THE ECONOMICS OF SOCIAL HOUSING:

IMPLICATIONS FOR WELFARE, CONSUMPTION, AND LABOR MARKET COMPOSITION

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THE ECONOMICS OF SOCIAL HOUSING:

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De economie van sociale woningbouw:
implicaties voor welvaart, consumptie en de opbouw van de beroepsbevolking
(met een samenvatting in het Nederlands)

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Mark Kattenberg
Haarlem, March 2014

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Chapter 1

Introduction

1.1 The economics of social housing

The aim of social housing is to provide dwellings to households that have difficulties finding housing on their own. To keep social housing affordable, rents in the social housing sector are often regulated below the market rent.[1] However, this changes the costs and benefits of living in social housing, which might in turn unintendedly alter the behavior of its inhabitants and other economic agents.

Many economists believe that such a nominal rent freeze has several negative effects.[2] It would cause an undersupply and lower quality of social housing, while on the demand side of the housing market it would create excess demand. In addition, social housing provides tenants an incentive not to move, which might increase unemployment duration.[3] The opposition of these economists to rent control is perhaps best illustrated with a quote by Lindbeck and Samuelson (1977): "Next to bombing, rent control seems to be the most efficient technique so far known for destroying cities."

[1] For this reason, I will use the terms 'social housing' and 'rent-controlled housing' interchangeably.

[2] In a stratified random sample of 1990 American Economic Association members, 93.5 percent of the participants agreed (strongly or with provisions) with the statement that rent control reduces quality and quantity of housing, see Alston et al. (1992).

[3] Although they focus on homeownership, this point is also made by Van Ewijk and Van Leuvensteijn (2009).

However, rent control is hardly ever a mere nominal rent freeze. It often entails a comprehensive set of regulations to determine a 'fair rent' and to govern adjustments to the rent ceiling (over time and differentiated by location) that reflect local housing demand or local housing costs. Rent control is often accompanied by regulations on property rights, as well as regulations on housing supply and maintenance. In the Netherlands, such an elaborate institutional setting is in place, which might mitigate some of the economic effects of rent control.[4] Consequently, rent control might be less distortive than understood based on a nominal rent freeze.[5]

This dissertation aims to better understand the economic effects of rent control on the local economy, especially on local labor markets. The first part of this dissertation investigates the impact of rent control on the local economy, in particular the way self-selection into social housing is related to economic and location amenities (chapters two and four) and whether this has implications for the level and allocation of the consumption budget (chapters two and three). A further subject of study is whether the wage differential between homeowners and tenants of social housing is the result of low-skilled workers sorting into social housing, or whether living in social housing (or homeownership) itself affects wages (see chapter five).

The second part of this dissertation studies the interaction of local housing markets and local labor markets. In isolation, both housing market price rigidities due to rent control and labor market price rigidities reduce the geographical mobility of workers. Chapter six looks at the joint effects of housing and labor market price rigidities on the labor location.

Chapter seven considers the effect of the share of rent-controlled housing stock on local skill composition. As social housing is allocated to low-income workers and as these workers are hedged against changes in the house price, a negative effect of social housing on the share of high-skilled workers is ex-

[4]These more elaborate regulatory schemes are often referred to as secondary generation rent control, in contrast to the 'first generation' nominal rent freeze. See Arnott (1995); Lind (2001). However, secondary generation rent control schemes are quite heterogeneous across countries. See Fallis (1988) for several explanations of the heterogeneity of rent control schemes. Lind (2001); Scanlon and Whitehead (2007, 2008) provide descriptions of contemporary rent control schemes in Europe.

[5]Turner and Malpezzi (2003) mention that specific regulations under specific market conditions determine whether rent control is beneficial or not. In line with this, Arnott (1995) argues that a well-designed rent-control program can be beneficial.

pected. This is an additional channel by which local housing market characteristics influence local labor markets that has not explicitly been investigated before. Table 1.1 gives an overview of the economic effects of social housing that are considered in this dissertation.

Table 1.1: Studied economic effects of social housing

Economic effect	Type[a]	Chapter
Part A: microeconomic		
Timing of housing consumption	T	2
Allocation of consumption budget	T	2
Level of consumption budget	E	3
Allocation of non-durable consumption budget	E	3
Timing of housing consumption	E	4
Wages of workers	E	5
Part B: macroeconomic		
Location of workers	T	6
Location of workers (local skill composition)	E	7

[a] Type of research is either empirical (*E*) or theoretical (*T*).

Throughout this dissertation, the economic effects of social housing are analyzed from three specific angles. The first angle is that the local housing market status and local labor market status are mutually dependent. People differ with respect to observable characteristics (such as age, gender, and employment industry) as well as with respect to 'soft indicators' such as preferences, ability, or character. Ability and character might have important consequences for workers' labor market position, but might also be important for the self-selection into social housing or owner-occupied housing. I seek to correct for the mutual dependence of housing and labor market positions and the relation with unobserved 'soft' worker characteristics. This is done using propensity score matching, panel data estimators, and instrumental variables techniques.

A second angle that is explicitly taken into account concerns the heterogeneity of space. Economic activity such as the location of industries, firms and jobs are unequally divided over the country. This also holds for local public goods and consumer amenities such as the accessibility of natural parks, recreation facilities and open space. These differences between areas are internalized into the market price of housing, but not into the controlled rent. As a result, tenants of social housing in the economic core gain more from

rent control than tenants of social housing in the periphery. Consequently, the economic effects of social housing differ across space.

A third angle that I consider is the spatial dependence of aggregate economic variables. Spatial dependence reflects Tobler's Law that "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). The many jobs in the Amsterdam area not only increase housing demand in Amsterdam, but also in nearby regions. Spatial econometric techniques are used to control for the spatial dependence of local labor and housing market characteristics.

1.2 Institutional setting of the Dutch housing market

The object of study in this dissertation is the economic effects of social housing in the Netherlands. Generally speaking, the costs and benefits of rent control are determined by the institutional design of the housing market. The institutional nature of the housing and land markets in the Netherlands is very elaborate and exceeds mere rent control. Three important elements can be discerned:

1. Social housing is ubiquitous and of relatively good quality
2. The controlled rent and its annual increase are uniformly regulated
3. Strict urban planning and zoning regulations apply

Social housing is ubiquitous and of relatively good quality

An important feature of the Dutch housing market is that social housing is ubiquitous and of relatively good quality (see Figures 1.1 and 1.2). About one third of the housing stock consists of social housing.[6] Figure 1.1 shows that in

[6]See Donders et al. (2010). There are no statistics on the exact numbers of rent-controlled housing. However, there are several indicators and surveys that all indicate that the rent-controlled housing sector is very large. Donders et al. (2010) and Romijn and Besseling (2008) use the WoON-surveys. Romijn and Besseling (2008) find that 95 percent of rental houses have a rent below the rent ceiling. An alternative statistic considers the ownership of rent-controlled housing. According to Regeer and Van Daalen (2011), housing agencies were responsible for managing 2.2 million houses in 2011, about one third of the *total* housing stock. On average 98 percent of their stock is rent-controlled (Van Daalen et al., 2012).

the majority of municipalities, the social housing sector makes up 21-30 percent of the total housing stock. There is a positive relationship in the Netherlands between housing density and the share of housing that is owned by housing agencies: In the two largest cities, Amsterdam and Rotterdam, more than half of the total housing stock is owned by housing agencies. The magnitude of these numbers emphasizes the relevance of knowing how rent control of social housing influences outcomes on local housing and labor markets.[7]

Figure 1.2 shows the distribution of total housing stock values (excluding private rental housing) and social housing stock values. Social housing is clearly more dominant among the lower end of the value distribution. However, Figure 1.2 also indicates that the share of social housing in the middle of the value distribution (between €175,000 and €225,000) is about as large as that of owner-occupied housing. Among the higher house values, social housing still makes up about ten percent of the housing stock. This shows that social housing in the Netherlands is of relatively good quality.

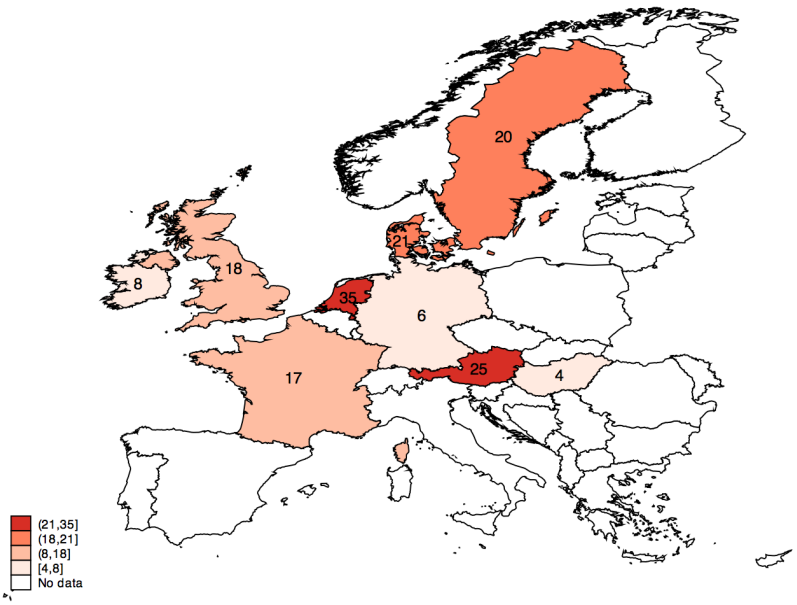
Recent empirical studies show that the quality of housing provided by housing agencies in the Netherlands can be said to be efficient, as the marginal willingness to pay for social housing quality is close to its marginal costs.[8] Housing agencies can provide social housing of the desired quality as they are independent, non-profit organizations. There are several reasons why they can offer such a large stock of social housing of relatively good quality.

First, the majority of the social housing stock was built when the housing corporations were effectively public organizations. Second, they benefit from financial guarantees, which lower their risk premium. Third, housing agencies often have a local monopoly or oligopoly in providing social housing (Donders et al., 2010). More often than not, they receive a discount from the municipality if they acquire land to construct social housing. Fourth, the

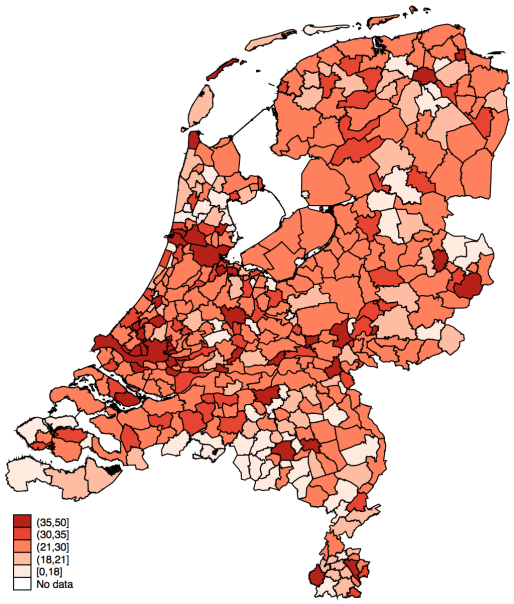
[7]However, the relevance of these insights is not limited to the Netherlands alone. The share of rent-controlled housing is often substantial in other European countries as well (Scanlon and Whitehead, 2007). Local housing markets where controlled housing forms a substantial share of the housing stock can be found in for instance California, New York and New Jersey (Simmons-Mosley and Malpezzi, 2006). Worldwide, about 40 percent of the population lives in rental housing with some form of controls on rents paid (Malpezzi, 1993). Furthermore, there is discussion across Europe to adopt a more value based system to determine the rents of social housing as applied in the Netherlands and England (Scanlon and Whitehead, 2007).

[8]See Van Ommeren and Koopman (2011); Van Ommeren and De Graaf-Zijl (2013).

Figure 1.1: Social housing in Europe and The Netherlands

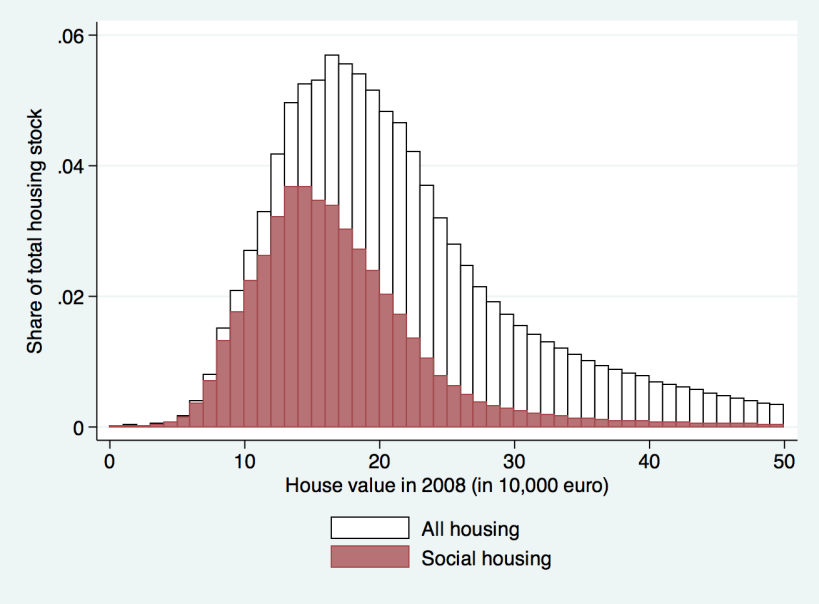


The share of the housing stock that consists of social housing for eight European countries (Scanlon and Whitehead, 2007). 35 percent of the Dutch housing stock consists of social housing. In comparison, this is 25 percent in Austria and 21 percent in Denmark. These countries form the top three countries with largest share of social housing sector. In contrast, the size of the social housing stock is only four percent in Hungary, six percent in Germany and eight percent in Ireland.



The share of the municipal housing stock in 2010 that is rented out by a (social) housing agency (in Dutch: "Huurwoningvoorraad in bezit van woningcorporatie"). In the majority of municipalities, the social housing sector equals 21-30 percent of the housing stock. In dense city municipalities such as Amsterdam, Rotterdam and Utrecht, the share of housing that is social housing is between 35 and 50 percent.

Figure 1.2: Distribution of owner-occupied and social housing value



The y-axis yields the share of housing in each house value interval for all housing and social housing (shaded). The difference between the two, is the share of owner-occupied housing within each interval. Thus almost five percent of all housing in the Netherlands has a value between 20 and 21 thousand euro (non-shaded bar). Two percent of all housing in the Netherlands has a value between 20 and 21 thousand euro and *is social housing (shaded bar).*

value of their properties has increased more than 200 percent over the period 1990-2006, which has increased the collateral of housing corporations. Nowadays, housing agencies have been selling parts of their property to finance new construction.[9]

In the Netherlands, housing agencies are neither public organizations nor private, profit maximizing corporations. Therefore, they are not effectively restrained by administrative or market forces and could arguably be more efficient.[10]

The controlled rent and its annual increase are uniformly regulated

Both the level of the controlled rent and the rent increases are regulated. At each point in time, the rent that has to be paid for social housing equals the

[9]Please note that this situation differs considerably from a private market in which profit-maximizing housing agencies are unable to benefit from such arrangements. Turner and Malpezzi (2003) observe that the majority of research is concerned with private markets, whereas in fact many social housing markets are public.

[10]See for instance Koning and Van Leuvensteijn (2010). They also point at a third problem, namely that internal control of housing agencies is insufficient as well.

rent at the start of the contract, augmented with the annual rent increase. Rent regulation prescribes that for social housing, the rent should always be below the rent ceiling (in Dutch: *maximaal toegestane huur*), which is based on characteristics of the house such as its size and the number of rooms that can be individually heated.[11] The annual increase of the rent (in Dutch: *maximaal toegestane huurverhoging*) should not exceed a maximum that is based on the inflation rate. It is possible for rents to rise in excess of the maximum allowed rent increase after an investment in housing quality that has been approved by the tenant.

The rent subsidy on controlled housing has resulted in longer waiting lists for social housing, especially in popular cities. In general, social housing within a local housing market is offered through an on-line platform open to all households. Households looking for social housing need to register. The on-line platform includes a description of any vacant housing and their rents. Households can express interest in a limited number of houses. The available housing is then generally assigned according to waiting time.[12]

Many households that are registered as 'looking for housing' do not actively search. Kromhout et al. (2006) mention that between 11 to 24 percent of the households on a waiting list have responded to a house offer in previous six months. Half of the households registered as 'looking for housing' indicate they do so to build up waiting time. The allocation mechanism of social housing is consequently beneficial to those who can afford to wait and detrimental to those who need social housing on short notice.

In addition to rent control, around 1.1 million households benefit from rent support. Tenants are eligible for rent support if their income is below a certain threshold and the rent they pay for their (independent) house is below a ceiling equal to the maximum allowed rent.[13] Demand for owner-occupied housing is subsidized as well using fiscal treatment. The rationale for this is

[11] To be more precise each house characteristic is rewarded with a number of points. As of July 1st, 2008, one point is awarded for every square meter of floor space. Two points are assigned to each room that can be heated individually by central heating. And a maximum of 25 points could be assigned based on characteristics that are not tied to the house, such as the proximity of stores and public parks. See Huurcommissie (2008).

[12] If the house is labeled to be used by a particular group of households, it is often assigned according to waiting time within that group of households.

[13] Total rent regulations and rent support benefits accrue to €14.5 billion (Donders et al., 2010).

that homeownership might create positive externalities.[14] As the price elasticity of housing supply in the Netherlands is very low, demand subsidy for the owner-occupied market increases house prices.[15] The combination of rent control of social housing and fiscal treatment of owner-occupied housing amplifies the wedge between house prices on the rental (social housing) and owner-occupied housing markets.

