area if transportation cost is lower than if it is higher. However, distances and the transportation costs are not included in the theory of comparative advantages.

Finally, the staple theory, a contribution from Canadian scholars, should be addressed. The theory suggests that economic growth is mainly traced back to staple exports because of its links to various industries. These links are classified into three categories: when production of staples demand other products as input factors (backward links), when production of other goods need staples as input factors (forward links), and when production of staples affect domestic consumer markets of other products indirectly (final demand links) (Brazzel & Hicks, 1968; Grant, 1974). Because of the spatial disparity of natural resources, the staple theory can explain regional development and, thus, interregional migration (Brazzel & Hicks, 1968; Jónsson, 1984).

3.4.5 Counterurbanisation, suburbanisation and urbanisation

Urbanisation is a migration behaviour dominated by people who move from rural to urban areas, while suburbanisation, which occurs when migration flow is from the city centre to the city's fringe, precipitates the decentralization of a metropolitan population (O'Sullivan, 2009). Mills (1972, p. 54) defined suburbanisation as a *"dispersion of population from the centers to the peripheries of urban areas"* and an urban area as (1972, p. 62) *"more suburbanised the more dispersed are residents and jobs around the centre of the urban area"*. Suburbanisation is, to some extent, a reaction to the consumers' wishes for larger houses and villas on larger lots than are offered in the city's centre. Accordingly, the fringe of cities moves farther away from the centre and the population density decreases. While suburbanisation occurs when the citizens and companies move from the centre of the city to the suburbs (the fringe of the city), counterurbanisation is *"a process of demographic deconcentration beyond that of suburbanisation of metro decentralization"* (Mitchell, 2004, p. 17) or, as Dahms and McComb (1999, p. 130) put it in their description of penturbia, one kind of counterurbanisation, when "*people are leaving suburbia in metropolitan regions, and moving to distant small towns and villages where land is cheaper and one can find a quiet haven*". Therefore, counterurbanisation occurs when people move from the city to an adjacent area beyond the closest hinterland and do not have direct access to the city's local infrastructure, such as buses, schools, and waterworks.

Approximately thirty years ago, a persistent flow of migration from urban to rural areas in Europe and USA (Dahms & McComb, 1999; Mitchell, 2004; Stockdale et al., 2000) was dominated by metropolitan citizens with preferences unmet by urban communities. According to Dahms and McComb (1999), counterurbanisation was observable within a region at least 120 kilometres away from the centre of a city. Mitchell (2004) discussed the reasons for counterurbanisation and classified them into three groups: ex-urbanisation, displaced-urbanisation, anti-urbanisation. Mitchell defined ex-urbanisation as occurring when urban citizens move to the countryside but still want to communicate with the city because at least one member of the family still works and has a social network in the city (Oates, 1999, p. 1120). This type of migration, from the suburbs to the villages much farther away (Dahms & McComb, 1999), gives the family an opportunity to buy larger houses or villas on larger lots in peaceful neighbourhoods for a reasonable price.

Displaced-urbanisation is migration from urban to rural areas based on pure economic reasons, so the household's income (or cash flow) is the only yardstick in this case. Cheap houses, job availability, income, and total expenses are the reasons for migration in the displaced-urbanisation category (Mitchell, 2004). Increased housing prices in the urban areas provide a centrifugal effect that encourages part of the population to decrease debts by selling centralized housing and buying cheaper housing in the suburbs or farther away. Some professions, such as unskilled labour in large-scale industry, can get higher wages in rural areas than in urban areas, so they migrate and leave their jobs in the city. Others have to commute back to the urban area. ("*Commuting is the transportation of people for the exchange of labour service*" (Mills & Hamilton, 1972, p. 226)). Therefore, migration can either increase or decrease commuting; if people work in the city, urbanisation cancels commuting, while suburbanisation and counterurbanisation create it. The magnitude of commuting is largest in the presence of counterurbanisation.

Migration driven by aversion to the city that can arise from criminality, traffic congestion, pollution, and high taxes, is called anti-urbanisation. The desire to live and work in a smaller community also influences anti-urbanisation. Mitchell (2004, p. 24) classified anti-urbanisation into three categories: "back to the land movement", "penturbia", and "amenity driven retirement migration". The back to the land movement refers to migration driven by the search for a radical new lifestyle in which the settler becomes relatively self-sufficient or sustainable. Penturbia refers to migration in which the migrant moves both his or her residence and work from the urban area to the rural area (Mitchell, 2004). Amenity-driven retirement migration refers to a commonly known wish amongst the elderly to live in quiet, friendly neighbourhoods, where they can enjoy amenities (Dahms & McComb, 1999; Mitchell, 2004). These different motives can be simultaneously active. Several recent technology improvements, such as the advent of the internet, have changed the conditions for residence like counterurbanisation for the better (Mitchell, 2004). Further economic growth will probably fuel that trend.

Counterurbanisation can be explained by the theory of classical economics, where all the motives addressed above can be explained by a change in consumer preferences with respect to the constraint that income determines the bid-rent curve. Here, as in most of the previous theories, transportation cost plays a central role. Suburbanisation and, to some extent, counterurbanisation becomes increasingly possible if transportation costs decrease, although this factor is not mentioned directly in the literature.

3.5 Interregional migration and transportation improvements

Economic theory suggests that migration is driven by spatial utility or welfare differentials (Sjaastad, 1962). Household benefits and costs are the key variables behind welfare; benefits are highly related to income and amenities, while the costs are classified into private and social cost. Private cost is classified into two categories: monetary cost and non-monetary cost. Monetary cost is the direct migration cost, along with an increase in expenditures for food, transportation, housing, and the like, while non-monetary cost is primarily related to opportunity cost and what the author calls psychic cost. Psychic cost is related to leaving family, friends, and surroundings, all of which are sometimes counted as part of social capital.

Since Sjaastad accounts for the social cost, the social benefit could also be included in the theory because of the agglomeration economies (Henderson, 1974), where an additional citizen contributes to higher productivity and, thus, wages for all citizens.

Based on Sjaastad's argument, where the migration decision is an investment decision, Greenwood (1975) presented the following model:

$$PV_{ij} = \sum_{t=1}^{n} \frac{I_{jt} - I_{it}}{(1+\rho)^t} - \sum_{t=1}^{n} \frac{C_{jt} - C_{it}}{(1+\rho)^t}$$

where I denotes household income, C cost of living, and ρ the discount rate. The present value, PV, is the spatial difference between the present value of the future income and the cost. One emigrates from region j to region i if the present value is positive, $PV_{ij} > 0$. Since only part of the migration cost is charged in the first period, time tends to increase the investment's payback, PV_{ij}. Therefore, time tends to encourage migration, so younger citizens become more likely to migrate than elderly citizen since they have more time left to live and reach the return of the migration (investment). If the discount rate rises, any positive payback decreases, so a higher discount rate discourages migration. There are several views among economists regarding the interpretation of the discount rate. Firstly the opportunity cost of capital that the discount rate should reflect the returns from comparable investment projects, that the discount rate is the borrowing cost of money because the consumer may have to borrow money to finance projects, and secondly the discount rate is the social rate of time preference that reflects the consumer's preference to consume today rather than tomorrow (Dixon et al., 1994, pp. 39-40). Furthermore, the discount rate tends to be higher if a risk is involved (Levy & Sarnat, 1994). Therefore, generally high interest rates, an older population, and greater risk all discourage migration.

Present income and costs are usually seen as good proxies for data on future income and cost since they are difficult to acquire in empirical studies. Regional earning levels are assumed to be more appropriate than aggregate income.

Greenwood (1975) argued that net migration is not necessarily well correlated with household income but that household income is probably correlated with in-migration, but not out-migration. Out-migration is dependent on the level of individual mobility, so it tends to be correlated with age, education, and other individual characteristics. In this case, migration is led by two decisions: shall I move and where shall I move?

Tiebout (1956) discussed the impact on migration of expenditures for local public goods by assuming that consumer-voters were fully mobile and rational and that they have full knowledge of the expenditure pattern among a large number of localities. By their "votes", the consumers affect the expenditure patterns of local public goods. If a consumer's view happens to be that of a minority group that is not fully satisfied, he or she will migrate to another community that offers a more satisfying service pattern. If the number of communities is sufficiently large, the entire society will reach an optimal allocation, and the needs of all members will be met.

Many economists have contributed to Tiebout's theory. Graves (1979) continued with the relationship between climate and net migration when he disaggregated the sample between age and race. Quality of life was the topic of Roback's (1979) paper, which attempted to determine the various impacts of amenities on local economic factors. Blomquist, Berger, and Hoehn (1982) pointed out that interregional amenity differences involve more than public services and include quality of life, such as weather conditions, crime and pollution, among other factors. Their analysis revealed that quality of life does matter to migration, as earlier research concluded, and that "compensation for location-specific, non-traded amenities takes place in both the labour and the housing market" (Blomquist et al., 1988, p. 105).

Mieszkowski and Zodrow (1989) investigated whether local taxes affect interregional migration in order to determine an efficient method of taxation. They suggested that, because of free migration, head taxation[18] was an inefficient method, while tax on land rent was an efficient method. They also observed that government intervention is necessary to reach an optimal spatial distribution of the population in all cases, except when regions are equal in size. Gyourko and Tracy (1991) contributed observations about institutional strength to this field of economic research and showed that intercity fiscal differentials are almost as important as amenity differentials and that quality-of-life rankings were more malleable than earlier researchers had suggested. They also determined that the presence of organised worker unions had an insignificant effect on local value.

Fischel's (1992) note discussed the effectiveness of zoning[19] and the burden of property taxes. Fischel asked whether zoning laws and regulations were sufficiently effective to support the view of Hamilton or Mieszkowski and Zodrow regarding property taxes. Fischel discussed many misleading papers but concluded that there was enough evidence for zoning to be binding. Fischel also suggested that property taxes were less of a local burden than other taxes; otherwise, they would have been voted out when he refers to the experience in the USA.

"Fiscal decentralization is in vogue" (Oates, 1999, p. 1120) is the first sentence of a paper in which the author provides an overview of the theory of fiscal federalism. According to the basic theory, the role of the central government is limited to macroeconomic stabilization and income redistribution, while the local government should provide public goods and services whose consumption is limited to their own jurisdictions. This observation is closely connected to the Tiebout model, where the local authorities adjust the supply to the majority of the citizens, promote inter-jurisdictional competition, and, to some

[18] The authors seems to choose to discuss head taxes as a specific example for local taxes dependent on individuals residence because Tiebout (1956) did it in his prestigious article.

[19] Zoning is a device for land planners and authorities to determine the geographical outlines or shape of regions in order to seperate them in spesific units.

extent, improve democracy. However, even though the assumptions of the Tiebout model are not valid for some European countries, these communities would still gain on decentralization because of the spatial disparity of optimal resource allocation and the combination of the local population that make its preferences vary from one jurisdiction to another. Oates also discussed environmental federalism, inter-jurisdictional competition, a laboratory federalism, market-preserving federalism, the political economy of fiscal federalism, and fiscal decentralization in developing and transitional economies.

In the concept laboratory for federalism, a single municipality with extraordinary policies is used as a "guinea pig" in order to identify the most efficient policies. The discussion of inter-jurisdictional competition and environmental federalism is striking when arguments are made for the "race to the bottom". Harsh inter-jurisdictional competition leads to continuously decreasing taxes and environmental standards in order to attract new investments, resulting in possible harm to the welfare of the citizens. However, competition is necessary in order to create discipline in local governmental spending. Furthermore, Oates pointed out that one of the keys to the market-preserving federalism is the separation of monetary and fiscal powers, where decentralized governments face stern budget constraints. Finally, using both international and domestic comparison, the author tried to shed light on whether fiscal decentralization leads to economic growth but was not able to confirm causality.

3.5.1 Disequilibrium and equilibrium models

The disequilibrium model

The basic disequilibrium model (Hunt, 1993; McCann, 2001) assumes that the migration of workers between two regions can be explained by wage differences. In what follows, we first derive the demand for labour in a single region and then show the effects different wages have on migration.

Consider a firm that uses land, l^q, and labour, N, to produce the composite good x. The production process is characterised by constant returns to scale, and the firm operates under perfect competition. The firm's cost minimization problem can be rewritten as

$$Min\, C(w, r)$$

$$s.t.$$

$$Q = f(l^q, N)$$

where the cost function is non-decreasing in wages, w, and interest, r, homogeneous of degree 1, concave, and continuous.

In the simple case of a Cobb-Douglas production function, the minimization problem becomes

$$Min\ C = wN + rl^q$$

$$s.t.$$

$$Q = b(l^q)^{\alpha} N^{\beta}$$

where b is a constant, and α and β are parameters. The conditional demand function for labour can then be defined as

$$N(w, r, Q) = r^{\alpha} \left(\frac{\frac{1}{\alpha} - 1}{w} \right)^{\alpha} \frac{Q}{b}$$

The inverted demand function may then be rewritten as

$$Eq.\ 3.8 \qquad w(N, r, Q) = \frac{r\left(\frac{1}{\alpha} - 1\right)}{\sqrt[\alpha]{\frac{bN}{Q}}}$$

The first derivative of wage, w, with respect to the number of workers, N, is defined as

$$w_N = -\alpha \frac{r\left(\frac{1}{\alpha} - 1\right)}{\sqrt[(\alpha-1)]{\frac{bN}{Q}}} \left(\frac{b}{Q}\right) > 0$$

and the second derivative with respect to labourers becomes

$$w_{NN} = -\alpha(\alpha-1)\frac{r\left(\frac{1}{\alpha}-1\right)}{\sqrt[\alpha]{\frac{bN}{Q}}}\left(\frac{b}{Q}\right)^2 < 0$$

The demand curve can be expressed graphically (Figure 3-12). The shape of the inverted demand curve is negative, non-linear and convex, which means that wages must decrease in order for the firm to be willing to hire more workers.

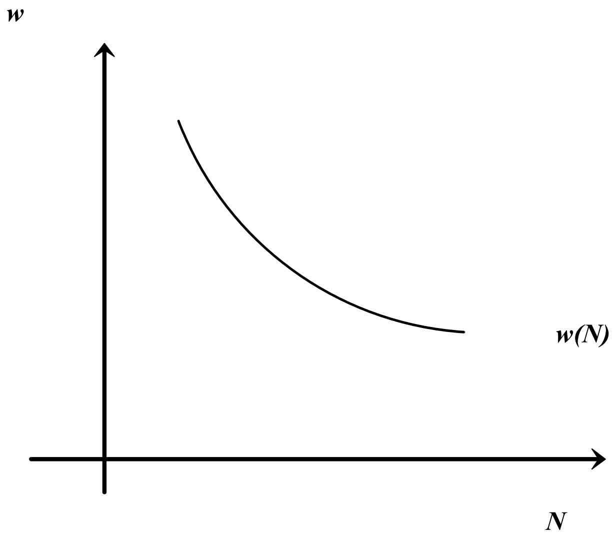

Figure 3-12. Labour demand curve.

In the case of two regions, the inverted demand function may be rewritten as

$$Eq.\ 3.9 \qquad w_i^* = \frac{r\left(\frac{1}{\alpha}-1\right)}{\sqrt[\alpha]{\frac{bN_i}{Q}}}\ ; \qquad i = 1,2$$

where N_1 and N_2 denote employment in Regions 1 and 2, respectively, $N_1 + N_2 = N$, and N is fixed, $\bar{\bar{N}}$. Every variable included can be assumed to vary between regions, but here we assume only that wages, the numeraire good, and the population are region-specific. A graphic representation of the model is shown in (Figure 3-13), where LD_1 and LD_2 represent inverted labour demand functions in Regions 1 and 2, respectively. The intersection of the two curves determines the labour allocation in each region.

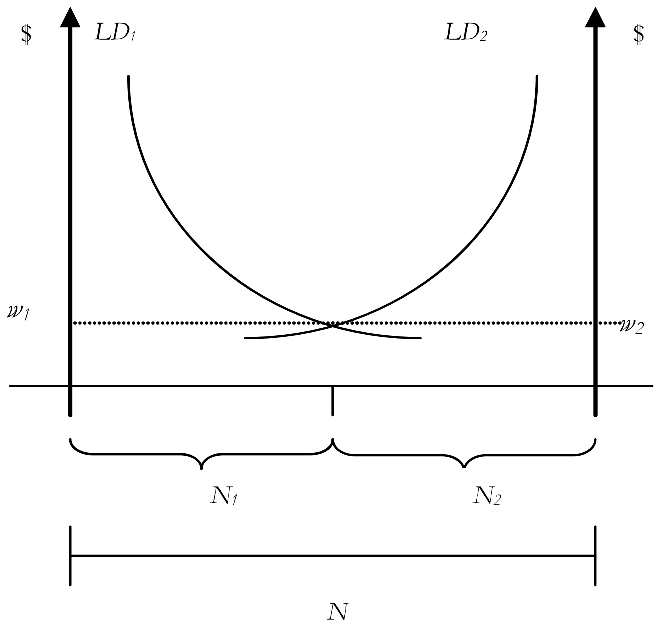

Figure 3-13. The disequilibrium model.

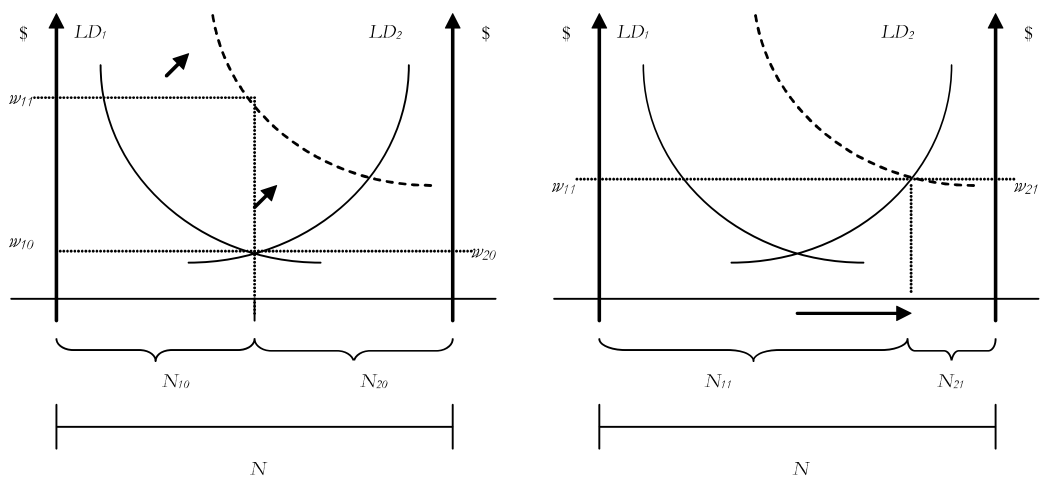

Figure 3-14. A technology improvement and an interregional migration according to the disequilibrium model.

Assume now that demand for labour in one of the regions—say, Region 1—increases because of technological improvements (Figure 3-14). Accordingly, the demand curve LD_1 shifts up, and wages in Region 1 consequently rise, which brings about an influx of workers from Region 2, with wages at first much higher than is eventually sustainable. Over time, wages fall again in Region 1 until they become the same again in both regions. In the process, employment in Region 1 has increased, and it has fallen in Region 2. Although elegant, the model does not coincide well with reality, as it does not satisfactorily explain the existence of spatial wage differences.

A simple equilibrium model

Graves (1980) suggested another model for interregional migration, where migration is not brought about by wage differentials but by different tastes for amenities. Unlike the disequilibrium model, the equilibrium model includes the consumers' utility curve, not the demand for labour, but adds amenities to the basic disequilibrium model. The model assumes that workers' utility depends on the consumption of goods and services, x, and local amenities, C. Both X and C can be regarded as vectors. The utility function is assumed to be continuous in X and C and strictly convex. Utility is maximised, subject to the budget constraint

$$I = P_x X + P_c C$$

where I represents income, and P_x and P_c represent the price of X and C, respectively. In what follows, the price of tradable goods is set equal to unity.

Two of the first-order conditions yield

$$\textit{Eq. 3.10} \qquad P_c = \frac{\frac{\partial U}{\partial C}}{\frac{\partial U}{\partial X}}$$

and the third can be rewritten as

$$\textit{Eq. 3.11} \qquad C = (I - X)\frac{1}{P_c}$$

When Eq. 3.11 is inserted into Eq. 3.10 and solved for C, an expression for the optimal consumption becomes

$$\textit{Eq. 3.12} \qquad C = (I - X)\frac{\frac{\partial U}{\partial X}}{\frac{\partial U}{\partial C}}$$

Eq. 3.12 suggests that the consumption of climate increases if the marginal utility of climate, $\partial U/\partial C$, increases. Income increases the consumption of climate, and the slope of the budget constraint is equal to the slope of the utility curve.

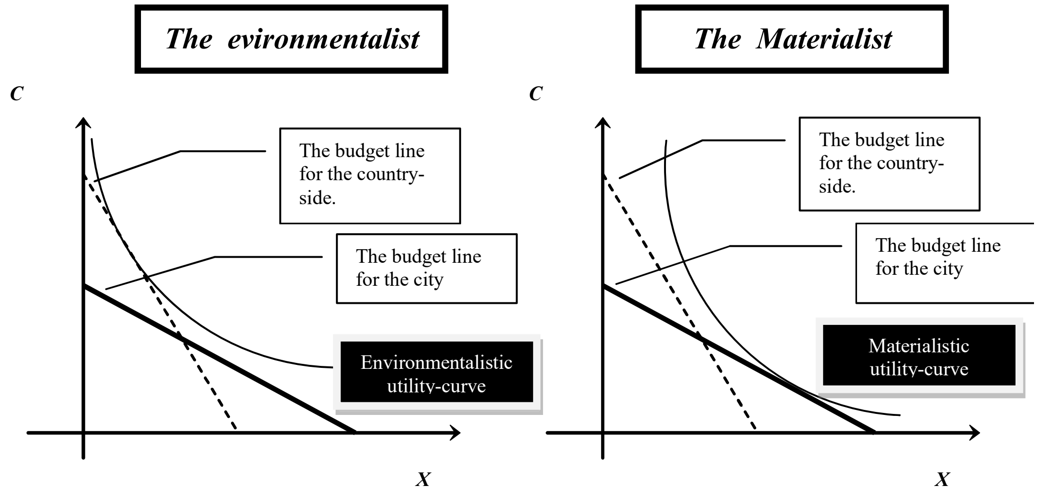

Figure 3-15. A simple equilibrium model.

Using a simple utility analysis, the model can be used to illustrate the choices of two individuals, the materialist and the environmentalist, where the former chooses a bundle high on goods and low on amenities (living in the city), and the latter chooses a bundle low on goods and high on amenities (living in a rural environment) (Figure 3-15).

The Equilibrium model

The equilibrium model may be expanded to include both consumers and firms (Roback, 1982); that is, interregional migration is analysed using a general equilibrium model of utility and labour demand curves. Next, we derive the model in order to apply comparative static analysis and show that regions of low amenity levels must compensate their inhabitants with high wages. On the other hand, the industries in regions with high amenity levels are compensated with lower wages to keep interregional migration in equilibrium. As before, the model assumes perfect competition in all markets, but in this case, the model is solved for one region only and interpreted implicitly for both regions when interregional migration is discussed.

Workers

Workers are assumed to be homogeneous and to maximise utility by choosing the most favourable combination of a composite good, x, residential land, l^c, and a bundle of amenities, A.

$$Max\, U(x, l^c, A)$$

The utility function is assumed to be continuous in x, l^c, and A and to be strictly convex. The utility function is maximised subject to the constraint

$$w + J = x + l^c r$$

where total income equals the sum of wages, w, and non-labour income, J, the price of the composite commodity, p_x, is set equal to unity, and r is the interest rate or price of residential land.

The associated indirect utility function, which shows the level of utility, k, that is attainable given prices and income, is defined as

$$V(w, r; A) = k$$

where the indirect utility function is a function of rent dependent on wages and a constant level of amenities, A, and utility, k. The partial derivative of rent with respect to wages must be positive, $\partial r/\partial w > 0$, to keep a constant utility, k. That is, an increase in wages must be compensated with higher rents if the level of utility is to remain unchanged.

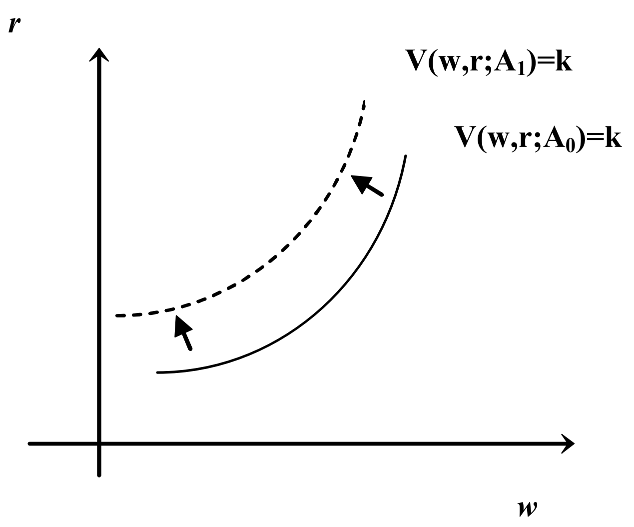

Figure 3-16. The indirect utility curve.

As Figure 3-16 shows, the slope of the indirect utility curve in the (w, r) plan is positive, with the curvature of the line representing the degree of substitution between the composite good, x, and land for housing, l^c. It is assumed that higher amenities increase utility, $\partial V/\partial A > 0$. In the (w, r) plan, amenities, A, become part of the curve's constant, so when amenities increase from A_0 to A_1, the curve shifts up and to the left in the graph. Thus, an increase in amenities must shift the indirect utility curve to the left in the (w, r) plan in order to maintain a constant utility level, k (the dotted line in Figure 3-16 where $A_0 < A_1$). Therefore, if rent is constant, the same utility can be reached for a lower wage, and if wages are constant, the same utility is reached for a higher rent.

Firms

Firms produce goods according to the production function

$$X = f(l^p, N; A)$$

where X is a function of the production of a composite good with a number of workers, N; land use, l^p; and amenities, A. Production enjoys constant returns to scale. In the presence of perfect competition, the unit cost function must be equal to the product price in equilibrium. Letting product price equal unity, the cost function may be rewritten as

$$C(w, r; A) = 1$$

where it is a function of rent, r, wages, w, and a constant level of amenities, A. The cost function is non-decreasing in w and r, homogeneous of degree 1, concave, and continuous. Since the unit cost is increasing in both factor prices, the partial derivative of rent r with respect to wages, w, must be negative, $\partial r/\partial w < 0$, for costs to remain at unity. We can now present the results graphically (Figure 3-17).

The curvature of the cost curve reflects the input-factors' degree of substitution. Roback (1982) defined both unproductive and productive amenities, where the unproductive amenities are costly, $\partial C/\partial A > 0$, and the productive ones are favourable for the firm, $\partial C/\partial A < 0$. Clean air is an example of an unproductive amenity because it is costly for the firms to preserve clean air, and good weather is an example of a productive amenity because bad weather is costly for firms. In the case of unproductive amenities, production costs increase when the level of those amenities increases. Therefore, an increase in the level of amenities shifts the cost curve to the left in the (w, r) plan in order to keep cost constant. Therefore, if unproductive amenities increase, cost increases, $\partial C/\partial A > 0$, and the rent is constant, wages must decrease to keep the overall cost constant.

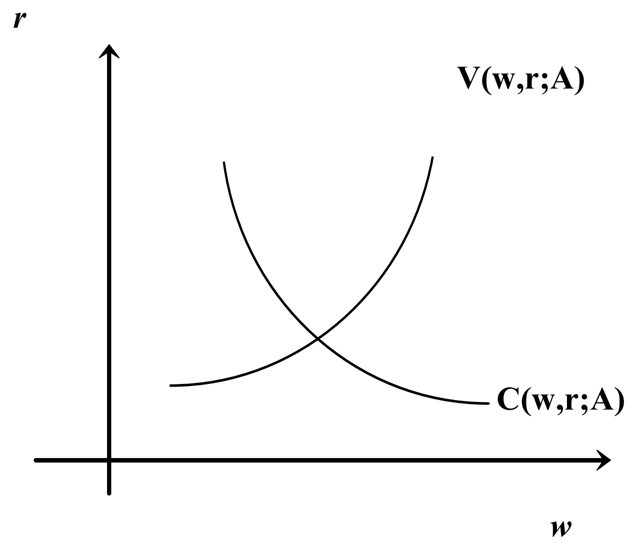

Figure 3-17. The equilibrium model.

For a given level of amenities, A, the equilibrium values of w and r can now be determined at the intersection of the indirect utility curve and the cost frontier.

Assume now that the amenities are unproductive in a world with two regions, 0 and 1, with different levels of amenities, A_0 and A_1, because of differing government environmental restrictions. Here, $A_0 > A_1$. The cost curve and indirect utility curve in Region 1 are to the right, and in Region 0 they are to the left (Figure 3-18). Therefore, given that rent remains constant, the wages must be higher in Region 1 than in Region 0 in order to keep the inhabitants of both regions at the same utility level, k. If not, migration will occur and the geographical differentials of wages and amenities will be zero. Therefore, higher amenities are compensated by lower wages when it comes to regions. Roback (1982) illustrates that the impact of decreased unproductive amenities must be positive on wages, but the impact on rent can be both negative and positive.