Strict urban planning and zoning regulations apply

The third particular feature of the Dutch housing market is the presence of strict urban planning and zoning regulations. These are imposed to preserve local public goods such as open space and to regulate externalities on the housing market. Urban planning and zoning regulations are binding restrictions.[16] Formally, they have to be updated every ten years, but it is possible to change them earlier by approved municipal amendments. As a results of these regulations, the elasticity of housing supply in the Netherlands reflects the political response to increased house prices. This might explain the low level of price elasticity of housing supply in the Netherlands.

The planning system also has its effect on the growth of cities. The Dutch housing policy has two conflicting goals. Since the housing shortage in the aftermath of the Second World War, political forces have been very much concerned with house construction and the house construction sector. While construction 'in city areas' (in Dutch: *binnenstedelijk gebied*) is encouraged, the construction of housing still requires the provision of residential land. At the same time, however, the Dutch housing policy is geared towards the conservation of open space. As a result, population growth did not always occur in large cities (which could amplify agglomeration externalities), but occurred in smaller 'growth-cities' (in Dutch: *groeikernen*).[17]

[14]DiPasquale and Glaeser (1999) present evidence that suggest the existence of such externalities. These externalities are mentioned as a justification for the mortgage tax deduction (see (MinVROM, 2000, p 296); MinBZK (2011)). In 2005, homeowners in the Netherlands received a net fiscal subsidy of €14.25 billion (Donders et al., 2010).

[15]See Donders et al. (2010); CSED (2010); Vermeulen (2008). Vermeulen (2008) presents evidence that the price elasticity of the supply of owner-occupied housing is .04 percent, whereas the hypothesis that the price elasticity of *total* housing supply is zero could not be rejected.

[16]Evidence is provided by the fact that land increases in value once it is declared to be residential land, see Vermeulen (2008).

[17]This might be why Zipf's Law is found not to hold in the Netherlands, see chapter three in Groot et al. (2010).

1.3 Outline

This dissertation has been divided into two parts. The first part studies how heterogeneous workers self-select into social housing and how this affects consumption expenditure, the allocation of the consumption budget to housing and other goods, and the income of workers. It does so by presenting a theoretical model in chapter two and three empirical studies in the chapters that follow. The second part considers the macroeconomic effects of social housing on local housing and labor markets. Chapter six then investigates how labor market and housing market price rigidities affect the composition of cities following changes in local workforce productivity. In closing, chapter seven considers the effect of the social housing stock on the share of high-skilled workers.

Chapter two

Social housing is not allocated randomly to workers. Tenants of social housing with high incomes benefit more from rent control than tenants with low incomes (Gyourko and Linneman, 1989). Also, the prevalence of high-income workers in social housing increases with local house prices (Van Daalen et al., 2012). This is peculiar as tenants of social housing do not pay these market prices. In chapter two I show that both observations can be explained by local amenities influencing the self-selection into social housing.

It is shown that rent control changes the allocation of the budget such that some tenants of social housing are unrestricted in their consumption of housing quality and other are restricted. 'Unrestricted tenants of social housing' consume on their demand curve, provided they can adjust the quality of social housing after a change in income.[18]

The income level at which workers decide to leave the social housing sector is shown to be determined by the level of location amenities. This refines the argument by Glaeser (2003) that rent control leads to social mixing only if local housing demand if high. I expand on this by arguing that the compo-

[18] As the majority of moves by rent-controlled tenants is within the rent-controlled housing sector, it is natural to assume that rent-controlled tenants can adjust the amount of rent-controlled housing services.

sition of the social housing stock is biased against social mixing: In growing cities with many location amenities, rent-controlled tenants will have higher incomes, thereby reducing social mixing.

Finally, the welfare analysis in this chapter shows that the contribution to the welfare loss of social housing increases with the income of the tenant and the market rent. Therefore the welfare loss created by rent control can be reduced by decreasing the social housing stock or by reallocating social housing from high-income workers to low-income workers (especially in areas with high market rents).

Chapter three

The literature on the relationship between house prices and consumption has been inconclusive whether the correlation is the result of wealth effects or that consumption and house prices are driven by a common factor.[19] The analysis in this chapter follows the strategy of Attanasio et al. (2009) and considers whether the national house price index over the period 1980-1999 has influenced the consumption of homeowners differently than that of tenants.[20]

In line with the common factor hypothesis I conclude that the marginal effect of house prices on consumption is positive and decreases with age. Results from the propensity score matching procedure confirm the positive marginal effect of house prices on consumption that decreases with age for both homeowners and tenants. Based on the findings in chapter three, one can conclude that the current crisis on the Dutch housing market is insufficient to explain the low propensity to consume in the Netherlands.

In the second part of chapter three it is tested whether housing market tenure type leads to changes in the *allocation* of the budget over basic goods,

[19]Campbell and Cocco (2007) find that old households increase consumption after a positive change in house prices, whereas both young and old tenants reduce consumption, which they interpret as evidence in favor of the wealth hypothesis. Bostic et al. (2009) estimate that the price elasticity of consumption to house prices is about 6 percent. Using aggregate data Chen et al. (2010) find evidence for a positive effect of house prices on consumption as well.

On the other hand, studies by Attanasio and Weber (1994); Attanasio et al. (2009) show that young households increase consumption more in response to changing house prices than old households, which they interpret as evidence in favor of the common factor hypothesis. They do, however, employ different empirical strategies and use different survey years. Cristini and Almudena (2013) consider the specifications used by Campbell and Cocco (2007) and Attanasio et al. (2009) and conclude that evidence in favor of the common factor hypothesis is more robust.

[20]The data does not allow for the separate consideration of house prices across regions.

housing (in general), recreation and alcohol and tobacco. Again, propensity score matching is used to select similar household pairs. This allows for the computing of the average treatment effect (in each year) of living in rent-controlled housing on consumption, conditional on the consumption budget and household characteristics.

The results suggest that tenants of social housing spend less on housing and more on recreation. The average treatment effect has been falling over time, which is in line with a falling difference between imputed market rents and observed controlled rents. In line with the model of chapter two I find evidence that tenants of social housing spend more on recreation if they are similar in characteristics to homeowners.

Chapter four

Chapter four tests whether the income level at which workers leave the social housing sector increases with the level of local amenities. This hypothesis follows directly from the model presented in chapter two. Previous empirical research concludes that rent control reduces the overall propensity to move house.[21] Chapter four hypothesizes that this effect might be different for transitions from the social housing sector and transition within the social housing sector. Making this distinction between the direction of the transitions is informative on the relationship between house prices and the allocation of social housing, on the misallocation costs of rent control and on the rate social housing becomes available for new entrants in the short run.

Estimation results are based on a unique household panel dataset constructed from administrative records provided by Statistics Netherlands. The results suggest that the effect of rent control benefits on household mobility is large for transitions within the social housing sector, whereas it is limited for transitions from the social housing sector. In line with the model presented in chapter two the probability to leave the social housing sector decreases with rent control benefits for high-income workers only. In contrast, all tenants of

[21] See, for instance, Gyourko and Linneman (1989); Ault et al. (1994); Nagy (1995); Munch and Svarer (2002); Simmons-Mosley and Malpezzi (2006) for empirical results using various estimation methods including OLS, logistic regression, and duration models.

social housing reduce transitions within the social housing sector if rent control benefits increase.

Chapter five

In the Netherlands workers living in rent-controlled housing earn on average 25 percent lower wages compared to homeowners. Chapter five studies whether this wage differential is the result of the sorting of low-skilled workers into social housing, as implied by chapter two. Alternatively, the wage differential could reflect a causal relationship between housing market tenure type. Both social housing and homeownership might influence wage rates as they reduce labor market mobility by increasing the transaction costs of moving (De Graaf et al., 2009).

As of today no study has empirically investigated the effect of rent control on wages. Two studies have investigated the effect of homeownership on wages with diverging results: Munch et al. (2008) find that homeowners earn about 5 percent higher wages than tenants, whereas Coulson and Fisher (2009) conclude that homeowners in the United States earn on average 30 percent lower wages.

The panel nature of the data allows to control for the sorting effect of low-skilled workers into social housing, which is shown to be an important driver of the wage differentials. There is no evidence that either homeownership or living in social housing influences the wage rate.

Chapter six

Local housing markets and local labor markets are not independent. Chapter six studies the workings of both the labor and housing market when characterized by price rigidities. This is done by combining the spatial model of Moretti (2011) with the labor market matching framework developed by Pissarides (2000).

Price rigidities in the labor market enter the model in the form of nominal wage rigidities that are the result of a supra-regional bargaining process. They reduce the mobility of labor if there are limited spatial differentials in

unemployment rates or if wages are not adjusted in response to local changes in productivity.

Price rigidities in the housing market enter in the form of housing vouchers that enable the holder to rent housing at the rent ceiling. Their effect on the housing market crucially depends on the distribution of rent control housing vouchers among workers of different skill levels: If rent control housing vouchers are allocated mainly to low-skilled workers, both the inflow of high-skilled workers and outflow of low-skilled workers after a productivity shock to high skilled labor will be lower. The reverse occurs if rent-control housing vouchers are allocated mainly to high-skilled workers.

In general, housing market price rigidities are found to amplify labor market price rigidities after a productivity shock to high-skilled labor. Vice versa, the effect of housing market price rigidities on the relocation of high- and low-skilled workers can be seen to be generally lower if labor market price rigidities are present. In contrast, housing market price rigidities mitigate labor market price rigidities after a productivity shock to low-skilled labor.

Chapter seven

Moretti (2011, 2013) shows how local skill composition is driven by the net local wage rate, adjusted for local housing costs. As rent control impacts the housing costs in the social housing sector, it could affect the growth of cities and their skill composition (see chapter six). This might reduce agglomeration externalities that stem from the clustering of high-skilled workers.[22] If so, this provides a new channel by which rent control distorts outcomes on the local labor market, in addition to its effect on unemployment.

This hypothesis is tested using longitudinal panel data on forty NUTS 3 regions in the Netherlands (in Dutch: *COROPs*). This data is augmented with information on productivity and employment for eight sectors in these years at the NUTS 3 level. I condition on the local high-skilled wage premium and local house prices, which might be correlated with changes in (unobserved) location amenities. This creates an endogeneity problem. Therefore these

[22] Moretti (2004) presents evidence that clustering of high-skilled workers increases nominal wages of all skill types. For the Netherlands, De Groot et al. (2013) find that the wage elasticity to the percentage of high-skilled workers equals 2.9-5 percent (depending on skill-type).

variables are instrumented using the data on sectoral productivity and employment, as well as data on historic housing density.

Rent control is found to reduce the percentage of high-skilled workers in a region. Ceteris paribus a ten percentage point increase of the rent-controlled housing stock is found to reduce the percentage of high-skilled workers in a region with 1.5 percentage points. This effect seems to be limited: If the social housing stock of Utrecht would be halved from forty to twenty percent of the housing stock, the percentage of high-skilled workers in Utrecht would increase with three percentage points only. The low magnitude of this effect is presumably due to the self-selection of high-income tenants into social housing in places with many local amenities, as described in chapter two.

1.4 Insights for the future of social housing in the Netherlands

The institutional reform of the Dutch housing sector is on the political agenda. As I have no doubt that the social housing sector will be transformed in the near future, I end this chapter by setting out some insights provided by this dissertation that may contribute to the discussion on the future of social housing in the Netherlands.

It is shown in chapter three that tenants of social housing spend more on basic goods, recreation and alcohol and tobacco. However, chapter two shows these gains of social housing are smaller than the costs of rent control. Therefore, the private benefits of rent control do not give an *economic* rationale to increase the social housing sector, quite the contrary. Chapter four concludes that social housing reduces the propensity to move, especially for transitions within the social housing sector. I do not find evidence that this influences the wage rate of workers living in social housing.

I show in chapter two that high-skilled workers self-select into social housing if house prices are high, which cannot be prevented by entry regulations based on income. Public interest in this sorting mechanism has increased and the pricing mechanism of social housing has been adjusted in order to prevent

this.[23] Chapter two presents an argument against high-skilled workers living in social housing that is based on efficiency: High-income workers contribute more to the welfare loss than low-income workers. Therefore the welfare loss created by rent control can be reduced by decreasing the social housing stock or by reallocating social housing from high-income workers to low-income workers (especially if market rents are high).[24]

Reducing the share of social housing that is inhabited by high-income households is often considered to be 'fair'. Also, it improves the efficiency on the housing market. It should be realized, however, that this will increase local labor market distortions. It is shown in chapter seven that while a negative relationship between the size of the social housing stock and the percentage of high-skilled workers exists, it is but modest in size. If one would impose legislation that ensures social housing is inhabited by low-income workers only, the effect of social housing on local skill composition is expected to be larger. Therefore, improving the allocation of social housing to low-skilled workers provides an 'efficiency vs. efficiency trade-off': It will increase efficiency on the housing market and decrease it on the labor market.

[23] As of July 2011, the rent of new contracts is allowed to increase more in attractive locations in the country (the so-called *schaarstegebieden*). As of July 2013 rents in the social housing sector were made dependent on income: Rents were allowed to increase with the inflation rate plus 2.5, 3.5 and 4 percent maximums for low-, middle-, and high-income households. Here, middle-income households are defined as earning an annual income between €33,614 and €43,000. The government aims to introduce a new pricing mechanism on 1 July 2014 in which rents of social housing are based on house values, see BZK (2013).

[24] The welfare loss can be eliminated by decontrolling all social housing and letting the winners compensate the losers. However, such a policy is likely to be unfeasible.

Part A:
A micro-economic perspective on rent control of social housing

Chapter 2

Why do the rich live in social housing?

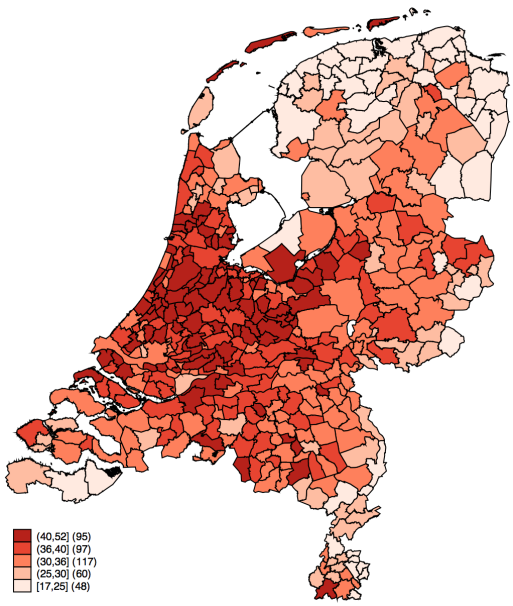
2.1 Introduction

In many municipalities in the Netherlands a considerable share of the social housing segment is inhabited by rich households.[1] Figure 2.1 illustrates that the proportion of social housing that is occupied by high-income households is spatially clustered. In the north-east of the country, the proportion of the social housing stock inhabited by households with income exceeding €33,000 is less than 25 percent, whereas in the center of the country this ratio is over 40 percent.

Also, there exists a positive correlation between house prices and the share of social housing inhabited by rich households. This is shown in Figure 2.2 where the size of each circle reflects the size of the municipal housing stock. The positive relationship between house value and the proportion of the social housing stock inhabited by high-income households seems not to be driven the size of the municipal housing stock.

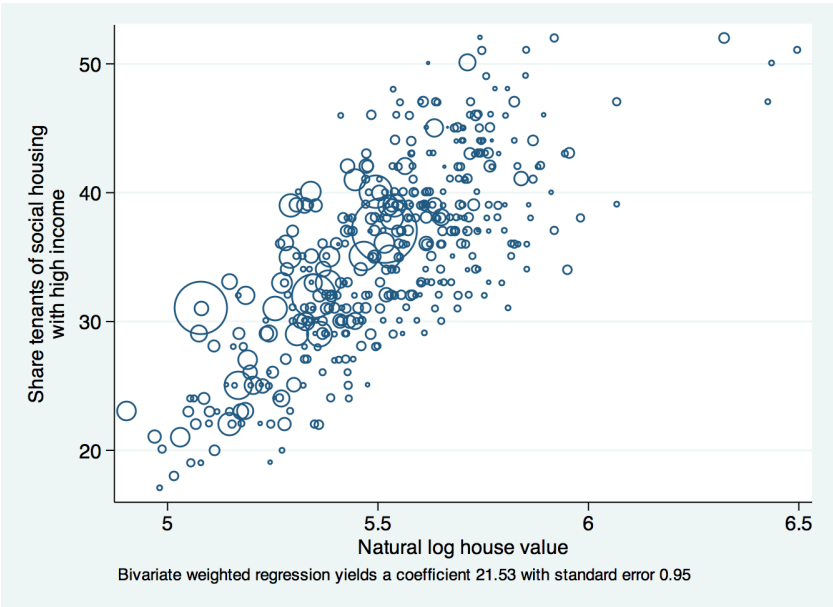
[1] I refer to households earning 33 thousand euros annually or more as 'high-income households', although this equals the 2011 average affordable income (in Dutch: *besteedbaar inkomen*). Statistics Netherlands (CBS) refers to them as *scheefwoners*.

Figure 2.1: Share of tenants of social housing with high income



Source data: Van Daalen et al. (2012).
The figure shows the municipal share of tenants of social housing with high income. High-income households are defined to earn annual income equal to €33,000 or more.

Figure 2.2: Share of tenants of social housing with high income and house value



Source: own calculations based on Van Daalen et al. (2012); CBS (2013).
Size of the circle represents size of municipal housing stock.

Entry regulations do not differ across the country, and therefore cannot explain this positive correlation. Affordability cannot explain it either, as tenants of social housing do not pay market rents and as the rent ceiling is uniformly regulated across the country. Instead, I argue that *self-selection* of heterogeneous workers into social housing based on location amenities generates the positive correlation between house prices and the share of rich households in social housing. It is shown that this self-selection mechanism increases the welfare costs of social housing.

A key observation is that location amenities are internalized in the market rent of housing, but not in the controlled rent of social housing. This allows tenants of social housing to consume location amenities for free. Therefore, the more location amenities, the higher will be the income at which workers move to uncontrolled housing. This creates a positive correlation between income of rent-controlled tenants and local house prices, even if entry into the rent-controlled housing stock is uniformly regulated. It also explains why high-income households benefit more from rent control than low-income households (Gyourko and Linneman, 1989).

This chapter presents a stylized theoretical model in which rational workers maximize utility by consuming housing quality, a composite good and local amenities. workers can consume social housing of different quality as long as it does not exceed a predefined quality threshold.[2,3] Workers self-select into either social housing or uncontrolled housing, which allows to distinguish three groups: Some workers will rent uncontrolled housing. The remaining workers, living in social housing, can be subdivided into those who will consume *on* their expansion path ('unrestricted tenants of social housing') and those who will consume *off* it ('restricted tenants of social housing'). This implies that the costs associated with rent control differ from those based on

[2]As the majority of moves by rent-controlled tenants is *within* the rent-controlled housing sector, the assumption that rent-controlled tenants can adjust quality of rent-controlled housing is natural. A model where tenants on *rent support* can choose the number of housing services consumed is presented in Koning and Ridder (1997); Le Blanc and Laferrère (2001); Kim et al. (2004).

[3]The economic literature uses housing services instead of housing quality as the market rent of a dwelling depends on characteristics of the house and the location amenities it provides access to. However, as I focus on the fact that location amenities (part of housing services, but not of house quality) are not priced in the controlled rent, using housing services is not desirable.

models in which all tenants of social housing consume off their demand curve by construction.[4]

Amenities have been shown to be important for the location decision of workers (see among others Brueckner et al. (1999); Glaeser et al. (2001); Van Duijn (2013)). I show that location amenities not only influence location decisions of high-income and low-income workers in the uncontrolled housing market (Brueckner et al., 1999), but also in the rent-controlled housing market. Also, I show that the welfare costs of rent control are increasing in location amenities.

Finally, I show that high-income workers contribute more to the welfare loss of rent controlled social housing than low-income workers. This implies that the self-selection of high-income tenants of social housing increases the welfare costs of it. Stated differently, policy that reallocates social housing from high-income workers to low-income workers will reduce the welfare loss of rent control.[5]

The remainder of this chapter is organized as follows. Section 2.2 presents the theoretical model. Section 2.3 shows that the correlation between income of social tenants and house prices does not disappear if entry regulations are imposed. Welfare implications of the self-selection into social housing are discussed in section 2.4. Finally, section 2.5 concludes.

2.2 Tenure choice and consumption

I model the choice of type of housing tenure in a partial equilibrium framework. As in Lyytikäinen (2006), the model is based on a standard model of consumption of two goods with a budget restriction: workers maximize utility by consuming housing quality q, a composite good x and location amenities A given their budget Y. Utility is increasing and strictly concave in the

[4]Many partial market equilibrium analyses of housing demand and rent control stress that rent control provides benefits *and costs* to rent-controlled tenants, see Arnott (1995); Turner and Malpezzi (2003); Simmons-Mosley and Malpezzi (2006). In these models workers consume on their demand curve at uncontrolled prices and suddenly are subject to rent control. As a result they necessarily consume off their demand curve: given the rent-controlled price, they would be willing to consume rent-controlled housing of better quality than they currently do.

[5]Of course, this policy is second-best. The welfare loss of social housing can be eliminated by decontrolling social housing. If winners compensate the losers no agent will be worse off. However, this first best solution is likely to be politically infeasible.

consumption of housing quality, the composite good and location amenities.[6] Housing and the composite good are normal goods.

There are two types of housing with different prices: rent-controlled housing that can be rented at $\bar{r}$ per unit of quality, and uncontrolled housing with market rent r_l. The subscript l refers to location. Local market rents are increasing in the level of amenities and the controlled rent is independent of local amenities.[7]

Workers are assigned a local housing market and are presented the option to rent controlled housing. However, rent-controlled housing is available up to a quality threshold $q = \bar{q}$. Thus, supply of controlled housing quality is perfectly elastic on the domain $q = [0, \bar{q}]$. Supply of uncontrolled housing quality is perfectly elastic. Workers can consume uncontrolled housing in all regions and moving costs are zero.

Denote the type of housing tenure with $\tau = o$ for uncontrolled tenants and home-owners, and $\tau = c$ for controlled tenants. The budget constraint of workers equals $x = Y - r^{\tau} q$, where x is the numeraire good. Given the local housing market for which the housing voucher is valid, the decision of the worker is to maximize utility by choosing the optimal type of tenure.

$$\max_{x,q,\tau} \quad U^{\tau}(x, q, A_l) \quad \text{s.t.} \quad x = Y - r^{\tau} q$$

$$\text{with} \quad r^{\tau} = \begin{cases} r_l & \text{if} \quad \tau = o \\ \bar{r} & \text{if} \quad \tau = c \end{cases}$$

2.2.1 Utility of uncontrolled workers

Let $U^o(x, q, A_l)$ denote utility if workers chooses uncontrolled housing. Uncontrolled workers maximize utility if the ratio of marginal benefits equals the

[6] I do not impose further restrictions on the shape of the utility function. Section 2.A shows results hold for a general CES-utility function.

[7] Scanlon and Whitehead (2007, 2008) illustrate that across Europe a large part of the rental housing sector is regulated based on either construction costs, income of tenants or house characteristics, but not on location amenities. Furthermore, to keep the model simple, it is assumed that the presence of rent-controlled housing does not increase house prices of uncontrolled housing. This assumption does not drive the outcomes of the model.

ratio of marginal costs as in equation (2.1).

$$\frac{\partial U^o}{\partial q} = r_l \frac{\partial U^o}{\partial x} \tag{2.1}$$

Indirect utility V^o is a function of income and the price of uncontrolled housing as in equation (2.2).

$$U^o(x, q, A_l) = V^o(Y, r_l) \tag{2.2}$$

Indirect utility of uncontrolled workers does *not* depend on the local level of amenities, because any increase in location amenities is offset by a corresponding increase in house prices, to which workers respond by changing consumption such that utility does not change. This occurs whenever equation (2.3) is satisfied.

$$\frac{\partial r_l}{\partial A_l} = \frac{\partial U^o / \partial A_l}{\partial U^o / \partial x} \frac{1}{q} \tag{2.3}$$

Proposition 1. *No spatial arbitrage: if tenants of uncontrolled housing maximize utility, and local house price change with the local amenity stock according to* (2.3) *, then utility of uncontrolled workers $U^o(x, r, A_l)$ is independent of the local amenity level.*

Proof. No spatial arbitrage implies that workers in uncontrolled housing cannot increase utility by moving to another location l. As moving is costless, no spatial arbitrage requires that

$$U^o(x, q, A_l) = U^o(x, q, A_{l'}) \quad \forall \quad l, l'$$

This condition can only hold if the full derivative of $U^o(x, q, A_l)$ towards A_l is zero. To solve substitute the budget constraint $x = Y - r_l q$ into the utility function and take the full derivative of utility to local amenities:

$$\frac{dU^o(x, q, A_l)}{dA_l} = -\frac{\partial U^o}{\partial x}\left[\frac{\partial r_l}{\partial A_l} q + \frac{\partial q}{\partial A_l} r_l\right] + \frac{\partial U^o}{\partial q}\frac{\partial q}{\partial A_l} + \frac{\partial U^o}{\partial A_l}$$

equate $\frac{dU^o(x,q,A_l)}{dA_l}$ to zero and rearrange to get

$$\frac{\partial U^o}{\partial x}\left[\frac{\partial r_l}{\partial A_l}q + \frac{\partial q}{\partial A_l}r_l\right] = \frac{\partial U^o}{\partial q}\frac{\partial q}{\partial A_l} + \frac{\partial U^o}{\partial A_l}$$

Utility maximizing uncontrolled workers consume on their demand curve, such that equation (2.1) holds. Use (2.1) to replace the first term at the right hand side with $\frac{\partial U}{\partial x}\frac{\partial q}{\partial A_l}r_l$, which cancels out after opening up the brackets. Solving for $\frac{\partial r_l}{\partial A_l}$ yields equation (2.3).

Equation (2.3) implies any increase in utility from consuming more location amenities, is offset by having to pay higher (uncontrolled) house prices. Therefore, tenants of uncontrolled housing cannot increase utility by changing the consumption of location amenities. □

2.2.2 Utility of rent-controlled workers

Let $U^c(x, q, A_l)$ denote utility if the worker rents controlled housing in l. The indirect utility function is defined as V^c. Note that V^c depends on the local level of amenities in location l.[8]

$$U^c(x, q, A_l) = V^c(Y, \bar{r}, A_l) \tag{2.4}$$

Uncontrolled workers maximize utility if they spend their budget on housing and the composite good such that the ratio of marginal benefits equals the ratio of marginal costs. If they spend their budget according to this decision rule, they could not be better off and are 'on their demand curve'.

$$\frac{\partial U^c}{\partial q} = \bar{r}\frac{\partial U^c}{\partial x} \tag{2.5}$$

As controlled housing can only be provided up to the quality level $\bar{q}$, $U^c(x, q, A_l)$ is continuous in q on the domain $q = (0, \bar{q}]$. Define Y^s as the income level such that the worker is on the expansion path and the worker consumes housing of quality $\bar{q}$.

[8] As V^c depends on more than prices and income, it is not an indirect utility function in the true meaning of the word.

Definition 1. *Y^s is the income level at which workers in controlled housing consume on their demand curve and consume housing of quality equal to $\bar{q}$.*

If income is below Y^s, each marginal increase in income is spend on both controlled housing quality and the composite good according to (2.5). However, if income equals at least Y^s and the worker remains in controlled housing, each marginal increase in income can only be spend on the composite good. This increases utility as well, but less than if the worker would be on the demand curve.

Proposition 2. *Indirect utility of utility maximizing workers in rent-controlled housing $V^c(Y, \bar{r}, A_l)$ increases with income with a kink at Y^s. Derivatives of utility towards income are given by*

$$\frac{\partial V^c(Y,\bar{r},A_l)}{\partial Y}|_{Y<Y^s} = \frac{\partial U^c}{\partial x}\frac{\partial x}{\partial Y} + \frac{\partial U^c}{\partial q}\frac{\partial q}{\partial Y} > \frac{\partial U^c}{\partial x}\frac{\partial x}{\partial Y} = \frac{\partial V^c(Y,\bar{r},A_l)}{\partial Y}|_{Y^s<Y}$$

Proof. workers maximize utility if equation (2.5) holds. As $\partial U^c/\partial q_l > 0$ and $\partial U^c/\partial x_l > 0$ each marginal increase in income is divided over both goods x_l and q_l. However, as the maximum level of q_l equals $\bar{q}$, it follows from definition 1 that $V^c(Y, \bar{r}, A_l)$ is increasing and continuous in Y on the domain $Y = [0, Y^s)$. If income exceeds Y^s, workers can spend each marginal increase in income on the composite good only. As $\partial U^c/\partial x_l > 0$, $V^c(Y, \bar{r}, A_l)$ is increasing and continuous in Y on the domain $Y = (Y^s, \infty)$. Therefore $V^c(Y, \bar{r}, A_l)$ has a kink at Y^s. □

Proposition 3. *Indirect utility of workers in controlled housing increases with the local amenity level.*

Proof. Substitute $x^c = Y - \bar{r}q^c$ into the utility function for controlled tenants and take the full derivative to local amenities:

$$\frac{dU^c(x,q,A_l)}{dA_l} = -\frac{\partial U^c}{\partial x}\left[\frac{\partial \bar{r}}{\partial A_l}q + \frac{\partial q}{\partial A_l}\bar{r}\right] + \frac{\partial U^c}{\partial q}\frac{\partial q}{\partial A_l} + \frac{\partial U^c}{\partial A_l}$$

Note that $\frac{\partial \bar{r}}{\partial A_l} = 0$ as the rent ceiling does not depend on local amenities. Workers in rent-controlled housing maximize utility if equation (2.5) holds. Use (2.5) to substitute $\frac{\partial U^c}{\partial q}\frac{\partial q}{\partial A_l} = \bar{r}\frac{\partial U^c}{\partial x}\frac{\partial q}{\partial A_l}$, which then cancels out. Therefore,

the full derivative of utility of controlled workers to the local amenity stock equals the partial derivative (which is positive). As a result, the indirect utility function of rent-controlled workers depend on income, the rent ceiling *and* the local level of amenities as in equation (2.4). □

2.2.3 Choice of tenure type and consumption quantities

Utility of uncontrolled workers with income Y is equal across the country as location amenities are perfectly priced into house prices (proposition 1). Yet, utility of rent-controlled workers with income Y varies across the country with the level of location amenities (proposition 3). In this subsection, I will show that workers choose to live in controlled or uncontrolled housing in location l depending on their income and the amenity level.

Proposition 4. *Workers with income equal to or below Y^s rent controlled housing.*

Proof. Workers in uncontrolled and controlled housing maximize utility if equations (2.1) and (2.5) hold. As controlled housing can be rented up to the quality threshold $\bar{q}$, equation (2.5) can only hold if $Y \leq Y^s$. Divide equation (2.1) by (2.5) and solve for $r_l/\bar{r}$ to derive equation (2.6).

$$\frac{r_l}{\bar{r}} = \frac{(\partial U^o/\partial q)\ /\ (\partial U^o/\partial x)}{(\partial U^c/\partial q)\ /\ (\partial U^c/\partial x)} \tag{2.6}$$

As $r_l/\bar{r} > 1$ for all l and utility is concave and increasing in the composite good x and housing quality q, equation (2.6) implies that controlled workers can consume more of the composite good than uncontrolled workers given equal consumption of housing quality q. As they can consume more, utility of rent-controlled tenants exceeds that of uncontrolled workers if $Y \leq Y^s$. □

Next, define Y^{A_l} as the income level such that the worker is indifferent between living in controlled and non-controlled housing. It follows from proposition 3 that Y^{A_l} increases with the local amenity level A_l given r_l.

Definition 2. *Y^{A_l} is the income level such that the worker is indifferent between living in controlled and non-controlled housing.*

Proposition 5 states that workers with income below Y^{A_l} will rent controlled housing, whereas workers with income exceeding Y^{A_l} will rent uncontrolled housing.

Proposition 5. *Utility maximizing workers with income exceeding Y^{A_l} will consume uncontrolled housing of quality exceeding $\bar{q}$ at the market rent r_l.*

Proof. Workers with income Y^{A_l} are indifferent between renting controlled or uncontrolled housing (Definition 2). Workers in uncontrolled housing with income Y^{A_l} consume more housing quality ($q > \bar{q}$) and fewer units of the composite good than workers with equal income in controlled housing.

Utility is increasing and concave in consumption of the composite good. Therefore, if both types spend any marginal increase in income solely on the composite good, utility of uncontrolled workers with income Y^{A_l} increases more than utility of controlled workers with this income level. Thus workers with income exceeding Y^{A_l} are better off renting uncontrolled housing. □

Proposition 6. *Utility maximizing workers with income in between Y^s and Y^{A_l} will consume rent-controlled housing of quality $\bar{q}$.*

Proof. Based on Definition 2 and Proposition 5 the following equations holds:

$$V^o(Y^{A_l}, r_l) = V^c(Y^{A_l}, \bar{r}, A_l) \qquad \text{(Definition 2)} \tag{2.7}$$

$$V^o(Y, r_l) > V^c(Y, \bar{r}, A_l) \quad \text{if} \quad Y > Y^{A_l} \qquad \text{(Proposition 5)} \tag{2.8}$$

As V^o is monotonically increasing in Y and V^c is a monotonically increasing function in Y on the domain $Y = (Y^s, \infty)$, it follows that $V^o(Y, r_l) < V^c(Y, \bar{r}, A_l)$ for $Y^s < Y < Y^{A_l}$. □

Propositions 4, 5 and 6 state that the optimal tenure type is a function of income and location amenities. Workers with income equal or smaller than Y^{A_l} will rent controlled housing, whereas workers with income exceeding will rent uncontrolled housing.

Note that the group of rent-controlled workers consists of two subgroups. The first group with income $Y \leq Y^s$ consumes housing of quality $q \leq \bar{q}$ at the controlled rent. Their consumption bundle is optimal as they consume

according to equation (2.5). Hence they are unrestricted tenants that consume on their demand curve.

The second group of rent-controlled workers with income $Y^s < Y \leq Y^{A_c}$ would be willing to consume housing of higher quality than $\bar{q}$ at the controlled rent $\bar{r}$. Thus they consume off their demand curve. As their desired bundle is infeasible they are referred to as restricted tenants of rent-controlled housing.

Definition 3. *Unrestricted tenants of rent-controlled housing are workers who rent controlled housing and consume on their demand curve. By proposition 4, all workers with income $Y \leq Y^s$ are unrestricted tenants of rent-controlled housing.*

Definition 4. *Restricted tenants of social housing are workers who rent social housing and consume off their demand curve. By proposition 5, they are defined as workers in l with income $Y^s < Y < Y^{A_l}$.*

For unrestricted tenants of rent-controlled housing and tenants of uncontrolled housing, consumption of the composite good and housing quality is defined by the expansion path and budget restriction. Restricted tenants of controlled housing spend $\bar{r}\bar{q}$ on housing and $Y - \bar{r}\bar{q}$ on the composite good. Thus consumption of housing quality and the composite good is given by equation (2.9), where the superscript * indicates the value is in accordance with equation (2.1) or equation (2.5).

$$x = \begin{cases} Y - r^\tau q^* & \text{if} \quad Y \leq Y^s \quad \text{or} \quad Y \geq Y^{A_l} \\ Y - \bar{r}\bar{q} & \text{if} \quad Y^s < Y < Y^{A_l} \end{cases} \tag{2.9}$$

A graphical representation of the model is presented in section 2.B.