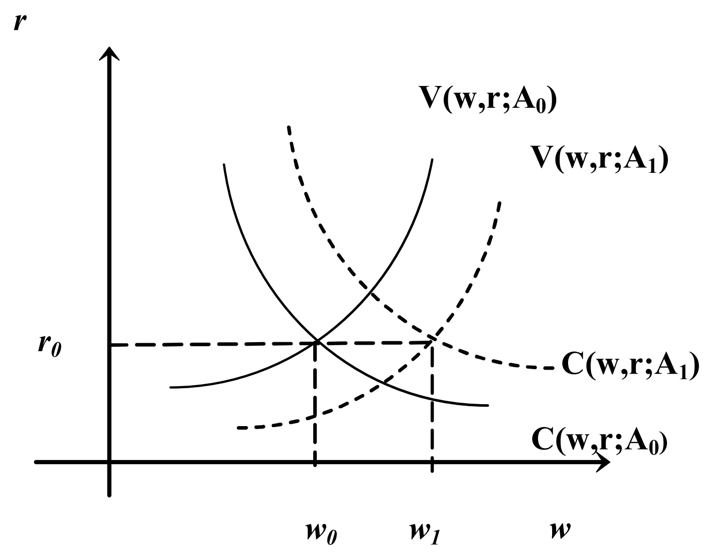

Figure 3-18. The equilibrium model: Stable interregional migration and geographic differentials of wages and amenities.

3.5.2 Harris-Todaro model

This chapter discusses the Harris-Todaro model, which was constructed in order to analyze interregional migration in developing countries and thus the analysis will focus only on unskilled workers. The model is derived in order to discuss the theoretical impact of unemployment and expectations (risk) on interregional migration. In this context, the Harris-Todaro model is in the disequilibrium/equilibrium family.

The present discussion and analysis is based on Harris and Todaro (1970). The model assumes two sectors—agriculture, a, and manufacturing, b—and two regions—the rural area where agriculture is located, noted as Region 1, and the urban area where manufacturing is located, noted as Region 2. Some of the manufactured goods are exported to pay for the agricultural goods. The rural area can trade labour, and if rural employees work in the city, part of the income (in manufactured goods) is sent back to families at home. Part of the urban employment has no rural ties. The industries are perfectly competitive. Unemployment exists.

Harris and Todaro makes eight different technological assumptions for the model. The first assumption regards the agricultural production function:

$$Eq.\ 3.13 \qquad Q_a = q(N_a, \bar{\bar{L}}, \bar{\bar{K}}_a), \qquad \frac{\partial q}{\partial N_a} > 0\ and \frac{\partial q^2}{\partial N_a^2} < 0$$

where output of the agricultural good, Q_a, is a function of rural labour, N_a, land, L, and capital, K. Both land and capital are fixed: $\bar{\bar{L}}$ and $\bar{\bar{K}}$, so labour is the only variable input factor. The assumption regarding marginal production follows the law of diminishing returns, where the first derivative is positive and the second is negative.

The model's second assumption covers the manufacturing production function:

$$Eq.\ 3.14 \qquad Q_b = f(N_b, \bar{\bar{K}}_b), \qquad \frac{\partial f}{\partial N_b} > 0 \text{ and } \frac{\partial f^2}{\partial N_b^2} < 0$$

where manufacturing output, Q_b, is a function of total labour (urban and rural migrants), N_b, and capital, K, and capital is constant, $\bar{\bar{K}}$. Land is not needed for the production of manufacturing goods, so labour is the only variable input factor in the production of manufactured goods. The assumption regarding the marginal production in manufacturing is also according to the law of diminishing returns: $\partial f/\partial N_b > 0$ and $\partial f^2/\partial N_b^2 < 0$.

The third assumption concerns price determination:

$$Eq.\ 3.15 \qquad P = \rho\left(\frac{Q_b}{Q_a}\right), \qquad \frac{\partial \rho}{\partial Q_a} > 0$$

The price, P, which is the price of the agricultural good in terms of the manufactured goods, is determined by the relative outputs of agricultural and manufactured goods. The goods are substitutes, and the price of the manufactured goods is the numeraire; that is, $P_b = 1$. Apparently, price must rise to motivate farmers to increase production, $\partial \rho/\partial Q_a > 0$, which is in line with the assumption of the law of diminishing returns. The farmer must be compensated for increasingly lower marginal productivity $\partial q^2/\partial N_a^2 < 0$, or else the supply will remain constant.

The fourth assumption covers the determination of the agricultural real wage:

$$Eq.\ 3.16 \qquad \omega_a = P\frac{\partial q}{\partial N_a}$$

The real wages in agriculture, ω_a, are the value of agricultural labour marginal productivity in terms of the manufactured goods, where the wages are equal to the product of labour marginal productivity, $\partial q/\partial N_a$, and the price of agricultural goods in terms of manufactured goods, P. Thus, the wages increase either when price increases or when the farmer's productivity increases. This effect occurs for several underlying reasons, including changed consumer preferences and technology improvements.

The fifth assumption regards manufacturing real wages:

$$\textit{Eq. 3.17} \qquad \omega_b = \frac{\partial f}{\partial N_b} \geq \underline{\omega_b}$$

The real wages in manufacturing, ω_b, are equal to manufacturing marginal labour productivity, where producers are assumed to be perfectly competitive. Here, it seems that the wages are dependent only on labour productivity because of the earlier assumption regarding the price of the manufactured goods' being normalized to 1. ω_b stands for the real wage, which is assumed to equal minimum wages, $\underline{\omega_b}$, because the analysis deals only with such cases since new migrants from the rural to urban regions, sent by their families in order to decreases uncertainty in household income, have no experience and skills. This assumption is proper since new migrants, who come as new unskilled labour, will be offered minimum wages. Thus, the manufacturing marginal labour productivity is equal to real minimum wages, or $\partial f/\partial N_b = \underline{\omega_b}$

The sixth assumption concerns expected urban real wages:

$$\textit{Eq. 3.18} \qquad \omega_2^e = \frac{\underline{\omega_b} N_b}{N_2}, \qquad \frac{N_b}{N_2} \leq 1$$

ω_2^e is the product of manufacturing, the real minimum wage, $\underline{\omega_b}$, and the employment share, N_b/N_2. Full employment means that $N_b = N_2$, and unemployment is present when $N_b < N_2$. Increased unemployment decreases the urban expected real wage if the real manufacturing minimum wage remains constant, $\underline{\omega_b}$.

The seventh assumption, which regards labour endowment, is a constraint in which

$$Eq.\ 3.19 \qquad N_a + N_2 = \bar{\bar{N}}_1 + \bar{\bar{N}}_2 = \bar{\bar{N}}$$

The sum of workers employed in agriculture, N_a, and total urban labour force, N_2, must be equal to the sum of the initial stock of workers in the rural area, $\bar{\bar{N}}_1$, and the urban area, $\bar{\bar{N}}_2$. The underlying assumption is that workers in the rural area can migrate to the urban area and can receive wages in terms of manufactured goods, which they send back home to the rural area. That is, if a worker is born in the rural area, then he/she is counted as part of the stock of rural workers, $\bar{\bar{N}}_1$, even though he/she works and lives in the urban area. This feature is an anomaly of the model among interregional migration models since the model is especially constructed for developing communities.

The stock of urban workers, $\bar{\bar{N}}_2$, is made up of proletariats who have no ties to the rural areas, so $N_2 \neq \bar{\bar{N}}_2$, must be due to the in-migration of rural workers to the urban area. Eq. 3.19 can be rewritten as $\bar{\bar{N}}_1 - N_a = N_2 - \bar{\bar{N}}_2$. If manufacturing employment is greater than the number of urban proletariats, $N_2 > \bar{\bar{N}}_2$, the difference must be resolved by rural workers when full employment is $N_a < \bar{\bar{N}}_1$ and $\bar{\bar{N}}_1 - N_a$ rural people live and work in the city. Urban proletariats do not work in the rural area.

The eighth assumption includes the equilibrium condition.

$$Eq.\ 3.20 \qquad \omega_a = \omega_2^e$$

Equilibrium exists when the agricultural real wage is equal to the urban expected wage. The model's central assumption is that rural-urban migration will cease when the equilibrium condition is met. The rural migrants maximize expected utility, and their migration pattern, $\dot{N}_2$, can be described as a function of the equilibrium condition, $\dot{N}_2 = \psi(\omega_2^e - \omega_a)$, where $\dot{N}_2$ is a time derivative, $\partial N_2/\partial t$, of the total urban labour force (permanent urban citizens plus migrants). According to Eq. 3.16 and Eq. 3.18, the model becomes

$$Eq.\ 3.21 \qquad \dot{N}_2 = \psi\left(\frac{\omega_b N_b}{N_2} - P\frac{\partial q}{\partial N_a}\right), \partial\psi/\partial N_b > 0, \qquad \psi(0) = 0$$

Recall that the model assumes unemployment, $N_b < N_2$. Therefore, rural-urban migration occurs if the expected urban wages increase, that is, when unemployment decreases. Rural-urban migration slows down or stops if the productivity of agriculture $\frac{\partial q}{\partial N_a}$ increases. If the price of the agricultural good increases the rural-urban migration decreases.

According to Eq. 3.17, $\omega_b = \partial f / \partial N_b$. Furthermore, Eq. 3.19 can be rewritten as $N_2 = \bar{\bar{N}} - N_a$ and Eq. 3.15 as $P = \rho(Q_b/Q_a)$. Thus, the equilibrium condition, Eq. 3.20, can be rewritten as

$$\textit{Eq. 3.22} \qquad \Phi = \rho(Q_b/Q_a)\frac{\partial q}{\partial N_a} - \frac{(\partial f/\partial N_b)N_b}{\bar{\bar{N}} - N_a} = 0$$

The locus of full employment points is $N_a + N_b = \bar{\bar{N}}$. Therefore, $N_a = \bar{\bar{N}} - N_b$. When $N_a = \bar{\bar{N}} - N_b$ is inserted in Eq. 3.22,

$$\textit{Eq. 3.23} \qquad \Phi = \rho(Q_b/Q_a)\frac{\partial q}{\partial N_a} - \frac{\partial f}{\partial N_b} = 0$$

Since Q_a is a function of N_a, Φ is implicitly dependent on N_a, and Eq. 3.23 can be solved for N_a. Similarly, Q_a is a function of N_b, so Eq. 3.23 can be written as:

$$\textit{Eq. 3.24} \qquad \rho(Q_b/Q_a) = \frac{\partial f/\partial N_b}{\partial q/\partial N_a}$$

This relationship can be interpreted implicitly in terms of migration, $N_a = \bar{\bar{N}} - N_b$. If the productivity in manufacturing increases, the price of agricultural goods must rise to maintain the equilibrium condition when full employment is $(N_2 = N_b)$ and no one wants to move away from the rural areas. If the productivity in manufacturing does not increase, the production of manufacturing goods will increase relative to agricultural goods, and people will migrate from the rural to the urban areas.

Many empirical models have been developed based on the Harris-Todaro framework, and it has been used in several empirical studies among developed countries (Beladi & Marjit, 1996; Butzer et al., 2002; Fidrmuc, 2004; Greenwood & Hunt, 1984; Greenwood et al., 1991; Mueser & Graves, 1995; Pekkala, 2003; Treyz et al., 1993), even though it was constructed to analyze interregional migration in less developed countries. One elegant example is found in Greenwood's (1991) paper. According to Eq. 3.21, interregional migration is dependent on the tension between the wages offered in the regions and unemployment (or expected wages). The contribution of Greenwood et al. (1991) was to establish that

Eq. 3.25

$$[(NLF_{t-1} + ECM_t)/NLF_{t-1}] = f\{[NPV(EI)/NPV(\overline{EI})], [A/\bar{A}]\}$$

where the net migration is the sum of the natural labour force in the previous period, NLF_{t-1}, and economic migration, ECM_t, divided by the natural labour force in the previous period[20]. Economic migration was defined by Greenwood et al. (1991) and Treyz et al. (1993) as the net economic migration of individuals who base their decisions on economic factors, and non-economic migrants in their study include military personnel, U.S. immigrants, and elderly persons (Treyz et al., 1993). The natural labour force is represented by the potential workers (those of a certain age) in the local population, rather than the estimation of the local employment. Economic migration is limited to the net migration of people of the same age, and interregional migration is dependent on relative income and amenities. To capture workers life time earnings, the net present value of income, $NPV(EI)$, is calculated and compared to other regions, $NPV(\overline{EI})$. Local amenities, A, are compared to the domestic average amenity value, $\bar{A}$.

Lifetime earnings are the net present value of expected income in each region, where $\tilde{g}$ is the expected growth rate, $\tilde{\rho}$ is the expected discount rate, and ϕ is the fixed proportion of income required for migrating.

$$NPV_{t_o} = EI_{t_o}\left\{\left[\sum_{t=t_0}^{T} \frac{(1+\tilde{g})^{t-t_0}}{((1+\tilde{\rho})^{t-t_0})}\right] - \phi\right\}$$

Greenwood et al. (1991) assumed that it is possible to estimate expected income with the relative income (the ‘wage bill’), RI, and the natural labour force. Thus, Eq. 3.25 becomes

Eq. 3.26 $$[(NLF_{t-1} + ECM_t)/NLF_{t-1}] = f\{RI, [A/\bar{A}]\}$$

By taking the natural logarithm of both sides, the empirical model becomes

[20] This definition might seem to drop a potential changes in the natural labour force traced back to youth (birth) and elderly (death), but it is probably because its purpose is to reflect a relative rather absolute migration in each area.

$$ln[(NLF_{t-1} + ECM_t)/NLF_{t-1}] = ln\,\alpha + \beta\; lnRI_t + e_t$$

where relative expected income is the only explanatory variable, and the individual constant term, α, captures the local amenities.

Travel distances are not explicitly included in the model, but transportation improvements tend to affect household income, especially when adjacent regions have better access to urban labour markets because of the agglomeration economies. Thus, the marginal impact of transportation improvements can be found by taking the partial derivative of interregional migration with respect to travel distances in Eq. 3.26:

$$Eq.\ 3.27$$

$$\frac{\partial\left[\left(NLF_{t-1} + ECM_t\right)/\,NLF_{t-1}\right]}{\partial d} = \frac{\partial f\left\{RI, \left\lfloor A/\overline{A}\right\rfloor\right\}}{\partial RI}\frac{\partial RI}{\partial d}$$

Relative income, RI, has a positive marginal impact on interregional migration because higher income attracts residents. Therefore, the first term of Eq. 3.27 is positive. Based on the arguments laid out above, travel distance has a negative impact on relative income, so the second term and the entire Eq. 3.27 become negative. Transportation improvements, including those that shorten travel time between cities and smaller adjacent towns, will have a positive impact on interregional migration in towns because of the return on wages through agglomeration economies.

Expectation is a significant contribution of the Harris-Todaro model. The special assumption regarding ties to the rural region is, to some extent, irrelevant assumption in developed nations, but its relevance is comparatively high in Iceland.

3.5.3 Stark's model

Stark's contribution to the Harris-Todaro framework provides a useful perspective on migration behaviour in less developed countries. Stark agreed that rural-urban migration is motivated by wage differentials, the probability of being employed, and urban rural remittances and tried to improve the weak presentation of risk in the standard Harris-Todaro model

(Stark & Levhari, 1982) by lowering the high risk to agriculture by sending a family member to work in the city (Stark & Levhari, 1982).

Stark was first occupied with rural-urban migration (Stark, 1980; Stark & Levhari, 1982; Stark & Lucas, 1988) and then later became more interested in international migration, especially regarding the relationship between rich and poor countries (Stark, 1995; Stark & Fan, 2007). Stark focused on the formation of human capital—the relationship between human capital and interregional migration—in an early model (Stark, 1995):

$$k\overline{w}_{Rich}(\theta^*) > w_{Poor}(\theta)$$

where k is the share of skilled workers in the entire labour force of the rich country ($0 < k < 1$), $\overline{w}_{Rich}$ is the average net wages for skilled workers in the rich country, w_{Poor} stands for skilled worker net wages in the poor country, θ is the workers' skill level, and θ^* is the top skill level migrating. People will migrate from a poor country to a rich one if this relationship holds. The model was constructed under the assumption of different skill levels and asymmetric information.

Stark and Wang (2002) presented a model in which the worker tries to maximize expected net earnings,

$$\widetilde{w}(\theta) = p[\beta\, ln(\theta + 1) + J] + (1 - p)[\alpha\, ln(\theta + 1) + \eta\, ln(\bar{\theta} + 1)] - c\theta$$

where $\widetilde{w}(\theta)$ denotes expected net earnings, θ human capital, and p the likelihood of being offered a job abroad, so p stands for migration in this model. J is earnings other than labour income, such as human capital externalities or welfare benefits, and $\bar{\theta}$ is the economy-wide average level of human capital. α and β are the return on human capital, and η reflects the value of the spillover effects or the externalities of average human capital. The first factor of the function, $p[\beta \ln(\theta + 1) + J]$, is wages in the foreign country, and the second, $(1 - p)[\alpha \ln(\theta + 1) + \eta \ln(\bar{\theta} + 1)]$, is wages in the home country. The last factor, $c\theta$, is the cost of forming human capital. The return of human capital in the foreign region is expected to be higher than its return in the home region, plus the spillover effect, $\beta > \alpha + \eta$.

Stark and Fan (2007) another simple and elegant version of Stark's model for seasonal migration between countries. Here,

$$u = u(x, c) = x - c$$

where u is the breadwinner's utility function, dependent on consumption, x, and the cost of being separated from his/her family, c. Seasonal migration refers to one family member who moves alone to another place for work while his/her family stays behind.

Consider two countries, 1 and 2. The breadwinner spends the fraction t of his/her time working in country 1 and $(1 - t)$ working in country 2. Consequently, his/her total earnings can be expressed as

$$x = I_1 t + I_2(1 - t)$$

where I is the nominal income in the respective countries. Even though the price level in country 1 is higher than the price level in country 2, real income is still higher in country 1. The cost, c, is assumed to be equal to θt^2. Thus, the utility function becomes

$$u = I_1 t + I_2(1 - t) - \theta t^2$$

and the first-order condition returns to workers the optimal choice of migration equal to

$$t^* = \frac{I_1 - I_2}{2\theta}$$

The second-order condition is sufficient. Migration will always exist when $I_1 - I_2 > 0$, it will be seasonal if $0 < t < 1$, and it will be permanent if $t = 1$.

One example of an empirical study based on Stark's contribution was provided by Hoddinott (1994), whose empirical model is

$$m = (age, education, L^{ps}, L^{p}, HHDC),$$

where migration, m, is dependent on age, education, household demographics characteristics, $HHDS$, parents' wages, w_p, and transfers from parents to son, w_{ps}. Land, L, is a proxy variable for wages, w.

3.5.4 Gravity models

Gravity models, which are frequently used in empirical studies on interregional migration (Andrienko & Guriev, 2004; Greenwood & Hunt, 2003; Lin & Christiadi, 2006; Okubo, 2007; Pellegrini & Fotheringham, 2002; Rogers et al., 2002), are based on the gravity law of physics. According to Carrothers (1956), Carey (1865) was probably the first person to explain human interaction using the gravity law of physics. Carey argued that physical and social elements are ruled by the same fundamental law and claimed that, since man is a molecule in society, the law of molecular gravitation is highly relevant in the context of human interactions like interregional migration and trade.

Ravenstein (1885) was probably the first to use a relationship comparable to the gravity model to explain interregional migration. Ravenstein's empirical study suggested that migration favours the largest cities and that migration, which is largest from the localities closest to the city, decreases with distance. This idea may be put forward in the following fashion:

$$m_{ij} = \frac{f(M_j)}{d_{ij}}$$

where migration, m, from location i, to the location j, is dependent on the distance between them, d_{ij}, and the population of the in-migration locality, M_j. According to this model, the population has a positive impact on in-migration, such that the larger the population is, the larger the level of in-migration. In other words, people tend to attract other people. This context is similar to that of agglomeration economies since both the size of the local populations (i, j) and length of travel distance between the relevant localities (i, j) are included. Agglomeration economies increase when the size of the population increases and when transportation costs decrease, so the size of the local population may be a good proxy variable for agglomeration economies. Agglomeration economies result in higher wages and higher capital returns.

According to Carrothers, Young offered a new non-linear version of the model in the 1920s:

$$m_{ij} = k\frac{Z_j}{d_{ij}^2}$$

Here, the relationship between migration and distance is non-linear, and a constant of proportionality, k, is included in the model, while Z_i is called the force of attraction in destination i, and the numerator is an unspecified force of the attraction in destination j. A modern version of the gravity model may be expressed as:

$$\textit{Eq. 3.28} \qquad m_{ij} = k\frac{M_i^{\alpha}M_j^{\beta}}{d_{ij}^{\vartheta}}$$

where α, β, and ϑ denote the unknown parameters that must be estimated. Now, the population in the out-migration destination counts and the power of the distance, ϑ, is variable. A vector of different regional pull- and push-force variables other than the local population can be included in the model (Alonso, 1978). Amenities may therefore easily be added to this model, as in the following:

$$\textit{Eq. 3.29} \qquad m_{ij} = k\frac{M_i^{\alpha}M_j^{\beta}A_i^{\nu}A_j^{\zeta}}{d_{ij}^{\vartheta}}$$

where ν and ζ are unknown parameters. Another interesting version of this model was presented by Phan and Coxhead (2010):

$$I_{j,1} = MAX\{(1 - m_{ij,1})I_{i,0} + m_{ij,1}I_{j,0} - C(m_{ij,1}, m_{ij,0}, d_{ij})\}$$

In this model, a potential migrant maximizes income by choosing to reside in either region i or j in period 1. His/her decision is based on the knowledge he/she has of income, I, in both regions in the present period. A potential migration will entail costs of C, which depend on distance, d, and the migration rate, m, in the present and the next period. Then the cost function is assumed to be

$$C = \bar{C}m_{ij,1}^{\alpha}m_{ij,0}^{\beta}d_{ij}^{\vartheta}$$

where $\bar{C}$ is the indirect migration cost, that is, the part of the migration cost that is not related to the migration rate or distance. The model assumes that $\alpha > 0, \beta < 0,$ and $\vartheta > 0$, so the maximization problem yields

$$m^*_{ij,1} = \left(\frac{I_{j,1} - I_{i,1}}{\alpha \bar{C} m^{\beta}_{ij,0} d^{\vartheta}_{ij}} \right)^{\frac{1}{\alpha - 1}}$$

According to the model, the migration rate for the next period is dependent on the income differentials. If income is higher in region j, migration occurs from i to j. Indirect migration cost, $\bar{C}$, and distance, d, both have a negative impact on migration, and the previous migration rate has a positive impact on migration since $\beta < 0$ because the previous migration refers to the stock of existing migrants and proxies for the migration network that stimulates migration.

The empirical model can be found by taking the natural logarithm of both sides of Eq. 3.28:

Eq. 3.30 $$ln\, m_{ij} = ln\, G + \alpha\, ln\, M_i + \beta\, ln\, M_j + \upsilon\, ln\, A_i + \zeta\, ln\, A_j - \gamma\, ln\, d_{ij}$$

The partial derivative of interregional migration with respect to travel distances reveals a negative relationship (Eq. 3.31), as in the Harris-Todaro model:

Eq. 3.31 $$\frac{\partial m_{ij}}{\partial d_{ij}} = -\gamma G \frac{M_i^{\alpha} M_j^{\beta} A_i^{\upsilon} A_j^{\zeta}}{d_{ij}^{(\gamma - 1)}}$$

Accordingly, the impact of the transportation improvements on interregional migration will be positive.

3.5.5 Core-periphery model: General equilibrium model

The core-periphery model is based on the Dixit-Stiglitz model (1977), which is an advanced general equilibrium model for regions in the presence of monopolistic competition. According to Fujita (2010), a general location theory gathered momentum following the Dixit-Stiglitz model, which is the essence of the New Economic Geography and is the latest contribution of spatial economics. The model can be used to explain migration, both implicitly, as Fujita, Krugman, and Venables (1999) did with a large dynamic general equilibrium model, and explicitly, as Baldwin (2001; 2003) did with a dynamic migration model.

The general equilibrium model includes tension among three forces: market access, cost of living, and a market crowding-out effect. The first force, the market access effect, pulls firms in monopolistic competition toward the largest city, where they gain a larger home market and can export to smaller cities. The cost of living effect attracts labour toward areas with a lower price level, which tend to be larger cities where there are more businesses and competition is more intensive, *ceteris paribus*. The third force, the market crowding-out effect, covers the impact of lower price levels—and thus, lower profits of monopolistic firms following intensified competition—on the likelihood that they will move to another city with fewer firms and a higher price level. Baldwin (2003, p. 10) said:

> According to the core-periphery model (i.e. New Economic Geography theory), the first two forces encourage migration toward the largest cities, and the third encourages migration back to the smaller rural areas. The first two effects have been called the agglomeration force and the third the dispersion force. It has also been pointed out that the agglomeration force is close to what has been called the circular or cumulative causality in earlier theories.
>
> Moreover, endogenous factors, such as changed preferences and technology improvements, shock the local economy and trigger migration. Assume an economy with two regions, south and north, where a net migration is triggered by a technology improvement from the north to the south. According to the force of market access, the oligopoly firms move toward the enlarged market in the south. Therefore, the supply of goods and services increases in the south, competition increases, and prices decrease. These changes attract more migrants to the south because of the cost of living force, and the flow of immigrants will continue until the crowding-out effect kicks in, when lower prices force the industry either to reduce wages or to move to the north for higher prices, causing some employees to move back to the north.

If the agglomeration force dominates the dispersion force, any migration shock would lead to a self-reinforcing cycle, a total extinction of the defending region, and the entire population's locating in the offensive region. However, if the dispersion force dominates the agglomeration force, the migration shock becomes self-correcting. According to the model, the trade cost (transportation cost included) determines the relative strength of these forces —trade cost increases the dispersion force — so if the trade cost is very low or close to zero, the agglomeration force dominates the dispersion force. Accordingly, transportation improvements contribute to the centralization of the population; that is, they contribute to stronger urban areas and weaker rural areas (Baldwin et al., 2003, pp. 10-11). Therefore, a firm of monopolistic competition would not benefit from relocation[21] following increased competition in this example because competition would be intense in both regions because of the absence of trade costs. The firms would stay in the south region and export to the north region as long as it still has inhabitants. The basic version of the core-periphery model is solved by a numerical simulation of the following general equilibrium of eight functions (Fujita et al., 1999):

Eq. 3.32 $$I_1 = \mu v w_1 + \frac{1-\mu}{2}$$

Eq. 3.33 $$I_2 = \mu(1-v) w_2 + \frac{1-\mu}{2}$$

Eq. 3.34 $$G_1 = \left[v w_1^{1-\sigma} + (1-v)(w_2 T)^{1-\sigma}\right]^{1/1-\sigma}$$

Eq. 3.35 $$G_2 = \left[v(w_1 T)^{1-\sigma} + (1-v) w_2^{1-\sigma}\right]^{1/1-\sigma}$$

Eq. 3.36 $$w_1 = \left[Y_1 G_1^{\sigma-1} + Y_2 G_2^{\sigma-1} T^{1-\sigma}\right]^{1/\sigma}$$

Eq. 3.37 $$w_2 = \left[Y_1 G_1^{\sigma-1} T^{1-\sigma} + Y_2 G_2^{\sigma-1}\right]^{1/\sigma}$$

[21] Firm relocation does both include that companies move their location from A to B and that it closes down in A and an another new comparable company is established in B.

Eq. 3.38 $$\omega_1 = w_1 G_1^{-\mu}$$

Eq. 3.39 $$\omega_2 = w_2 G_2^{-\mu}$$

These functions represent the optimal solutions for the industry and the consumers in regions i, where $i \in [1,2]$. They represent the regions' total income, I_i, price level, G_i, nominal wages, w_i and real wages, ω_i. ν is the share of manufacturing labour in Region 1. Accordingly, $1-\nu$ represents Region 2's share of manufacturing labour. If $\nu = 1$, every manufacturing labourer works and lives in Region 1, so the model becomes stable if and only if $\omega_1 \geq \omega_2$ because the manufacturing labourers will not move out of Region 1.

3.5.6 Core-periphery model: Dynamic migration model

Even though the core-periphery model (CPM) is a large equilibrium model in which economic growth is the core concept, Baldwin et al. (2003) developed a simple dynamic migration model based on the CPM as another approach where the household, not the industry, is the core subject. Here, the agglomeration force and the dispersion force are both included in the migration cost, so the model is more in line with Henderson's (1974) approach using the growth of the cities, while the previous version of the CPM is closer to the disequilibrium model, where the industry is the core subject and the household is implicitly included. This model includes all primary features of the CPM, both the agglomeration and the dispersion force, and is easier to solve in a comparative static analysis then was the previous version of the CPM.

The model, first proposed by Baldwin (2001), concerns a typical household facing a choice between migrating from the south to the north or staying where it is. Households in both regions are identical, and they face the following utility maximization problem:

Eq. 3.40

$$\max_{m_i} \int_0^\infty \left[N_i \omega + \left(\frac{1}{F} - N_i \right) \omega^* - \frac{\tilde{\gamma} m_i^2}{2N_i \left[(1/F) - N_i \right]} \right] e^{-\rho t} \, dt$$

where F is the number of households in both regions, ρ is the subjective discount rate, t refers to time, and i refers to the region. Since ω is real wages (or w/P, where P is the price level in the north) at home (north), ω^* is real wages abroad (south), and N_i is the northern labour supply, the first term in the large bracket is the typical household's income from its immobile factor. Real wage indicates utility or the "*index for worker's instantaneous utility*", as Baldwin (2001, p. 32) put it. The parenthesis of the second term stands for the labour share in the south, where the labour share is equal to $N^w/F - N_i$, where $N^W$is the world labour supply that has been normalized to unity. The last term is a migration cost, $c(m_i, N_i)$, a combination of congestion cost, a welcoming committee, and an old-folks effect. The congestion cost reflects the additional cost concerning traffic congestion; that is, there is more time spent on transportation when the community becomes more crowded, $\tilde{\gamma}m_i$. The variable $\tilde{\gamma}$ allows the migration cost to vary.