2.2.4 Variation in income across local housing markets

This subsection discusses how spatial variation in location amenities creates spatial variation in the local income level of tenants of social housing as shown in Figure 2.2. For simplicity, consider a region with workforce of mass equal to one. Let $f(Y)$ denote the probability density function of income. Recall that all tenants with income equal or below Y^{A_l} will live in rent-controlled housing. Thus the share of workers in rent-controlled housing s_l is given by equation

2.10.

$$s_l = \int_0^{Y^{A_l}} f(Y)dY \tag{2.10}$$
$$o_l = 1 - s_l$$

Average income of tenants in rent-controlled housing $av(Y)_{s_l}$ is given by equation (2.11) and increasing in Y^{A_l}.

$$av(Y)_{s_l} = \int_0^{Y^{A_l}} f(Y)YdY \tag{2.11}$$

Consider an arbitrary income threshold $\tilde{Y}$ that is lower than Y^{A_l}. Let s_l^+ denote the share of workers in rent-controlled housing for whom income exceeds this arbitrary threshold.

$$s_l^+ = \frac{\int_{\tilde{Y}}^{Y^{A_l}} f(Y)dY}{\int_0^{Y^{A_l}} f(Y)dY} \tag{2.12}$$

It follows from equation (2.12) that the share of all rent-controlled tenants with income exceeding $\tilde{Y}$ increases with Y^{A_l}. As both uncontrolled house prices and Y^{A_l} are increasing in the level of local amenities, equation (2.12) implies there is a positive relationship between the share of rent-controlled workers with income exceeding a certain threshold value and the level of location amenities in the housing market.

2.3 Regulating entry into rent-controlled housing

This section shows that entry regulations of the social housing stock does not alter the outcomes of the model. As a result entry regulations are unable to prevent that social housing is rented by high-income workers.

The model is adapted to contain two periods. Workers perfectly smooth income over both periods, such that expected income in both periods is equal. At the start of each period, workers are allowed to change housing tenure. Allocation of rent-controlled housing is regulated based on income: Only workers with income equal or below $\bar{Y}$ are allowed to *enter* rent-controlled hous-

ing. Ensure the constraint on income is binding for restricted tenants of rent-controlled housing by assuming $Y^s < \bar{Y} < Y^{r,A}$ in all l.[9]

To study how location amenities influence the income at which households change tenure type, I allow for a positive income shock γ that occurs to all workers in between period one and two.[10] Let subscripts denote time periods, such that Y_1 is income in period one and $Y_2 = Y_1 + \gamma$ equals income in period two. A crucial assumption, in line with regulations on rent-controlled housing in the Netherlands, is that the income ceiling no longer applies once workers live in rent-controlled housing. Hence the exit out of rent-controlled housing is not regulated.

The equations on page 32 summarize the outcomes of the model. As the income ceiling is binding, all workers with income below the income ceiling will rent social housing in period one and those above it will rent uncontrolled housing. Consumption of housing increases with income for unrestricted tenants of rent-controlled housing. This is also true for tenants of uncontrolled housing, who are those workers with income exceeding the income threshold $\bar{Y}$.

In the second period the (binding) income ceiling for rent-controlled housing no longer determines who rents controlled or uncontrolled housing. Rent-controlled workers will move to the uncontrolled housing sector in the second period, only if the income shock raises income above Y^{A_l}. As the maximum income of rent-controlled workers in period one equals $\bar{Y}$ and all workers receive the unexpected income shock γ, workers with income in period two equal to or smaller than $\min(\bar{Y} + \gamma, Y^{A_l})$ will be living in rent-controlled housing. All other workers will rent uncontrolled housing in the second period.

In the first period, all workers with income below the income threshold will be living in rent-controlled housing, see equation (2.13).

$$s_1^{'} = \int_0^{\bar{Y}} f(Y_1) dY_1 \tag{2.13}$$

[9] $\bar{Y} < Y^s$ yields similar results. The income constraint is not binding if $Y^{A_l} < \bar{Y}$.

[10] It occurs to all workers such that the share of workers in rent-controlled housing exceeding a certain threshold is tractable. Results do not depend on this assumption.

Tenure choice and consumption of the composite good and housing quality in each period are given by the following equations:

Choice of tenure

First period

$$\tau_1 = \begin{cases} c & \text{if} \quad Y_1 \leq \bar{Y} \\ o & \text{otherwise} \end{cases}$$

Second period

$$\tau_2 = \begin{cases} c & \text{if} \quad Y_2 \leq \min(\bar{Y} + \gamma, Y^{A_l}) \\ o & \text{otherwise} \end{cases}$$

Consumption

First period

$$x_1^* = \begin{cases} Y_1 - \bar{r}q_c^* & \text{if} \quad Y_1 \leq Y^s \\ Y_1 - \bar{r}\bar{q} & \text{if} \quad Y^s \leq Y_1 \leq \bar{Y} \\ Y_1 - r^o q_c^* & \text{if} \quad \bar{Y} < Y_1 \end{cases}$$

Second period

$$x_2^* = \begin{cases} Y_2 - \bar{r}q_c^*, & \text{if} \quad Y_2 \leq Y^s \\ Y_2 - \bar{r}\bar{q} & \text{if} \quad Y^s \leq Y_2 \leq \min(\bar{Y} + \gamma, Y^{A_l}) \\ Y_2 - r^o q_c^*, & \text{if} \quad \min(\bar{Y} + \gamma, Y^{A_l}) < Y_2 \end{cases}$$

Note that $Y^{r,A} < \bar{Y} + \gamma$ indicates that some workers who were rent-controlled in period one switch to uncontrolled housing in period two. In contrast, if $\bar{Y} + \gamma < Y^{r,A}$ those workers who rented controlled housing in period one, will still do so in period two.

The share of workers in rent-controlled housing in period 2 is given by equation (2.14). The upper limit of the second integral contains $Y^S + \gamma$ as all workers with income equal or below Y^s in period one rented controlled housing.

$$s_2^{'} = \int_0^{\min(Y^{A_l}, \bar{Y}+\gamma)} f(Y_2) dY_2 \tag{2.14}$$

Therefore, the average income of workers in rent-controlled housing in periods 1 and 2 equals:

$$av(Y)_{s_1^{'}} = \int_0^{\bar{Y}} f(Y_1) Y_1 dY_1 \tag{2.15}$$

$$av(Y)_{s_2^{'}} = \int_0^{\min(Y^{A_l}, \bar{Y}+\gamma)} f(Y_2) Y_2 dY_2 \tag{2.16}$$

Consider an income threshold $\tilde{Y}$ that is lower than the minimum of Y^{A_l} and $\bar{Y} + \gamma$. Let $s_2^{+'}$ denote the share of workers in rent-controlled housing in period two for whom income exceeds this threshold (relative to the number of rent-controlled workers). Equation (2.17) increases with Y^{A_l} as long as conditions are such that some workers change tenure type because of the income shock (provided $Y^{A_l} < \bar{Y} + \gamma$).

$$s_2^{+'} = \frac{\int_{\tilde{Y}}^{\min(Y^{A_l}, \bar{Y}+\gamma)} f(Y_2) dY_2}{\int_0^{\min(Y^{A_l}, \bar{Y}+\gamma)} f(Y_2) dY_2}, \tag{2.17}$$

As both uncontrolled house prices and Y^{A_l} are increasing in the level of local amenities, equation (2.17) implies there is still a positive relationship between the share of rent-controlled workers with income exceeding a certain threshold value and the level of location amenities in the housing market.

Compare equation (2.10) to (2.14) and equation (2.12) to (2.17) under the assumption that $Y = Y_2$. They indicate that size of the rent-controlled housing stock (in period two) and the distribution of income among workers in rent-controlled housing is not affected by the income threshold if the income at which workers will move from the social housing sector is lower than the income ceiling plus the positive income shock. Thus regulating entrance into rent-controlled housing on income does not change the allocation of rent-

controlled housing if regulations on entry are loosely binding ($\bar{Y}$ is high) or in locations with few location amenities (Y^{A_l} is small).

2.4 Implications for welfare

The previous part of this chapter has shown that the income of workers and location amenities determine the self-selection of high-income workers into social housing. Entry regulation based on income could not prevent this self-selection. In this section, I will discuss the welfare implications of this sorting mechanism on the housing market.

The costs of rent control equal the rent the lessor of social housing forgoes. Equation (2.18) defines these costs, where demand for housing as a function of income is given by $q^* = D(Y)$. Given the price difference between social housing and uncontrolled housing, the costs of rent control are increasing in income as long as $Y < Y^s$ and remain constant as long as $Y = [Y^s, Y^{A_l}]$. If $Y^{A_l} < Y$ the costs of rent control become zero as workers will rent uncontrolled housing.

$$C(Y, r_l) = \begin{cases} (r_l - \bar{r})D(Y) & \text{if} \quad Y \leq Y^{A_l} \\ 0 & \text{if} \quad Y^{A_l} < Y \end{cases} \tag{2.18}$$

Next, define the benefits of rent control $B(Y, r_l)$ (in equivalent variation) as the increase in income a worker in uncontrolled housing would require in order to be indifferent between renting social or uncontrolled housing.

Definition 5. *Equivalent variation $B(Y, r_l)$ is the income increase required by workers in uncontrolled housing to be indifferent between renting social housing or uncontrolled housing: $V^o(Y + B(Y, r_l), r_l) = V^c(Y, \bar{r}, A_l)$.*

It follows from Definition 2 that $B(Y^{A_l}, r_l) = 0$. [11] As housing is a normal good, workers substitute away from consuming housing quality if the rent

[11] Workers with income exceeding Y^{A_L} do not live in social housing, and therefore their benefits from rent control are set to zero. Would they be living in social housing, Proposition 5 implies that workers with income exceeding Y^{A_L} would be willing to give up income ($B(Y, r_l) < 0$) in order to leave the social housing sector.

increases. This implies that the costs of rent control of social housing are at least as large as the benefits of social housing and rent control is inefficient.

Let $x^*(Y + C(Y, r_l), r_l)$ be the utility maximizing consumption of the composite good if the worker would receive the costs of rent control $C(Y, r_l)$ in addition to his income Y while renting uncontrolled housing. Let $x^*(Y, \bar{r})$ denote the optimal consumption of the composite good if the worker would rent social housing at the controlled rent $\bar{r}$. As x is the numeraire, these quantities can be used to compute the welfare loss if income is at most Y^s. Therefore, the welfare loss of rent control is given by equation (2.19).

$$
\begin{aligned}
L(Y, r_l) =& C(Y, r_l) - B(Y, r_l) \\
L(Y, r_l) =& \begin{cases} x^*(Y + C, r_l) - x^*(Y, \bar{r}) & \text{if} \quad Y \leq Y^s \\ \bar{q}(r_l - \bar{r}) - B(Y, r_l) & \text{if} \quad Y^s < Y \leq Y^{A_l} \\ 0 & \text{if} \quad Y \leq Y^{A_l} \end{cases}
\end{aligned}
\tag{2.19}
$$

Proposition 7. *Rent control of social housing creates a welfare loss if $Y \leq Y^s$.*

Proof. The proof follows from the fact that for any discrete price change, Slutsky compensated demand will be larger than Hicksian compensated demand (Mas-Colell et al., 1995, p. 72). The welfare loss for someone with income $Y \leq Y^s$ who lives in a city with market rent r_l equals $L(Y, r_l) = x^*(Y + C(Y, r_l), r_l) - x^*(Y, \bar{r})$. $L(Y, r_l)$ is positive if $x^*(Y + C(Y, r_l), r_l) > x^*(Y, \bar{r})$ which occurs if $Y < Y^s$.

Definition 5 implies that the points $[x^*(Y + C(Y, r_l), r_l), q^*(Y + C(Y, r_l), r_l)]$ and $[x^*(Y, \bar{r}), q^*(Y, \bar{r})]$ are on the same indifference curve. Also, as $x^*(Y + C(Y, r_l), r_l)$ and $x^*(Y, \bar{r})$ are interior optimal values, they are described by equations (2.1) and (2.5). As $\bar{r} < r_l$ and the utility function is strictly concave, the two bundles can only be described by equations (2.1) and (2.5) if $x^*(Y + C(Y, r_l), r_l) > x^*(Y, \bar{r})$ and $q^*(Y + C(Y, r_l), r_l) < q^*(Y, \bar{r})$. Therefore, the costs of rent control always exceed the benefits if $Y < Y^s$. □

Proposition 8. *Rent control of social housing creates a welfare loss that increases with income Y and the market rent r_l if $Y < Y^s$.*

Proof. Define $Y < Y'$ such that $Y, Y' < Y^s$. Use equation 2.19 to write:

$$L(Y', r_l) - L(Y, r_l) > 0$$
$$\left[x^*(Y' + C(Y', r_l), r_l) - x^*(Y + C(Y, r_l), r_l)\right] > \left[x^*(Y', \bar{r}) - x^*(Y, \bar{r})\right] \quad (2.20)$$

Thus the welfare loss increases with income if the change in optimal consumption of the composite good if the worker were compensated in equivalent income for renting uncontrolled housing increases more than the change in optimal consumption of the composite good if the worker's income increases and he would rent social housing.

Again, the quantities in equation (2.20) are interior optimal solutions that are described by equations (2.1) and (2.5). As $\bar{r} < r_l$ and housing and the composite good are normal goods, workers will consume more of the composite good if (compensated variation of) income increases. This implies equation 2.20 holds and therefore the welfare loss from living in rent-controlled social housing increases with income.

Next, define $r_l < r_{l'}$ to prove that the welfare loss increases with the market rent. Workers in the uncontrolled market consume on their expension path given by equation (2.1) and the composite good is a normal good. The definition of a normal good states that its consumption is increasing in income. Therefore, $x^*(Y + C(Y, r_{l'}), r_{l'}) > x^*(Y + C(Y, r_l), r_l)$ if $C(Y, r_{l'}) > C(Y, r_l)$. Equation 2.19 shows this condition is true. □

It follows from equation 2.18 that the costs of providing rent control do not increase with income once income exceeds Y^s, simply because consumption of housing quality cannot increase. However, as the benefits from rent control decrease if income goes to Y^{A_l} from below, the welfare loss of providing rent controlled social housing remains positive.

Proposition 9. *Rent control of social housing creates a welfare loss if* $Y^s < Y \leq Y^{A_l}$, *that is increasing in income.*

Proof. The welfare loss of rent control equals the costs of rent control minus the benefits. It follows from equation 2.18 that the welfare costs of rent control are constant on the domain $Y = (Y^s, Y^{A_l}]$. Thus for the welfare loss to increase

with income, it is sufficient that the benefits of rent control decrease with income on this domain. From Definition 5 it follows that $Y + B(Y, r_l) \leq Y^{A_l}$ for any value of $Y = [Y^s, Y^{A_l}]$. This can only be true if $B(Y, r_l)$ is decreasing in income.

Assume that benefits of rent control $B'(r_l)$ would not decrease in income but remain constant. Then there would exists a value of income $Y^{A_L} - B'(r_l) < Y' < Y^{A_l}$ such that compensating variation of income exceeds Y^{A_l}. This implies that indirect utility $V^o(Y' + B'(r_l), r_l, A_l) > V^o(Y^{A_l}, r_l, A_l)$. This cannot be true as Definitions 2 and 5 and Proposition 2 require that $V^o(Y' + B'(r_l), r_l) < V^o(Y^{A_l}, r_l)$. Thus benefits of rent control cannot be constant (nor increase), and therefore the benefits of rent control should decrease in income if $Y = [Y^s, Y^{A_l}]$. As on this domain the costs of rent control are constant, this implies that the welfare loss of rent control is increasing in income if $Y = [Y^s, Y^{A_l}]$. □

Proposition 10. *Rent control of social housing creates a welfare loss if $Y^s < Y \leq Y^{A_l}$, that is increasing in the market rent.*

Proof. This follows from the proof of Proposition 8. □

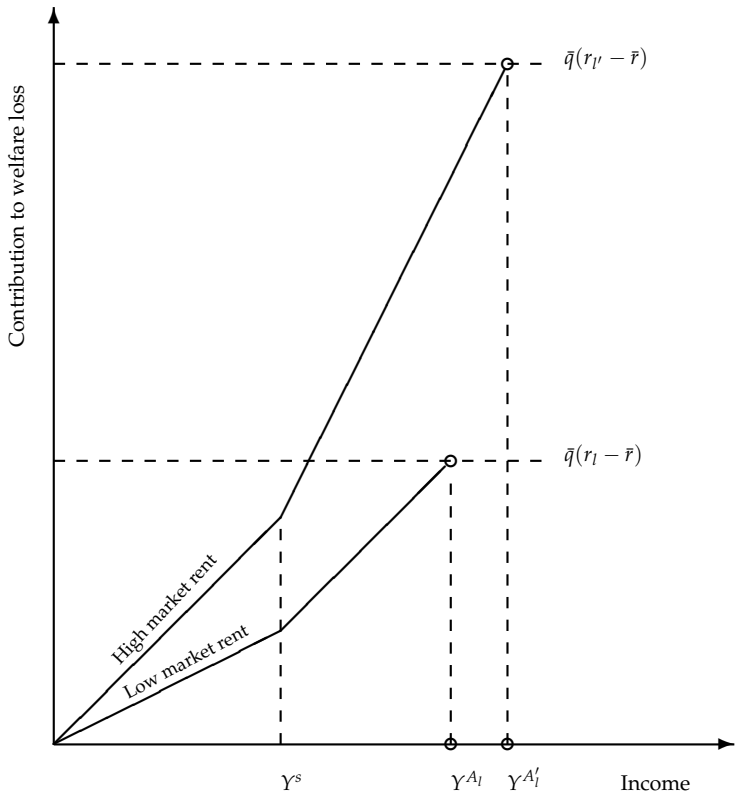
Propositions 7 to 10 are summarized in Figure 2.3. Figure 2.3 illustrates that rent control is inefficient as it creates a positive welfare loss if income exceeds zero. The Hicks-Kaldor principle that 'winners can compensate losers' holds as all workers in social housing would be better off if they would be compensated for renting uncontrolled housing by receiving the welfare costs in addition to their income. However, few schemes in which winners compensate losers are observed, indicating that designing such a scheme might be unfeasible.

Figure 2.3 also illustrates that the contribution to the welfare loss increases with income. Conditional on the market rent high-income workers in social housing contribute more to the welfare loss than low-income workers. Therefore, the misallocation costs of rent control are not only larger if housing is allocated randomly among tenants (Glaeser and Luttmer, 2003), but that self-selection of high-income tenants into social housing increases the misallocation costs of rent control even more. This implies that the welfare loss of rent

control can be reduces by reallocating social housing to low-income workers. Regulation that limits the income level of tenants of social housing will reduce the welfare loss of social housing. This might provide a politically feasible mechanism by which the welfare loss of rent control might be reduced.

Finally, Figure 2.3 shows that social housing is more distortive if the market rent increases. This has two reasons. First, this increases the slope of the function that describes the contribution to the welfare as a function on income. Second, it increases the income level at which workers remain in the social housing sector from Y^{A_l} to $Y^{A_l'}$.

Figure 2.3: Contribution to the welfare loss as a function of income and market rent



Contribution of a worker with income Y to the welfare loss from social housing for different levels of market rent. The contribution to the welfare loss is always positive (Propositions 7 and 9). The contribution to the welfare loss is larger if market rents are high (Propositions 8 and 10) and increasing in income (Propositions 8 and 9).
The contributions to the welfare loss are defined up to the point Y^{A_l} as workers with higher income rent uncontrolled housing. Y^{A_l} is increasing in the market rent, see Proposition 3 and Definition 2. In the point Y^{A_l} the contribution to the welfare loss equals the costs of rent control as the benefits from rent control are zero: $B(Y^{A_l}, r_l) = 0$ (Definitions 2 and 5). The costs of rent control are given by $\bar{q}(r_l - \bar{r}$ if $Y = [Y^s, Y^{A_l}]$, see equations (2.9) *and* (2.18).

2.5 Conclusion

In attractive cities the rich live in social housing as this enables them to consume the location amenities for free. This mechanism has been explained using a stylized theoretical model in which rational workers maximize utility by consuming housing quality, a composite good and local amenities. The more location amenities are present, the higher will be the income level at which rent-controlled tenants start renting uncontrolled housing. This explains the positive relation between uncontrolled house prices and income of rent-controlled tenants and why tenants with high-income benefit more from rent control.

A contribution of the model is that it allows for the self-selection of high-skilled workers into social housing if the market rent is high. As a result, three types of workers can be considered.

The first group consists of workers with income below Y^s live in social housing and consume on their demand curve, as the optimal level of social housing quality does not exceed the quality threshold. The second group of workers has an income between Y^s and Y^{A_l}. workers in this group maximize utility if they consume the maximum quality of rent-controlled housing and spend the remainder on the composite good. These workers are restricted in their consumption and consume off their demand curve. The third group consists of workers with income exceeding Y^{A_l}. This group lives in uncontrolled housing and consumes on the demand curve again.

Another contribution of the model is that it illustrates how the self-selection of high-skilled workers into social housing influences the welfare loss of social housing. Previous research has indicated that the welfare loss of rent control might be larger if social housing is allocated randomly (Glaeser and Luttmer, 2003). I show that self-selection into social housing increases the welfare loss of social housing.

I find that social housing is always inefficient: The contribution of a worker to the welfare loss is positive regardless of his income. However, the contri-

bution to the welfare loss is increasing in both income and the market rent. Therefore, policy that reduces the self-selection of high-income workers into social housing if market rents are high will reduce the welfare loss associated with rent control. The same holds for policy that reallocates social housing from high-income workers to low-income workers.

The result that the income level at which workers move from the rent-controlled housing segment depends on local amenities, has important implications for the effect of rent control on local inequality. Glaeser (2003) mentions that rent-control reduces segregation only in growing cities as home-owners in declining cities will have lower income (are more similar to rent-controlled tenants). In addition to this, the model in this chapter suggests that rent-controlled tenants are more similar to uncontrolled tenants in growing cities, because of the self-selection of high-income into controlled housing in these places.

In the remaining chapters I test the model's implications for consumption and tenure choice. Equation (2.9) indicates that consumption patterns differ between tenants who rent controlled and uncontrolled housing, because the housing rent influences consumption of the composite good as well. In chapter three I study whether the budget shares devoted to basic goods, housing, recreation and alcohol and tobacco are different for home-owners (uncontrolled workers) and workers in rent-controlled housing. Equation (2.9) also shows how consumption patterns of restricted rent-controlled workers differ from those of unrestricted tenants of rent-controlled housing. This is tested in chapter three as well.

In chapter four I test the hypothesis that the income at which workers consume uncontrolled housing is increasing in the amenity level. I do so by considering the relationship between the mobility of workers and the difference between the controlled rent and market rent of their house. The panel dimension of the data allows to control for the sorting of heterogeneous workers (with different ability or preferences) into rent-controlled housing across the country. In addition, I distinct between moving house within the rent-controlled housing sector and between moving house out of the rent-controlled housing sector into the uncontrolled housing sector.

2.A Application to CES-utility

I follow Brueckner et al. (1999) and show that our results apply to a general three input CES-utility function. Consider the following application in which workers of type $\tau = o, c$ maximize a CES-utility function (with constant returns to scale) subject to a budget constraint.

$$\max \mathrm{U} \quad \text{s.t.} \quad Y = px + r^{\tau}q, \quad r^{\tau} = r_l, \bar{r}$$
$$U(x, q, A_l) = \left(ax^{\rho} + bq^{\rho} + (1-a-b)A_l^{\rho}\right)^{\frac{1}{\rho}}$$

Note that only the composite good x and housing quality q are priced and enter the budget constraint. The level of location amenities is internalized into the local price for uncontrolled housing $r^o = r_l$, but not in that of controlled housing $r^c = \bar{r}$. As before, I have $r_l > \bar{r}$ for all l.

If an interior solution exists utility maximizing workers will spend their budget Y over housing and the composite good such that the ratio of marginal benefits equals the ratio of marginal costs. The expansion path is given by:

$$x = \left(\frac{b}{a}\frac{p}{r^{\tau}}\right)^{-\sigma} q, \quad \sigma = \tfrac{1}{1-\rho}$$

and the (potentially infeasible) consumption of housing quality and the composite good that maximizes utility equals

$$\begin{aligned} x^{*\tau} &= \frac{a^{\sigma}}{p^{\sigma}}\left(\frac{Y}{a^{\sigma}p^{1-\sigma} + b^{\sigma}(r^{\tau})^{1-\sigma}}\right) \\ q^{*\tau} &= \frac{b^{\sigma}}{(r^{\tau})^{\sigma}}\left(\frac{Y}{a^{\sigma}p^{1-\sigma} + b^{\sigma}(r^{\tau})^{1-\sigma}}\right) \end{aligned} \tag{2.21}$$

$x^{*\tau}$ and $q^{*\tau}$ in (2.21) only maximize utility if they are feasible and if they are an interior solution. The model assumes that any level of uncontrolled housing quality can be supplied, and therefore the combination of x^{*o} and q^{*o} in equation (2.21) maximize utility for tenants in uncontrolled housing. For controlled tenants this is slightly different as controlled housing can only be supplied up to $\bar{q}$. The definition of Y^s states that for tenants in controlled housing an interior solution according to (2.21) only exists as long as income is not larger than

Y^s. This allows to solve for Y^s as

$$Y^s = \bar{q}\frac{\bar{r}^\sigma}{b^\sigma}\left(a^\sigma p^{1-\sigma} + b^\sigma \bar{r}^{1-\sigma}\right)$$

Consequently, indirect utility of home-owners is given by equation (2.22).

$$V^o(Y, r_l, A_l) = \left[\left(a^\sigma p^{1-\sigma} + b^\sigma r_l^{1-\sigma}\right)^{1-\rho} Y^\rho + (1-a-b)A_l^\rho\right]^{\frac{1}{\rho}} \tag{2.22}$$

The indirect utility function of rent-controlled workers is given by equation (2.23).

$$V^c(Y, \bar{r}, A_l) = \begin{cases} \left[\left(a^\sigma p^{1-\sigma} + b^\sigma \bar{r}^{1-\sigma}\right)^{1-\rho} Y^\rho + (1-a-b)A_l^\rho\right]^{\frac{1}{\rho}} & \text{if } Y \leq Y^s \\ \left[a\left(\frac{Y-\bar{r}\bar{q}}{p}\right)^\rho + b\bar{q}^\rho + (1-a-b)A_l^\rho\right]^{\frac{1}{\rho}} & \text{if } Y \geq Y^s \end{cases} \tag{2.23}$$

Equations (2.22) and (2.23) show that workers with income $Y \leq Y^s$ are always better off consuming rent-controlled housing. Note that they maximize utility by consuming *on* their demand curve.

Y^{A_c} is the income level at which a tenant is indifferent between consuming controlled housing of quality $q > \bar{q}$ at the market rent r_c or consuming uncontrolled housing quality $q = \bar{q}$ at the controlled rent $\bar{r}$. As tenants of rent-controlled housing with income exceeding Y^s are in a corner solution, solving for Y^{A_c} is tedious. However, proving its existence is less cumbersome.

Proposition 11. *The income level at which tenants are indifferent between renting controlled or uncontrolled housing exists.*

Proof. Note that if $Y = Y^s$ workers prefer to rent $\bar{q}$ housing quality at the controlled rent over renting uncontrolled housing: $V^o(Y^s, r^l) < V^(Y^s, \bar{r}, A_l)$.

Next, given their income level, controlled tenants who consume controlled housing for free, are always better off than tenants who pay a positive controlled rent $\bar{r}$. Suppose there is an income level $\tilde{Y}^{A_c}$ such that a worker is indifferent between consuming uncontrolled housing at the market rent, or consuming rent-controlled housing $\bar{q}$ for free. If $\tilde{Y}^{A_c}$ exists workers with income $\tilde{Y}^{A_c}$ prefer to consume uncontrolled housing at the rent r_l over consuming un-

controlled housing at a positive controlled rent: $V^o(\tilde{Y}^{A_l}, r^l) > V^(\tilde{Y}^{A_l}, \bar{r}, A_l)$ if $0 < \bar{r} < r_l$.

As V^c and V^o are monotonic increasing functions in Y the intermediate value theorem states that Y^{A_l} exists, provided that $\tilde{Y}^{A_l}$ exists.

First, define $\tilde{V}^c$ as the indirect utility function if $Y > Y^s$ and $\bar{r} = 0$.

$$\tilde{V}^c = \left[a\left(\frac{Y}{p}\right)^\rho + b\bar{q}^\rho + (1-a-b)A_l^\rho\right]^{\frac{1}{\rho}} \tag{2.24}$$

$\tilde{Y}^{A_l}$ is the income level for which $\tilde{V}^c(\tilde{Y}^{A_l}, \bar{r} = 0, A_l) - V^o(\tilde{Y}^{A_l}, r_l, A_l) = 0$. Define Δ as the difference of both indirect utility functions taken to the power γ and plug in equations (2.22) and (2.24):

$$\begin{aligned} \Delta &\equiv \left(V^O\right)^\rho - \left(\tilde{V}^C\right)^\rho = \gamma Y^\rho - b\bar{q}^\rho \\ \gamma &= \left[\left(a^\sigma p^{1-\sigma} + b^\sigma r_l^{1-\sigma}\right)^{1-\rho} - \frac{a}{p^\rho}\right] > 0 \end{aligned} \tag{2.25}$$

As $b^\sigma r_l^{1-\sigma} > 0$ it follows that $\gamma \geq 0$. Therefore, the difference between both indirect utility functions taken to the power γ is a linear upward sloping function in income. Thus the difference in utility terms is concave and increasing in Y. This completes the proof that $\tilde{Y}^{A_l}$ exists. From this it follows that Y^{A_l} exists as well. □

Figure 2.4 graphs the indirect utility functions in equations (2.22) and (2.23). If income is below Y^{A_l} indirect utility is maximized if the worker consumes rent-controlled housing. If income exceeds Y^{A_l} the worker consumes uncontrolled housing. Figure 2.4 also shows that if income is between Y^s and Y^{A_c} utility maximizing workers (restricted controlled tenants) end up in a corner solution: they consume controlled housing of quality $\bar{q}$ and spend the remainder of their income on the composite good.

Finally, I consider expenditures. Consumption of the housing quality is given by equation (2.26) and consumption of the composite good by equation

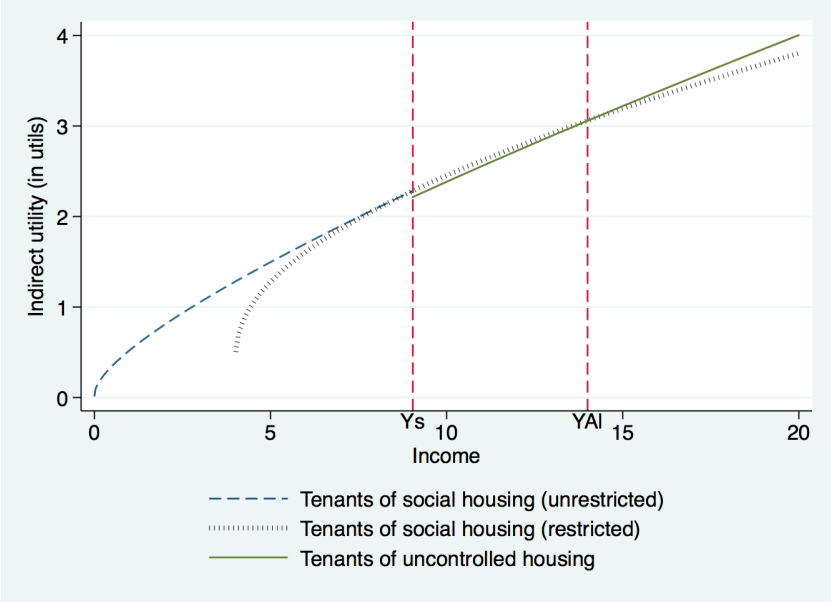
(2.27).

$$q^* = \begin{cases} \frac{b^\sigma}{\bar{r}^\sigma}\left(\frac{Y}{a^\sigma p^{1-\sigma}+b^\sigma \bar{r}^{1-\sigma}}\right) & \text{if} \quad Y \leq Y^s \\ \bar{q} & \text{if} \quad Y^s < Y < Y^{A_l} \\ \frac{b^\sigma}{r_c^\sigma}\left(\frac{Y}{a^\sigma p^{1-\sigma}+b^\sigma r_c^{1-\sigma}}\right) & \text{if} \quad Y \geq Y^{A_l} \end{cases} \tag{2.26}$$

$$x^* = \begin{cases} \frac{a^\sigma}{p^\sigma}\left(\frac{Y}{a^\sigma p^{1-\sigma}+b^\sigma \bar{r}^{1-\sigma}}\right) & \text{if} \quad Y \leq Y^s \\ \frac{Y-\bar{r}\bar{q}}{p} & \text{if} \quad Y^s < Y < Y^{A_l} \\ \frac{a^\sigma}{p^\sigma}\left(\frac{Y}{a^\sigma p^{1-\sigma}+b^\sigma r_c^{1-\sigma}}\right) & \text{if} \quad Y \geq Y^{A_l} \end{cases} \tag{2.27}$$

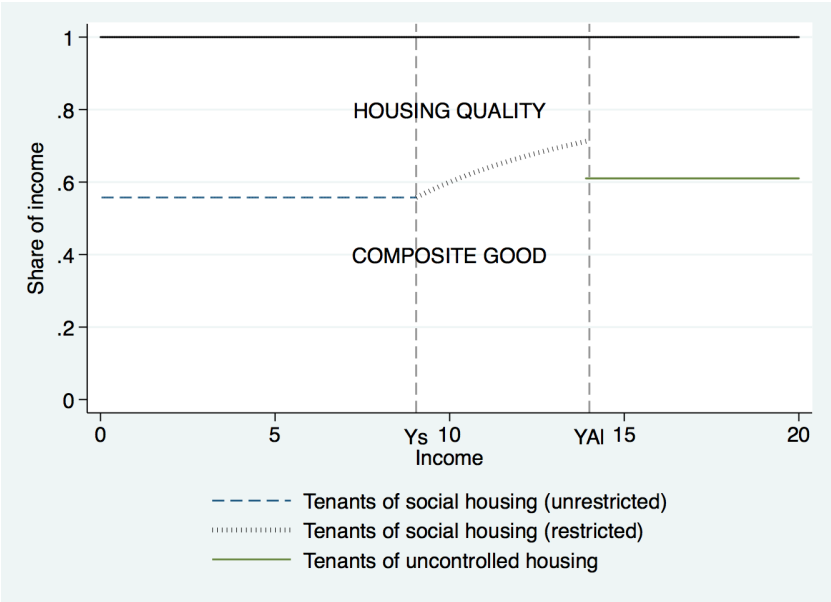
Figure 2.5 summarizes this by plotting how the budget share going to housing q/Y and the composite good x/Y changes with income. Under the shown parameterization of the CES-utility function the decrease in rent causes unrestricted controlled workers to spend a larger share of their budget on housing. For restricted controlled tenants the share of budget spend on housing is decreasing in income. This occurs as they cannot increase consumption of housing, and therefore the budget share declines with income.