The welcoming committee effect captures the idea that migration is easier when it has been going on for a while since it is easier to migrate to a region of inhabitants with a similar background. Therefore, the migration cost decreases as migration increases. In this case, the cost of south-to-north migration falls as the stock of southerners in the north rises, or $1/N_i$. The old-folks effect reflects resistance, as people leave something valuable behind when they migrate; the old-folks effect (or cost of resistance) can be high for an individual who has a large family and many friends and higher for individuals who had a pleasant childhood in their original location than who did not. Therefore, the cost that is due to the old-folks effect is lower for the first migrant than the second, if all other costs are equal. Thus, the cost from of the old-folks effect increases with fewer southerners, noted formally by $(1/[1/F - N_i])$.[22]

The third factor of Eq. 3.40 consists of the product of all three elements of the migration cost. The migration cost includes effects comparable to both the agglomeration and the dispersion force, the congestion and the old-folks effect capture the dispersion force, and the welcoming committee affect captures the agglomeration force.

The maximization problem is subject to the following constraint:

[22] $[1/F - N_i]$ stands for the number of northerners who work in the South, since N^w has been normalized to unity.

$$Eq.\ 3.41 \qquad \dot{N}_i = m_i$$

The time derivative of northern labour supply, $\dot{N}_i$, is equal to northern net in-migration, m_i. The present derivation follows the steps of Neher (1990, p. 170) such that the present value of the Hamiltonian function becomes

$$Eq.\ 3.42$$

$$H = \left[N_i\omega + \left(\frac{1}{F} - N_i \right)\omega^* - \frac{\tilde{\gamma} m_i^2}{2N_i\left[(1/F) - N_i\right]} + Wm_i \right] e^{-\rho t}$$

where W is the co-state variable that captures the asset value of migration[23]. Let $\partial W/\partial t = \dot{W}$. Three first-order conditions occur: the maximum principle (MP), the portfolio balances condition (PB), and the dynamic constraint (DC):

$$Eq.\ 3.43 \qquad (MP)\frac{\partial H}{\partial m_i} = \frac{\tilde{\gamma} m_i}{N_i\left[(1/F) - N_i\right]} = W_t$$

$$Eq.\ 3.44 \qquad (PB)\frac{\partial H}{\partial N_i} = \dot{W} = \rho W - \left(\omega - \omega^* - c_{N_i}\right);$$

$$\text{where} \qquad c_{N_i} = -\frac{\tilde{\gamma} m_i^2\left(\frac{2}{F} - 4N_i\right)}{\left(\frac{2N_i}{F} - 2N_i^2\right)^2}$$

$$Eq.\ 3.45 \qquad (DC)\frac{\partial H}{\partial W} = \dot{N}_i = m_i$$

where $\dot{N}_i = \partial N_i/\partial t$. Baldwin included a classical endpoint condition, $\lim_{t\to\infty} e^{-\rho t} W m_i = 0$, which has no practical impact on the problem's solution. The endpoint condition reflects that the asset value is zero at the far end of an infinitely long period of time. No value is

[23] Comparable to λ (the shadow price) in the standard analysis.

transferable between regions by the inhabitants in the final year of the period; everything is consumed.

To reach a synthesised dynamic system of necessary conditions for optimal migration, the first-order conditions have to be united. Initially, Eq. 3.43 can be rewritten as

$$m_i = \frac{WN_i(1/F - N_i)}{\tilde{\gamma}} \qquad \textit{Eq. 3.46}$$

When multiplied by $\frac{F}{F}$, Eq. 3.46 becomes

$$m_i = \frac{WN_i(1 - FN_i)}{F\tilde{\gamma}} \qquad \textit{Eq. 3.47}$$

From it which follows (Eq. 3.45)

$$\dot{N}_i = \frac{WN_i(1 - FN_i)}{F\tilde{\gamma}} \qquad \textit{Eq. 3.48}$$

Eq. 3.48 can be simplified. Assuming household symmetry, north stands for a representative region and the, i, notation for the northern labour supply can can be dropped, $N_i = N$.[24] Since world labour supply, N^w, is normalized to unity and thus the northern labour supply, N, is a share noted by n_N, the number of households can be normalized to unity as well, $F = 1$, so $n_N = FN$ and thus $N = n_N = FN$.[25] Let $\partial n_N/\partial t = \dot{n}$. Finally, let $\gamma = F\tilde{\gamma}$, and the aggregate migration equation becomes:

$$\dot{n}_N = \frac{Wn_N(1 - n_N)}{\gamma} \qquad \textit{Eq. 3.49}$$

where n_N is a share of world labour in the north, or N/N^w, where N^w stands for the world labour supply. Now it is convenient to include the second FOC with the first and the third. Eq. 3.44 can be simplified.

[24] By household symmetry the household are identical in numbers in both regions and the notation, i, can be dropped.

[25] F stands for all household while not necessary all of them are part of the labour supply, N, and thus $0 \leq N \leq F$ and thus $0 \leq n_N \leq 1$.

If neither the welcoming committee nor the old folks effect is time-dependent, as in Baldwin (2001), it follows that $c_{N_i} = 0$. Eq. 3.44 can then be rewritten as:

$$\text{Eq. 3.50} \qquad \dot{W} = \rho W - (\omega - \omega^*)$$

Eq. 3.50 assumes that migrants have rational forward-looking expectations. However, if the migrants are myopic, their expectations become static, and Eq. 3.50 becomes

$$\text{Eq. 3.51} \qquad 0 = \rho W - (\omega - \omega^*)$$

Or

$$\text{Eq. 3.52} \qquad W = (\omega - \omega^*) / \rho$$

Finally, by inserting Eq. 3.52 into Eq. 3.49, the household optimal migration behaviour in the dynamic model can be written as:

$$\text{Eq. 3.53} \qquad \dot{n}_N = \frac{n_N(1-n_N)(\omega - \omega^*)}{\gamma\rho}$$

If Eq. 3.53 is equal to zero, then the steady state[26] of the equilibrium is obtained, and no one will migrate; if Eq. 3.53> 0, then it is favourable to migrate from the south to the north; and if Eq. 3.53 < 0, then a north-to-south migration is favourable.

Migration is dependent on wages. If wages, ω, increase in the north Eq. 3.53> 0 and south-to-north migration becomes attractive, *ceteris paribus*. If wages, ω^*, increase in the south Eq. 3.53< 0 and north-to-south migration becomes attractive, *ceteris paribus*.

The rate of migration to the north, $\dot{n}_N$ is dependent on the population in the north (or the share of the world population in the

[26] *Steady state* is a long-run equilibrium that includes accumulation and technical change (dynamics) (Eatwell et al., 1987 1987, p.626). The same understanding is in Dornbush and Fischer (1990) but is coloured by a macroeconomic point of view. Bannock, Baxter, and Davis (1972) state that steady state growth is *"a feature of an economy in which all variables grow (or contract) at a constant rate.... If these rates are maintained indefinitely, steady state growth exists".*

north, n_N). However, this process is not infinite because $\partial \dot{n}_N / \partial n_N > 0$ and $\partial^2 \dot{n}_N / \partial n_N^2 < 0$ .The initial migration will fuel itself until a certain level is reached, at which point the cost from the old-folks effect and the traffic congestion will dominate the benefit of the welcoming committee effect, and the migration will stop, *ceteris paribus*. Therefore, if transportation improvements are successful and traffic congestions are less frequent, the south-to-north migration becomes more extensive. This result is in line with the previous version of the CPM.

Migration is also dependent on the direct migration cost, γ. When migration cost increases, the household becomes less willing to migrate, *ceteris paribus*.

According to Eq. 3.53, the discount rate, ρ , discourages migration. The exact value of the discount rate is assumed to be equal to or larger than zero and equal to or less than one: $0 \leq \rho \leq 1$.

According to Baldwin et al. (2003), the CPM and related models have several disadvantages. Firstly, the role of inhabitants' expectations is neglected. Secondly, the models are difficult to test empirically and must be analysed with a numerical simulation. Thirdly, the framework of these models "*is unable to investigate the impact of different own and cross elasticity's on firm's location"* (Baldwin et al., 2003, pp. 110-111). Finally, an unrealistic assumption of the iceberg cost exists, where the trade cost increases automatically following an increase in prices.

Ottaviano (2002) developed an alternative quasi-linear framework that does not include this imperfection while retaining the major characteristics of the core-periphery model. Ottaviano's framework adds housing prices to the previous version (Baldwin et al., 2003, p. 129):

Eq. 3.54
$$\dot{n}_N = [(\omega - R) - (\omega^* - R^*)](1 - n_N)n_N$$

where $(\omega - R)$ and $(\omega^* - R^*)$ are "the northern and southern indirect utility levels of commuting and land costs" (Baldwin et al., 2003, p. 129). The results concerning transportation improvements are identical in Ottaviano's model to those in Baldwin (2001) and Fujita, Krugman, and Venables (1999). All three models tend to centralise the residents in a community of two regions.

The core-periphery model's contribution is the dynamic aspect of migration, especially how migration is dependent on the local population.

Moreover, CPM drops the assumption regarding competitive markets in favour of assuming that markets are characterized by monopolistic competition, which is closer to reality. The most remarkable contribution of CPM is that it suggests that transportation improvements between the two regions do not contribute to geographically dispersed residents, as the equilibrium model suggests.

3.6 Housing market and interregional migration

Based on the core-periphery model, Baldwin et al. (2003) argued that the relationship between interregional migration and housing prices is endogenous: in-migration influences housing prices positively and housing prices have a negative effect on migration. The disequilibrium, the equilibrium, and the Harris-Todaro models allow for the influence of housing prices implicitly through household income such that higher housing prices reduce real wages and trigger out-migration.

To explain the relationship of the housing market and interregional migration, we divide the economy into three areas: an urban, an intermediate, and a rural area. The intermediate area[27] is adjacent to the urban area, within approximately 120 kilometres from the city centre, and the rural area is beyond the intermediate area. The conurbation area consists of the urban and intermediate areas. The relationship of housing prices and interregional migration in the conurbation area begins with transportation improvements, including shortening distances between the city and the intermediate area, making travel cheaper so it becomes favourable to commute from locations that are more distant. There are two types of effects: one concerning the residents of the city and another the inhabitants of the intermediate area affecting. Firstly, better and cheaper access to a city's labour market increases the probability that the intermediate areas' inhabitants will get more jobs that are more interesting and pay higher wages, increasing agglomeration economies. Secondly, the local price level will also decrease because of the lower transportation cost. Accordingly, the probability for outward migration near the fringe of the conurbation area decreases, and decreases negative pressure on local housing prices.

[27] Definition: the intermediate area is the capital areas' "collar". Municipalities of the conurbation area apart from the capital area: intermediate area = conurbation area minus the capital area.

According to Murata and Thisse (2005), workers are mobile and tend to commute for work. When transportation cost decreases, they can alleviate the cost of living in an urban area by residing in more dispersed areas. For a city's residents, transportation improvements make distant towns available, as the increased transportation costs are compensated with lower housing prices. This situation increases the probability of migration into the intermediate area and moves the fringe of the conurbation area farther out, as suggested by the theory concerning counterurbanisation. Thus, the demand for housing increases in the intermediate area, and the housing prices increase. The migration to the intermediate areas will stop when the housing prices no longer compensate for the commuting cost from the intermediate area to the city centre.

In light of the obvious fact that real wages are affected by changes in the price level, the relationship between housing prices and interregional migration in the rural areas is connected only through real wages (RI). The reason is that housing prices are included in the local price level. The partial derivative of interregional migration with respect to housing prices in Eq. 3.26 provides the formal interpretation of its relationship:

Eq. 3.55

$$\frac{\partial\left[\left(NLF_{t-1} + ECM_t\right)/ NLF_{t-1}\right]}{\partial h} = \frac{\partial f\left\{RI, \left[A / \overline{A}\right]\right\}}{\partial RI}\frac{\partial RI}{\partial h}$$

The first term is positive, and the second term is negative, so the relationship is negative, as expected, suggesting that transportation improvements facilitate a migration into an intermediate area.

Part I

4 The relationship of housing prices and transportation improvements: Location and marginal impact.

4.1 Introduction

Does travel distance have an impact on housing prices in a sparsely populated country? Iceland is an interesting subject for this question because it is large but sparsely populated, it is geographically isolated, it has one single central business district (CBD), and a data sample for the entire country is available for a long period of time. This paper examines this relationship by a fixed effect panel data model in order to capture the pure effect of transportation improvements in this country and to test whether location makes any marginal difference to the results – that is, whether proximity of municipalities to CBD change the benefit from transportation improvements.

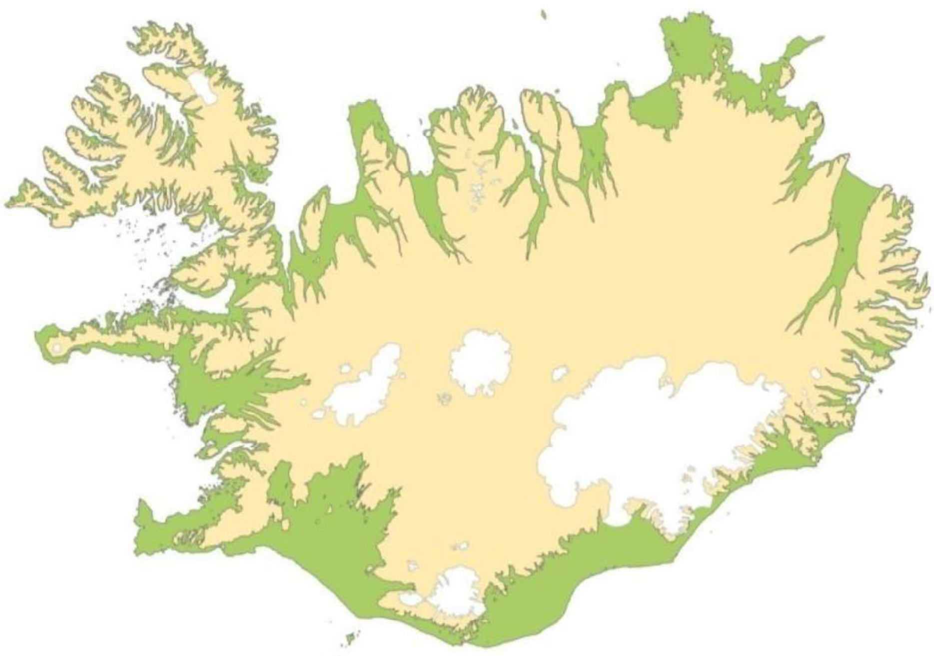

Figure 4-1. Lowland of Iceland

Lowland is defined as land with an elevation of 0-200 metres above sea level (green shaded area). Source: National Land Survey of Iceland

Iceland is an island of 103,000 km^2 in the North Atlantic Ocean. A large part of Iceland (principally the highlands) is not suitable for people to live in due to the harsh climate, especially during the winter. Thus, relatively few of Iceland's inhabitants live more than 200 metres above sea level. Only 24,700 km^2 of Iceland's land area is below 200 metres above sea level[28] (Figure 4-1); the higher elevations are mostly in the centre of the island. The population was fairly evenly distributed on the lowland (Figure 4-1) until the beginning of the late 19th century, when a relatively large and steady flow of migration 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. This includes Reykjavík, the largest town in Iceland, with 113,000 inhabitants; Kópavogur, the second largest, with 25,800; 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 northern coast. In total, there were 300,000 inhabitants in Iceland in January 2006.

Table 4-1. Size and location of towns in Iceland - December 2005.

Town's population	Total	South coast	West coast	North coast	East coast
Population of 0-500	60	13	19	18	9
Population 501-1,000	17	5	3	4	3
Population 1,001-10,000	25	13	5	4	5
Population >10,000	4	3	0	1	0
Total	105	34	27	27	17

Source: Statistics Iceland

The towns and villages outside the capital area are still evenly spread around the coastline as they did in the earlier stages of the urbanisation of Iceland (in late 19th century), but they now have fewer inhabitants in total than do the four largest towns of Iceland (Table 4-1). Many farms have been completely or partly abandoned. The remaining population centres are small. Note that, Iceland is a very sparsely populated country compared to other European countries, even though the size of lowland is only included in the calculation.

Although, there are approximately 100 towns and villages in Iceland (Table 4-1), the capital area is the only business centre that is large

[28] 43,100 km^2 of Iceland's land mass is at an elevation of less than 400 metres.

enough to have been able to offer a wide variety of goods and services. Therefore, access to the capital area brings benefits to the residents of rural Iceland. Since public transportation in rural Iceland is very limited, inhabitants rely on their own vehicles. Several types of export industries, evenly dispersed in the rural area, are dependent on speedy and efficient transportation, such as tourism, agriculture, and the fishing industry. Thus, the transportation system appears extremely important to the Icelandic economy, especially in order to improve local scale economies. However, travel in Iceland has long been very hazardous. A harsh climate, high mountains, deep fjords, and bad roads have made for poor travel conditions. Icelandic roads have been primitive compared to those in other European countries. But transportation improvements over the past 25 years have been considerable (Table 4-2 and Table 4-3). It is very interesting to investigate how valuable improved access to the capital area has been to the residents of rural Iceland. Many wide rivers, along with other characteristics of the landscape and a limited road works budget, have made Iceland's road network unusually circuitous. Furthermore, narrow gravel roads have been the most common type of thoroughfare until recently, especially in the rural areas. As a result, transportation improvements in Iceland have generally aimed at shortening distances (Table 4-3) by building larger bridges and tunnels, as well as making roads safer by replacing gravel surfaces with pavement[29], rather than building expressways and increasing the number of lanes, as in other developed parts of the world.

According to Fujita and Thisse (2002, pp. 78-91), McCann (2001), and Fujita (1989), the price of land and real estate is highest in city centres and decreases with every unit of distance from city centre. Thus, when some areas are pulled closer to the city centre through an improvement in transportation, the land values 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 areas. The formation of the bid-rent curve is sometimes called the distance gradient.

[29] According to the Icelandic Road Administration and Statistics Iceland, only about 800 km of state-administered roads were paved in the year 1981, rising to 4,400 km at the beginning of the year 2007, or approximately 50% of major and collector roads.

Table 4-2. Transportation improvements 1981–2006.

All values are in kilometres except for bridges which are counted. Source: Icelandic Road Administration.

Type of transportation network	1981	2006	Difference	Relative difference
Total length of roads	11602	13058	1456	13%
Paved roads	814	4397	3583	440%
Tunnels	1.5	27	25.5	1700%
Bridges	1298	1221	-77	-6%

All values are in kilometres except for bridges which are counted. Source: Icelandic Road Administration.

According to Baldwin et al. (2001; 2003), transportation improvements lead to higher local housing prices in the peripheries affected due to the increased demand which follows in the wake of lower transportation costs, and the improved access they offer to the labour market and the markets for goods and services. Baldwin et al. (2001; 2003) used the core-periphery model in their analyses, which Krugman (1991b), as cited in (Baldwin et al., 2003), has called the core of the new geographical economics. However, in this article, the relationship between transportation improvements and housing prices will be investigated on the basis of 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. Tyrvainen 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 sparsely populated country such as Iceland.

The research question of this article is as follows: Do transport improvements between conurbation and periphery areas and the capital area affect the local price of houses? This could also be phrased as follows: *Do rural areas benefit from better access to relatively large urban areas due to an improved transportation system?* This will be tested by an estimation of the distance gradient in Iceland. It is also interesting to investigate whether the reason benefits vary for the CBD's adjacent municipalities than in municipalities farther away is because of potential access. Thus, another research question will be addressed: *Is there a marginal difference between the impact of transportation improvements 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 to the recent literature in spatial economics, and discusses the construction of the research question. Section 2 contains a 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 consists of a summary and concluding remark.

4.2 Literature review

Many studies have documented the relationship between local housing prices and travel distance between the houses in question and some desirable or undesirable phenomenon, such as central business district CBD, an attractive view, or a 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, such as Gibbons and Machin (2005) Machin (2005) evaluated the benefits of railway access in London by looking at housing prices. Their general finding was that housing prices rose by 9.3% following transportation improvements of this kind. Comparable conclusions were presented in a very similar study by Bae et al. (2003) of 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 centre. Bowes and Ihlanfeldt (2001) studied the impacts of railway transit stations on residential property values; the results were very different from station to station due to the wide range of positive and negative externalities, such as retail service and criminal activity.

Several empirical studies have documented the impact of travel distance to the CBD on local housing prices. Empirical studies devoted to researching the effects of access improvements from large outlying areas to a relatively strong CBD were not easily found. However, Archer et al. (1996) explored such a topic using data from Dade County Florida (which contains the city of Miami). 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 estimating the economic impact 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's centre 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 housing prices. The study was based on primary source data from the six largest metro areas in Ohio (Haurin & Brasington, 1996, p. 356). School quality, along with arts and recreational opportunities, was found to have positive influence on real estate prices. The crime rate was however found to have a negative influence on housing prices (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. the area which is 12 to 20 miles distant from the city centre. My study seems to be most comparable to McMillen's (2003) study, in which the researcher evaluated the return of centralization in Chicago using a repeat sales model, and concluded that housing 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 housing prices can be explained by differences in new construction, demographic variables, manufacturing employment, proximity to downtown, and aggregate school enrolment. In another investigation of spatial variation in 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 kilometre 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 between housing prices and travel distances for a large area around a relatively strong CBD were not as easily found as expected. The studies listed above are the closest matches. My study is different from previous studies in five ways. First and foremost, no study has investigated the spatial disparity of the marginal impact of transportation improvements on local housing prices. Secondly, an analysis of the distance gradient covering data sample from an entire country is an exception within the literature and has never been implemented on a panel data sample before. Thirdly, the fixed effect model has never been implemented before in order to separate the impact of CBD's proximity to rural localities from their own local amenity values. Fourthly, no study has focused on a sparsely populated country such as Iceland and the question of whether this relationship will be significant, given the circumstances. Finally, Iceland is, among islands, an unusually isolated geographically.

4.3 The model

The empirical model is based on von Thünen's theory of land rent, extended by Alonso (1964), Mills (1972), Muth (1969), and Evans (1973, p. 6) 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 chapter 3.3.2. According to Fujita (1989, pp. 16, 26) and Kiel and McClain (1995a, pp. 314-315), the general context from the basic model in Eq. 3.5 can be derived through a log linear utility function into an equation of the following form:

$$Eq.\ 4.1 \qquad h(d) = Ae^{-bd}$$

where h is the land value, d 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. 4.1 becomes

$$Eq.\ 4.2 \qquad \ln h(d) = \ln A - bd$$

This equation has been frequently used in various versions in house price research. Furthermore, it is the most common form of the equation 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 (1996, p. 148), Kiel and McClain (1995a, p. 319; 1995b, p. 248), and Haurin and Brasington (1996, p. 356). The equation describes a non-linear relationship of the semi-logarithmic type. Instead of estimating a simple model as follows,

$$lnh_{it} = \alpha_i + d_{it}\beta_1 + \varepsilon_{it}$$

economists frequently implement an extended model,

$$lnh_{it} = \alpha_i + d_{it}\beta_1 + cz'_{it} + \varepsilon_{it}$$

where z'_{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 (Archer et al., 1996; Cunningham, 2006; De Bruyne & Van Hove, 2006), demographics (Case & Mayer, 1996), population density (De Bruyne & Van Hove, 2006; McDonald & Osuji, 1995), the 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 lot size (Cunningham, 2006; Kiel & McClain, 1995b; McMillen, 2003), house age (Archer et al., 1996; De Bruyne & Van Hove, 2006; Kiel & McClain, 1995b; McMillen, 2003; Tyrvainen & Miettinen, 2000), indicators for house building material and type of construction (McMillen, 2004; Tyrvainen & Miettinen, 2000), number of rooms (Kiel & McClain, 1995b), number of bathrooms (Kiel & McClain, 1995b), number of storage areas (McMillen, 2003, 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, 2004).

Furthermore, local economic factors can be among the relevant explanatory variables, such as 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, for example the presence of a lake or an attractive view (Cunningham, 2006; De Bruyne & Van Hove, 2006; Kiel & McClain, 1995b; Tyrvainen & Miettinen, 2000), arts and recreational opportunities (Haurin & Brasington, 1996, p. 351), any kind of local dangers (Cunningham, 2006), and crime rate (Haurin & Brasington, 1996).

However, standard panel data models, such as fixed- and random effect models, generally return more efficient estimators than pooled ordinary least square (POLS) models. Furthermore, since the relationship of local housing prices and transportation improvements is the present focal point, the fixed effect model is more appropriate where the variable coefficient returns a within individual variation or the time variation and returns the between individual variation into the individual constant term. Thus, it is reasonable to apply the following fixed effect empirical model,

$$\text{Eq. 4.3} \qquad lnh_{it} = \alpha_i + d_{it}\beta_1 + z'_{it}\beta_2 + v'_{it}\beta_3 + \varepsilon_{it}$$

where the natural logarithm of house price, h, is dependent on the distance, d, to the capital area, or CBD, several other explanatory variables, z', dummy variables, v', and relevant residuals, ε, of every municipality, i, in every single period, t. Note that α_i is the individual constant term.

Another version of the model could be more appropriate to the data sample than the semi-logarithm version. It is a model of quadratic distance version, which has been implemented at least once before by McDonald and Osuji (1995). The model is as follows:

Eq. 4.4 $$lnh_{it} = \alpha_i + d_{it}\beta_1 + d_{it}^2\beta_1 + z'_{it}\beta_2 + v'_{it}\beta_3 + \varepsilon_{it}$$

The model is identical to the semi-logarithm model except for an additional variable for quadratic distance, d_{it}^2. The reason for this additional variable is that it is possible for it to have a different marginal impact with respect to location because proximity to the CBD is generally more valuable to population near the downtown area of the city than to those living farther away. Furthermore, it is even possible that the population farther away dislikes the quality of cities and prefers the amenity values offered in rural areas.

It is possible that the presence of Akureyri which is approximately 300 km away from the capital city makes the implementation of the traditional version of the empirical model inappropriate. Even though Akureyri cannot be considered a populous town in comparison with towns on the European continent, it is the largest centre outside the capital area and there is no other town in the rural area of Iceland close to Akureyri in population. Thus, it is a strong or a significant centre for the north coast of Iceland, called the capital of north Iceland among Icelanders. Therefore, the housing price of Akureyri is likely to be extraordinary high with respect to distance from CBD and cause an unusual u-turn to the bid-rent curve. Thus, the quadratic distance model (QDM) of polycentric version can be more appropriate choice.

In this version of the model, the distance from Akureyri, a, is included. In order to construct a polycentric model, to make it possible to detect potential different marginal impacts, two distance variables were constructed for each centre to every municipality, Reykjavík s and Akureyri u where the actual value becomes valid if it reflects a closer centre and zero otherwise: If $d < a$ then $s = d$, else $s = 0$, If $d > a$ then $u = a$, otherwise $u = 0$.

Furthermore, the model had to reflect the fact that the larger centre, Reykjavík, might have some marginal impact towards municipalities closer to the second largest centre, Akureyri. Thus, a specific variable, e, was constructed to include additional distance: If $d > a$ then $e = d - a$, otherwise $e = 0$. This is almost completely comparable to the previous work of Partridge, Rickman, Ali, and Olfert (2009, p. 451). Thus the quadratic distance version of the polycentric model becomes as follows:

Eq. 4.5

$$lnh_{it} = \alpha_i + s_{it}\beta_1 + s_{it}^2\beta_2 + u_{it}\beta_3 + u_{it}^2\beta_4 + e_{it}\beta_5 + z'_{it}\beta_6 + v'_{it}\beta_7 + \varepsilon_{it}$$

Total household income, housing characteristics, housing supply and population are other explanatory variables than distance variables. There are two dummy variables, one for three municipalities on the east coast and another for municipalities closer to Reykjavík than Akureyri, having the value 1 if Reykjavík is closer to municipalities and 0 else. The dummy variable for three municipalities on the east coast is intended to reflect the fact that an unusually large-scale local investment project has been in progress there since 2003, i.e. a large hydroelectric plant and an aluminium smelter.

This model (Eq. 4.5) is suitable for the evaluation of the relationship between housing prices and transportation improvements, because the distance parameters, s , u , and e, captures the relative influence of the respective factors on housing prices, and the data used to represent distance is the length of the roads between the centre of each municipality and the centre of the two CBD’s, expressed in kilometres (further description of the data is in the next section). Thus, the distance parameters reflect the relative influence of single unit road shortening on the real unit price of houses, *ceteris paribus*. Furthermore, note that this evaluation is limited to transportation improvements which involve a reduction in driving distance.

4.4 Data

The data for this analysis comes from Iceland and covers the annual average numbers of all Icelandic municipalities from 1994 to 2006. Iceland is divided into 79 municipalities in this paper. However, there has been a trend towards increasing the size of municipalities by amalgamation in recent years. Therefore the data has been transformed into one identical sample of municipalities completely comparable to the situation in the year 2006.

Data

The data on housing prices[30] in this study come from the Land Registry of Iceland. The explanatory variables included in Eq. 4.5 are drawn from various sources, including the Commissioner of Inland Revenue, Statistics Iceland, and the Icelandic Road Administration.

Data on road distances was obtained from Fjölvís Publishing Company, but was originally collected by the Icelandic Road Administration. This is the most central explanatory variable of present study, where transportation improvements lead to shorter distances between locations. It will, however, not cover all types of transportation improvements because many such improvements lead to the shortening of the time spent in travelling without changing the travel distance.

All information on homes, such as age and size, was obtained from the Land Registry of Iceland, along with house price data, as mentioned before. The data on population and total income were obtained 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 variables. Data on population is for December 1 of each year, and data on road distances for January 1 each year. The data series were spatially classified by municipality, except data on road distance. Data on road distance was classified by locality. The data series were then transformed to relate to municipalities rather than localities.

The data for the supply of houses were determined by the total number of houses divided by local population. This was found to be appropriate because in Iceland the variation in local population in different municipalities is quite large, and therefore the expected marginal impact of each additional dwelling is also quite large and variable.

Total income per capita is given for each municipality. It is based on total taxable income in each municipality divided by the number of tax payers. The amounts have been corrected for inflation.