Figure 2.4: Indirect utility as function of income



Indirect utility of unrestricted tenants of social housing, restricted tenants of social housing and tenants of uncontrolled housing as a function of income. Parameters are fixed at $a = b = 1/3$, $\rho = .25$, $p = 1$, $\bar{r} = \bar{h} = 2$, $r_c = 2.2$.

Figure 2.5: Division of income over housing and the composite good



Budget allocated to housing quality and the composite good for unrestricted tenants of social housing, restricted tenants of social housing and tenants of uncontrolled housing as a function of income. Parameters are fixed at $a = b = 1/3$, $\rho = .25$, $p = 1$, $\bar{r} = \bar{h} = 2$, $r_c = 2.2$.

2.B Graphical representation

Th left panel of Figure 2.6 shows the optimal consumption of workers with income not exceeding Y^{A_l} if they would be consuming uncontrolled housing. Similarly, the right panel does so if they would consume social housing. Both panels have units of housing quality on the x-axis and units of the composite good on the y-axis.

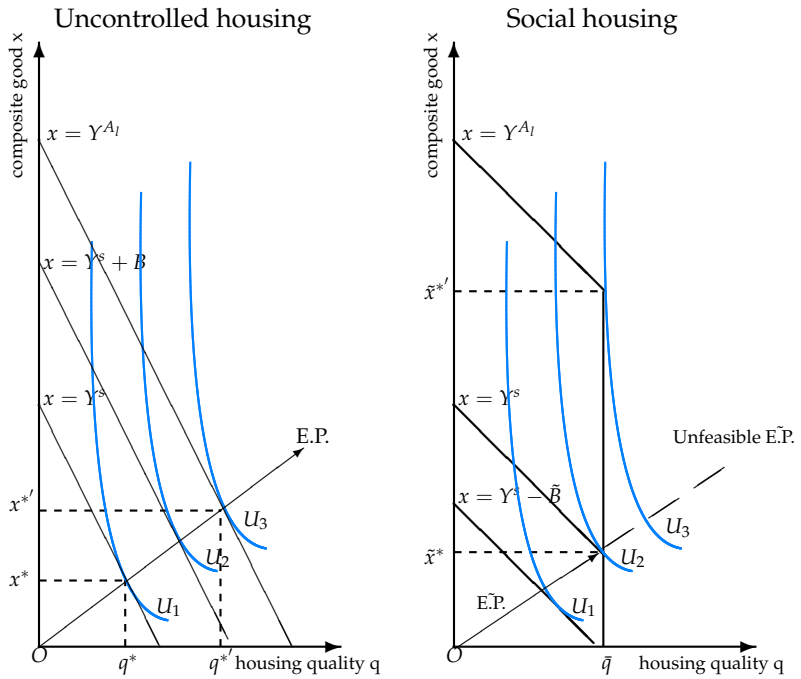
The downward sloping straight lines in the left panel are the budget lines on the uncontrolled housing market with slope $-r_l$. The lower line is the budget line for workers with income Y^s. The upper line is the budget line for workers with income Y^{A_l}. All points below the budget line are feasible consumption bundles given the income of the worker. The curved lines U_1, U_2 and U_3 are indifference curves, where utility curves further from the origin indicate higher utility levels.

In the left panel of Figure 2.6 workers with budget Y^s maximize utility at U_1 if they consume q^* units of uncontrolled housing and x^* units of the composite good. For workers with budget Y^{A_l} all points below the budget line and on the curve U_2 are feasible. However, workers maximize utility if they consume on the intersection with the budget line and U_3 in the point $(q^{*'}, x^{*'})$. The upward sloping vector going through the welfare maximizing consumption bundles and the origin is the expansion path ("E.P"). All consumption bundles on it are combinations of uncontrolled housing quality and the composite good that maximize utility.

The right panel of Figure 2.6 shows optimal consumption if workers would consume social housing. The downward sloping straight lines in the left panel are still the budget lines for workers with income Y^s and Y^{A_l}, however, the slope is less steep at $-\bar{r}$. They become vertical at $\bar{q}$ as social housing is not available at higher quality levels.

For workers with income Y^s all points on U_1 that are on or below the budget line are feasible. These workers maximize utility if they consume exactly $\bar{q}$ units of social housing and $\tilde{x}^*$ units of the composite good such that they are on the utility curve U_2. As $U_1 < U_2$ workers with income below Y^s are better off renting social housing (Proposition 4).

Figure 2.6: Optimal choice of tenure if $Y \leq Y^{A_l}$



Consumption of the composite good and housing quality given income. The left panel shows (optimal) consumption if uncontrolled housing quality would be consumed, the right panel shows (optimal) consumption if social housing quality would be consumed.

Note that the kink in the budget line does not affect workers with income Y^s or lower, as they can consume the utility maximizing units of social housing (which will not exceed $\bar{q}$) and the composite good (which will not exceed $\tilde{x}^*$) on the expansion path E.$\tilde{\text{P}}$. Therefore, workers with income not exceeding Y^s are unrestricted tenants of social housing (see Definition 3).

For workers with income exceeding Y^s this is different: As they cannot consume more than $\bar{q}$ units of housing quality at the social housing sector, consuming on the expansion path is unfeasible. Therefore, these workers consume exactly $\bar{q}$ units of social housing and spend the remainder on the composite good. Thus if income rises over Y^s, only consumption of the composite good increases. Their consumption bundle is not on the expansion path (Definition 4).

Workers with income Y^{A_l} maximize utility if they consume $\bar{q}$ units of housing quality and $\tilde{x}^{*\prime}$ units of the composite good, which yields utility equal to

U_3. If they consume uncontrolled housing, their optimal consumption bundle equals $(q^{*'}, x^{*'})$ which yields utility equal to U_3 as well. Workers with income Y^{A_l} are therefore indifferent between living in uncontrolled or social housing (Definition 2). Also, this implies that workers with income $Y^s \leq Y < Y^{A_l}$ will consume social housing of quality $\bar{q}$ (Proposition 6).

The left panel of Figure 2.7 shows the optimal choice of consumption if income is at least Y^{A_l} and workers rent uncontrolled housing. Workers with income Y^+ can attain a maximum utility level of U_4 if they consume the bundle $q^{*''}, x^{*''}$ which is on their expansion path $E.P$.

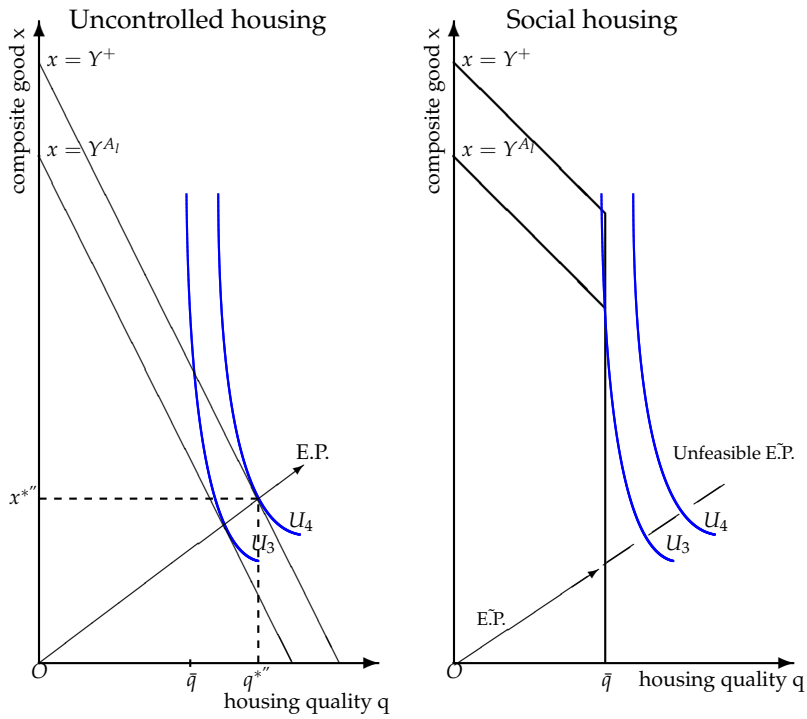
The right panel of Figure 2.7 shows this situation if the worker were to rent social housing. In this case the utility level U_4 cannot be reached, as U_4 is located above the budget line or to the right of $\bar{q}$. Thus tenants with income exceeding Y^{A_l} will prefer to rent uncontrolled housing (Proposition 5).

Figures 2.6 and 2.7 show that workers with income below Y^{A_l} will choose to live in social housing, whereas those with income exceeding Y^{A_l} will rent uncontrolled housing. Moreover, the group of workers in social housing can be subdivided into workers with income not exceeding Y^s whose consumption bundle is on their expansion path ('unrestricted tenants of social housing') and those whose consumption bundle is not on the expansion path ('restricted tenants of social housing').

Figure 2.8 shows the welfare effects of rent control of social housing for a worker with income Y^s. This worker would have utility U_1 if he would rent uncontrolled housing, rent control of social housing enables him to rent $\bar{q}$ units of social housing and utility increases to U_2. The costs of rent control born by the lessor of social housing equal $C = q(r_l - \bar{r})$. This can be measured in units of the composite good on the vertical axis. The benefits of rent control of social housing can be expressed in equivalent variation of income as the increase in income B he would require in order to be indifferent between living in social housing or uncontrolled housing. Rent control leads to a loss in welfare equal to $C - B$.[12]

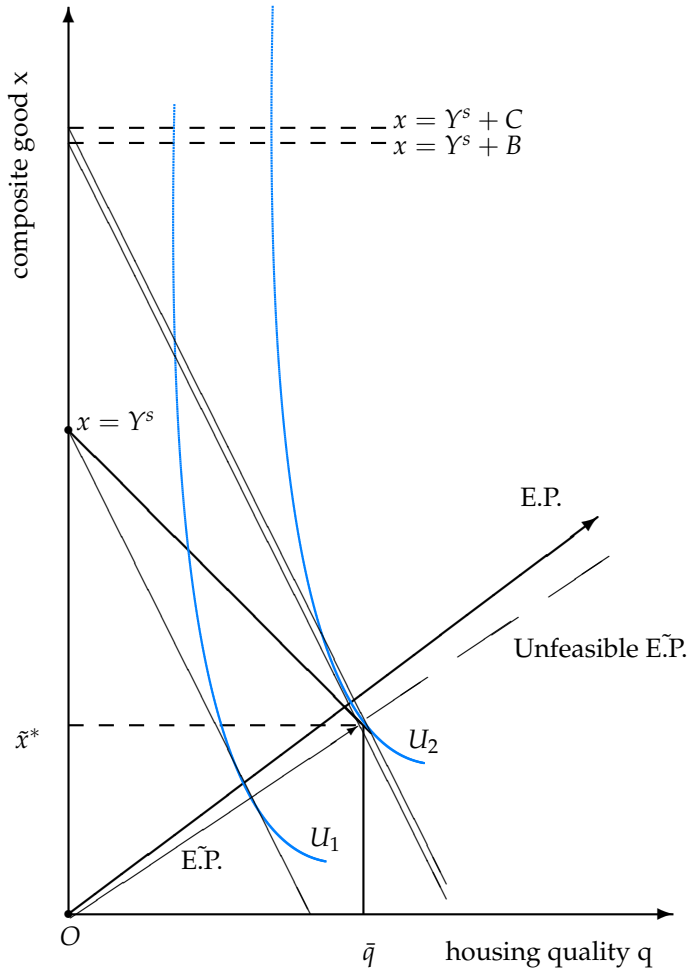
[12] Alternatively, one could use compensating variation in income to express benefits from rent control as done in the right panel of Figure 2.6. Compensating variation is defined as the income

Figure 2.7: Optimal choice of tenure if $Y \geq Y^{A_l}$



Consumption of the composite good and housing quality given income. The left panel shows (optimal) consumption if uncontrolled housing quality would be consumed, the right panel shows (optimal) consumption if social housing quality would be consumed.

Figure 2.8: Effects on welfare



The figure shows the contribution to the welfare loss for a worker with income Y^s. Equivalent variation of income for a worker with income Y^s at market rent r_l equals B. The costs of rent control equals $C = \bar{q}(r_l - \bar{r})$. Costs of rent control always exceed the benefits.

$\tilde{B}$ tenants of social housing would be willing to give up in order to remain in social housing. In general $B \neq \tilde{B}$. A special case occurs if income equals Y^{A_l} as then $B = \tilde{B} = 0$.

Chapter 3

Consumption and housing market tenure

3.1 Introduction

Rising house prices have been used to explain the increase in consumption in the 1990s and early 2000s. If correctly so, housing tenure might have important implications for consumer spending and the business cycle (Leamer, 2007). This chapter provides an all round perspective on the relationship between housing market tenure and consumption by investigating the effect it has on the *level* of consumption and the *allocation* of the consumption budget.

The first part studies whether housing market tenure influences the level of consumption. I consider three hypotheses that might explain the co-movement of house prices and expenditures. An unexpected increase in house prices might result in (unexpected) equity gains (wealth hypothesis) or reduce the credit constraint (credit constrained hypothesis). Both might be an incentive for home-owners to raise consumption (Campbell and Cocco, 2007). On the other hand, the co-movement of both consumption and house prices might be the result of both variables being influenced by common factors (common factor hypothesis, see Attanasio et al. 2009, 2011).

In the second part I investigate whether housing market tenure is important for the allocation of the budget over consumer goods. According to

the model of chapter two some tenants of rent-controlled housing are better off consuming the maximum number of rent-controlled housing services at the controlled rent instead of consuming more housing services at the market rent. These households underconsume housing and overconsume other goods. Thus rent control changes the allocation towards the composite good.

3.2 Literature

Homeowners who plan to live in their house for a long time are perfectly hedged against price changes, and therefore consumption is not affected by housing prices (Sinai and Souleles, 2005; Campbell and Cocco, 2007). However, this does not hold for households planning to move down. According to the wealth hypothesis an increase in house prices increases expected future wealth, which enables them to raise consumption (Attanasio et al., 2011). For homeowners who plan to trade up or households entering the owner-occupied housing market the effect of house prices on consumption is ambiguous (Attanasio et al., 2009): On the one hand, their future wealth increases the potential to consume. On the other hand, since both the prices of the current and the future house go up, they might need to save more in order to finance their move.

According to the wealth hypothesis the effect of house prices on consumption by tenants is ambiguous as well. A negative effect of housing prices on consumption is expected as tenants planning to enter the owner-occupied housing market need to save more to finance the house. However, if an increase in housing prices discourages tenants from entering the owner-occupied housing market altogether, they might respond by increasing consumption, see Engelhardt (1994).

The second explanation for the effect of house prices on consumption focuses on the collateral provided by housing. An increase in house prices or innovations to the financial sector reduce the credit constraint of homeowners as their net-equity increases (see among others Muellbauer and Murphy (1990); Aoki et al. (2004); Iacoviello (2004); Chen et al. (2010)). According to

the collateral hypothesis housing prices influence the consumption by homeowners only, but should not influence consumption by tenants.

Finally, according to the common factor hypothesis there is no causal relationship between house prices and consumption. Instead, their co-movement is explained by both variables being related to a common factor. For instance, an unexpected increase in productivity might increase consumption. It might also increase the demand for housing. Now, if the price-elasticity of housing is low, the productivity shock will result in rising house prices (King, 1990; Pagano, 1990; Attanasio et al., 2009). If indeed productivity is the driver of both processes, young households are expected to increase consumption more compared to old households, as their change in lifetime income from labor is larger (Attanasio et al., 2009, 2011).

As mentioned before, the evidence on which mechanism explains the co-movement of house prices and consumption is mixed. Using micro-data, Campbell and Cocco (2007) find that old households increase consumption after a positive change in house prices, whereas young and old tenants reduce consumption, which they interpret as evidence in favor of the wealth hypothesis. Bostic et al. (2009) estimate that the price-elasticity of consumption to housing prices is about six percent. Using aggregate data Chen et al. (2010) find evidence for a positive effect of house prices on consumption as well. However, Attanasio and Weber (1994) find that young households increase consumption more in response to house prices than old households, which they interpret as evidence in favor of the common factor hypothesis. A similar conclusion using more data points is found by Attanasio et al. (2009). Cristini and Almudena (2013) consider the specifications used by Campbell and Cocco (2007) and Attanasio et al. (2009) and conclude that evidence in favor of the common factor hypothesis is more robust.

The economic literature on consumption allocation studies how household characteristics and labor market characteristics influence the consumption of households. Kalwij et al. (1998) study how household demographics, the budget and female labor supply influence the allocation of budget over consumer goods. Kalwij and Salverda (2004) investigate how the allocation of budget is

influenced by employment status, the budget and household characteristics, where they especially focus on the determinants of spending on consumer services. Ferrer-Carbonell and van den Bergh (2004) use a similar framework to study the determinants of unsustainable consumption. Kalwij (2005) studies how the arrival of children affect households income, savings and expenditure.