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[30] The Land Registry of Iceland collected these data from the original source: written contracts between housing 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 over a certain period. Both the duration and number of payments vary substantially from contract to contract. In order to make housing price data more comparable, the Land Registry of Iceland calculates a so-called cash price for every contract. This is, in fact, the present value of the contract price. The dependent variable in this chapter is the cash price.

The variables for house characteristics represents only sold houses in each municipality. Their values are divided by number of sold dwellings in order to improve comparability.

Table 4-3. Variable description and sample statistics.

Variable (acronym)	Description	Mean	Standard deviation
Road distance Reykjavík (RDIR)	Average distance in kilometres between municipalities and Reykjavík, in absolute terms	96.94	136.51
Road distance Akureyri (RDIA)	Average distance in kilometres between municipalities and Akureyri, in absolute terms	64.40	110.86
Marginal road distance Reykjavík (RDRM)	Additional average distance in kilometres between municipalities and Reykjavík, in absolute terms	124.76	173.51
Marginal road distance Reykjavík (RDRM)	Dummy variable for splitting municipalities, 1 for being closer to Reykjavík than Akureyri.	0.62	0.49
Housing price (HOPR)	Real price of housing, in Icelandic krónur	10,300,000	5,430,470
Total Income (TINC)	Total income per capita, in thousands of Icelandic krónur	2,327.53	744.86
Housing age (HAGE)	Average age of houses sold, in absolute terms	31.86	12.81
Housing size (HSIZ)	Average size of houses sold, in square metres	152.77	69.59
Number of dwellings (HONR)	Average number of dwellings in each house	1.02	0.08
Dwelling's floor (HOFL)	Average number of floor, reflecting the dwellings position in heights from the ground	1.59	0.61
Rooms pr. dwelling (HORO)	Average number of rooms pr. dwelling	3.44	0.96
House building material wood (HOM6)	Share of dwellings where wood is outwall's building material	0.23	0.26
Balcony size (HOBA)	Average size of balcony, in square metres	2.33	3.57
Parking/Garage (HOPA)	Share of dwellings where either parking place or any type of garage is included	0.44	0.27
Lot size (HOLO)	Average size lots, in square metres	594.86	441.30
Population (POPU)	Municipality population, in absolute terms	3,581.42	12,748.14
Aluminium East Coast (ALEA)	Large scale local investment. New aluminium smelter on the east coast of Iceland	0.01	0.09
Supply of houses (HNPP)	The supply side is represented by the local number of houses divided by number of inhabitants.	0.39	0.07

The data in this table, i.e. mean and standard deviation, is based on annual averages transformed by means of Eq. 4.5.

The averages and the standard deviation of the explanatory variables as well as of the dependent variable show considerable variation (Table 4-3). The standard deviation of housing prices is approximately 1/2 of the mean and, of road distance much higher. This is evidence of large differences which show potential for robust explanations. However, this panel data sample is an unbalanced one since observations for several variables are missing.

4.5 Estimation results

The empirical model was set forth in chapter 4.3 (Eq. 4.4). Two versions of a fixed effect model will be tested, the semi-logarithm type (SLM) and the quadratic distance type (QDM). The analysis is divided into those two separate models in order to demonstrate the different effect of road distance on the nearest municipalities and the rest of the country and, thus, emphasize the diminishing marginal return of the transportation improvement's benefit with respect to distance. This could be rephrased by claiming that the relationship between an urban area and its adjacent regions is different from its relationship with regions further away. The results are presented in Table 4-4, including parameter coefficients, t-value, number of observations, n, R square, F-value, and special t-statistic for testing serial correlation in panel data, as recommended by several authors, such as Wooldridge (2002, pp. 176-177) and Verbeek (2004, pp. 108-110).

The result of the SLM returned an unexpected significantly positive sign on the estimator, truly because of the presence of Akureyri, which is approximately 300 km away from the capital city. Therefore, the housing prices in Akureyri are likely to be extraordinary high with respect to distance from CBD and to cause an unusual u-shape in the bid-rent curve. Therefore, the quadratic distance model (QDM) seems to be a more appropriate choice. Initially, the estimate suffered from serial correlation, which was sufficiently eliminated by a lagged variable of the residual, a method recommended by Wooldridge (2002, pp. 176-177) and Verbeek (2004, pp. 108-110). Multicollinearity was not observable in the results. The presence of endogeneity was tested against total income, and the hypothesis was rejected. Theoretically, total income affects housing prices, and housing prices tend to decrease total income in real terms through the price level. Heteroskedasticity was present and corrected by running a model of robust estimation. In the final version (Model 2), no problems were detected except for the normal distribution of the residuals, as confirmed by the Jarque-Bera test. The test statistic is equal to 6049, largely because of high kurtosis

Table 4-4. Relationship between housing prices and transportation improvements. A fixed effects panel data model comparing two approaches: a monocentric model in semi logarithm (SLM) and a quadratic distance (QDM) version.

Variable (acronym)	Model 1 Fixed effect SLM.	Model 2 Fixed effect QDM
Total Income (TINC)	0.000043 (1.57)	0.000049 (1.86)
Road distance Reykjavík (RDIR)	0.003452 (5.86)	-0.002890 (-3.24)
Road distance Reykjavík sq. (RDIR^2)		0.000008 (7.66)
Housing age (HAGE)	-0.009830 (-6.41)	-0.009430 (-6.40)
Housing size (HSIZ)	0.002317 (8.02)	0.002318 (8.00)
Number of dwellings (HONR)	-0.183280 (-1.55)	-0.172600 (-1.46)
Dwelling's floor (HOFL)	-0.025780 (-0.72)	-0.030430 (-0.86)
Rooms per dwelling (HORO)	0.048927 (2.53)	0.048001 (2.37)
House building material wood (HOM6)	0.021047 (0.31)	0.026435 (0.40)
Balcony size (HOBA)	0.006448 (2.33)	0.006740 (2.52)
Parking/Garage (HOPA)	0.016800 (3.19)	0.180114 (3.46)
Lot size (HOLO)	0.000080 (1.13)	0.000085 (1.22)
Local population (POPU)	0.000001 (0.50)	0.000001 (0.39)
Aluminium plant (ALEA)	0.209686 (5.38)	0.347625 (7.92)
Lagged residual (elt)	0.150893 (3.16)	0.116580 (2.47)
Constant term (alfa α)	15.329110 (72.51)	16.001430 (75.74)
Number of observations, n	1124	1124
F-value	63	62
R^2 within	0.5932	0.6109
R^2 between	0.0258	0.0001
R^2 overall	0.0291	0.0047
Serial correlation	No	No
Multicollinearity	No	No
Heteroskedastisty	Robust	Robust
Residual distribution	Not normal: JB=6195	Not normal: JB=6049
Panel data sample	unbalanced	unbalanced

Dependent Variable: Natural logarithm of housing price (Ln(hopr)). Methods: Fixed effect panel data model. Statistical program: STATA. Values in parentheses are t-statistics.

(in excess of 11), which indicates that an unusually high share of residuals was close to the mean, but the skewness close to 1 seems to be in line with normal distribution: skewness is zero in the normal distribution. In some respects, this result threatens the efficiency of the estimators less than if skewness were to blame (Table 4-4).

The result of the analysis using data from all municipalities shows a significantly negative relationship between housing prices and the distance between Reykjavík and other municipalities. The marginal impact of a reduction in distance is $\partial lnh_{it}/\partial d_{it} = -0.00289 + 0.00001578d_{it}$. This relationship is strictly convex. The real price of houses reveals a clear sign of a marginal rate of diminishing return with respect to a decentralized location; in other words, the value of a central location in Iceland has an increasing marginal rate of return.

However, according to the results, local housing prices decrease by approximately 0.3 percent following a one-kilometre increase in road distance from the centre of the CBD, *ceteris paribus* (Model 3). This impact lowers marginally by 0.001578 percent, so improvements in transportation that shorten the distance of municipalities in rural area of Iceland from the capital area tend to increase local real estate prices in real terms. This impact grows as transportation improvement draws closer to the CBD.

The age of a house influences its real price since, as a house gets older, the house price decreases by 0.9 percent in real terms for every year, *ceteris paribus*. House size also has a significant impact on local housing prices, as the price increases by 0.2 percent for every square metre of house enlargement. Rooms per dwelling and presence of a balcony, a garage, and parking returned significant impacts along with expected signs. The housing prices in three municipalities on the east coast are about 35 percent higher than prices in other municipalities because of a large-scale local investment.

A reasonable criticism occurred because of the positive sign in model 1 and the positive sign in model 2 beyond 184 kilometres from Reykjavík. These results are probably due to the existence of Akureyri, so we constructed and tested a polycentric model of two CBDs.

The absence of data for mortgage interest rate and supply of housing also drew criticism. Reliable data on mortgage interest rates were not available for the entire period. Reliable data was available for the supply

Table 4-5. Relationship between housing prices and transportation improvements. A fixed effect panel data model comparing two approaches: a polycentric model in semi logarithm (SLM) and a quadratic distance (QDM) versions.

Variable (acronym)	Model 3 Fixed effect SLM.	Model 4 Fixed effect 2SLS SLM	Model 5 Fixed effect QDM	Model 6 Fixed effect 2SLS QDM
Total Income (TINC)	0.000013 (0.37)	0.000146 (1.65)	0.000004 (0.11)	0.000127 (1.46)
House supply (HNPP)	-2.677330 (-4.00)	-5.130370 (-4.62)	-2.410020 (-3.61)	-4.850890 (-4.07)
Road distance Reykjavík (RDIR)	0.002093 (2.43)	0.000633 (0.58)	-0.002180 (1.70)	-0.0044 (-2.28)
Road distance Reykjavík sq. (RDIR^2)			0.000008 (4.08)	0.000009 (3.13)
Road distance Akureyri (RDIA)	0.012067 (1.33)	0.002487 (0.20)	-0.072410 (-1.73)	-0.032010 (-0.49)
Road distance Akureyri sq. (RDIA^2)			0.000133 (2.06)	0.000056 (0.54)
Marginal road distance Reykjavík (RDRM)	0.002750 (2.53)	0.002835 (2.46)	0.003235 (2.82)	0.003079 (2.47)
Dummy Reykjavík (DMRE)	1.952338 (1.08)	0.308844 (0.13)	-9.112000 (-1.54)	-3.718970 (-0.41)
Housing age (HAGE)	-0.009760 (-5.90)	-0.009110 (-8.52)	-0.009710 (-5.89)	-0.009320 (-8.59)
Housing size (HSIZ)	0.002333 (8.53)	0.002294 (15.16)	0.002319 (8.61)	0.002283 (15.09)
Number of dwellings (HONR)	-0.185220 (-1.18)	-0.235060 (-1.88)	-0.178450 (-1.13)	-0.236770 (-1.92)
Dwelling's floor (HOFL)	-0.019270 (-0.36)	-0.071240 (-1.83)	-0.020300 (-0.38)	-0.069680 (-1.80)
Rooms pr. dwelling (HORO)	0.100667 (4.28)	0.079664 (5.73)	0.100090 (4.28)	0.086154 (5.85)
House building material wood (HOM6)	0.158226 (2.26)	0.087616 (1.75)	0.157776 (2.27)	0.096319 (1.88)
Balcony size (HOBA)	0.009076 (2.41)	0.006165 (2.34)	0.008911 (2.37)	0.006076 (2.33)
Parking/Garage (HOPA)	0.144742 (2.55)	0.136979 (3.10)	0.142768 (2.50)	0.134433 (3.03)
Lot size (HOLO)	0.000028 (0.47)	-0.000014 (-0.35)	0.000030 (0.51)	-0.000042 (-1.00)
Local population (POPU)	0.000030 (4.13)	0.000016 (1.08)	0.000030 (4.22)	0.000017 (1.18)
Aluminium plant (ALEA)	0.073168 (0.64)	-0.167890 (-1.10)	0.103441 (0.92)	-0.137500 (-0.86)
Lagged variable				-0.015811 (-0.35)
Constant term (α)	13.902990 (7.87)		23.898790 (4.59)	
Observations, n	811	702	811	695
F-value	39	33	39	29
R^2 within	0.5782		0.5845	
R^2 between	0.0569		0.0009	
R^2 overall	0.0002		0.0025	
R^2 centred		0.5991		0.5989
R^2 uncentred		0.5991		0.5989
Serial correlation	No	No	No	No
Multicollinearity	No	No	No	No
Heteroskedastisty	Robust	No	Robust	No
Residuals distribution	Not normal: JB=3203		Not normal: JB=3378	
Panel data sample	Unbalanced	Unbalanced	Unbalanced	Unbalanced
Sargan test		0.75		0.74
Cragg-Donald Wald F statistic		26.03		4.93
Anderson canon. corr. LM statistic		26		29

Dependent Variable: Natural logarithm of housing price (Ln(hopr)). Methods: Fixed effect panel data model with instrument variables. Statistical program: STATA. Values in parentheses are t-statistics.

side (hnpp) from 1994-2006. However, a specially constructed time dummy variables captures all potential macroeconomic impacts (Appendix) so the variable for interest rate could be dropped. Therefore, the analysis was repeated along with an explanatory variable for the supply side, distance from Akureyri, in order to improve the estimation. The model accords with Eq. 4.5.

Heteroskedasticity was present in the data. The residuals of the estimation were not normally distributed, and the explanatory variables, total income (TINC) and housing supply (HNPP), were endogeneous. It is perhaps not very serious that the residuals are not normally distributed because high kurtosis, or kurtosis in excess of 5, is mostly to blame. The high kurtosis in the distribution of the residuals means that a high proportion of the residuals is close to the mean of the residuals but skewness of the value of approximately 1 almost suggest a normal distribution of the residuals. In some respects this threatens the efficiency of the estimators less than if skewness was to blame. It was deemed proper to respond to these endogeneity and heteroskedasticity problems by running a 2SLS robust estimator on the data. (Model 6). Serial correlation was detected in that version and was sufficiently eliminated by a lagged variable of the residual. Total income and house supply were the endogenous variables. Theoretically, house supply has impact on housing prices and housing prices tend to increase supply of dwellings. Moreover, income tends to have positive impact on housing prices and high housing prices can attract high income household. In this case the instruments used were: lagged version of labour income, local population, housing prices, number of dwellings, share of elderly in local population and number of dwellings divided by local population.

The result of the analysis using data from all municipalities shows a significant negative relationship between housing prices and the distance between Reykjavík and other municipalities. The marginal impact of a reduction in distance is $\partial \ln h_{it} / \partial d_{it} = -0.0044 + 0.000017\, d_{it}$. It implies that the marginal impact of transportation improvements increases housing prices by approximately 0.4% for houses closest to the city centre and reduces them by 0.002% for every kilometre away. However, this impact is limited to municipalities closer to Reykjavík than Akureyri. Several other significant parameter signs were comparable to the former analysis (Model 2)[31].

[31] The dummy variable for new aluminum factory on the east coast returns negative sign. It was unexpected turn from the former results. A thorough inspection of

In some ways this result is comparable to many other studies, but in other ways it is not. While other studies have detected the classical bid-rent curve, the present study detects only its time dimension (within variation) which brings a pure impact of transportation improvements and leaves the local amenity value to the fixed constant term of the model (Hsiao, 2006; Verbeek, 2004). This changed the marginal impact of distance from being constant to variable in comparison with the results of other studies (Cunningham, 2006; De Bruyne & Van Hove, 2006; McDonald & Osuji, 1995; McMillen, 2003; Tyrvainen & Miettinen, 2000) and my other analysis (Karlsson, 2007) for a random effect model in a recent working paper. McMillen (2003, p. 287) evaluated the relationship between price and central location in Chicago using a repeat sales model and concluded that housing prices decline by more than 8% for every mile away from the CBD. That is approximately 5% per kilometre. This is an unusually large distance gradient and not a reliable figure, since the same author (2004) presented opposite results for the same area one year later. In other studies, the distance gradient is generally closer to my result, 0.41 on the average within the conurbation area – that is, municipalities within the range of 0-120 km from the CBD. 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. Tyrvainen and Miettinen (2000, p. 215) concluded that house value decreases by 0.11% for every 1% distance in kilometres away from the centre of the Salo district in Finland. De Bruyne and Van Hove (2006) came up with rather different figure from Belgium, with a gradient somewhere between 0.001 and 0.002%. Note that this is the only study that covers an entire country like present study. The present figure for Iceland's CBD, decreasing marginally by 0.002% from 0.44%, is not close to the result from Belgium. In the De Bruyne and Van Hove study, a cross-section data sample was used instead of the panel data sample as in the present study. Furthermore, the fixed effect approach returns the time variation of

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the data showed that the supply (HNPP) and total income (TINC) were responsible. The supply variable was constructed as number of houses divided by local population. Since the period of time covers only the construction period of the aluminum factory and other necessary facilities the population increased extremely which reduced the local supply of houses down with respect to population. The total income increased at the same time. So, the method traces the increse in local housing prices to the supply and total income and the difference is negative reflected by the dummy variable.

the bid-rent curve instead of a cross-section impact which returns variation closer to an amenity value rather than transportation improvements. De Bruyne and Van Hove (2006) use a semi-logarithm model, instead of a model with more curvature, such as the quadratic distance model, as is used in the present study.

It is obvious that distance has a stronger effect when the transportation improvement is located closer to the capital area. This is to some extent in line with earlier studies (Cunningham, 2006; De Bruyne & Van Hove, 2006; McDonald & Osuji, 1995; McMillen, 2003; Tyrvainen & Miettinen, 2000). The distance gradient is generally steeper in studies representing only cities and their suburbs, such as McMillen (2003), McDonald and Osuji (1995), and Cunningham (2006), compared to studies covering larger areas, such as Tyrvainen and Miettinen's (2000) study of a large district in Finland, and De Bruyne and Van Hove's (2006) study of one country. But why is this? One likely explanation is related to labour market boundaries and other development factors, particularly counterurbanisation. Counterurbanisation is urban out-migration motivated by changes in household economy or preferences such as relative housing prices, amenity values and the like. It has been detected for several decades both in Europe and USA, especially in a certain range from the CBD (Dahms & McComb, 1999; Mitchell, 2004; Stockdale et al., 2000). Thus, when the distance between the CBD and other rural localities becomes shorter, it makes commuting more profitable, increasing the wealth of the existing rural population and supporting any additional counterurbanisation. This development decreases marginally by distance from the CBD. This causes the negative relationship between housing prices and distance to have certain limits.

That is to some extent in line with Johansson et al. (2003) where it is suggested that labour markets have been integrating over extended geographic areas. This research which is based on the influence of commuting on the labour market, on travel demand behaviour and residential location might shed some light on the results of present paper. Johansson et al. (2003) suggest that the general commuter is marginally more sensitive to longer time distances than shorter ones. The willingness to commute more than 60 minutes is very low, when the time distances become shorter the willingness increases rapidly and progressively. This is in line with my results. Since commuting cost is compensated by lower housing cost and the CBD offers the widest variety of jobs and highest wages (So et al., 2001), it must be obvious that the returns to investment in a transportation improvement will be marginally higher if the improvement is closer to the city centre than if it is further away, as the inhabitants become progressively more willing to spend time commuting.

The notion of women being more sensitive than men to travelling time or time distance (Johansson et al., 2003) due to their having on average more household responsibility than men (Freedman & Kern, 1997; Turner & Niemeier, 1997) is also interesting in this regard because there tends to be relatively fewer women than men in rural areas than in urban areas (So et al., 2001) and the adjacent municipalities. Thus, the response of women to commuting distances would favour transportation improvements located close to CBD.

The result of present paper suggests that transportation improvements, including those that shorten distances, 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 logically related to the fact that the inhabitants of areas adjacent to the CBDs have higher preferences for access over amenity values compared to inhabitants of more distant areas.

Presently, the world is suffering from a global financial crisis which hit the Icelandic economy very hard. Economic growth in Iceland has been rapid for the last decade, or on the average by 4.7% each year in the period 1998-2007. The Icelandic economy is presently in a very bad shape as growth was negative 2009 by -6.5%, -3.5% 2010, and according to the OECD (2011) economic forecasts the growth will be 2.2% 2011, and 2.9% 2012. The value of the Icelandic currency is approximately 50% of what it was in the beginning of the year 2008. The government has to cut down expenses and taxes have already been increased. The unemployment rate was close to 1% in the beginning of the year 2008 and approaches 10% now. Real disposable income has decreased by more than 20% in 2008-2010 and the forecasts suggest that it will increase slowly from now on (Pétursson et al., 2011, p. 27). The housing prices have fallen by approximately 30% in the same period and according to a economic forecast of Central bank of Iceland (Pétursson et al., 2011, p. 21) the fall in real housing price will stop in late 2011 and a period of slow increase will start. The transport cost will increase because the oil price rises when the Icelandic krónur depreciates and it will not easily be compensated by lower housing prices. Gasoline prices increased by somewhat less than 50% in the period February 2009 to February 2011 and have risen since. However, the value of travellers' time has decreased because of lower real wages and this has reduced travel cost. Citizens living in the fringe of the conurbation area will move closer to the city centre when the overall travel cost increases. This leads to a slowing down or elimination of the counterurbanisation and the housing prices will decrease more at the fringe of the conurbation area than in the city centre. This seems to be the case, because it is in line with recent data from Statistics Iceland on interregional migration: the net flow of citizens from the capital area to the adjacent regions reversed in 2009. This means that spatial extension of the labour market in the capital shrinks and moves closer to the city centre again. Thus, the marginal impact of transportation improvements on housing prices becomes greater in the short run following the financial crisis as the bid-rent curve becomes steeper.

Economic recovery can be expected in Iceland in the future, but the value of the currency may never reach again the strength of the recent boom years. Transport cost can be expected to decrease again. Eventually it will reach the pre-crisis level despite the continued devaluation of the currency if all goes well. Thus it is reasonable to believe that the financial crisis will have negligible influence in the long run on the marginal impact of transportation improvements on housing prices, as the bid-rent curve falls back again, *ceteris paribus*.

4.6 Conclusion

The aim of this study was to measure the influence of transportation improvements on the local real housing prices. The analysis was based on annual average housing prices, distance from the CBD (the capital area), total household income, and several other relevant explanatory variables for all municipalities in Iceland from 1994 through 2006. The data were analyzed with a fixed-effect model in several different versions in order to detect pure impacts of improvements in transportation. A quadratic distance model was most appropriate for the present data sample.

The analysis clearly shows that the relationship between local housing prices in Iceland and transportation improvements in form of shortening the distance from the CBD, i.e. the capital city, is statistically significant and negative. The marginal impact of a reduction in distance is $\partial \ln h_{it} / \partial d_{it} = -0.0044 + 0.000017\, d_{it}$. It implies that the marginal impact of transportation improvements increases housing prices by approximately 0.4% for houses closest to the downtown area of the city and reduces them by 0.002% for every kilometre away. However, this impact is limited to municipalities closer to Reykjavík than Akureyri. 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 certain type of interactions between citizens of the CBD and other municipalities in Iceland is limited to distance, such as commuting.

The general conclusion from this analysis is that in sparsely populated countries, such as Iceland, transportation improvements which reduce the distance from a municipality to the CBD tend to increase local housing prices. The results suggest that the increase will be largest for municipalities close to the CBD than those which are farther away.

4.7 Appendix

Table 4-6. The estimates for time dummies.

Variable (acronym)	Model 3 Fixed effect SLM.	Model 4 Fixed effect 2SLS SLM	Model 5 Fixed effect QDM	Model 6 Fixed effect 2SLS QDM
Time dummy 2	-0.008560 (-0.23)	-0.572370 (-3.61)	-0.005910 (-0.16)	-0.584220 (-3.75)
Time dummy 3	-0.033750 (-0.83)	-0.577190 (-3.96)	-0.032690 (-0.81)	-0.591620 (-4.08)
Time dummy 4	0.037510 (0.93)	-0.526110 (-3.93)	0.043847 (1.11)	-0.532900 (-4.01)
Time dummy 5	0.068659 (1.53)	-0.526050 (-4.62)	0.076558 (1.68)	-0.533420 (-4.77)
Time dummy 6	0.141467 (2.94)	-0.469540 (-4.64)	0.150693 (3.08)	-0.470040 (-4.72)
Time dummy 7	0.162844 (3.29)	-0.456040 (-4.62)	0.171690 (3.40)	-0.460350 (-4.75)
Time dummy 8	0.123386 (2.37)	-0.513380 (-5.94)	0.132288 (2.51)	-0.518650 (-6.07)
Time dummy 9	0.154300 (2.91)	-0.466670 (-5.73)	0.163454 (3.05)	-0.468350 (-5.88)
Time dummy 10	0.232612 (3.83)	-0.353810 (-4.79)	0.240214 (3.93)	-0.356010 (-4.90)
Time dummy 11	0.336612 (5.15)	-0.229180 (-3.84)	0.339444 (5.20)	-0.234760 (-3.98)
Time dummy 12	0.544469 (7.45)	-0.073840 (-1.71)	0.548724 (7.52)	-0.078070(-1.83)
Time dummy 13	0.631739 (7.99)		0.635238 (8.03)	

Dependent Variable: Natural logarithm of housing price (Ln(hopr)). Methods: Fixed effect panel data model with instrument variables. Statistical program: STATA. Values in parentheses are t-statistics.

Part II

5 A small city, agglomeration economies, and the value of access

5.1 Introduction

Housing prices in Iceland have historically fluctuated significantly: they were stable in the early 1990s, rose rapidly in the late 1990s and early 2000s, and decreased substantially after reaching an all-time high in 2007. This chapter considers how the spatial disparity of housing prices has developed in Iceland and the underlying economic causes of that disparity.

Many have argued that the spatial disparity of housing prices tends to follow a certain structure (Fujita, 1989; Fujita & Thisse, 2002, pp. 78-91; McCann, 2001), usually a negative distance gradient in which price declines with distance from a central business district (CBD). This relationship is represented by the slope of the so-called bid-rent curve. The existence and shape of the bid-rent curve is dependent on consumers' preferences for access over amenities. If access becomes more valuable than amenities, the curve steepens, reflecting an increased spatial disparity of housing prices in favour of urban housing prices.

The constant term of the bid-rent curve accounts for agglomeration economies because the intercept is the housing price in the CBD, which is where all of the agglomeration takes place. The higher the agglomeration is, the more intense the competition for land is, leading to higher housing prices. According to Henderson (2003), as the number of people employed in the knowledge-based industry grows, so does the value of proximity, an effect that Henderson calls localization and urbanisation economies, which represent economies of scale because of the geographic concentration of firms. The economies of scale that are due to the geographic concentration of firms are called agglomeration economies (McCann, 2001). In the presence of agglomeration economies, average production cost is generally lower, which in knowledge-based industries increases profits, returns to shareholders, and the real wages of highly skilled labour, *ceteris paribus*. In addition, an agglomeration economies increases local housing prices since they are highly correlated with household income. Agglomeration economies tend to be spatially limited, especially when spillover effects are considered. Acs (2002) confirmed the significance of university research spillover effects within a range of fifty miles from the innovative metropolitan statistical area (MSA) and Rosenthal and Strange (2005) suggested that this range is even narrower. These studies indicate that because of increased and denser population in the urban areas of Iceland, spillover effect may have increased and thus the agglomeration economies, leading to relatively higher value of locations in urban areas compared to the rural areas of Iceland. This would lead to increased spatial disparity of housing prices in favour of the capital area. This effect would be captured by the constant term of the bid-rent curve.

Furthermore, educated workers presumably prefer access to amenity value more often than less educated workers do, since access increases the probability that educated workers will find suitable employment. In that sense, educated workers behave like a firm facing monopolistic competition, whereas unskilled workers face stiffer competition and lower earnings. A large labour market works in favour of skilled workers and brings them higher expected returns on their educational investments than a smaller market would.

The research question of present research addresses whether the shape of the bid-rent curve in Iceland has changed between the periods 1995-2000 and 2001-2006. If the slope of the bid-rent curve and the constant term for the CBD increase significantly between the two relevant periods when corrected for other possible explanations for spatial disparity of housing prices, such as household income and housing characteristics, evidence of increased agglomeration economies and households' preference for access over amenity values in Iceland is found, *ceteris paribus*.

The current study is different from previous work in four ways. Firstly, none of the previous researchers has simultaneously studied both the level of development of agglomeration economies and preference for access over amenities. Secondly, none of the previous research has focused on a community as sparsely populated as Iceland. Thirdly, the data sample of the present study covers a whole country. Finally, the country studied in the current research, an isolated island, is geographically an unusual market in the literature on agglomeration economics.

The organization of the research is as follows. Section 1 presents the introduction and a description of the paper's purpose. Section 2 introduces the geography and economy of Iceland. Section 3 contains the theoretical background and provides a short overview of basic theory and recent literature. Section 4 contains a theoretical discussion of the model and several other possible approaches, while Section 5 provides definitions and describes the data, its origins, construction, and transformation. Section 6 contains the analysis and results, and Section 7 provides a summary and concluding remarks.

5.2 Iceland

Iceland is sparsely populated, and its main industries have historically been fisheries and farming. While the knowledge-based industry has been small but growing during the twentieth century, it expanded during the latest economic expansion (1995-2007), as the growth of highly skilled employment suggests (Table 5-4). Generally, the local service industry is closely connected to the size of the local export industry. The vast majority of the knowledge-based industry in Iceland, such as IT technology, pharmaceutics and banking, is located in the capital area, and the capital area is the only business centre that is large enough to offer a wide variety of goods and services. Thus, the knowledge-based industry and the service industry are responsible for a large share of the capital area's exports and sales to other domestic regions. Iceland's other export industries—including, in order of importance, the energy intensive sector, the fishing industry, tourism, and agriculture—are based in various rural regions and are highly dependent on speedy and efficient transportation.

The domestic transportation system relies heavily on a single coastal ring-road (the red line in Figure 5-1), but it also includes many secondary roads (black lines in Figure 5-1) that connect more distant villages and areas. Domestic commercial transport relies mainly on vehicles. The main international airport and the harbours that serve most of the country's exports and imports are located in or close to the capital city.

Most of the export industry in the rural areas of Iceland is based on natural resources. Because of capacity constraints, especially in fishing, the growth potential in resource-based industries is limited, but the growth of knowledge-based industries is considerably larger, making the labour market more attractive in the capital area than in the rural area.

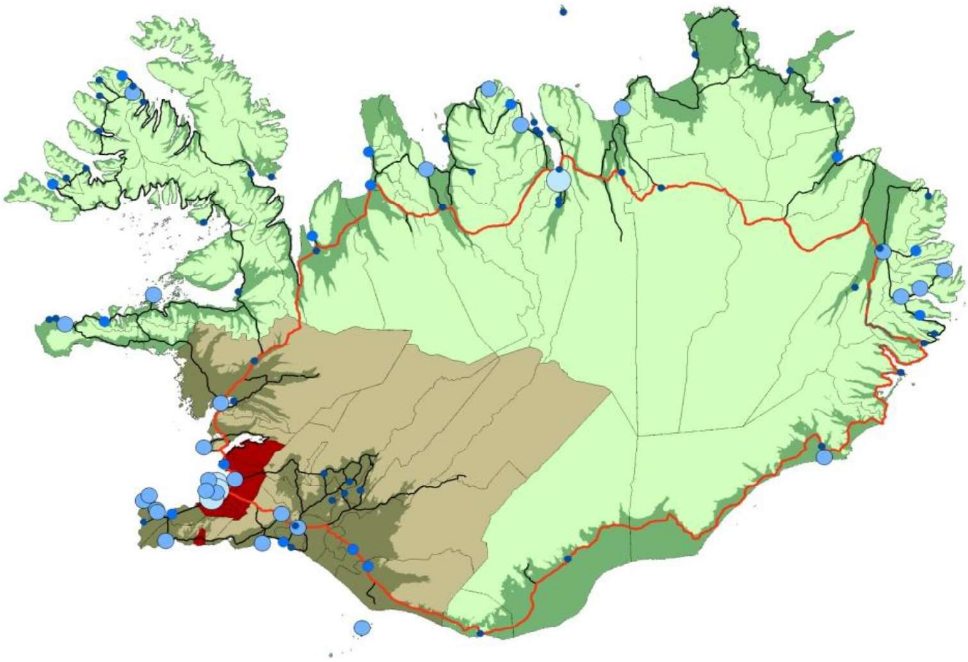

Figure 5-1. Geographic overview of Iceland.

The capital area is shaded red. The intermediate area is shaded brown, and the countryside is green. Blue dots of four different sizes represent towns and villages with populations of 0-500, 501-1,000, 1,001-10,000 and more than 10,000, respectively. The rural area is both green areas and the blue dots in that area. Lowland (below 200 metres above sea level) is shaded dark green. Highway number 1, the coastal ring-road, is indicated by a red line. While there are many secondary roads, black lines represent the main roads in this category. The borders of municipalities are denoted by thin green lines.

The population is rising faster in the capital area of Iceland than in the rural areas, despite increasing housing prices in the capital area. The population in the capital area grew by more than 20 percent in the period that includes latest economic expansion (1994-2006), even though housing prices in the capital area were approximately 50 percent higher than they were in the rural areas, with the price differential growing during the period of rapid economic expansion. During 1994-2006 housing prices increased by 97.9 percent in the capital area but only by 67.8 percent in the rural areas (Table 5-1). At the end of 2006, 62 percent of the population lived in the capital area.

A part of the explanation for this development in population dispersal is probably the shift towards knowledge-based industries, which are located primarily in the capital region in Iceland. The latest economic expansion in Iceland was more intensively driven by the knowledge-based industry than former expansions were. The weight increases most in the most knowledge-driven categories. In the financial, real estate, renting and business activities, the weight increased from 16.8 percent to 25.4 percent between 1981 and 2006 while the weight of primary industry fell by 48 percent and manufacturing by 37 percent (Table 5-2). The weight of other service activities, which are also more knowledge intensive than the primary industry, increased by 37 percent in the same time period.

Table 5-1. Population and housing prices: a comparison of two periods and two areas of Iceland.

Source: Statistics Iceland

	Capital area - growth		Rural area – growth		Ratio (cap./dist.)	
Indicator	1993/1981	2006/1994	1993/1981	2006/1994	1993	2006
Population	25.1%	22.4%	2.2%	4.9%	1.79	2.33
Housing prices	-3.2%	97.9%	-11.8%	67.8%	1.51	1.75

All values are in real terms.

Table 5-2. Percentage of gross domestic product by economic activity.

Source: Statistics Iceland

Industry	1981	1986	1993	1994	2006
Agriculture, hunting, forestry and fishing	12.2%	12.8%	11.9%	11.3%	6.4%
Industry, including energy (partly manufacturing)	24.0%	25.0%	19.7%	20.4%	15.1%
Construction	9.1%	8.3%	7.7%	7.1%	11.3%
Wholesale and retail trade, hotels and restaurants, transport and communication	20.5%	20.2%	21.3%	22.3%	17.9%
Financial, real-estate, renting and business activities	16.8%	16.3%	18.4%	17.7%	25.4%
Other service activities	17.5%	17.4%	20.9%	21.2%	23.9%

Only selected years are in the table. The criteria for selection were the beginning and the end of the periods: 1981-1993 and 1994-2006.

The shift toward knowledge-based industries went hand in hand with a better-educated labour force (Table 5-3). The number of workers with a college degree (ISCED 5,6) increased by 13.3 percent annually in the period 1991-2006, while there were no changes in the numbers of workers who finished basic (ISCED 1,2) and secondary education (ISCED 3,4). A ten-year basic education is compulsory in Iceland, but it is of concern that a significant proportion of the population still does not seek secondary education. In fact, 35 percent of the labour force had only a basic education in 2006, which was unchanged from 1991. Those who finish a secondary education were more likely to a finish college degree in 2006 than they were in 1991.

Table 5-3. Icelandic labour force education levels 1991–2006.

The labour force is defined as 16-74-year-old individuals. Source: Statistics Iceland.

Labour skills	1991	2006	Standard deviation	Trend annually	%Trend annually
Total labour force of Iceland	140,500	174,600	9,799	1,990	1.42%
Basic education, ISCED 1,2	59,700	60,300	4,384	-48	-0.08%
Secondary education, ISCED 3,4	65,600	68,000	2,072	-28	-0.04%
University education, ISCED 5,6	15,20	45,700	10,309	2,023	13.31%

The increased education of the labour force is also reflected in employment numbers for Iceland, where the highly skilled category is the fastest growing (Table 5-4).

These educational trends suggest that the industries have become increasingly knowledge-based, especially in the capital area. The Icelandic labour market grew by 31,900 man-years in the period 1994-2006, of which 24,200 were in highly skilled occupations—20,100 in the capital area and only 4,100 in the rural areas. Highly skilled workers increased by 4.4 percent annually in the capital area and only by 0.9 percent in the rural areas, while skilled workers increased by 1.1 percent in the capital area and decreased by 0.5 percent in rural areas. At 3.7 percent, the employment growth for unskilled workers was higher in the rural areas than in the capital area, where it was 2.8 percent. Further, the absolute trend in highly skilled and skilled occupations is higher than it is among the unskilled in the capital area, while it is lower (and actually decreasing) in the rural areas. This trend indicates that agglomeration economies have been rapidly accelerating in the Icelandic economy for at least two decades.

Table 5-4. Employment in Iceland by occupational group and area 1994–2006.
Source: Statistics Iceland

Area	Labour skills	1994	2006	Difference	Standard deviation	Trend	%Trend
Capital area							
	Total employment	81,400	110,200	28,800	23,085	2,051	2.5%
	Highly skilled occupations	31,900	52,000	20,100	10,633	1,400	4.4%
	Skilled occupations	43,800	51,100	7,300	11,247	488	1.1%
	Unskilled occupations	5,600	7,200	1,600	1,711	159	2.8%
Rural areas							
	Total employment	56,300	59,400	3,100	14,202	124	0.2%
	Highly skilled occupations	17,400	21,500	4,100	4,708	158	0.9%
	Skilled occupations	38,000	35,700	-2,300	9,213	-201	-0.5%
	Unskilled occupations	4,400	5,700	1,300	1,336	163	3.7%

Employment is measured by man-years. 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 occupations include elementary occupations.

Changes in household preference in favour of access over amenity values may also be responsible for these developments. Cities offer better access to a variety of services, such as education, cultural events and health care, than rural areas do. According to Statistics Iceland, the demand for cultural services has been rising for the last decade. Icelanders visit museums, theatres, and cinemas more often than is the norm in other Nordic countries (Table 5-5), and these institutions are primarily located in the capital region of Iceland. Moreover, Icelanders increased their use of both museums and theatres between 1995 and 2006, while the supply of cinemas declined; museum visits per 1000 inhabitants increased by 59 percent, theatre visitors per 1000 inhabitants increased by 25 percent, and the number of cinema seats per 1000 inhabitants fell by 31 percent. Museums and theatres are probably better economic indicators for culture than cinemas are, since closer substitutes to cinemas, such as video-on-demand (VOD) and the supply of films and videos on the internet, have entered the market in Iceland recently. Visits and visitors are also better economic indicators than seats are, so, the indicators suggest that the preference of Icelandic household for culture has been increasing.

Table 5-5. Museums, theatres and cinema statistics year 1995 and 2006.
Source: Nordic Council of Ministers

Country	Denmark	Finland	Iceland	Norway	Sweden
1995					
Museums, visits per 1000 inhabitants	1,930	783	3,108	2,042	1,837
Theatres, visitors per 1000 inhabitants	492	370	700	296	334
Cinemas, seats per 1000 inhabitants	9	11	39	21	23
2006					
Museums, visits per 1000 inhabitants	1,875	862	4,935	2,011	2,170
Theatres, visitors per 1000 inhabitants	419	637	874	384	351
Cinemas, seats per 1000 inhabitants	11	11	27	18	17
Relative difference from 1995 to 2006					
Museums, visits per 1000 inhabitants	-3%	10%	59%	-2%	18%
Theatres, visitors per 1000 inhabitants	-15%	72%	25%	30%	5%
Cinemas, seats per 1000 inhabitants	22%	0%	-31%	-14%	-26%

Life expectancy is very high in Iceland. According to Eurostat statistics, Iceland has the third-highest life expectancy among the EU and EFTA countries (Table 5-6). Furthermore, data from Statistics Iceland show that life expectancy has been increasing for many years, suggesting that access to specialized health service is good, that health care has been improving in Iceland, and that the inhabitants find it increasingly convenient or important to use it[32].

This international comparison shows that Icelanders have high preference for the specialized health care service that is available only in larger urban

[32] A good health care sector has been provided by the politicians, probably because of signals from the voters, especially since the government has been dominted by right-wing parties during all of the twentieth century.

Table 5-6. Life expectancy in EU and EFTA countries
Top 10 EU and EFTA countries in life expectancy in 2006. Source: Eurostat

Country	Life expectancy in years
Switzerland	81.84
Italy	81.44
Iceland	81.23
Spain	81.08
Liechtenstein	81.03
France (metropolitan areas)	81.01
Sweden	80.96
France	80.95
Norway	80.60
Cyprus	80.33

areas. Cities usually offer better cultural opportunities and health care than rural areas, so if the importance of such services has been growing in Iceland, the preference for access over amenity values could have been increasing as well. Therefore, the growing spatial disparity of housing prices can be traced to increased agglomeration economies, to changed preferences for access over amenity values, or both.

5.3 Theoretical background

The value of proximity is captured by localization and urbanisation economies, which reflects economies of scale due to geographical concentration (Henderson, 2003, p. 1). These are also known as agglomeration economies (McCann, 2001). These two effects are called Marshall, Arrow, Romer (MAR) and Jacobs economies in a dynamic context (Henderson, 2003, pp. 1-2). The former refers to decreasing average costs due to an increased number of firms in the same industry. The second presents decreasing average costs due to an increased number of firms overall. 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 an industry located in the CBD 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 shifts upwards in the relevant CBD following increased economies of localization or urbanisation.

The bid-rent curve is Alonso's extension of von Thünen'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). As stated earlier, the bid-rent curve is dependent on consumers' preferences for access over amenity value, which reflects the different contribution of urban and non-urban areas to consumer's utility. The urban area offers its residents access to a wide variety of services and employment opportunities. The non-urban areas, however, offer their residents better natural recreation and 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 in the spatial structure of housing prices, which often decline with distance from the CBD, due to a greater impact of access relative to amenity value.

If consumers prefer access to amenity value, they will migrate to the CBD following improved localization and urbanisation economies, and the entire real estate market will be affected. When urban residence becomes more attractive, the demand for both residential and industrial premises will increase, and the distance gradient will become steeper (Figure 5-2, to the left), *ceteris paribus.*

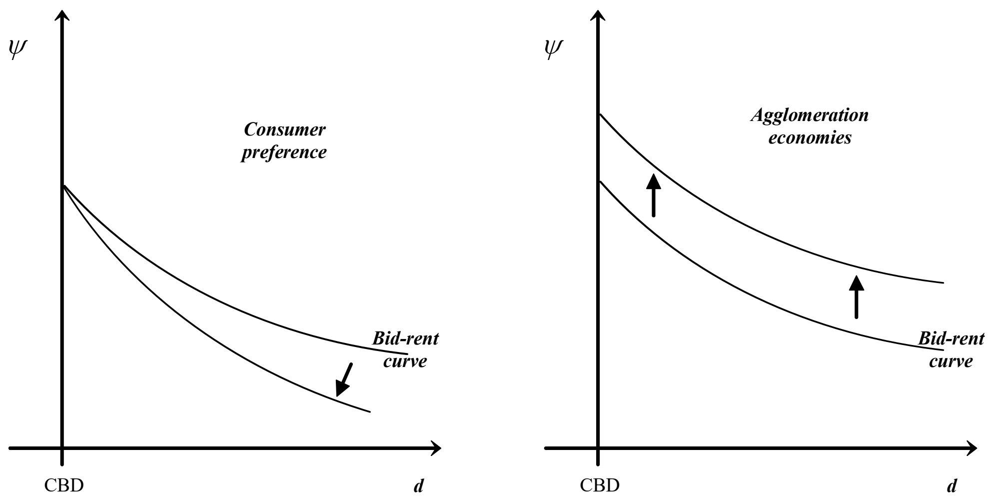

Figure 5-2. The impact of increased agglomeration economies or preference of access over amenities on the bid-rent curve.

According to Fujita (1989) the bid-rent curve is found by solving the maximisation problem in which the consumer's utility is maximised by choosing a location with respect to distance from the central business district, d, and by consuming lots of size l, and composite goods, x, subject to his or her budget. The budget reflects how the consumer's income, I, can be spent on complementary goods, lot size multiplied by its price, $h(d)$, and transport cost, $T(d)$.

$$\max_{d,x,l} U(x,l)$$

$$\text{subject to } x + h(d)l = I - T(d)$$

The bid-rent curve becomes (Karlsson, 2008),

Eq. 5.1 $$\psi(d,u) = \max_{z,s} \left\{ \frac{I - T(d) - x}{l} \middle| U(x,l) = u \right\}$$

Differentiating the bid rent, ψ, in Eq. 5.1 with respect to distance, d, yields a relationship (Eq. 5.2) that characterizes the relationship between the consumer's willingness to buy land for housing and distance,

Eq. 5.2 $$\frac{\partial \psi(d,u)}{\partial d} = -\frac{T'(d)}{l} < 0$$

According to Fujita (1989, p. 14), $T'(d) > 0$ so $\partial\psi(d,u)/\partial d < 0$, as stated in Eq. 5.2 and as has been concluded in many empirical studies, such as McMillen (2003), Kiel and Zabel (1996), and Fujita and Thisse (1993). A similar presentation of the theoretical model is found in Fujita (1989, p. 22). Eq. 5.2 represents one of the two key factors of the present study. As the Eq. 5.2 becomes increasingly negative, the bid-rent curve becomes increasingly steeper (Figure 5-2, to the left), suggesting that the spatial disparity of housing prices increases as a result of changes in consumer preferences for access over amenities (McCann, 2001).

The constant term of the bid-rent curve may be written as:

$$Eq.\ 5.3 \qquad \psi(0,u) = \max_{x,l}\left\{\frac{I-x}{l}\middle| U(x,l)=u\right\}$$

Eq. 5.3 is the other key term in this research. The constant term is clearly related to household income, I, composite goods, x, and lot size, l. In the presence of competitive markets, agglomeration economies result in higher profit, higher real wages, and higher household income, so a constant term that is significantly higher for the CBD today than it is tomorrow (Figure 5-2, to the right) suggests that the agglomeration economies have increased.

5.4 The model

The hedonic price model is the most frequently used approach in research on the spatial disparity of housing prices in the economic literature (Archer et al., 1996; Cunningham, 2006; Gibbons & Machin, 2005; Haurin & Brasington, 1996; Kiel & Zabel, 1996; McMillen, 2003, pp. 289-290; Plaut & Plaut, 1998, p. 213; Tyrvainen & Miettinen, 2000). The model introduces house and lot characteristics to the standard analysis of the bid-rent curve (Cunningham, 2006, p. 6; Tyrvainen & 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 the Fourier repeat sales approaches (McMillen, 2003, p. 291). The standard repeat sales approach is similar to the hedonic model but includes data only on houses that have been sold more than once in the relevant period (Kiel & McClain, 1995a, p. 315; McMillen, 2003, p. 290). Several studies, such as those of Cunningham (2006), Eshet et al. (2007), Kong et al. (2007), Haurin and Brasington (1996), Kiel and Zabel (1996), have used the pure hedonic price approach, and several, such as that of Archer et al. (1996), have used the pure repeat sales model. Other have used the mixed hedonic and repeat sales model approaches, including studies by Gibbons and Machin (2005), McMillen (2003) and Kiel and McClain (1995a).

The approach that this chapter takes is based on 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 had been suitable. However, many municipalities in Iceland have such low populations that a repeat sales model approach would eliminate them 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, pp. 6, 16), Kiel and McClain (1995a, pp. 314-315), and chapter 4 in the present thesis, the general context from the basic model, $h(I,T,d,x,l)$, can be derived through a log linear utility function into an equation in the following form in its simplest version,

$$\textit{Eq. 5.4} \qquad h(d) = Ae^{-bd}$$

where h is the housing price, d 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. 5.4 becomes

$$\textit{Eq. 5.5} \qquad \ln h(d) = \ln A - bd$$

This equation has been used extensively in housing price research that is based on the hedonic price model, and it is routinely used in the field of housing price research regarding relevant dependent variables, as can be seen, e.g. in 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. 319; 1995b, p. 248). The equation is a non-linear relationship of semi-logarithmic type. Instead of estimating a simple model like

$$\textit{Eq. 5.6} \qquad lnh_{it} = \alpha_i + d_{it}\beta_1 + \varepsilon_{it}$$

economists frequently implement an extended model,

$$\textit{Eq. 5.7} \qquad lnh_{it} = \alpha_i + d_{it}\beta_1 + cz'_{it} + \varepsilon_{it}$$

where z'_{it} is a vector of relevant additional explanatory variables for which the model must control and c is a vector of coefficients. Thus, it is reasonable to apply the empirical model

$$\textit{Eq. 5.8} \qquad lnh_{it} = \alpha_i + d_{it}\beta_1 + z'_{it}\beta_2 + v'_{it}\beta_3 + \varepsilon_{it}$$

where the natural logarithm of the housing price, h, is dependent on the distance, d, to the capital area, or CBD; to several other explanatory variables, z'; to dummy variables, v'; and to relevant residuals, ε, of every municipality, i, in every single period, t. The selection of the explanatory variables which will be controlled for in the present model were based on similar studies and classified in several categories. Based on earlier literature (Case & Mayer, 1996; De Bruyne & Van Hove, 2006; McDonald & Osuji, 1995), the first category is local economic factors, such as household income and presence of exceptional manufacturing activity and transportation improvement, which approach is in line with the basic theoretical model (see Eq. 5.8). Household income is represented by local average income. There is a dummy variable for three municipalities in the neighbourhood of an unusually large-scale local investment project in an aluminium smelter that began in 2003. There is another dummy variable for Hvalfjörður tunnel. It captures the effect of a transportation improvement financed by a road toll, as the Hvalfjörður tunnel was the only transportation project in Iceland that was financed by a road toll in the relevant period. As in many earlier studies (Andrews et al., 2002; Archer et al., 1996; Cunningham, 2006; De Bruyne & Van Hove, 2006; Kiel & McClain, 1995a, 1995b; McMillen, 2003, 2004; Tyrvainen & Miettinen, 2000), the second category is a group of hedonic variables for housing quality, such as lot size, housing age, house building materials and type of construction, number of rooms, number of bathrooms, and existence of a garage. These factors shift the model from a standard bid-rent curve to a version of hedonic price model. The third category is a group for local demographic factors**,** such as population, which is comparable to some previous work (Archer et al., 1996; Cunningham, 2006; De Bruyne & Van Hove, 2006). Finally, as in many extant papers (Cunningham, 2006; De Bruyne & Van Hove, 2006; Haurin & Brasington, 1996; Kiel & McClain, 1995b; Tyrvainen & Miettinen, 2000), indicators for some kind of amenity value, such as the presence of a lake or an attractive view, arts and recreational opportunities (Haurin & Brasington, 1996, p. 351), any kind of local dangers, and crime rate, reflect a significant aspect of the distance gradient. A dummy variable for Akureyri is the only variable that reflects a value for access since it is the largest town in rural Iceland with an outstanding supply of arts and recreational opportunities.

As in my previous analysis (chapter 4), the presence of Akureyri, which is approximately 300 kilometres from the capital city makes the implementation of the traditional version of the empirical model inappropriate. Thus, a polycentric version based on the work of Partridge, Rickman, Ali, and Olfert (2009, p. 451) is implemented.

$$lnh_{it} = \alpha_i + s_{it}\beta_1 + u_{it}\beta_2 + e_{it}\beta_3 + z'_{it}\beta_4 + v'_{it}\beta_5 + \varepsilon_{it} \qquad \text{Eq. 5.9}$$

where s, u and e are three travel distance variables: s is the travel distance to Reykjavík for municipalities that are closer to Reykjavík than Akureyri, u is the travel distance to Akureyri for municipalities that are closer to Akureyri than Reykjavík, and e is the additional travel distance to Reykjavík for municipalities that are closer to Akureyri than Reykjavík. Let a be the travel distance from all municipalities to Akureyri: if $d > a$, then $u = a$, otherwise $u = 0$; and if $d < a$, then $s = d$, otherwise $s = 0$. In order to determine whether proximity to the larger CBD, the capital city, is valuable to municipalities that are closer to Akureyri than to Reykjavík, additional variables were constructed as follows: if $d > a$, then $e = d - a$, otherwise $e = 0$. An additional argument for this model is provided in chapter 4. Two dummy variables, one for Reykjavík and another for Akureyri, were constructed in order to detect agglomeration economies. Therefore, the two-period comparison of this model—where the difference between the coefficients for s and u detects the changes in preference for access over amenity values and where changes in the dummies for Akureyri and Reykjavík accounts for changes in agglomeration economies, *ceteris paribus*—is suitable for the subject of this paper

5.5 Data

For the purposes of this research, Iceland is divided into 79 municipalities that cover the entire period from 1995 to 2006, which is less than one business cycle since the bottom of the previous recession was close to 1995 and the top of the latest expansion close to 2006. All data from the previous study (Table 4-3) are included, with the exception that the variables for travel distance were replaced by travel time (Table 5-7) as the latter variable is more accurate. Travel time includes both the shortening of road distances and improved road quality when gravel roads are paved. The travel time was calculated as follows: $t_{it} = \left(\pi_{it}\, {}^{60}\!/_{90} + \left(1 - \pi_{it}\right){}^{60}\!/_{70}\right)d_{it}$. t_{it} is travel time, d_{it} is travel distance and π_{it} is the share of paved road between each municipality and the CBD. The municipality is identified by i and time by t. Average speed is assumed to be 90 kilometres per hour on a paved road and 70 kilometres per hour on gravel.

Table 5-7. Variable description and sample statistics.

Variable (acronym)	Description	Mean	Standard deviation
Travel time Reykjavík (TTRE)	Average travel time in minutes for each municipality closer to Reykjavík than to Akureyri from the capital city, in absolute terms	72.6	103.0
Travel time Akureyri (TTAK)	Average travel time in minutes for each municipality closer to Akureyri than to Reykjavík from Akureyri, in absolute terms	43.4	78.2
Marginal travel time Reykjavík (TTRM)	Average additional travel time in minutes from Reykjavík for each municipality closer to Akureyri than to Reykjavík, in absolute terms	79.9	119.7
Dummy for Akureyri (AKUR)	Dummy variable for a municipality outside the capital area with an unusually populous centre: 1 for Akureyri and 0 for all other municipalities.	0.013	0.112
Hvalfjörður tunnel (TUNN)	Dummy variable for a large transportation improvement project. 1 for Hvalfjörður tunnel.	0.210	0.408

The data in this table is based on annual averages, transformed by means.

A dummy variable for Hvalfjörður tunnel was also added to the present model (Table 5-7). The dummy variable takes the value of 1 beginning in 1998 in the case of the four municipalities that were closest to the tunnel. These municipalities were on other side of the tunnel and benefitted from a shortened travel distance to Reykjavík. The four municipalities are within a range of an approximately fifty kilometres radius north of the tunnel.

Akureyri (Table 5-7) is the largest urban community outside the capital area and it is represented by a dummy variable.

The averages and standard deviations of the explanatory variables and the dependent variable show considerable variation. That the standard deviation of housing prices is approximately half of the mean (Table 4-3), and the standard deviation of road distance is more than three-fourths of the mean (Table 5-7) is evidence of large differences, which shows potential for robust explanations. However, this panel data sample is unbalanced since observations for several values are missing.

5.6 Estimation results

The empirical model for testing the hypothesis was presented in previous chapter, Eq. 5.9. To investigate the development of the bid-rent curve, the relationship of travel time to the local real price of houses, among other relevant variables, as in Eq. 5.9, is estimated by a random effects model, as argued in chapter 4. A random effects model is more appropriate to the present analysis than a fixed effects model, as the random effects model includes both within and between variation of the data sample, while a fixed effects model returns only within variation (Hsiao, 2006; Verbeek, 2004). In previous estimation we were only occupied with the impact of distance and pure transportation improvements on the value of housing while the standard theory of the bid-rent curve includes both distance and the qualities of locations. Since the present research investigates whether the spatial variation is traced back to the value of access or the agglomeration economies the entire variation of the data sample behind the bid-rent curve is needed. By including the between variation, the estimated coefficient captures the value of the specific local divergence, along with the pure distances. A Hausman test supported that suggestion.

Initially, the estimations suffered from serial correlation, but this problem was sufficiently eliminated by a lagged variable of the residual, a method recommended by Wooldridge (2002, pp. 176-177). Furthermore, the presence of heteroskedasticity was addressed by running a robust estimator. Multicollinearity was not detected, except between the Reykjavík dummy and local population. The dummy for Reykjavík was discarded, so evidence for changed agglomeration economies was based on the Akureyri dummy alone.

Endogeneity was tested and was found to be present only in Model 2–that is, for the period 2001-2006, and only related to the total income variable. Total income is most likely strongly correlated with labour income, the percentage of elderly people in the local population should affect total household income on average, and total income can correlate with the transferable cod quota[33] such that, the greater the fishing quotas are, the greater the average total houshold income is. Cod was chosen because it is the most valuable fish species. Therefore, the instruments were labour income, percentage of elderly in the local population, and transferable cod quotas. The Sargan test was implemented and it resulted in a rejection of the hypothesis of weak instruments since it returned the estimator 0.0395, which is considerably lower than its critical value of 5.99. The results for the first step estimation are presented in the appendix.

The results presented in Table 5-8 include parameter coefficients, z-values, number of observations, R^2, and t-statistics for a special test of serial correlation. For simplicity, the estimations for time dummies are presented separately in the appendix. The results were as expected: The newer bid-rent curve for Reykjavík and the nearest municipalities was steeper than the older bid-rent curve, where the slope was -0.00214 for 2001-2006 and only -0.00053 for 1995-2000 (Table 5-8). As expected, the dummy variable for Akureyri changed between periods, going from 0.302542 in the first period to 0.69825 in the second. Both coefficients were significant. The Hausman test suggests an implementation of a random effect model for the data in the period 1995-2000 but not in the period 2001-2006 (Table 5-8), so x_{it} and α_i may be correlated. Even so, a random effect model will be used because 1) both within and between variations are needed to detect the presence of access and agglomeration economies, 2) a random effect model is suggested for the data in the previous period, and models should be compared to identical models and 3) the Hausman single parameter test suggests that the coefficient for travel time is close to sufficient in the random effects model (Model 2 in Table 5-8). 4) in the present case the Hausman test's "worst case scenario" indicates that the coefficient for travel time partly includes the impact of other implicit factor as well and that they have a joint impact on housing prices. If true, distance could have an impact on household preferences that is not explicitly represented in the model, since people who live close to a city are more likely to prefer of urban residence than are people who live farther away. However, that simply reveals the true

[33] In 1983 the present fisheries management was established in Iceland with the general characteristics of a traditional cap and trade system. The amount of allowable catch varied widely from year to year because of the size of the fish stocks. The quotas have been transferable since 1989.

Table 5-8. Relationship between housing prices and travel time from CBD: A random effect panel data model comparing two periods.