Studies on rent control mainly consider the effect on the consumption of housing services (see overviews by Arnott (1995); Turner and Malpezzi (2003)). Evidence on the effect of rent control on non-housing consumption is limited. Le Blanc and Laferrère (2001) find that rent-controlled tenants consume ten percent more housing services and eleven percent more on other goods. Wang and Kinsey (1994) find that strictly rationed housing has a positive spillover effect on savings, but not on consumption.

3.3 Data

It is investigated whether housing tenure changes the level and allocation of the consumption budget by estimating life cycle consumption model and Engel curves. I use data from the Dutch budget survey (in Dutch: *Budget Onderzoek*). Data has been collected by Statistics Netherlands over the years 1978-2000 and in 2003 and 2004. It has previously been used by Statistics Netherlands to construct the price index and socio-economic statistics. The data has been used for quantitative scientific research before.[1] The data are collected over the period 1980-1999. The first two waves are omitted in order to avoid measurement errors related to the start-up of the project as suggested in Kalwij et al. (1998). The waves in 2003 and 2004 are not used either as household income and rents are differently defined in these years.

The data is collected by Statistics Netherlands using a stratified sampling scheme, where households are stratified according to social-economic position (self-employed, employed, not active on labor market), household size, gender of single-person household and annual household income (Gebruikershandboek Budgetonderzoek 1999). As the response rate is generally low (for

[1] See Kalwij et al. (1998); Ferrer-Carbonell and van den Bergh (2004); Kalwij (2005)

instance 23 percent in 1999), sample weights are used in all tables, statistics and regressions to provide output that is representative for the Netherlands.

All households keep a 'regular' daily record of all expenses per item if expenses exceed the threshold of around 16 euro (35 Dutch guilders), except when being on holiday. Holiday expenses are recorded in a separate holiday record. Expenses less than the threshold are recorded in a separate intensive record for a short period of time. The period in which the intensive record has been kept has been reduced to about a month in 1979 to seven or eight days in 1998.

Total expenditures on non-durables are defined as the sum of expenditures on the categories basic goods, housing, recreation and alcohol and tobacco. These categories contain 80 percent of total household expenditures on average. The part from total expenditures that is spend on non-durables (or that is saved) is omitted to prevent the creation of measurement error due to expenditures that carry on into the (unobserved) future. Total spending is grouped into the following categories:

1. **Basic goods:** Expenditures on food, clothing and personal care (excluding expenditures on alcoholic beverages, smoking, and health insurance).

2. **Housing:** Expenditures on rent (tenants) and imputed rent (homeowners), heating and light. This group does not contain expenditures on durable goods like heaters, lamps, etc.

3. **Recreation:** Expenditures on holidays (in the country and abroad), recreation and transport.

4. **Alcohol and tobacco:** Expenditures on alcoholic beverages and smoking.

Some selections are made on the total sample of 47,021 household observations. Households with unknown type of tenure, with a head of household aged below eighteen or living in uncontrolled rental housing are removed from the sample. Tenants in the liberalized sector are removed from the es-

timation sample as the number of observations is insufficient.[2] Self-employed are not included in the sample as one cannot distinguish between firm and household expenditures. See Table 3.1 for an overview.

Table 3.1: Sample adjustments

Description	Observations left
Starting number of observations	47,021
Remove households with unknown tenure type	46,716
Keep households with head of household 18 or older	46,714
Remove tenants in liberalized housing sector	46,277
Remove self-employed (including farmers)	41,430
Remove missing observations	35,795
Remove households with zero income or expenditure	35,783

As can be seen from Table 3.2 expenditure and consumption patterns of households vary considerably. On average, households in rental housing have lower total expenditures. They spend relatively more on alcohol and tobacco *and* basic goods, whereas they spend less on housing and recreation.

Table 3.2: Budget shares

	Tenants (1)		Owner-occupied (2)		Difference (1-2)	
	mean	sd	mean	sd	difference	p-value
Expenditure (€)[a]	35,907	14,147	50,572	18,958	-14,664.9	<0.0001
Budget shares(%)[a]						
Basic goods	37.4	10.8	36.0	11.2	1.4	<0.0001
Housing	32.1	11.4	32.3	10.4	-0.2	0.0617
Recreation	27.0	13.5	28.8	14.7	-1.8	<0.0001
Alcohol and tobacco	3.5	3.7	2.9	3.1	0.6	<0.0001

[a] Based on 35,783 observations, 20,674 on homeowners and 15,109 on tenants of social housing.

The surveys include measures of net annual income, household composition. Job and house characteristics are included as well. These variables are included as household composition might influence the demand for certain type of goods. The same holds for labor market position, which might influence the amount of trust the household has in the stability of his earnings.

[2] In most of the years there are 25 observations (or less), which is considered a too low number to base conclusions on. Including tenants in the liberalized sector does not change results.

Finally, house characteristics are used to compare the preferences for households for house characteristics.

Table 3.3 lists the variables that are included in the specification. It also shows the difference in means between tenants and owner-occupied households. In general the average realization for tenants is different from that of owner-occupied households. On average, owner-occupied households have larger families and are better educated. Interestingly, the probability that a household is an owner-occupied household is greater among households with head aged below 50. They also have better earning jobs and are less likely to be unemployed. Finally, owner-occupied households live in larger houses on average. Because of space, cohort dummies have not been tabulated. However, they are strongly correlated with age.

Table 3.3: Descriptive statistics

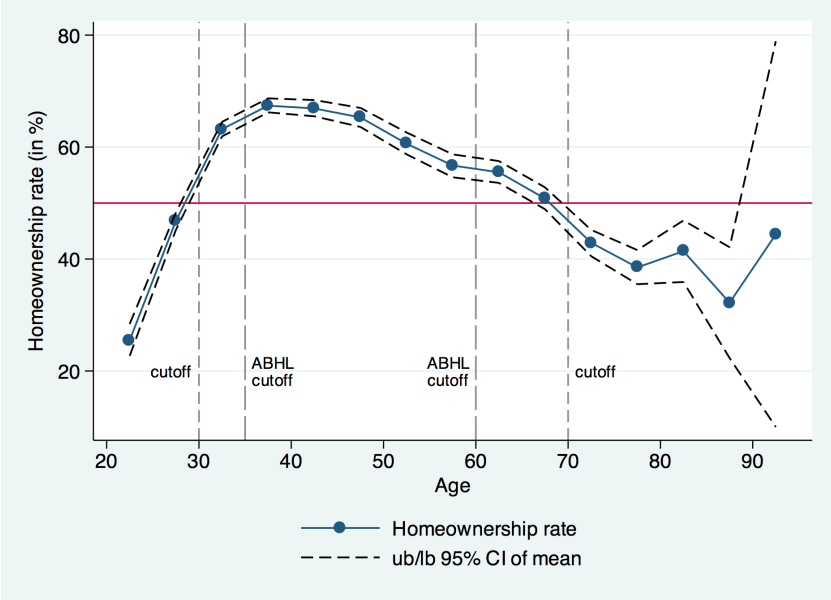
	Tenants 1		Homeowners 2		Difference 1-2	
	mean	st. dev	mean	st. dev.	mean	p-value
Household characteristics[a]						
Ln of household size	0.77	0.54	1.01	0.48	-0.24	<.0001
(Ln of households size) squared	0.89	0.84	1.25	0.89	-0.36	<.0001
Household composition indicators: One if...						
Single person household	0.25	0.43	0.1	0.31	0.15	<0.0001
Single family household	0.73	0.45	0.88	0.33	-0.15	<0.0001
Multiple family household	0.01	0.09	0.01	0.09	<0.01	0.915
One child in household	0.13	0.34	0.15	0.36	-0.02	<0.0001
Two children in household	0.16	0.36	0.24	0.43	-0.08	<0.0001
Three children in household	0.05	0.21	0.09	0.29	-0.04	<0.0001
Indicator age of household head: One if...						
$18 \leq$ age < 25	0.04	0.20	0.01	0.11	0.03	<0.0001
$25 \leq$ age < 30	0.14	0.35	0.09	0.28	0.05	<0.0001
$30 \leq$ age < 35	0.13	0.34	0.17	0.37	-0.04	<0.0001
$35 \leq$ age < 40	0.12	0.32	0.18	0.38	-0.06	<0.0001
$40 \leq$ age < 45	0.09	0.28	0.13	0.34	-0.04	<0.0001
$45 \leq$ age < 50	0.07	0.26	0.10	0.30	-0.03	<0.0001
$50 \leq$ age < 55	0.06	0.24	0.07	0.26	-0.01	0.0033
$55 \leq$ age < 60	0.07	0.25	0.06	0.24	0.01	0.2658
$60 \leq$ age < 65	0.07	0.26	0.07	0.25	<0.01	0.0165
$65 \leq$ age < 70	0.08	0.28	0.06	0.24	0.02	<0.0001
$70 \leq$ age < 75	0.06	0.25	0.04	0.18	0.02	<0.0001
$75 \leq$ age < 80	0.04	0.19	0.02	0.13	0.02	<0.0001
$80 \leq$ age < 85	0.01	0.11	0.01	0.08	0	<0.0001
$85 \leq$ age < 90	<0.01	0.06	<0.01	0.04	<0.01	<0.0001
$90 \leq$ age < 95	<0.01	0.02	<0.01	0.01	<0.01	0.4183
Indicator highest educational level obtained by head of household or spouse: One if...						
Primary level	0.23	0.42	0.12	0.32	0.11	<0.0001
Secundary level, first step	0.25	0.44	0.18	0.39	0.07	<0.0001
Secundary level, second step	0.32	0.47	0.34	0.47	-0.02	0.0092
Tertiary level, first step	0.15	0.35	0.27	0.44	-0.12	<0.0001
Tertiary level, second step	0.05	0.21	0.09	0.29	-0.04	<0.0001
Job characteristics[a]						
Employment indicator: one if the main wage earner is...						
Employee	0.56	0.50	0.75	0.43	-0.19	<0.0001
Not employed	0.44	0.50	0.25	0.43	0.19	<0.0001
Type of job indicator: one if the job is...						
Scientific	0.11	0.31	0.21	0.41	-0.10	<0.0001
Higher managerial	0.04	0.19	0.09	0.29	-0.05	<0.0001
Other	0.42	0.49	0.44	0.50	-0.02	<0.0001
House characteristics[a]						
Type of house indicator: one if the house is/has...						
A detached single family house	0.01	0.12	0.21	0.41	-0.20	<0.0001
An appartment	0.43	0.49	0.09	0.28	0.34	<0.0001
A single family row house	0.54	0.50	0.69	0.46	-0.15	<0.0001
Constructed prior to 1945	0.33	0.47	0.42	0.49	-0.09	<0.0001
Constructed within 1945 and 1979	0.55	0.50	0.45	0.50	0.10	<0.0001
Constructed in 1980 or later	0.12	0.32	0.13	0.33	-0.01	0.0003
One or two rooms	0.07	0.26	0.02	0.13	0.05	<0.0001
Three to four rooms	0.47	0.50	0.24	0.43	0.23	<0.0001
Five or more rooms	0.46	0.50	0.74	0.44	-0.28	<0.0001
Income and expenditure[a]						
Annual net income	49,774.41	20,392.07	70,257.29	27,564.35	-20,482.88	<.0001
Annual expenditures	35,894.45	14,172.15	50,567.8	18,964.12	-14,673.35	<.0001
Annual expenditures on...						
Basic goods	13,589.2	6,851.03	18,142.36	8,240.53	-4,553.16	<0.0001
Housing	10,321.56	2,311.18	15,177.76	4,435.88	-4,856.2	<0.0001
Recreation	10,678.53	8,583.56	15,766.48	11,580.08	-5,087.95	<0.0001
Alcohol and tobacco	1,305.15	1,496.84	1,481.19	1,696.38	-176.04	<0.0001

[a] Based on 35,783 observations, 20,674 on homeowners and 15,109 on tenants of social housing.

Homeownership rate among age groups

Next, I turn to the definition of young, middle aged and old households and the homeownership rate among these groups. Figure 3.1 illustrates that the homeownership rate in the Netherlands follows an inverse-u distribution in age.

Figure 3.1: Homeownership and age



Dots represent homeownership rates for different five year intervals of age. Dots are placed at the middle of the interval. 'ABHL cutoff' indicate the cutoff values for age used by Attanasio et al. (2009). 'cutoff' is the cutoff presented in this chapter.

Attanasio et al. (2009), hereafter denoted as ABHL, define young and old households as households with a head younger than 35 or older than 60. Their classification results in the homeownership rate being over 50 percent for young households and below 50 for old households (see Table 3.4). Therefore, I define young households to be those with a head of household younger than 30, whereas old households are those with a head older than 70. Table 3.4 indicates this results in the homeownership rate being around 40 percent for both young and old households. The cutoffs used in this chapter better reflect the distribution of the homeownership rate over the various age categories.

Table 3.4: Homeownership rate for various definitions of agegroups

	homeownership rate	
Definition	This chapter[a]	ABHL[b]
Young	42.8	53.7
Middle aged	62.2	64.6
Old	41.1	48.6

[a] *Middle aged households aged between 30 and 70*
[b] *Middle aged households aged between 35 and 60*

3.4 Estimation strategy life-cycle consumption model

It is investigated whether housing tenure influences the *level* of consumption by specifying life cycle consumption along the lines of Attanasio et al. (2009). Denote consumption for household h in period t as X_t^h. Assume this can be approximated as a function of a lifetime wealth W^h and the place in the life-cycle. The effect of the place in the life cycle is a function of age, which reflects differences in needs, household composition and discount rate over the course of life. ε is an error term that reflects unanticipated shocks to lifetime wealth and current income, see equation (3.1).

$$X_t^h = k(age^h)W^h exp(\varepsilon_t^h) \tag{3.1}$$

Take logs and separate $log\ k(age^h)$ into a part that depends on age only $f(age^h)$ and a part that depends on household characteristics $\gamma' z_t^h$. This yields equation (3.2).

$$log(X_t^h) = f(age^h) + \gamma' z_t^h + log(W^h) + \varepsilon_t^h \tag{3.2}$$

Taking the average across cohorts yields the pseudo-panel equivalent, where the household specific lifetime wealth W^h is represented by the cohort-specific average α^c. This equation can be estimated on individual data for household h in cohort c (indicated with superscript ch) in equation (3.3). Here ν_t^{ch} reflects the deviation in consumption from the cohort average, with expectation assumed to equal zero. Both methods assume that the expectation of ε_t^c is zero

over the sample period and the average of lifetime wealth in each cohort can be represented by a cohort fixed effect. Also, the age profile is assumed to be fixed across cohorts.

$$log(X_t^{ch}) = \alpha^c + f(age^c) + \gamma' z_t^{ch} + \varepsilon_t^c + \nu_t^{ch} \tag{3.3}$$

Equation (3.3) specifies the basic life-cycle consumption path for households. The level of consumption changes with the cohort, because the expected lifetime wealth changes with the productivity level. Equation (3.3) does not include income as expected lifetime income is incorporated in the deterministic and constant terms in z_t^{ch}, whereas unexpected shocks to income enter via ν_t^{ch}. Adding income as a regressor would not be in line with the theoretical life cycle framework that is applied. Also, if current income is correlated with future income, current income will be correlated with the error term ε_t^c (Attanasio et al., 2009).

Adding house prices hp_t to this baseline model helps to identify whether shocks to house prices can be considered an unexpected innovation within the life cycle model. In order to distinguish the wealth and collateral hypothesis from the common factor hypothesis Attanasio et al. (2009) suggest to add a function of real house prices hp_t and analyze its effect for young, middle aged and old households. Thus, they estimate equation (3.4). The sign and magnitude of the δ coefficients indicate whether the effect of house prices on consumption is larger for young households or old households, which identifies whether house prices influence consumption via the wealth/collateral or via the common factor mechanism.

$$\begin{aligned} log(X_t^{ch}) =& \alpha^c + f(age^c) + \gamma' z_t^{ch} \\ &+ \delta_1 hp_t Y + \delta_2 hp_t M + \delta_3 hp_t O + \mu_t^{ch} \\ \mu_t^{ch} =& \varepsilon_t^c + \nu_t^{ch} \end{aligned} \tag{3.4}$$

Note that equation (3.4) assumes that $\hat{Y} = \hat{M} = \hat{O} = 0$ and therefore these covariates do not need to be included. Otherwise, as Y is correlated with $g(hp_t^{ch})Y$ omitted variable bias might occur (Brambor et al., 2006). Therefore

equation (3.4) is extended by including these constitutive terms in equation (3.5). Also, as the division into young, middle aged and old households depends on arbitrary cutoff-points, an interaction model that interacts house prices with age (and age squared) is specified in equation (3.6).

$$\begin{aligned} log(X_t^{ch}) =& \alpha^c + f(age^{ch}) + \gamma' z_t^{ch} + Y + M + O \\ &+ \delta_1 hp_t Y + \delta_2 hp_t M + \delta_3 hp_t O + \mu_t^{ch} \qquad (3.5) \\ log(X_t^{ch}) =& \alpha^c + f(age^{ch}) + \gamma' z_t^{ch} \\ &+ \delta_{age} age^{ch} hp_t + \delta_{age^2} (age^{ch})^2 hp_t + \mu_t^{ch} \qquad (3.6) \\ \mu_t^{ch} =& \varepsilon_t^c + \nu_t^{ch} \end{aligned}$$

To summarize, a life-cycle consumption model is estimated where house prices are interacted with age to distinguish the wealth/collateral hypothesis from the common factor hypothesis. Various specifications are considered. Table 3.5 summarizes how the sign on the interaction effects can be used to distinguish the different hypotheses. Note that without making an explicit distinction between home-owners and tenants (as in the row overall) it is not possible to distinguish the wealth hypothesis from the collateral hypothesis.