Variable (acronym)	Model 1 1995-2000 Random effect Robust model, Previous period	Model 2 2001-2006 Random effect Robust, 2SLS model Present period
Total Income (TINC)	0.000101 (1.38)	0.000225 (3.33)
Housing supply (HNPP)	-3.116840 (-4.15)	-1.682630 (-3.82)
Travel time Reykjavík (TTRE)	-0.000530 (-2.22)	-0.002140 (-4.26)
Travel time Akureyri (TTAK)	-0.000700 (-1.42)	-0.001190 (-1.77)
Marginal travel time Reykjavík (TTRM)	0.000003 (0.01)	0.001005 (1.53)
Dummy for regions closer to Reykjavík (DMRE)	0.035398 (0.35)	0.492686 (2.35)
Dummy for Akureyri (AKUR)	0.302542 (3.15)	0.698250 (3.75)
Housing age (HAGE)	-0.012030 (-5.69)	-0.008320 (-3.48)
Housing size (HSIZ)	0.003036 (7.59)	0.002061 (10.78)
Number of dwellings (HONR)	-0.302650 (-1.48)	-0.013890 (-0.12)
Rooms per dwelling (HORO)	0.061121 (1.64)	0.080623 (3.16)
House building material is wood (HOM6)	0.166331 (1.80)	0.113555 (1.11)
Balcony size (HOBA)	0.010747 (2.88)	0.013016 (1.99)
Parking/Garage (HOPA)	0.107812 (1.61)	0.264575 (3.06)
Lot size (HOLO)	-0.000096 (-1.15)	0.000027 (0.37)
Local population (POPU)	0.000007(5.66)	0.000006 (4.33)
Aluminium plant (ALEA)		0.153379 (1.55)
Hvalfjörður tunnel (TUNN)	0.170144 (3.03)	0.173720 (2.12)
Lagged residual (el_{t-1})	-0.094040 (-1.25)	
Constant term (alfa)	16.818060 (39.88)	15.278640 (38.47)
Number of observations, n	333	395
R^2 within	0.6518	0.5579
R^2 between	0.6997	0.7910
R^2 overall	0.6894	0.7268
Serial correlation	No (t=1.94)	No (t=-1.90)
Multicollinearity	No	No
Heteroskedastisty	robust	robust
Residual distribution	Not norma (JB=758)	Not normal (JB=2575)
Panel data sample	unbalanced	unbalanced
2SLS	No	Yes
Sagan test		0.0395
Hausman test Chi2-test	18	36
Hausman single parameter test (t-test)	0.93	2.07

Dependent Variable: Natural logarithm of housing price (Ln(hopr)). Methods: Random effect panel data model, with instrument variables when necessary, along with a robust estimator because of heteroskedasiticity. Statistical program: STATA.

value of access (both tangible and intangible benefits of proximity) that is one of the main purposes of the study. There is no reason to expect that travel time has an impact on housing prices through other potential variables that should be included to the model.

The bid-rent curve became steeper, while the population increased in the capital area, as shown in Table 5-1. Therefore, the higher relative housing price of the capital area is caused by the increasing attractiveness of the capital area. Since the analysis included the spatial diversity of other relevant economic factors, such as income, population, housing age, and several known large-scale investments, this result is likely to be either evidence of changed consumer preferences in Iceland in favour of access over amenity value or evidence of improved agglomeration economies because of rapid industrial structural change over the last decade. As argued earlier, the latest economic expansion in Iceland was primarily driven by the knowledge-based industry (Table 5-2), followed by a more highly educated labour force (Table 5-3), which is reflected in the growth in the number of people in highly skilled occupations in the capital area (Table 5-4). Since agglomeration economies were present in Akureyri, the results could also be interpreted as evidence of increased agglomeration economies in Reykjavík, since Reykjavík is almost ten times larger than Akureyri, the knowledge-based industry tends to have higher localization economies than the manufacturing industry does, and agglomeration economies tend to be greater in a diversified city (O'Sullivan, 2009, pp. 235-240).

These results have several limitations. It would have been better for the overall estimation to have a dummy variable for Reykjavík. In addition, a variable for local population density would have provided a better estimate for agglomeration economies since time variations could have been a factor. The increased value of access over amenities was not detectable in Akureyri and its closest municipalities since the slope’s increase is not significant. The size of the community can be the reason. There is no explanatory variable for the development of industrial structure in Iceland, but the impact of that development has been accounted for to some extent since the population is presumably correlated with the variety of industries and employment opportunities. Note that the relationship between local housing prices and population is positively significant (Table 5-8).

The model was also estimated separately for the metropolitan area alone. In this estimation, the municipalities of the conurbation area[34] were selected based on a study on the interaction of cities with their neighbouring regions. The authors suggested that a conurbation area is a region within a 120-kilometre radius from a city centre (Dahms & McComb, 1999). A conurbation area has – a much more frequent and diverse interaction with the city than do regions beyond.

When the slope of the conurbation area's distance gradient for 1995-2000 was estimated and compared against the bid-rent curve for 2001-2006, the results were not as expected. The latter bid-rent curve was flatter, changing from -0.00356 in 1995-2000 to -0.00263 in 2001-2006 (Model 3 compared to Model 4 in Table 5-9). However, the coefficient for the previous period was not significantly different from that of the previous period. Once again, the Hausman test suggests implementation of a random effect model for the 1995-2000 data but not or the 2001-2006 data (Table 5-9). Based on arguments for the previous estimation, the random effects model is implemented in both cases.

The analysis suffered from autocorrelation, which was sufficiently eliminated by a lagged variable of the same type as in previous estimation. Thereafter, autocorrelation, multicollinearity, and hetero-skedasticity (notations in Table 5-9) were not problematic in the results. The results indicate that the distance gradient of the bid-rent curve in the conurbation area is slightly flatter today than it was earlier.

The estimated slopes of the bid-rent curves of the present study, in the range of 0.05-0.36 percent, are in line with results from several other studies. McDonald and Osuji (1995, p. 261) found the slope to be approximately 1 percent for the city of Chicago. A 0.7 percent distance gradient was among Cunningham's (2006, p. 18) results for the CBD of Seattle. Tyrvainen and Miettinen (2000, p. 215) concluded that housing value decreased by 0.11 percent for every 1 percent distance in kilometres away from the centre of the Salo district in Finland. De Bruyne and Van Hove (2006) came up with a gradient somewhere between 0.001 percent and 0.002 percent for Belgium. The present figure

[34] Now a segmentation of the country into three basic areas is introduced as the urban area, the intermediate area, and the rural area. The conurbation area includes the urban and the intermediate area (Figure 1). Only urban and rural areas were used earlier. District ares included rural and intermediate areas.

Table 5-9. Relationship between housing prices and travel time from CBD: A random effect panel data model comparing two periods in the conurbation area.

Variable (acronym)	Model 3 Random effect Robust model, Previous period 1995-2000	Model 4 Random effect Robust model, Present period 2001-2006
Total household income (TINC)	0.000240 (2.70)	0.000107 (4.05)
Housing supply (HNPP)	0.177970 (0.18)	-2.385290 (-2.42)
Travel time to Reykjavík (TIRE)	-0.003560 (-2.39)	-0.002630 (-1.45)
Housing age (HAGE)	-0.010190 (-3.33)	-0.017430 (-4.64)
Housing size (HSIZ)	0.002916 (19.02)	0.004434 (4.3)
Number of dwellings (HONR)	-0.321360 (-2.08)	-0.806960 (-1.06)
House building material wood (HOM6)	-0.260170 (-2.55)	-0.103800 (-0.80)
Balcony size (HOBA)	0.001300 (0.23)	0.012614 (2.33)
Parking/Garage (HOPA)	-0.148070 (-2.32)	0.220439 (1.68)
Lot size (HOLO)	0.000115 (1.70)	
Local population (POPU)	0.000001 (1.08)	0.000006 (3.40)
Hvalfjörður tunnel (TUNN)	0.011443 (0.17)	0.152398 (1.38)
Lagged residual (elt-1)		0.721449 (3.56)
Constant term (α)	15.981560 (40.41)	17.380260 (21.14)
Number of observations, n	163	117
R^2 within	0.8095	0.2846
R^2 between	0.6673	0.6492
R^2 overall	0.7645	0.5545
Serial correlation	No (t=-1.48)	No (t = 1.99)
Multicollinearity	No	No
Heteroskedastisty	robust	robust
Residual distribution	Not normal (JB=34)	Not normal (JB=91)
Panel data sample	unbalanced	unbalanced
Hausman test Chi2-test	0.52	83
Hausman single parameter test (t-test)	2.43	-1.57

Dependent Variable: Natural logarithm of housing price (Ln(hopr)). Methods: Random effect panel data model with instrument variables, along with a robust estimator because of heteroscedasiticity. Statistical program: STATA.

for Iceland's CBD, 0.47 percent, is close to that of other published results, while the lower figure, 0.03 percent for the entire country, is closer to the Belgian result.

According to the results, the distance gradient is becoming increasingly steep for the entire country but flatter for the conurbation area. Is there any logical explanation for this apparent contradiction? It is possible that, even though the value of access has been increasing, more inhabitants of the CBD appreciate amenity values and tend to combine those two qualities. This could be evidence of an increase in both access and amenity values where the local price of housings in rural municipalities farthest away from the CBD is decreasing compared to the capital and the intermediate areas, since the rural area is capable only of providing amenities, while the conurbation area provides both access and amenities.

Table 5-10. Growth of population and housing prices: comparison of two periods and three areas of Iceland.

Source: Statistics Iceland

	Conurbation area					
	Capital area		Intermediate area		Rural area	
Indicator	1993/1981	2006/1994	1993/1981	2006/1994	1993/1981	2006/1994
Population	25.1%	22.4%	8.1%	18.9%	-0.8%	-2.9%
Housing prices	-3.2%	97.9%	-15.6%	86.7%	-9.0%	49.1%

Growth is calculated as the value at the end of the period divided by the value at the beginning (minus 1).

The population and housing price data from the relevant period support this notion. The population increase has been similar in the capital area (22.4%) and the intermediate area (18.9%) in the more relevant period (1994-2006), while these regions experienced a similar increase in housing prices, 97.9% and 86.7% (Table 5-10). By contrast, the population of rural areas decreased by 2.9%, while experiencing a significantly smaller increase in housing prices, 18.9%.

Data for interregional migration was only available for the period 1986-2006. By comparing two ten-year annual averages of migration (1986-1995 and 1997-2006 in Table 5-11) it became evident that there was a polarisation in the migration of the intermediate area since the migration was negative in the earlier period and positive in the latter (from -0.7% on the average to 0.5%) while the migration remained positive in the capital area and negative in the rural area (Table 5-11). Marginally, the changes were also greater for the intermediate area than for the capital area and the rural area.

Table 5-11. Population and interregional migration: comparison of two periods and three areas of Iceland.

Source: Statistics Iceland

	Conurbation area					
	Capital area		Intermediate area		Rural area	
Indicator	1986-1995	1997-2006	1986-1995	1997-2006	1986-1995	1997-2006
Average population	147,497	178,124	38,861	42,390	70,943	66,865
Net average migration	1,175	820	-275	210	-900	-1,030
Migration/population	0.8%	0.5%	-0.7%	0.5%	-1.3%	-1.5%

The annual average of two ten-year periods.

Therefore, the result could be explained by a relatively new trend in interregional migration, counterurbanisation, which is characterized by out-migration from urban areas to adjacent rural areas (Dahms & McComb, 1999; Mitchell, 2004; Stockdale et al., 2000). Since the motivation for counterurbanisation is partly for amenities and since the bid-rent curve is becoming flatter in the conurbation area of Iceland, counterurbanisation has been detected in Iceland.

5.7 Conclusion

There is a statistically significant relationship between housing prices and travel time from the capital of Iceland to other municipalities. This research shows that this relationship has become increasingly stronger recently, probably because of increased preference for access over amenities. The strength of the relationship may also be due to improved localization and urbanisation economies since the latest economic expansion in Iceland has been driven more by the knowledge-based industry than were former expansions and since knowledge-based industry tends to have higher localization economies than manufacturing industry does. These are the results when correcting for a regional disparity in total income, population, and housing age and several other relevant explanatory variables.

Weak evidence was found of counterurbanisation in Iceland. Although the spatial disparity of local housing prices has increased in the entire country, it has decreased within the conurbation area.

These results are considerably robust, as they are based on a large data series of all 79 municipalities in Iceland from 1995 to 2006.

A poor representation of industrial structure counts as a weakness of the results. Some indicator for either a specific industrial structure or the variety of local industries would have been a better proxy variable for the potential urbanisation and Jacobs economies and number of firms for localisation and MAR economies. A variable for local population density would have been another way to improve the model, since proximity is the prime condition for agglomeration economies. The method however, indicates that when the spatial variation of housing prices has been detected for all known explanators the difference, the agglomeration economies, is traced by the constant term. Other weaknesses were minor.

5.8 Appendix

This appendix contains an overview of time dummies from present models. The results are presented in two separate tables in the hope that doing so will make the paper clearer.

Table 5-12. Estimates for time dummies.

Variable (acronym)	Model 1 1995-2000	Model 2 2001-2006	Model 3 1995-2000	Model 4 2001-2006
Time dummy for 1996 (tdum16)	-0.020520 (-0.56)		-0.073320 (-3.27)	
Time dummy for 1997(tdum17)	0.034361 (0.80)		-0.091600 (-2.41)	
Time dummy for 1998 (tdum18)	-0.023280 (-0.47)		-0.073370 (-1.49)	
Time dummy for 1999 (tdum19)	0.054696 (0.93)		-0.029630 (-0.45)	
Time dummy for 2000 (tdum20)	0.050343 (0.87)		0.001918 (0.02)	
Time dummy for 2001 (tdum21)		-0.043560 (-1.13)		
Time dummy for 2002 (tdum22)		(dropped)		
Time dummy for 2003 (tdum23)		0.058204 (1.13)		0.152320 (3.79)
Time dummy for 2004 (tdum24)		0.112050 (2.39)		0.139324 (3.83)
Time dummy for 2005 (tdum25)		0.263595 (5.02)		0.312302 (7.94)
Time dummy for 2006 (tdum26)		0.295946 (5.02)		0.453328 (11.5)

Dependent Variable: Natural logarithm of housing price (Ln(hopr)). Methods: Random effect panel data model, with instrument variables when necessary, along with a robust estimator because of heteroscedasiticity: labour income and size of the labour market. Statistical program: STATA.

Table 5-13. First-step regression of 2SLS for model 2.

Variable (acronym)		Model 2 2001-2006
Housing supply (HNPP)		755.139300 (1.07)
Travel time Reykjavík (TTRE)		-0.183550 (-0.39)
Travel time Akureyri (TTAK)		0.092461 (0.13)
Marginal travel time Reykjavík (TTRM)		0.393036 (0.52)
Dummy for closer to Reykjavík (DMRE)		283.167900 (1.31)
Dummy Akureyri (AKUR)		-56.782700 (-0.15)
Housing age (HAGE)		-0.578930 (-0.28)
Housing size (HSIZ)		-0.041430 (-0.18)
Number of dwellings (HONR)		-48.363900 (-0.23)
Rooms per dwelling (HORO)		16.984490 (0.74)
House building material wood (HOM6)		-174.833000 (-1.97)
Balcony size (HOBA)		3.834374 (0.69)
Parking/Garage (HOPA)		34.608240 (0.46)
Lot size (HOLO)		0.007527 (0.13)
Local population (POPU)		-0.002600 (-0.93)
Aluminium plant (ALEA)		-193.735000 (-1.09)
Hvalfjörður tunnel (TUNN)		-228.164000 (-1.48)
Time dummy 2001 (tdum21)		-351.252000 (-5.01)
Time dummy 2002 (tdum22)		-353.212000 (-5.21)
Time dummy 2003 (tdum23)		-331.342000 (-5.13)
Time dummy 2004 (tdum24)		-257.474000 (-4.31)
Time dummy 2005 (tdum25)		-100.785000 (-1.79)
Labour income (linc)	Instrument variable 1	1.109803 (11.70)
Share of elderly in total population (eldp)	Instrument variable 2	-1016.730000 (-0.94)
Local transferable fish quotas in cod (toqu)	Instrument variable 3	0.000001 (0.40)
Constant term (alfa)		-45.666800 (-0.09)
Number of observations, n		395
R^2 within		0.4950
R^2 between		0.7468
R^2 overall		0.7030

Dependent Variable: Total household income. Methods: Random effect panel data model. Statistical program: STATA.

Part III

6 Interregional migration, transportation improvements, and gender

6.1 Introduction

Domestic populations of western countries have been moving from rural to urban areas or from periphery to central areas. This development has been studied by scientists for many decades and they have proposed many theories to explain it. This paper addresses the problem of capturing the effect of transportation improvements on interregional migration in a sparsely populated country—in this case, Iceland—and tests whether its location has had any marginal effect. The research question of present paper is the following: Does improved transportation between major urban centres and the adjacent rural areas have an impact on interregional migration in a thinly populated country?

A rough inspection of data for interregional migration of all municipalities in Iceland for two recent decades (1986-2006) (Figure 6-1) shows that positive net migration was limited to the two largest municipalities (Reykjavík on the southwest coast and its closest municipalities and Akureyri on the north coast) in the period of 1987-1996 but stretched out to other smaller and adjacent municipalities in the period 1997-2006. One visible exception on the east coast is due to the construction of a large-scale aluminium production plant and the construction of a new power plant during the 2004-2006 period. The project was located in three municipalities on the east coast—Fjarðarbyggð, Fljótsdalshérað, and Fljótsdalshreppur—while the aluminium productions plant itself was located in Fjarðarbyggð. A new large power plant was built in Fljótsdalshreppur to support the aluminium smelter. The net migration was favourable in only one of the municipalities, Fljótsdalshérað, during the period of 2002-2006. Note that many immigrants lived there only during the construction phase of the investment and had no other plans since large mobile camps were constructed for them.

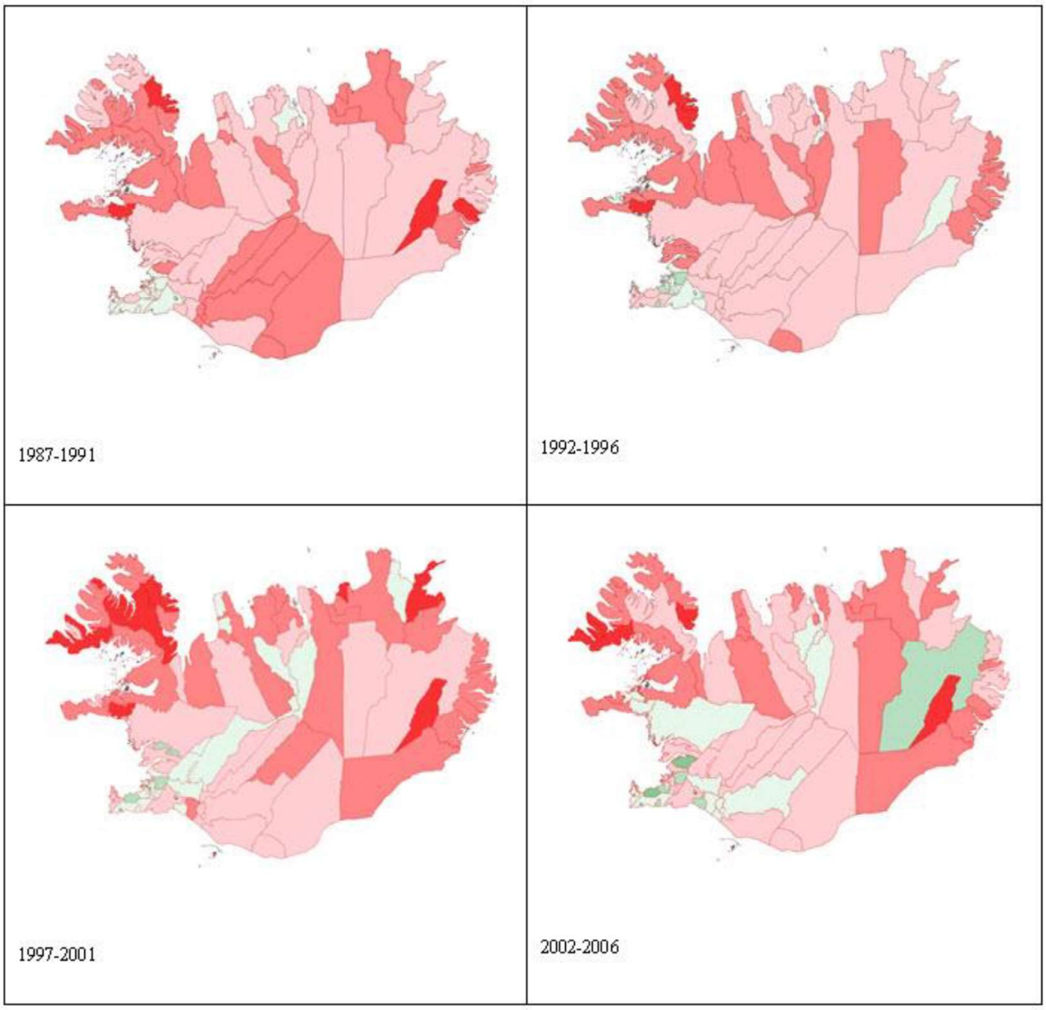

Figure 6-1. The development of interregional migration in Icelandic municipalities (79).

The average interregional migration in municipalities of Iceland in the four most recent five-year periods. Green represents municipalities with positive net migration and red municipalities with negative net migration. The darker the greater the migration and runs by 0.1 percentage for each level. Source: Statistics Iceland

Iceland is sparsely populated and is exceptionally dependent on the road network because of limited supply of other transportation modes such as scheduled flights, trains, or ferries. Some economic theories suggest both in-migration to and out-migration from rural areas occur following transportation improvements between urban and rural areas. Assume a two-region world, rural and urban, where the rural region is transport-intensive because rural products must be transported to the market at the urban area, and the rural household must travel to the urban area for specialized services. According to the equilibrium model, transportation improvements between the regions would bring more benefits to the transport-intensive region through labour productivity and real wages and cause urban-to-rural migration (McCann, 2001). The inflow to the rural areas would stop when the spatial wage differentials matched the inverse spatial amenity differentials. Harris and Todaro (1970) and Stark and Levhari (1982) added uncertainty to the equilibrium model, suggesting that uncertainty could be reduced following a transportation improvement increasing access of the inhabitants of the rural area to the labour market of the urban area.

However, according to the theory of the New Economics of Geography, the core-periphery model (CPM) suggests that transportation improvements could lead to the opposite development — rural-to-urban migration — because the model includes two counteractive forces: the agglomeration force, a centripetal effect driven by agglomeration economies, and the dispersion force, a centrifugal effect that covers the tendency of firms to avoid competition by moving back to the rural area when the market gets crowded. In Baldwin's (2001) CPM migration model, the dispersion force covers the costs related to urban traffic congestion. Thus, any demand or supply shock changes the relative household utility between the regions, such that inhabitants would emigrate from the region of lower household utility. If the agglomeration force dominates the dispersion force, the lower-utility region would lose all of its population. Since transportation and congestion cost are part of the dispersion force, any transportation improvement would reduce that cost, increasing the probability of the dispersion force's being dominated by the agglomeration force. This effect occurs both because of lower urban dis-amenities (traffic congestion) and because the monopolistic firm gets better access to the rural area following a transportation improvement so it can export goods there instead of moving when the competition increases. Accordingly, New Economic Geography suggests that transportation fuels population centralisation (Baldwin et al., 2003).

Therefore, the answer to the research question concerning whether transportation improvements between major urban centres and the adjacent rural areas have an impact on interregional migration in a thinly populated country is the subject of present study, as is determining whether the answer is in line with the disequilibrium model or the New Economic Geography.

The organisation of the rest of this chapter is as follows. Section 2 provides a literature review, while Section 3 derives the empirical model. Section 4 describes the data construction and handling and contains the analysis and the results. Finally, the summary and concluding remarks are in Section 5.

6.2 Literature review

Tiebout (1956) brought the equilibrium aspect to the disequilibrium model (see chapter 3.5.1). Previously, the disequilibrium model had suggested that migration was a response to any geographical wage differential and that the local population was only in equilibrium when real wages were equal in all regions. With Tiebout's contribution, migration was possible even though wages were equal in all regions because of different levels of local public service. Later, other factors were addressed as local amenities. Graves (1979) contributed geographical differences in climate, Blomquist, Berger, and Hoehn (1988) contributed crime and pollution and other factors classified as quality of life, and Gyourko and Tracy (1991) argued that institutional strength was part of the quality of life of the local population.

Harris and Todaro (1970) and Stark (1982) added uncertainty to the disequilibrium by replacing income with expected income and extended their models to include amenities (see chapters 3.5.2 and 3.5.3, especially Eq. 3.26). Their models were constructed for developing nations, but they have been implemented for developed nations as well (Greenwood et al., 1991; Pekkala, 2003; Treyz et al., 1993).

The gravity model is, to some extent, different from the disequilibrium heritage (see chapter 3.5.4). The gravity model assumes that interregional migration between two regions is dependent on the local populations and the distance between them (Carrothers, 1956), so distance is explicitly included in the model such that, the longer the distance, the less migration occurs between the regions. The model is based on a model in physics, but it has been successful in explaining interregional migration (Krugman, 1995) and has been implemented in empirical migration studies for several decades (Carrothers, 1956). The most common known version of the model is Eq. 3.28.

CPM is the latest contribution to spatial economics (see chapter 3.5.6). The model assumes three effects behind the location of the industries: a market access effect, a cost of living effect, and a market crowding-out effect. The market access effect reflects the fact that monopolistic firms attract large markets, so they locate in a large city and export to smaller cities. The cost of living effect refers to the attractiveness of lower prices to labour, which tends to gravitate to larger cities where there are more jobs and prices are lower. However, low prices repel monopolistic firms, so these firms look for another market where the prices are higher, either by relocating or by exporting. If the transportation cost is high, they tend to relocate, which is the essence of the market crowding-out effect. The market access affect and the cost of living affect fuels migration toward the largest cities, while the market crowding-out effect motivates migration back to the smaller cities. The first two effects are called the agglomeration force and the third is the dispersion force (Baldwin et al., 2003, p. 10; Fujita et al., 1999). Later, Baldwin (2001) constructed an explicit model for interregional migration based on CPM (Eq. 3.53).

The difference between the classical equilibrium model and the New Economic Geography is primarily that the New Economic Geography explicitly includes agglomeration economies and transportation costs (The gravity model includes transportation cost as well). Moreover, New Economic Geography assumes monopolistic competition, while the equilibrium model assumes perfect competition. The contribution of Harris and Todaro (1970) and Stark (1982) to the equilibrium model was an attempt to move away from the assumption of perfect competition, since they included expected income. Even though it is comparable to what Baldwin (2001) did, the standard CPM did include markets with monopolistic competition. The difference between Baldwin (2001), Harris and Todaro (1970), and Stark (1982) lay in the presence or absence of agglomeration economies, urban dis-amenities, and more advanced analytical tools.

The bulk of the empirical study has been devoted to gravity-based and disequilibrium-based models, not the CPM. Based on a comprehensive search of the literature, no empirical study has included an examination of the relationship between interregional migration and transportation improvements.

6.3 Model

The choice of model for the present study of interregional household migration is complicated, because there are many good models available. The gravity model (Eq. 3.28) has two shortcomings for the present study. First, despite its success, it comes from the field of physics, so it has received criticism from economists. However, economists have been relatively successful in explaining the economic intuition of the model. The second shortcoming of the gravity model has to do with the available dataset for Iceland, which does not include sufficient information to implement the gravity model, especially when it comes to distances. In order to detect sufficient numbers of transportation improvements, the data has to cover at least two decades. Since there are 79 municipalities and the model needs distance between them (79×79) all through the entire period, data from about 125,000 different observations are needed to implement the gravity model for the present study over twenty years[35]. This effort could not be completed in a reasonable time frame.

The core-periphery model (Eq. 3.53 and alternatively Eq. 3.54) is applicable to the empirical model of the present study, both because it is based on solid economic theory and because it is the most recent theory in spatial economics and thus interesting to test in order to investigate whether it reveals any new aspects of the migration or returns better overall estimation than previously obtained. However, the theory has a disturbing weakness for Iceland connected to the crowding-out effect where it suggest that a firm of monopolistic competition avoids competition in the city by moving to smaller community of where the competition is less and profit greater. Why should a company of monopolistic competition want to move to a smaller city in Iceland since Reykjavík is much larger in terms of population than other urban communities? More specifically, Reykjavík and its adjacent areas have close to 200,000 inhabitants, and Akureyri, the second-largest "city" has only 17,000 inhabitants. While there are fewer companies in the smaller city, the market is much shallower, so relocating a monopolistic competition firm will return neither higher sales prices nor sufficient demand, especially if the firm is highly specialized. Therefore, the

[35] It is data for distance between all the 79 municipalities for twenty years or $79 \times 79 \times 20 = 124{,}820$.

argument for relocation to smaller cities is weak for Iceland. The theory on which the core-periphery model is based, assumes a community of many cities and towns of not that different sizes. This assumption might be sound in the context of continental Europe, or the US, where city populations are much more comparable and not for Iceland, where the city populations are not very comparable.

Core-periphery models have seldom been subject to empirical investigation since they are dynamic and thus more appropriate for numerical simulations. The equilibrium model and the Harris-Todaro model fit the available data better than the gravity model. Both include amenities, rely on a sound economic theory, and have been successful in many empirical studies. Since interregional migration of Iceland has never been estimated by empirical models previously, the present study will be based on a Harris-Todaro theoretical model instead of the recent Core-periphery model. An implementation of the Core-periphery model would be an outstanding future research for comparison of present results. The Harris-Todaro model is an extension of the equilibrium model, which includes consumers' expectations (and, therefore, risk). Although the model was constructed to analyze interregional migration in less developed countries, it is frequently used as an empirical migration model (Mitchell, 2004) in both developing countries and developed countries (Greenwood et al., 1991; Pekkala, 2003; Treyz et al., 1993).

Following derivation of the empirical model is almost identical to Greenwood et al. (Greenwood et al., 1991, pp. 1382-1383). According to both the equilibrium model and the Harris-Todaro model, net migration, m, of region i and period t, is dependent on expected relative lifetime earnings, $\breve{L}\breve{E}$, and relative amenity ($\breve{A}$) spatial differentials. Now, Harris-Todaro model (Eq. 3.25) can be written in simpler terms,

$$\textit{Eq. 6.1} \qquad m_{it} = \breve{L}\breve{E}_{it} + \breve{A}_{it}$$

since proportional net migration in Eq. 3.25 is the sum of the natural labour force in the previous period, NLF_{t-1}, and economic migration, ECM_t, divided by the natural labour force in the previous period. Economic migration is defined as the net economic migration of individuals who base their decisions on economic factors. The natural labour force is represented by the local population's potential workers, rather than local employment. Thus, the number of people within a certain age range is used to represent the natural labour force. Economic migration is limited to the net migration of people within the age range of 16-74, since others don't make migration decisions based on the condition of the labour market.

The Harris-Todaro model assumes that expected lifetime earnings motivate migration decisions (Greenwood et al., 1991; Harris & Todaro, 1970; Treyz et al., 1993): expected lifetime earnings in region k are the net present value of expected income in region k:

Eq. 6.2 $$\widetilde{L}\widetilde{E}_{k,t_0} = \left[\sum_{t=t_0}^{T} \frac{I(1+\widetilde{g})^{t-t_0}}{(1+\widetilde{\rho}_t)^{t-t_0}} \right] - \phi$$

where I is income, $\widetilde{g}$ is the expected growth rate, $\widetilde{\rho}$ is the expected discount rate, and ϕ is the fixed proportion of income required for migrating. Expected relative lifetime earnings, $\breve{L}\breve{E}$, are equal to expected lifetime earnings in region k divided by the average of the expected lifetime earnings in all other regions. If the expected growth rate can be assumed to be identical among all regions, only a comparison of relative income ("wage bill"), $\breve{I}$,

Eq. 6.3 $$\breve{I}_{it} = \frac{\widetilde{I}_{it}}{\overline{I}_{it}}$$

is needed in Eq. 6.1 instead of expected relative lifetime earnings (Greenwood et al., 1991, p. 1383), $\breve{L}\breve{E}$, where relative income is equal to expected income, $\widetilde{I}$, divided by regional average income, $\overline{I}$ - that means that a potential migrant only looks at the expected income the first period instead of all future periods since the development of earnings is identical in all regions. Relative amenities, $\breve{A}$, are found in a similar way: the local amenities, A, are divided by the national average of amenities, $\overline{A}$:

$$Eq.\ 6.4 \qquad \breve{A}_{it} = \frac{A_{it}}{\bar{A}_{it}}$$

Therefore by substituting $\breve{L}\breve{E}$ by $\breve{I}$ in Eq. 6.1 the empirical model can be presented as follows:

$$Eq.\ 6.5 \qquad m_{it} = \breve{I}_{it} + \breve{A}_{it}$$

When it comes to the regression model, a standard panel data model, such as a fixed-effect or random-effect model, seems to be an excellent choice, since they usually return more efficient estimators than do pooled ordinary least square (POLS) models. Moreover, a fixed effect model identical to Eq. 4.5 is appropriate since the impact of transportation improvements is the central subject here as well. Thus, the present empirical model becomes as follows:

Eq. 6.6

$$m_{it} = \alpha_i + I_{it}\beta_1 + A_{it}\beta_2 + s_{it}\beta_3 + s_{it}^2\beta_4 + u_{it}\beta_5 + u_{it}^2\beta_6 + e_{it}\beta_7 + z'_{it}\beta_8 + v'_{it}\beta_9 + \varepsilon_{it}$$

where net migration, m, is dependent on relative income, I; relative amenities, A; the distance to the closer centre, either Reykjavík s or Akureyri u; a vector of relevant additional explanatory variables, z'; a vector of relevant dummy variables, v'; and the residuals, ε, of every municipality, i, in every single period, t. α_i is the individual constant term and amenities are represented explicitly in A. Relative local taxes, supply and price of dwellings, and transferable fishing quotas are among other explanatory variables. Table 6-1 illustrates the entire list of variables. There are also many dummy variables, almost all of which are related to amenities (see Appendix). One of the dummy variables relates to the establishment of a large aluminium production plant in 1998 in eastern Iceland, while others relate to tragedies, like the snow avalanches in the Westfjords in 1995 and 1996. For technological reasons, one additional dummy variable, e, was constructed for municipalities closer to Reykjavík than to Akureyri; the variable has the value 1 if Reykjavík is closer to the municipality and zero otherwise.

The quadratic distance version of the model (Eq. 6.6) is suitable for the evaluation of the relationship between interregional migration and transportation improvements, because the distance parameters s , u , and e capture the relative influence of the respective factors on interregional migration. The travel time between the centre of each municipality and the centre of the two CBDs, expressed in minutes, is the data used to represent distance. Thus, the distance parameters reflect the relative influence of the single-unit shortening of travel time on the interregional migration, *ceteris paribus*.

6.4 Data

The present analysis is based on data from Iceland, a country divided into 79 municipalities[36]. The migration model needs data for several variables: net-migration, income, price level, housing prices, unemployment, transportation improvements, and other local idiosyncrasies. This data was collected for the period of 1986-2006. At this period there was a considerable amalgamation of municipalities. To retain comparability, the data was transformed into one identical sample of municipalities completely comparable to the situation in the year 2006.

Data for migration were only available over the period from 1986 through 2006. Based on the Harris-Todaro model, the relevant net migration, $miec$, was calculated as the sum of the local workforce[37] in the previous period and the net migration in present period, m_l, divided by the local workforce in the previous period. Traditionally, the population in the 16-74 age range, l, has been counted as the workforce in Iceland. Therefore, $miec = (l_{t-1} + m_l) / l_{t-1}$.

Travel time includes both a shortening of road distances and improved road quality by, for example, paving gravel roads. The calculation was as follows: $t_{it} = \left(\pi_{it} \, {}^{60}\!/_{90} + \left(1 - \pi_{it}\right) {}^{60}\!/_{70}\right) d_{it}$, where t_{it} is travel time, d_{it} is travel distance, and π_{it} is the percentage of paved roads between each municipality and the CBD. Municipalities are

[36] There is a two-tier system in Iceland: the central level, with the central government, and the local level, with the municipalities. Counties are not a part of the system; the role of counties was more important historically, but they are now used mainly to determine jurisdictions for Iceland's courts and police.

[37] What Greenwood (1991) calls natural civilian labour force.

denoted by i and time by t. The average speed is assumed to be 90 kilometres per hour on a paved road and 70 kpm on gravel road[38].

According to the Harris-Todaro model, expected income is relevant to interregional migration, where expectations concerning employment are needed to evaluate expected income. Since expected employment was not available for the municipalities, unemployment was used to estimate the expected employment variable by subtracting the unemployment rate, u, from 1. Here, the unemployment rate is the number of registered unemployed persons divided by the number of inhabitants aged 16-74 years. Thus, the expected income was calculated as the product of labour income and expected employment, or $liex = i_l(1-u)$. Relative income, $lier$, is found by dividing local expected income by the national average of expected income. Housing prices and local taxes are also presented as relative means in this paper. All other explanatory variables are relative to the national average, as suggested by the Harris-Todaro model, except for dummy variables and travel time.

Relevant amenity values were collected by questionnaires to the local authorities and were represented by dummy variables. In addition information was gathered about natural disasters and weather conditions. If the relevant amenity was present somewhere in the municipality, the dummy variable took the value 1 during the given year and 0 otherwise. The complete list of the amenity dummy variables is presented in the Appendix.

The data series were reported as annual averages, except for population and road distance which were static. Data on population is taken as of 1 December every year, and the data on road distance is taken as of 1 January every year. Except for road distance and weather variables, the data series were spatially classified by municipalities. Data on road distance were classified by localities and since there could be many localities in each municipality the data was transformed from localities into municipalities by calculating the average. Data for weather variables were only available for counties.

[38] Icelandic Road Administration uses slightly lower numbers based on 12 years old study, which are according to them far too old because those figures tend to be unstable from year to year, depending on many factors such as economic growth. I chose to use the numbers above because according to my observations travellers in rural Iceland frequently tend to push the limits and exceed them. Furthermore, according to my estimation the results are not very sensitive to those numbers.

Table 6-1. Variable descriptions and sample statistics.

Variable (acronym)	Description	Mean	Standard deviation
Net migration (miec)	Sum of labourers in the previous period and net inflow of labourers divided by the number of labourers in the previous period. Number of labourers is defined as citizens in the age range of 16-74 years old.	0.984	0.033
Expected labour income	Relative expected income. Local labour income per capita divided by its national average.	1.002	0.211
Number of dwellings (hshn)	Relative number of dwellings. New dwellings (number of dwellings minus the number in the previous period) divided by number of dwellings, an artificial value for housing supply.	0.011	0.031
Local income taxes (lotr)	Relative local income taxes. Local income tax rate divided by the national average.	1.000	0.032
Travel time to Reykjavík (ttre)	Travel time between Reykjavík and municipalities closer to Reykjavík than to Akureyri.	72.552	103.019
Travel time to Akureyri (ttak)	Travel time between Akureyri and municipalities closer to Akureyri than to Reykjavík.	43.363	78.164
Marginal travel time to Reykjavík (ttrm)	Travel time between Reykjavík and municipalities closer to Akureyri than Reykjavík.	79.88	119.675
Housing price (hprr)	Relative housing price. Local housing price per square metre divided by the national average.	1.000	0.440
Fishing quotas ITQ (rrqr)	Relative ITQ. Local transferable fishing quotas (only demersal and flat fish) divided by the national average.	1.000	1.868
Changes in gender ratio	Annual changes in relative gender ratio. Gender ratio is the number of females divided by the number of males.	1.001	0.049
Local population average age (pagr)	Relative average age. Local average age divided by national average.	0.999	0.085
Local population (popr)	Relative population. Local population of municipalities divided by the national average.	1.000	3.482
Temperature (temr)	Relative average temperature. Average temperature in the relevant county divided by the national average.	1.000	0.211
Wind speed (winr)	Relative average wind speed. Average wind speed in the relevant county divided by the national average.	1.000	0.302

The explanatory variables included in Eq. 6.6 are drawn from sources that include the Commissioner of Inland Revenue, Statistics Iceland, and the Icelandic Road Administration. Information for the number and prices of dwellings was obtained from the Land Registry of Iceland. Data on road distances were received from Fjölvís Publishing Company and were originally collected by the Icelandic Road Administration. The data on unemployment and total income were received from the Directorate of Labour and the Icelandic Regional Development Institute. The Commissioner of Inland Revenue is the primary source for labour income. The Directorate of Fisheries contributed data on fishing quotas.

6.5 Results

The empirical model for testing the hypothesis is shown in Eq. 6.6. Neither multicollinearity, nor serial correlation, was present in the final model. The presence of heteroskedasticity was detected and thus a model of robust estimation was implemented. Endogeneity was tested in the variables for numbers of dwellings, expected labour income, and relative housing prices. The expectation is that the number of dwellings affects interregional migration since available housing is a condition for settlement, and interregional migration tends to decrease the number of dwellings because of lower demand in regions that lose citizens while it increases demand in regions that experience increase in population. Moreover, expected labour income should affect interregional migration to places where workers can get higher wages and from localities that pay lower wages, and interregional migration affects expected labour income through marginal productivity and income expectations. Furthermore, housing price should affect interregional migration since households are attracted to lower housing prices, and interregional migration affects housing price through housing demand. Of course, lower housing prices can prevent sales of housing while the buyer assumes it is still too high or seller too low with regard to future expectations but eventually the market reaches equilibrium and sales occur if the relevant community is not heading into total collapse.

Theoretically, the instruments for potential endogenous variables are total income, percentage of elderly, housing prices, and distance from Reykjavík. The number of dwellings, a proxy variable for housing supply, should be correlated with total income. Housing supply could increase when the numbers of retired persons increase as reflected by the percentage of elderly persons in the municipality. Expected labour income can correlate with the percentage of elderly, since retired tend to have lower total incomes. Furthermore, the relative housing prices should correlate with the percentage of elderly, total income, and distance from Reykjavík. Relative housing prices should correlate with total income, distance from Reykjavík, and percentage of elderly through supply of housing.

Endogeneity was only detected in the model for men and only in one variable, relative housing price. Its instruments include total income, percentage of elderly, and distance from Reykjavík. A model for endogeneity in a fixed effect estimation along with heteroskedasticity constructed in STATA, was implemented for the case of men (Model 2 in Table 6-2).

The results, along with the parameter coefficients, the number of observations, R^2, and t-statistics for a special test of serial correlation recommended by Wooldridge (2002, pp. 176-177), are presented for migration of both genders united and separately to enlarge the understanding of the migration pattern in Iceland (Table 6-2).

Despite its low R^2 value, the results present several useful suggestions concerning the question at hand, that is, whether transportation improvements between major urban centres and the adjacent rural areas have an impact on interregional migration in a sparsely populated country. The results for both genders (Model 1) suggest that transportation improvements (less travel time) between the CBDs and the rural area tend to affect interregional migration. This finding is especially significant regarding the travel time from Akureyri to municipalities closer to Akureyri than to Reykjavík. The significance is much weaker regarding travel time from Reykjavík, where the variable of first power is not significant (approved at the 13.5% significance level)[39]. This relationship is non-linear with global maximum somewhere between[40] the two CBD's, Reykjavík and Akureyri. This result is, to some extent, a remarkable combination of the theoretical suggestion of the New Economic Geography and the equilibrium model, where transportation improvements between the CBDs and the rural area beyond global maximum motivate net migration to the rural areas. The results are in line with the equilibrium model, where transportation improvements improve access to the capital city and lower the local price level. When these improvements take place in regions within the limits of the global maximum, they discourage net migration to the rural area. This finding is in line with New Economic Geography theory, where transportation improvements between two regions tend to reduce the benefit of monopolistic companies' locating in a region of higher agglomeration economies when the distance becomes "negligible" between the regions.

[39] The 95 percent confidence interval for ttre is [-0.000126, 0.00119], $ttre^2$ [2 -2.41e-06, -1.93e-07], ttak [0.0004895, 0.0025271], and $ttak^2$ [-0.0000127, -0.000002].

[40] Pure technically it is marginally highest at the distance of 205 minutes travel time from Reykjavík, 98 minutes from Akureyri, and 175 minutes when it comes to additional travel time to Reykjavík (for communities closer to Akureyri than Reykjavík).

Table 6-2. Relationship between interregional migration and travel time from CBD: A fixed effect panel data model. Comparing the gender included.

Variable (acronym)	Model 1 Both genders	Model 2 Men	Model 3 Women
Expected labour income	0.0492973(2.24)**	0.0052304 (0.22)	0.0939137 (2.74)**
Number of dwellings (hshn)	0.157647 (2.47)**	0.2487656 (4.58)***	0.2387962 (3.81)***
Local income taxes (lotr)	0.0210736 (0.35)	0.0306511 (0.26)	0.1600166 (1.79)*
Travel time to Reykjavík (ttre)	0.000532 (1.59)	-0.0007746 (-1.02)	-0.0001691 (-0.35)
Travel time to Reykjavík, squared (ttre2)	-0.0000013 (-2.30)**	0.000000372 (0.29)	-0.0000004 (-0.50)
Travel time to Akureyri (ttak)	0.0015083 (2.91)**	0.0011419 (1.07)	0.0007877 (1.12)
Travel time to Akureyri, squared (ttak2)	-0.00000762 (-2.91)**	-0.0000118 (-2.55)**	-0.0000060 (-1.83)*
Additional travel time to Reykjavík (ttrm)	-0.0005027 (-1.26)	-0.0008398 (-1.08)	-0.0006347 (-1.26)
Additional travel time to Reykjavík, squared	0.00000149 (1.89)*	0.00000174 (1.16)	0.0000017 (1.70)*
Closer to Reykjavík than Akureyri (dmr1)	0.0170526 (3.46)***	0.0215363 (0.86)	0.0200379 (2.95)**
Housing price (hprr)	-0.0071752 (-1.25)	0.0356503 (1.87)*	-0.0108339 (-1.50)
Fishing quotas, ITQ (rrqr)	0.0015975 (1.16)	-0.0000462 (-0.02)	0.0035887 (1.73)*
Local population average age (pagr)	-0.2561865 (-3.90)***	-0.1524846 (-1.78)*	-0.2668044 (-3.29)***
Local population (popr)	-0.0025802 (-0.36)	-0.0112463 (-0.90)	-0.0113834 (-1.16)
Hvalfjörður tunnel (tun3)	0.0119296 (1.08)	-0.0200068 (-0.78)	-0.0131609 (-0.86)
Large-scale energy-intensive production plant	-0.014728 (-1.68)*	-0.0506785 (-2.20)**	-0.0344701 (-2.34)**
Earthquakes, eruptions (avalanches)	0.0080842 (1.85)*	0.0090288 (1.37)	0.0028406 (0.56)
Elimination of the scallop stock	-0.0052915 (-0.30)	-0.0213929 (-1.20)	0.0013223 (0.06)
Temperature (temr)	0.0300313 (2.05)**	0.0603725 (3.24)***	0.0236128 (1.37)
Wind speed (winr)	0.0020751 (0.21)	0.0148345 (1.09)	0.0092041 (0.71)
Snow avalanche	-0.0015021 (-0.19)	(dropped)	
Upper secondary schools (ussc)	-0.0012577 (-0.18)	-0.0064151 (-0.74)	-0.0029644 (-0.35)
Homes for the elderly	-0.0013039 (-0.21)	-0.0075344 (-0.62)	-0.0024626 (-0.26)
Geothermal energy (geot)	-0.0114128 (-1.18)	-0.0008139 (-0.07)	-0.0257230 (-1.93)*
Cinema (cine)	-0.0003496 (-0.06)	0.00259 (0.35)	0.0070232 (0.95)
Central pool and hot tub (poho)	-0.0010541 (-0.14)	0.0023663 (0.29)	-0.0033488 (-0.33)
Skiing arena (skii)	0.0018984 (0.19)	-0.0077623 (-0.63)	0.0172454 (0.94)
Local public transportation (buss)	0.0008127 (0.10)	-0.0034408 (-0.40)	-0.0069582 (-0.89)
Low-priced groceries (grlo)	-0.0008211 (-0.24)	-0.0030391 (-0.49)	-0.0000269 (-0.01)
Time dummy 1996 (tdum16)	-0.0024034 (-0.65)		
Time dummy 1997 (tdum17)	0.0033483 (0.87)	0.009856 (1.49)	0.0043660 (1.09)
Time dummy 1998 (tdum18)	0.0002739 (0.06)	0.004188 (0.85)	0.0027372 (0.54)
Time dummy 1999 (tdum19)	0.0065674 (1.45)	0.0058585 (1.18)	0.0093109 (1.88)*

Time dummy 2000 (tdum20)	0.0084121 (1.96)**	0.0082377 (1.73)*	0.0107574 (2.16)**
Time dummy 2001 (tdum21)	0.0132651 (2.90)**	0.0137085 (3.02)**	0.0108331 (2.06)**
Time dummy 2002 (tdum22)	0.0119521 (2.53)**	0.007083 (1.52)	0.0113388 (2.17)**
Time dummy 2003 (tdum23)	0.0109127 (2.31)**	0.0040195 (0.87)	0.0110358 (2.02)**
Time dummy 2004 (tdum24)	0.0116913 (2.45)**	0.0086827 (1.98)**	0.0125442 (2.25)**
Time dummy 2005 (tdum25)	0.0073299 (1.41)	0.0019693 (0.46)	0.0086254 (1.46)
Time dummy 2006 (tdum26)	0.007586 (1.35)		0.0120652 (2.10)**
Constant term (_cons)	1.11597 (11.93)***		1.0119600 (7.66)***
Lagged residual t-1		0.6138511 (2.39)**	-0.1379948 (-2.68)**
Lagged residual t-2		-0.8481172 (-3.20)***	
Number of observations, n	767	571	654
R^2 within	0. 1392		0.1601
R^2 between	0.0002		0.1313
R^2 overall	0.0082		0.0535
Centred R^2		0.1411	
Serial correlation, t-test	-1.77	-1.43	0.16
Multicollinearity	No	No	No
Heteroskedastisity	Robust	No	Robust
Residual distribution	Not normal (JB=167)	Not normal (JB=2957)	Not normal (JB = 59)
Panel data sample	Unbalanced	Unbalanced	Unbalanced

Dependent variable net migration (miec) in model 1, net migration of men in model 2, net migration of women in model 3. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. In Model 2: Sargan test 0.53, Cragg-Donald Wald F statistic 17, and the Anderson canon. corr. LM statistic 65.

However, to enlarge the understanding of the result with respect to travel time to Reykjavík and to detect the origin of the insignificance, the model was estimated in two phases: the first for the sample covering travel time on the scale between 0 and 204 minutes from Reykjavík and the second covering travel time beyond 204 minutes from Reykjavík. A positive value was expected in the first phase and negative in the second phase. The result was as expected, although it was not significant (coefficient of 0.0002701 and t-value of 1.10) in the first phase; still, it was highly significant in the second phase (coefficient of -0.0015253 and t-value of -3.85). It is evident, then, that the impact of transportation improvements on interregional migration is strong and positive for very distant localities, while they are weak and negative for closer localities. Therefore, the effects described by the equilibrium model dominates are present in regions far from the capital area (beyond 204 minutes). In regions closer to Reykjavík (within 204 minutes), the effects described by New Economic Geography are present. The tension between effects weakens the results.

If this is true, one may wonder why localities close to Reykjavík have seen the greatest in-migration among all municipalities in Iceland over the last two decades. The answer may be related to a higher expected income and greater supply of housing. The housing supply has been greater in CBDs and adjacent municipalities than in rural areas during the relevant period of time. Wages in Iceland are dependent on occupation, industry, and many other factors, but have generally increased with proximity to the CBD's *ceteris paribus*, especially for highly skilled workers. Furthermore, wages outside the capital area have been much higher in communities based on fisheries, than agriculture. Moreover, average age is a significant explanatory variable in favour of Reykjavík and its adjacent municipalities. The population in Iceland tends to be younger the closer the municipalities are to the CBDs, mainly because of the presence of upper secondary schools and universities, diversified labour market, and changed preferences with respect to quality of life. The marginal impact of all these factors on net migration is greater than the impact of transportation improvements.

According to Treyz et al. (1993, p. 214), employment opportunities seem to have a greater impact on in-migration than the wage rate does, which Treyz et al. interprets as a reflection of migrants' aversion to risk. It was the intension of both the Harris-Todaro model and the contribution of Stark (1982) to address uncertainty about interregional migration in developing nations. Income uncertainty in the rural part of the community is reduced by sending a family member to the city to earn money to send back home. In the present study, expected wages that include risk through unemployment level have the largest impact on interregional migration. Migrants' and residents' attitude toward risk has been somewhat neglected in empirical studies of interregional migration. Andrulis (1982) and Kan (2003) addressed risk in different manners; their results suggested that risk-adverse inhabitants were less likely to emigrate. However, the result for expected income is in line with economic theory. Household income is a good proxy for wages, and the wage geographic differential has been the most common explanatory variable for interregional migration in classical economics.

The results of the present study also suggest that the supply of housing and the average temperature have a significant positive impact on in-migration, a finding in line with economic theory. The average temperature is an amenity value that tends to have a positive impact on in-migration. The average age of the local population had a significant negative impact on in-migration, as the average age increases the net migration lowers. It suggests that younger individuals move to successful regions. Younger people tend to congregate around universities, and successful regions tend to have high schools, universities, and growing knowledge-based industries. Therefore, schools and knowledge-based industries have the effect of seeming to distort the local age distribution.

Surprisingly, a set of service and amenity variables did not have a significant effect. The variables used here included earthquakes, eruptions, elimination of the scallop stock in Breiðafjörður, wind speed, snow avalanche, an upper secondary school, a home for the elderly, a geothermal water source, cinema, central pool with hot tub, skiing arena, local public transportation, and low-priced groceries. These variables may not have had a significant effect, because they are only dummy variables, except for wind speed and temperature. Hence, the real value of the variable which can differ widely from one place to another (such as the number of cinemas, the magnitude of an earthquake, and the like) was not captured. In addition, dummy variables preclude tests for potential non-linearity. An additional test suggested the non-linearity of amenities.

When the results between the genders (Models 2 and 3 in Table 6-2) were compared, differences became apparent, despite a generally poorer significance of the estimators. Firstly, women seem to be more sensitive than men to geographic wage differentials, probably because the gender wage difference tends to be higher in the rural area than in the CBDs (Ólafsson & Gíslason, 2006). Both genders are sensitive to the supply of housing. Average age has a negative impact on women's net migration, which may be because of younger women's willingness to attend high schools and universities and/or the excess burden of women's household duties, especially in the rural areas, where access to homes for the elderly is poorer than it is in the urban areas. According to Statistics Iceland, women were 63% of all university students in Iceland in the period 2001-2010. Time dummies, which capture the potential impact of macro variables, such as GDP, interest rates, or the value of the currency on interregional migration, are only significant for women during the period of 1999-2006. If the currency appreciates the profits of the export industry reduces (Farnham, 2005, p. 500).

The internal share of the export industry, especially tourism and the fishing industry, is much higher in the rural area's employment than it is in the CBDs. The jobs of these industries are generally female-dominated, which may explain the strong fit of the time dummies for women. Moreover, if GDP increases, many of the less liquid assets, such as houses and shares, become increasingly liquid and the demand for labour increases as well. An increase in GDP increases the mobility of potential migrants, and women seem to be more mobile than men. This suggestion is in line with those of other empirical studies (Greenwood & Hunt, 2003). That the coefficient for fish quotas became positive and slightly significant for the migration of women is not easily explained, since fisheries are a male-dominated industry. However, the fish-processing industry is female-dominated, and it can be more sensitive to the fishing quantity, since the wages for fish-processing are much lower than those for fishing. When separated by gender, the impact of the large aluminium smelter became significant and surprisingly negative, perhaps because the many foreigners who immigrated to the east coast were not captured by the interregional migration data. Because of the vast increase in wages following the investment on the east coast, the model forecasted a much greater increase in interregional migration than was the case. However, travel time becomes much less significant when genders are estimated separately; if anything, the significance is slightly stronger for men.

Since the estimates became generally poorer for men than women and since the literature suggests that women are more mobile than men when it comes to interregional migration (probably because of a higher expected return from migration) (Greenwood & Hunt, 2003; Ravenstein, 1885), our attention moved toward the aspects of the marriage market. Becker (1973) suggested that being married is more efficient than being single in terms of income, relative wages, and human capital (Becker, 1973). Moreover, married people tend to have less need for expensive entertainment, so households of singles tend to be marginally more expensive.

Furthermore, couples are more productive in housework than singles (Vernon, 2010). Given that all households involve a certain level of housework, collaboration and specialization tend to improve productivity in the industries, as well as in housework, and a household of couples is more likely to generate both collaboration and specialization

Table 6-3. Regression of fixed effects based on the gender ratio

Variable (acronym)	Model 4 Both genders	Model 5 Men	Model 6 Women
Expected labour income	0.0492113 (2.26)**	0.0204365 (1.40)	0.0911133 (2.74)**
Number of dwellings (hshn)	0.1577713 (2.47)**	0.0513609 (1.88)*	0.2421526 (3.89)***
Local income taxes (lotr)	0.0211116 (0.35)	0.0793430 (0.38)	0.1628229 (1.82)*
Travel time to Reykjavík (ttre)	0.0005321 (1.59)	0.0004617 (1.57)	-0.0001637 (-0.34)
Travel time to Reykjavík, squared (ttre2)	-0.0000013 (-2.30)**	0.0000008 (-2.01)**	-0.0000004 (-0.49)
Travel time to Akureyri (ttak)	0.0015067 (2.90)**	0.0007312 (2.98)**	0.0007320 (1.04)
Travel time to Akureyri, squared (ttak2)	-0.0000076 (-2.88)**	0.0000033 (-3.62)***	-0.0000055 (-1.64)
Additional travel time to Reykjavík (ttrm)	-0.0005031 (-1.26)	0.0005780 (-0.78)	-0.0006408 (-1.26)
Additional travel time to Reykjavík, squared	0.0000015 (1.89)*	0.0000011 (1.27)	0.0000017 (1.64)
Closer to Reykjavík than Akureyri (dmr1)	0.0170503 (3.46)***	0.0288022 (0.59)	0.0202803 (2.97)**
Housing price (hprr)	-0.0071852 (-1.25)	0.0126524 (1.51)	-0.0107231 (-1.49)
Fishing quotas, ITQ (rrqr)	0.0015952 (1.16)	0.0027727 (0.43)	0.0034174 (1.69)*
Gender ratio	-0.0013896 (-0.04)	0.0263815 (3.19)***	-0.0422459 (-1.22)
Local population average age (pagr)	-0.2563096 (-3.89)***	0.0638238 (-2.18)**	-0.2775495 (-3.46)***
Local population (popr)	-0.0026019 (-0.36)	0.0106150 (-0.37)	-0.0123628 (-1.25)
Hvalfjörður tunnel (tun3)	0.0119336 (1.08)	0.0165338 (1.75)*	-0.0130763 (-0.85)
Large-scale energy-intensive production plant	-0.0147401 (-1.68)*	0.0165832 (-1.30)	-0.0352270 (-2.33)**
Earthquakes, eruptions (avalanches)	0.0080830 (1.85)*	0.0067136 (1.47)	0.0028196 (0.56)
Elimination of the scallop stock	-0.0052861 (-0.30)	0.0198276 (-0.78)	0.0013007 (0.06)
Temperature (temr)	0.0300201 (2.04)**	0.0177040 (2.39)**	0.0233648 (1.36)
Wind speed (winr)	0.0020703 (0.21)	0.0118221 (0.19)	0.0096253 (0.74)
Snow avalanche	-0.0014981 (-0.19)	0.0301396 (-0.20)	(dropped)
Upper secondary schools (ussc)	-0.0012594 (-0.18)	0.0090276 (-0.25)	-0.0031002 (-0.37)
Homes for the elderly	-0.0013040 (-0.21)	0.0106512 (-0.49)	-0.0024802 (-0.26)
Geothermal energy (geot)	-0.0114475 (-1.18)	0.0088293 (0.36)	-0.0267418 (-2.00)**
Cinema (cine)	-0.0003337 (-0.06)	0.0075794 (-0.39)	0.0078583 (1.07)
Central pool and hot tab (poho)	-0.0010604 (-0.15)	0.0077846 (0.42)	-0.0037931 (-0.38)
Skiing arena (skii)	0.0019363 (0.20)	0.0117850 (-0.91)	0.0188269 (1.03)
Local public transportation (buss)	0.0008058 (0.10)	0.0092411 (0.47)	-0.0074421 (-0.97)
Low price groceries (grlo)	-0.0008400 (-0.24)	0.0064746 (-0.32)	-0.0002773 (-0.08)
Time dummy 1996 (tdum16)	-0.0023832 (-0.66)	0.0049919 (-1.31)	(dropped)
Time dummy 1997 (tdum17)	0.0033662 (0.87)	0.0049943 (-0.19)	0.0043828 (1.09)
Time dummy 1998 (tdum18)	0.0002836 (0.06)	0.0056251 (-1.22)	0.0027242 (0.54)
Time dummy 1999 (tdum19)	0.0065837 (1.45)	0.0056386 (0.15)	0.0092883 (1.88)*
Time dummy 2000 (tdum20)	0.0084397 (1.95)*	0.0058444 (0.62)	0.0109282 (2.19)**
Time dummy 2001 (tdum21)	0.0132784 (2.89)**	0.0057969 (1.39)	0.0106515 (2.04)**
Time dummy 2002 (tdum22)	0.0119682 (2.53)**	0.0060565 (0.70)	0.0112754 (2.15)**
Time dummy 2003 (tdum23)	0.0109306 (2.30)**	0.0060724 (0.68)	0.0110869 (2.03)**
Time dummy 2004 (tdum24)	0.0117047 (2.45)**	0.0061362 (0.62)	0.0124371 (2.24)**
Time dummy 2005 (tdum25)	0.0073490 (1.41)	0.0061474 (0.01)	0.0086895 (1.46)
Time dummy 2006 (tdum26)	0.0075861 (1.35)	0.0062008 (-0.18)	0.0116069 (2.03)**
Constant term (_cons)	1.1175830 (11.22)***	dropped	1.0659670 (8.01)***
Lagged residual			-0.1160200 (-2.14)**
Number of observations, n	767	767	654
R^2 within	0.1392		0.1639
R^2 between	0.0002		0.1219
R^2 overall	0.0081		0.0464
Centred R^2		0.0760	
Serial correlation, t-test	-1.77	-1.78	0.19
Multicollinearity	No	No	No
Heteroskedastisity	Robust	No	Robust
Residual distribution	Not normal (JB=167)	Not normal (JB=1645)	Not normal (JB = 57)
Panel data sample	Unbalanced	Unbalanced	Unbalanced

Dependent variable net migration (miec) in model 1, net migration of men in model 2, net migration of women in model 3. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. In Model Two: Sargan test 0.81, Cragg-Donald Wald F statistic 31, and Anderson canon. corr. LM statistic 111. Analysed by STATA commands xtreg, fe robust and xtivreg2.

in housework than is a household of singles. Marginal productivity also has an effect, since the effort of some housework, such as mopping floors, cooking, dusting, washing bathrooms, and household maintenance, tends to be insensitive to the number of adult residents. For example, the frequency of meals is not dependent on the number of family members. The marginal labour productivity at work also tends to fall during the day, since modern households tend to have two breadwinners, housework extends the total number of working hours each day. Given that the housework is constant each day, it becomes more efficient for two adults to finish household duties than one, with respect to individual marginal capacity. Thus, scale economies are present in running households, and there is reason to believe that the welfare per capita for singles is lower than for couples. Therefore, given that the need for spare time (leisure) is constant, time to spend on work increases and the income per capita becomes higher for couples than for singles, on average.

Given that the traditional couple pattern (two adults of opposite sexes) dominates, any imbalance between genders increases the probability of being single and living alone. Therefore, if the number of women is lower than the number of men following an out-migration, the likelihood of becoming single increases for men, leading to the out-migration of men in the next period.

A test of whether the interregional migration of men could be explained more fully when the likelihood of marriage and its contribution to utility are included is undertaken by adding a proxy variable for the lower likelihood of marriage to the present model. This variable represents a change in the gender ratio, σ, in the previous period:

$$\Delta\sigma_{it-1} = \left(\frac{\sigma_{it-1}}{\sigma_{it-2}}\right)$$

If this variable, $\Delta\sigma_{it-1}$, is lower than one, women became fewer relative to men in the previous period. The result supports the notion (Table 6-3) that men tend to migrate to regions where the number of women increased relative to men in the previous period; that is, a lower likelihood for marriage fuels out-migration of men. Note that the serial correlation found in the previous analysis is no longer present which indicates that it may have been entirely traceable back to women migration. Moreover, the results for men become more statistically significant for travel time with the inclusion of this new variable. Thus, it appears that the variation for travel time present in the analysis for both genders stems from men.

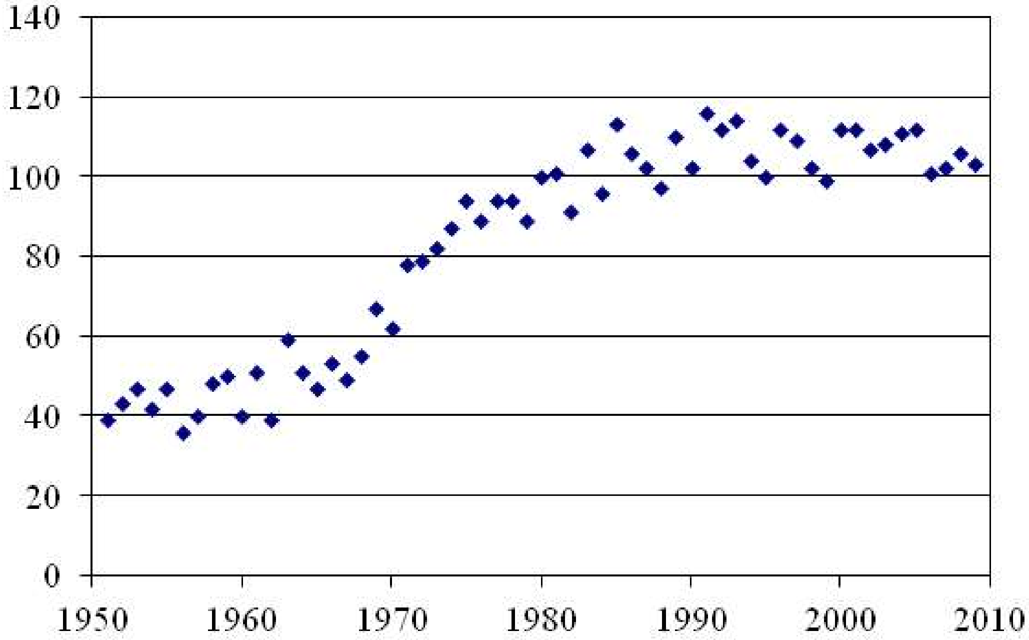

Figure 6-2. Divorce frequency per 10,000 married couples in Iceland from 1951 through 2009.

Source: Statistics Iceland

Since a migration motive of this kind is led by unmarried persons, it is dominated by either the young or divorced. Therefore, it could be argued that an increased frequency of divorce would increase interregional migration. The frequency of divorce increased rapidly in the 1970s in Iceland (Figure 6-2), ten years prior to the obvious negative turn in the population in small urban areas outside the capital area (Figure 2-4). It is possible that women's out-migration from small urban areas did not take off while they were well paid in the fish-processing industry. However, when the industry restructured in the 1980s, single women left and looked for opportunities elsewhere. It is also possible that new trends, such as the increased divorce rate, kicked in much earlier in the captial area than in rural areas, so even though the national average of divorce frequency increased in the 1970s, the trend could have hit the rural areas five to ten years later. No statistics are available to confirm the notion.

6.6 Conclusions

Transportation improvements between the CBDs and the rural area have a significant impact on net interregional migration in a thinly populated country with one small city, several small towns, and a widely dispersed rural area, such as Iceland. This study shows that this relationship is non-linear, a second-degree function, with a local maximum in a distance somewhere between 99-204 minutes' travel time from the CBDs, *ceteris paribus*. This result indicates that the transportation improvements have increased net interregional migration to destinations beyond the 99-204 travel time distance (local maximum) and decreased within this range. The result is therefore a mixture of the theoretical suggestions of the equilibrium model and the core-periphery model.

When the estimation was repeated for men and women separately, women's migration was more sensitive to expected wage geographic differentials because the gender wage differential is larger in the rural area than in urban areas. Womens' migration rate was also more sensitive to average age. Both genders were sensitive to housing supply, but men's migrations were more sensitive to travel time, probably because of their vulnerability regarding employment; according to New Economic Geography, distance to the CBD is a good proxy for employment opportunities. Moreover, men seem to follow women's initiative; when women move, men seem to move a year later, possibly because of their decreased probability of finding a spouse after women have emigrated.

These results are robust, as they are based on a large data series of all the 79 municipalities in Iceland from 1995 to 2006 and were analysed by a fixed-effect regression model.

6.7 Appendix. Dummy variables

Several dummy variables were constructed to capture potential difference in local amenities (Table 6-4).

Appendix. Dummy variables

Table 6-4. A list of collected dummy variables and sample statistics.

Variable (acronym)	Mean	Standard deviation
Playschool (plsc)	0.7605	0.4269
Primary school (prsc)	0.9211	0.2696
Upper secondary schools (ussc)	0.2439	0.4295
Universities, tertiary school (tesc)	0.0312	0.1738
Conservatorie (cons)	0.7595	0.4275
Distance learning (dile)	0.1144	0.3184
Elderly home (elho)	0.4981	0.5001
Doctor (doct)	0.5409	0.4984
Hospital (hosp)	0.2205	0.4147
Police (poli)	0.4596	0.4985
Geothermal energy (geot)	0.5798	0.4937
Cinema (cine)	0.2332	0.4230
Central pool (pool)	0.7585	0.4281
Central pool and hot tab (poho)	0.6714	0.4698
Skiing arena (ski)	0.1879	0.3907
Motocross arena (moto)	0.0857	0.2800
Local festival (lofe)	0.3783	0.4851
Theatre (thea)	0.1923	0.3942
Amateur theatre (tham)	0.5389	0.4986
Amateur choir (cham)	0.8442	0.3627
Sportsclub (spor)	0.9537	0.2101
Rescue squad (resc)	0.8179	0.3860
Harbour (harb)	0.6105	0.4878
Golf course (golf)	0.4961	0.5001
Salmon river (salm)	0.5399	0.4985
Local public transportation (buss)	0.1728	0.3782
Grocery (groc)	0.7337	0.4421
Low price groceries (grlo)	0.0983	0.2979
Ferry (ferr)	0.0253	0.1571
Large scale energy intensive production plant (poin)	0.0316	0.2010
New entrants in aluminium production (glal)	0.0190	0.1365
Earthquakes (aval)	0.0326	0.1777
Elimination the scallop stock (shel)	0.0019	0.0441
Snow avalanche (snow)	0.0107	0.1030

Due to multicollinearity and lack of internal (within) variation only several of them were used (Table 6-5).

Table 6-5. A list of used dummy variables and sample statistics.

Variable (acronym)	Mean	Standard deviation
Closer to Reykjavík than Akureyri (dmr1)	0.611318	0.487632
Hvalfjörður tunnel (tun3)	0.017527	0.131255
Akureyri (akur)	0.012658	0.111822
Snow avalanche (snow)	0.010711	0.102962
Upper secondary schools (ussc)	0.243914	0.429546
Universities, tertiary school (tesc)	0.031159	0.173789
Elderly home (elho)	0.498053	0.500118
Hospital (hosp)	0.220545	0.414715
Geothermal energy (geot)	0.579844	0.493704
Cinema (cine)	0.233204	0.422974
Central pool and hot tab (poho)	0.671373	0.469829
Skiing arena (ski)	0.187926	0.390748
Local public transportation (buss)	0.172834	0.378195
Low price groceries (grlo)	0.098345	0.297853
Large scale energy intensive production plant (poin)	0.031646	0.201000
Earthquakes (aval)	0.032619	0.177681
Elimination the scallop stock (shel)	0.001947	0.044097
Time dummies (tdum15-tdum26)	0.038462	0.192355

7 Dissertation conclusions

Rural-urban migration is the subject of the present dissertation. A flow of residents from rural areas to cities is a well-known pattern all over the world. The main reasons for this type of migration seem to be related to labour market issues, such as income and employment, as well as amenities and geographical differentials. Since any geographical isolation prevents the spatial distribution of immobile goods and services, it sounded reasonable to investigate the relationship of interregional migration and transportation improvements. Therefore, the following question was the central issue of this thesis: *Does transportation improvements that increase access to urban areas from rural areas affect migration from rural to urban areas?*

The thesis was constructed as follows: Following the introduction, descriptive statistics for transportation improvements and the spatial disparity of population development in Iceland were addressed. A thorough introduction to the theoretical background and the models of the spatial structure of housing prices and interregional migration was provided in the next chapter, called "Theories and Models". A brief overview of location theories was also included, since they are related to the analysis of migration. Finally, three empirical papers were presented in subsequent chapters.

The empirical part of the dissertation was based on data from Iceland, which provides an interesting case for this study because it is a large, but sparsely populated country in northern Europe that has experienced a massive and persistent flow of residents from the rural to the urban areas for a long time during which transportation improvements have been extensive. The capital area's share of the total population was 5 percent at the beginning of the twentieth century, but 62 percent at the end. At the beginning of the twentieth century, the total length of roads was less than 1,000 kilometres, but it was close to 12,000 kilometres at the end. The population of Iceland is relatively homogeneous when it comes to ethnic origin, culture, language, and the country is also geographically isolated, good access to natural resources, so it is a good representative for the northern periphery of the globe.

The research question was addressed in three papers. The first paper tested the significance and character of the relationship between transportation improvements and local housing prices since housing prices capture and reflect the value of the location for household residence. The second paper investigated the development of the bid-rent curve in order to go into the data in depth and increase understanding of the value of access, amenities, and agglomeration economies in a country like Iceland. The third paper examined the impact of transportation improvements on interregional migration.

The estimation was based on a data sample from all 79 municipalities in Iceland during the period 1994-2006. Despite the amalgamation of many municipalities during the relevant periods, all data was transformed in accordance with the boundaries of municipalities in 2006, yielding a robust panel data set. The majority of the data came from public data sources, except for the sets of amenities, which were collected through questionnaires directed to the administration of municipalities.

The bid-rent curve, based on von Thunen's theory (1966) of land-rent, was the theoretical background of the first paper, where the empirical investigation of transportation improvements and housing prices was implemented. According to the extended version of the theory (Alonso, 1964; Evans, 1973; Mills & Hamilton, 1972; Muth, 1969), there is a significant relationship between housing prices and the distance from the central business district (CBD). This relationship tends to be negative, where the price of housing is highest in the city centre and decreases the farther it is from the city centre. Accordingly, the slope of the bid-rent curve is negative, reflecting households' preference of access over amenities (McCann, 2001, pp. 109-113). The city centres offer better access to markets for labour, goods, and services than rural areas, while the rural areas are better in offering amenities, so if access is worth more than amenities, housing prices tend to reflect the negative slope of the bid-rent curve. The slope is positive when amenities are worth more than access. If access is more valuable than amenities, and accordingly, the slope of the bid-rent curve is negative, transportation improvements between the urban and rural communities should have a positive impact on the rural housing price.

It was the original intention of this study to implement a standard monocentric model of a semi-logarithm type, where Reykjavík was the only centre. However, investigation of the data showed that another version of the model, a quadratic distance model where the distance variable is addressed in quadratic terms, was more appropriate. The presence of Akureyri, the largest urban area outside the capital area, often called the capital of the North among Icelanders, seemed to affect the data for housing prices. Since Akureyri was close to the centre of the data set for distance [0,780], and since it had the highest housing price in the rural area of Iceland, the monocentric model did not seem appropriate. Therefore, a polycentric model (Partridge et al., 2009, p. 451) was constructed, a model with two or more centres, and implemented a distance gradient model of two centres. A fixed effects estimator was assumed to be a more appropriate estimator than a random effects model, which returns only a within variation - that is with only a variation within each municipality, not between them. One could also say that it returns only the time variation and the space variation to the individual constant term (reflecting local amenities). Since the distance variable measures the travel time between the relevant municipality and Reykjavík, a transportation improvement would return a shorter travel time the next year. Therefore, the fixed effects model illustrates the estimation relevant to the paper.

The result of the investigation suggested that any transportation improvement that leads to a decrease in travel time between rural and urban areas in Iceland increases housing prices in the rural area. However, this relationship is not linear; instead, it is negative and convex since the marginal impact is larger the closer the rural area is to the city centre. Therefore, any transportation improvement between the rural and urban area was likely to have a higher marginal impact on housing prices in the rural area if it was close to the urban area than if it was farther away. These results were valid for municipalities close to Reykjavík, but the results were much weaker for other municipalities, even though the pattern was identical.

The topic of the second paper, titled "A small city, agglomeration economies, and the value of access", was the development of the bid-rent curve and its economic interpretation. The estimators for the curve were estimated for the two periods and compared. The paper argued that the constant term of the bid-rent curve returned a good indicator for agglomeration economies, although the slope reflected the value of access. The theoretical background of the paper was the von Thünen model (1966), the same background as that of the first paper.

In the second paper, a random effects estimator of the bid-rent curve was an appropriate method since the value for amenities had to be included in the estimators.

The two-period comparison of the bid-rent curve the slope for the entire country illustrated that the relationship between housing prices and travel distance has been increasing, probably because access has become more valuable to the households of Iceland. When the data sample was limited to the conurbation area, the estimation returned weak evidence for the opposite development. If the evidence had been stronger, it could have indicated the presence of counterurbanisation. Moreover, the two-period comparison of the bid-rent curve and the constant term illustrated that the agglomeration economies are likely present in Akureyri. A test for the agglomeration economies in Reykjavík was not possible because of the multicollinearity traced back to the variable that should capture it, but if the agglomeration economies are present in Akureyri, they must also be present in the much larger city of Reykjavík, since the most recent period of economic growth in Iceland was primarily driven by the knowledge-based industry, and agglomeration economies tend to be greater in diversified cities (O'Sullivan, 2009, pp. 235-240). Prior to that, economic growth in Iceland was driven by the fishing industry.

The third paper, “Interregional migration, transportation improvements and gender”, examined whether transportation improvements between a rural and an urban area benefited the rural area in terms of reducing out-migration and increasing in-migration. The theory of spatial economics makes no clear suggestions in this regard, so the results could either favour or disfavour the rural area. According to the disequilibrium (Hunt, 1993; McCann, 2001), equilibrium (Roback, 1982), Harris-Todaro (Harris & Todaro, 1970), and gravity models (Carey, 1865; Carrothers, 1956), the results should be in favour of the rural area. However, since only the gravity model includes distance explicitly, the results suggest that the real wages in the rural area will increase following a transportation improvement between a rural and an urban area, fuelling rural in-migration. However, according to New

Economic Geography (Baldwin et al., 2003; Fujita et al., 1999), which is the most recent contribution to spatial economics, transportation improvements lead to rural out-migration because they increase the net benefit of the centralized industrial location. The industrial location and the necessary labour are determined by two counteractive forces: the agglomeration force and the dispersion force. Agglomeration economies do not need further explanation, but the dispersion force occurs when the monopolistic company moves out of a community to avoid competition and to receive monopoly power. Transportation improvements decrease the dispersion force because these improvements result in more competition from companies in other regions. If the agglomeration force dominates the dispersion force, the company will never benefit from moving. Therefore, if the transportation cost decreases enough for the agglomeration force to dominate the dispersion force, more companies of monopolistic competition that were previously located in the rural area will find it profitable to locate in the urban area and export to the rural area.

The empirical model was based on an extension of the Harris-Todaro (Harris & Todaro, 1970) version of the equilibrium model, where the dependent variable was limited to the net migration of inhabitants in the 16-74 year old age range. The explanatory variables were selected factors of labour, housing market conditions, and local amenities. Uncertainty was included in the variable for labour income through the probability of getting hired (1-unemployment). All variables were relative since they were divided by the national average. To detect a pure impact of transportation improvements against interregional migration, a fixed effects panel data model and a polycentric model were implemented, where Reykjavík and Akureyri served as Iceland's two main regional service centres. The model assumed a non-linear relationship such that the impact of transportation improvements on interregional migration could be marginally different with respect to location.

The result suggested that transportation improvements have had a significant impact on interregional migration. The impact between Akureyri and its neighbouring[41] municipalities was significant and non-

[41] Here the neighbouring communites of Akureyri were all communities closer to Akureyri than Reykjavík in terms of travel time. Accordingly, the neighbouring communites of Reykjavík were all communities closer to Reykjavík than Akureyri in terms of travel time.

linear, but the impact in the case of Reykjavík and its neighbouring municipalities was weaker. The impact was expressed as a non-linear relationship with a local maximum for Akureyri of 99 minutes' travel time from the centre and 204 minutes' travel time from the centre of Reykjavík, where the entire dataset for travel time for Reykjavík was [0,419] and that for Akureyri was [0,433]. The result was mixed: the dataset covering travel time between [0,203] for Reykjavík and [0,98] for Akureyri is in line with the New Economic Geography (Baldwin et al., 2003, pp. 10-11), where the impact of transportation improvement between Reykjavík and rural municipalities causes negative net migration for rural municipalities and the dataset covering travel time between [205,433] for Reykjavík and [100,419] for Akureyri is in line with the equilibrium model (Harris & Todaro, 1970), where the transportation improvement fuels positive net migration for rural municipality.

Moreover, the results suggested that the supply of housing, expected household income, average temperature, and the female gender-ratio had a significant positive impact on net-migration, which is in line with the economic theory (Roback, 1982). Household income is a good proxy variable for wages, since geographic wage differentials have been the primary explanatory variable for interregional migration in classical economics. The average temperature is an amenity value that tends to have positive impact on net-migration. The female gender-ratio captures the fact that there are fewer men than woman in the successful regions—those that have high schools, universities, and growing knowledge-based industries—and there are fewer men in universities than females. The average age of the local population returned a significant negative impact on net-migration. Here, as in the case of the female gender-ratio, the presence of schools and knowledge-based industries distorts the local age distribution. No other explanatory variables were significant. However, the overall results could have been stronger and more in line with the economic theory of interregional migration (Roback, 1982). A poor R^2 and bad results for the other variables of amenities were especially disappointing.

When the estimation was repeated for women and men separately, it was evident that women are more sensitive than men are to household income, probably because the gender wage difference is greater in the rural areas than it is in the capital areas. Therefore, women get greater rewards for rural-to-urban migration than men do. Low wages in the rural areas motivates women to “spin the wheel of fortune,” attend universities, and find a suitable job. The greatest chance for a well-paying, suitable job is in the capital area.

Women are more sensitive to variations in macroeconomic variables (through time dummies) than men are. We find that the variable significance kicked in at the beginning of the latest period of economic growth. The variables most likely to affect interregional migration are gross domestic product and the exchange rate. Economic growth tends to increase the demand for second homes, and if housing becomes more liquid, labour becomes spatially more mobile. Economic growth also tends to appreciate the exchange rate, which increases the pressure on export industries’ reconstruction, especially in the places where women traditionally work.

The supply of housing had a similar impact on men’s and women’s migration, while the impact of other variables on interregional migration was much weaker.

Since Iceland can represent all countries or communities in the northern periphery the results of this thesis can have policy implications for several areas dealing with rural-to-urban migration. Some (Bartik, 1990; Weiler, 2000) claim that government interventions are needed because of the involvement of market failures, such as a lack of information, immobile production factors, and externalities. It is preferable for any community to have numerous and varied residential locations, as people’s location preferences vary (Tiebout, 1956, p. 418). Since migration is often based on lack of information, uncertainty, and generates externalities, government intervention may be justified.

People’s preferences are not identical. In Iceland, geographically dispersed residences have been related to the extent to which the economy is based on the extensive harvesting and processing of natural resources. Furthermore, since Iceland is an island with active volcanoes, a viable residence in several regions could be a sensible part of public risk management of the population. Others (Minford & Stoney, 1991) have suggested that the market mechanism and less government intervention would produce better results in addressing regional problems.

The overall investigation has provided new understanding and a large panel data sample on Icelandic regions and thus presents opportunities for further empirical studies in spatial economics in the

Icelandic context. One logical extension is the estimation of the determinants of the spatial differences of household income. Other future studies could include the impact of the economic crisis on the spatial disparity of housing prices, household income, and the pattern of interregional migration.

Moreover, the non-linear nature of the results of the marginal impact of transportation improvements on local housing prices was both informative and challenging. The marginal impact tended to decrease with distance from the CBD, suggesting that transportation improvements between a CBD and extremely remote municipalities were not significant. Does that mean that transportation improvements don't affect such communities' housing markets at all? This is difficult to believe. Thus, the question concerning whether transportation improvements between a CBD and very distant municipalities could affect factors of the housing markets other than price, such as the quantity of sold assets, presents itself. That could be the case if the demand or the supply of housing is close to perfectly price elastic. Preliminary results (Karlsson, 2010b) support the notion.

Weak overall results in terms of interregional migration led the author's attention toward research based on micro data. The estimation could be repeated for the entire population of Iceland, where the data are based on individuals, since both individuals who migrated and those who stayed were included. The dependent variable would be binary, 1 for those who migrated and 0 for those who did not. A mixture of the binary choice model and panel data model would be appropriate. However, except for gender, age, origin, income and unemployment, most of the data on the explanatory variables would still be on the aggregate level. This approach has partly been taken by Magnusson (1998).

A sign of the presence of New Economic Geography (Baldwin et al., 2003, pp. 10-11; Fujita et al., 1999) in the impact between transportation improvements and interregional migration led my attention toward another approach, where the evidence for New Economic Geography would be inspected more thoroughly. That would be a contribution to the literature, since New Economic Geography has not been supported by many empirical investigations.

It is hoped that the present work contributes to the understanding of the interregional migration pattern in Iceland and in other sparsely populated, homogeneous populations of small urban communities far from the central markets of the European continent and the US. However, the results so far have been in line with the theories of economic theory (Baldwin et al., 2003; Harris & Todaro, 1970; Krugman, 1991a; Roback, 1982; Thunen, 1966) and partly in line with the majority of the empirical investigations on very different kinds of communities, such as Greenwood et al. (1991), Cunningham (2006), Graves (1980), McDonald and Osuji (1995), Pekkala (2003), Treyz (1993), Tyrvainen and Miettinen (2000).

8 Appendix

8.1 Thesis notation of variables

Table 8-1. Definition and notations of the thesis variables.

Notation and definition

Λ = Land rent

η = Sowing cost

ξ = Cultivation cost

δ = Share of cost that is expressed in money: von-Thünen model

φ = Harvesting and general farming cost expressed as the share of the gross production that goes into harvesting and farming

λ = Lagrange multiplier

τ = Transport cost per kilometre

ψ = Bid rent, housing

σ = Unspecified coefficients

μ = Unspecified coefficients

ω = Real wages

ν = Unknown coefficient in the Gravity model, comparable to lamda

γ = Transport cost in the migration model of Baldwina (CPM)

ρ = Discount rate

ϖ = Input price per unit; the unit price of rye on the farm itself in the von-Thünen model

ϑ= A power in the Gravity model

ζ = Unknown coefficient and other open tasks

A = Amenities

a = Unknown coefficient and other open tasks

b = Unknown coefficient and other open tasks

c = Production cost, per unit

d = Distance in kilometres from central business district

D = Transportation

e = Additional travel time from Akureyri to Reykjavík for municipalities closer to Akureyri than Reykjavík

F = Number of Households (families)

Thesis notation of variables

g = Growth

G = Price level

h = Housing price

i = Region, municipality, or any individual or location

I = Household total income

K = Capital

J = Non-labour income

L = Land

N = Workers

M = Population

m = Net migration

o = Climate

p = Production price, per unit

q = Production quantity, units

Q = Total production (all q's)

r = Interest rates

R = Rank

s = Travel time to Reykjavík for municipalities closer to Reykjavík than Akureyri

l = Lot size

T = Transport cost, total.

t = Time

U = Consumer utility

u = Travel time to Akureyri for municipalities closer to Akureyri than Reykjavík

v = Vector of dummy variables (in regression models)

y = Production input factor

w = Wages (nominal)

W = Hamilton multiplier

Y = Regional total income

x = Composite consumer goods, units

z = Vector of continuous variables (in regression models)

8.2 Geographical definitions

Table 8-2. Definitions of geographical areas and communities.

Area	Definition
Capital area	The capital city and adjacent municipalities: identical definition to Statistics Iceland.
Conurbation area	The capital area and other municipalities within 120 km from the capital city.
Intermediate area	The capital areas' "collar". Municipalities of the conurbation area apart from the capital area: Intermediate area = Conurbation area minus the Capital area.
Rural area	Area outside the capital area: both farm and urban communities outside the capital area included.
Countryside	Relating to the country or agriculture; communities of farms; the area outside the capital area where no urban communities are included.
Rural (small) urban communities	Urban communities outside the capital area; the rural area apart from the countryside; communities of farms are not included.
Urban communities	All urban communities; that is urban communities in both the rural and the capital areas.
Coastal areas	Urban communities and countryside along the coast where a high share of incomes comes from fisheries.
Inland	Urban communities and countryside not along the coast where a high share of incomes come from agriculture.

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