To overcome this limitation, one would want to interact house prices with tenure status. However, unobserved preferences regarding consumption of housing and other goods might make a comparison between home-owners and tenants suffer from selectivity bias. Propensity Score Matching (PSM) is used to generate a subsample of homeowners and tenants with similar observed characteristics. Section 3.A explains the PSM-procedure and shows the first stage results.

Table 3.5: Overview hypotheses explaining the level of consumption

Hypothesis	ME effect house prices		Interaction with age
wealth	overall	positive[a]	follows distribution homeownership rate
	homeowners	positive	follows distribution homeownership rate
	tenants	negative or positive	
collateral	overall	positive	follows distribution homeownership rate
	homeowners	positive	follows distribution homeownership rate
	tenants	none	
common factors	overall	positive	decreasing in age
	homeowners	positive	decreasing in age
	tenants	positive	decreasing in age

[a] Under the wealth hypothesis it is unlikely that any negative effect for tenants dominates the positive effect for homeowners.

3.5 Results life-cycle consumption model

Table 3.6 shows regression results in which age dummies for young, middle aged and old households are interacted with house prices.[3] Column one shows results for the dummy specification by Attanasio et al. (2009) with cutoffs at 35 and 60 years. Evidence is provided for a positive relationship between consumption and aggregate house prices that increases with age. This cannot be interpreted as evidence in favor of the wealth-hypothesis, as the relationship between homeownership rate and age is inverse u-shaped.

However, using other cutoff values in column two, I find that the consumption of middle-aged households reacts strongest to house prices, followed by young households and old households. This order reflects the average share of homeownership among those age groups (see Table 3.4) and therefore is evidence in favor of the wealth-hypothesis.

In column three, the specification is extended using the constitutive dummy variables for middle-aged and old households. If significant, these variables should be included to obtain consistent estimates. Including the constitutive terms changes the interpretation of the results. Evidence is provided that the positive relationship between consumption and house prices decreases with age, which is in line with the common factor hypothesis.

[3] House prices are in 10,000 euro. Including the log of real house prices yields similar results for all specifications.

In column four the log of net income is included in the specification. The variable is likely to be endogenous, so results should be interpreted with care. Most interaction terms become insignificant upon including income, which indicates that the interaction terms in the specification in column three are influenced by income. No clear-cut pattern arises as only middle-aged households are found to adjust consumption with respect to house prices. These results are in line with the explanation that income is a common factor that drives both consumption and house prices.

Table 3.6: Results non-durable consumption (dummy specification)

	(1)	(2)	(3)	(4)
Interaction real house prices with…				
Young households ABHL (age<35)	0.0181***			
	(0.0014)			
Middle-aged households ABHL (35<=age<60)	0.0195***			
	(0.0012)			
Old households ABHL (age>=60)	0.0259***			
	(0.0015)			
Young households (age<30)		0.0178***	0.0258***	0.0039
		(0.0015)	(0.0034)	(0.0030)
Middle-aged households (30<=age<70)		0.0222***	0.0214***	0.0090***
		(0.0012)	(0.0013)	(0.0011)
Old households (age>=70)		0.0132***	0.0129***	0.0019
		(0.0016)	(0.0035)	(0.0029)
Control variables				
Middle-aged households (age<30)			0.0734**	-0.0087
			(0.0282)	(0.0245)
Old households (age>=70)			0.0670	0.0056
			(0.0425)	(0.0363)
Age	0.0183***	0.0074***	0.0066***	0.0007
	(0.0016)	(0.0017)	(0.0017)	(0.0014)
Age squared	-0.0003***	-0.0001***	-0.0001***	-<0.0001**
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
log net annual income				0.5590***
				(0.0085)
Constant	10.5071***	10.5523***	10.4915***	4.3503***
	(0.1560)	(0.1434)	(0.1445)	(0.1318)
adj. R^2	0.462	0.463	0.463	0.622
F-statistic interation terms house prices	112.7	123.4	105.5	22.2
F-statistic p-value	<0.0001	<0.0001	<0.0001	<0.0001
Degrees model	38	38	40	41
N	35,783	35,783	35,783	35,783

Standard errors in round parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Variables not shown: 17 cohort dummies; log household size; log household size squared; dummies for SPH, SFH MFH; one dummy for not employed; three dummies for type of job, and four for educational level.

Dependent variable: log non-durable expenditure. Real house price measure in 10,000 euro.

These results might be driven by the (ad hoc) cutoff points that define young, middle aged and old households. Therefore house prices are interacted with a continuous measure of age and with age in quadratic form. House prices are interacted with the quadratic form of age, as this allows for a non-linear interaction effect as is expected under the wealth hypothesis.

Results are given in Table 3.7. Column one shows that consumption is positively related to house prices. The relationship between consumption and age is concave with the optimum at about age 40.[4] In column two house prices are interacted with age and the squared value of age. Evidence is found in favor of the common factor analysis, as the marginal effect of house prices on consumption decreases with age. A change in real house prices with €10,000 increases consumption with about 2.3 percent for households around age 30, but with 1.8 percent for households around age 65, see the upper left panel in Figure 3.2.

After including the log of net income, evidence is found that the marginal effect of house prices on consumption is inverse u-shaped, see column three or the bottom left panel in Figure 3.2. For heads of households with age between 35 and 70 a positive effect of house prices on consumption is found. Around age 50 the response in consumption is maximized: an increase in house prices with 10,000 euro increases consumption with about one percent.

The right panels in Figure 3.2 shows the marginal effect of age on consumption for a range of house prices. Evidence in favor of a marginal effect of age on consumption is not found (conditional on cohort dummies).

Table 3.7: Results non-durable consumption (interaction specification)

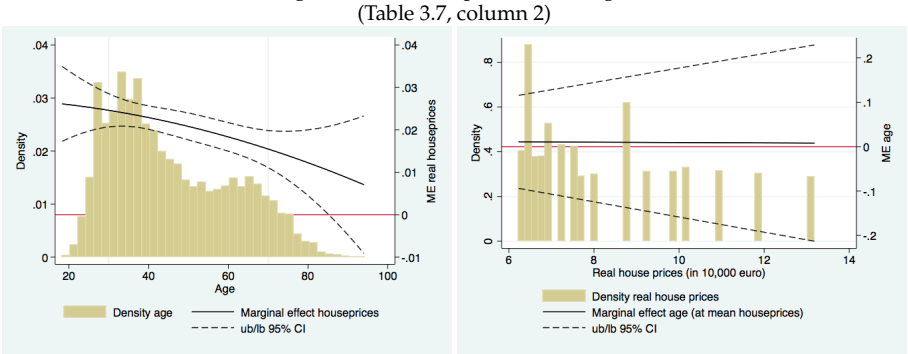
	(1)	(2)	(3)
Real house prices (in 10,000 euro)	0.0208***	0.0275*	-0.0182
	(0.0012)	(0.0113)	(0.0097)
Interaction age and real house prices		-<0.0001	0.0011**
		(0.0005)	(0.0004)
Interaction age squared and house prices		-<0.0001	-<0.0001**
		(0.0000)	(0.0000)
Age	0.0161***	0.0141***	-0.0022
	(0.0013)	(0.0041)	(0.0035)
Age squared	-0.0002***	-0.0002***	-<0.0001
	(<0.0001)	(<0.0001)	(<0.0001)
Log net annual income			0.5600***
			(0.0086)
Constant	10.4626***	10.4122***	4.4681***
	(0.1502)	(0.1748)	(0.1497)
adj. R^2	0.462	0.462	0.622
Degrees model	36	38	39
N	35,783	35,783	35,783

Standard errors in round parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Variables not shown: 17 cohort dummies, ln household size, ln household size squared, dummies for SPH, SFH MFH one dummy for not employed, 3 for type of job, and four for educational level
Dependent variable: log non-durable expenditure

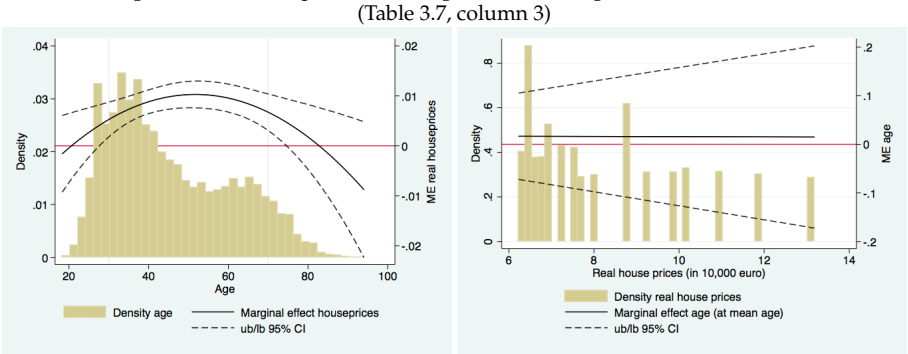
4 $\frac{\partial log(c)}{\partial age} = 0.0161 - 2(0.0002)$age which is zero when age is about 40.

Figure 3.2: Marginal effect of house prices and age

Marginal effect house prices (l) and age (r)
(Table 3.7, column 2)



Marginal effect house prices (l) and age (r), controlling for annual net income
(Table 3.7, column 3)



Next, the effect of house prices on consumption is considered for homeowners and tenants separately. The endogeneity of homeownership status is corrected for using propensity score matching (see section 3.A for the first stage results of the PSM-procedure). Column one of Table 3.8 indicates that in general consumption increases with house prices. An increase in house prices with 10,000 euro raises consumption with 1.7 percent. Also, the relationship between age and consumption is found to be concave, with the optimum around the age of 50.

Column two shows that the change in consumption with respect to house prices is lower for tenants than for homeowners. A 10,000 euro increase in house prices raises consumption with about 1.7 percent for homeowners. This is about one percent for tenants.[5]

[5]The coefficient on house prices equals 0.0166. The coefficient on the interaction term "House prices and tenants" equals -0.0067. The difference is about one percent.

Column three of Table 3.8 shows results for the specification in which local house prices are interacted with age for homeowners and tenants separately.[6] Results indicate that homeowners and tenants of different age respond differently to house prices. For both types of tenure status, the marginal effect of house prices decreases with age, see Figure 3.3: For homeowners aged between 18 and 50 the marginal effect of an increase in house prices with 10,000 euro ranges between two and one percent. For tenants the effect is around one percent for households aged between 18 and about 35 only. As a positive effect of house prices on consumption is found to exist for (a subsample of) tenants, the collateral hypothesis is ruled out.

Column four shows results if income is included in the specification. Now, no real evidence is found that house prices influence the consumption of homeowners or tenants. The lower panels of Figure 3.3 show that no significant marginal effect is found except for homeowners aged younger than 23. However, this group is very small in size (as is shown in the histogram) and most likely this positive marginal effect is the result of the linear specification of the interaction.

Overall, most of the evidence points in the direction of the common factor hypothesis as the marginal effect of house prices on consumption decreases with age and becomes insignificant if income (a potential common factor) is included. The propensity score matching reveals that young homeowners and young tenants consume more if house prices increase. For tenants, the effect of house prices on consumption becomes insignificant if they are about 35. For homeowners this occurs if they are about 60. Thus for home-owners the correlation between house prices and consumption (caused by common factors) is stronger than for tenants.

[6]Including interaction of house prices with age squared for homeowners and tenants separately yield insignificant coefficients and insignificant marginal effects for both house prices and age.

Table 3.8: Results non-durable consumption (PSM specification)

	(1)	(2)	(3)	(4)
Tenant	-0.0305	-0.0105	0.0252	0.1966**
	(0.0200)	(0.0526)	(0.0756)	(0.0656)
Real house prices	0.0168***	0.0166***		
	(0.0021)	(0.0021)		
House prices and tenants	-0.0072**	-0.0067**	0.0188**	0.0032
	(0.0024)	(0.0024)	(0.0066)	(0.0058)
House prices and homeowners		0.0301***	0.0159*	
		(0.0069)	(0.0062)	
Interaction of house prices with age ...				
for homeowners		-0.0003*	-0.0002	
		(0.0001)	(0.0001)	
for tenants		-0.0002	<0.0001	
		(0.0001)	(0.0001)	
Age	0.0108***	0.0110***		
	(0.0018)	(0.0021)		
Age squared	-0.0002***	-0.0002***		
	(<0.0001)	(<0.0001)		
Age and tenants		-0.0004	0.0098***	0.0018
		(0.0021)	(0.0021)	(0.0018)
Age squared and tenants		-<0.0001	-0.0002***	-0.0001**
		(<0.0001)	(<0.0001)	(<0.0001)
Age and homeowners			0.0109***	0.0095***
			(0.0022)	(0.0020)
Age squared and homeowners			-0.0001***	-0.0001***
			(<0.0001)	(<0.0001)
Log net annual income				0.5222***
				(0.0085)
Constant	10.7714***	10.7648***	10.6539***	4.5727***
	(0.2242)	(0.2192)	(0.2141)	(0.1744)
adj. R^2	0.362	0.363	0.363	0.519
Degrees model	38	40	42	43
N	16,386	16,386	16,386	16,386

Standard errors in round parentheses

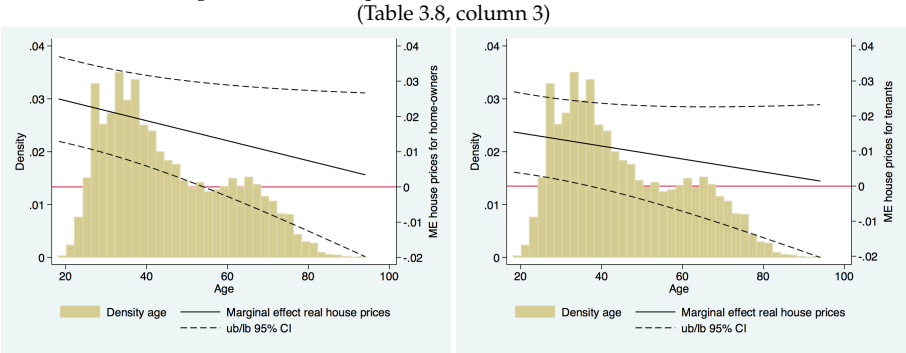
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Variables not shown: 17 cohort dummies, log household size, log household size squared, dummies for SPH, SFH MFH one dummy for not employed, 3 for type of job, and four for educational level

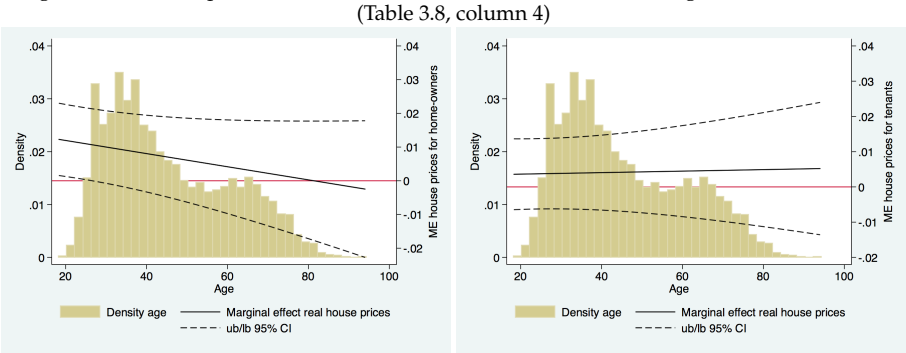
Dependent variable: Log non-durable expenditure

Figure 3.3: Marginal effect house prices (PSM)

Marginal effect house prices for homeowners (l) and tenants (r)
(Table 3.8, column 3)



Marginal effect house prices for homeowners (l) and tenants (r), controling for annual net income
(Table 3.8, column 4)



3.6 Estimation strategy budget allocation model

To investigate whether housing tenure alters the allocation of the consumption budget an Almost Ideal Demand System is estimated.[7] Deaton and Muellbauer (1980a) start from the log of the cost function, which they define as

$$log(C(U,p)) = A(p) + uB(p), \tag{3.7}$$

with

$$A(p) = a_0 + \sum_g a_g log(p^g) + \tfrac{1}{2}\gamma^*_{g'g} \sum_g \sum_g' log(p^g) log(p^{g'})$$

$$B(p) = \beta_0 \prod_g (p^g)^{b_g}$$

Where all α, β, b and γ are unknown weights that have to be estimated and $p^g, p^{g'}$ are prices of the goods g and $g' \neq g$. Let $h^{*g}(U,p)$ be the Hicksian demand for good g given utility level U and price vector p. As the cost function is given by $C = \sum_g p^g h^{*g}(U,p)$ the derivative of the log of the cost function to the log of price for good g yields the budget share of good g. Therefore, it can be shown that the budget share w^g is a function of a constant for good g (α_g), the prices of all other goods $p^{g'}$ and the price index $B(p)$:[8]

$$w^g = a_g + \sum_{g'} \gamma_{g'g} log(p^{g'}) + (b_g) uB(p), \tag{3.8}$$

$$\text{where} \quad \gamma_{g'g} = (\gamma^*_{gg'} + \gamma^*_{g'g})/2 = \gamma_{gg'}$$

To simplify this equation replace total costs $C(U,p)$ with total expenditure X under the assumption that they are equivalent. Solve equation (3.7) for u, where the price index $A(p)$ is indicated by $log(P)$. Substitute this into (3.8) to

[7] This part is based on Deaton and Muellbauer (1980a) and chapters two and three in Deaton and Muellbauer (1980b).

[8] To see why, start with $w^g = \frac{\partial A(p)}{\partial log(p^g)} + \frac{\partial uB(p)}{\partial p^g}\frac{\partial p^g}{\partial log(p^g)} = \frac{\partial A(p)}{\partial log(p^g)} + \frac{\partial uB(p)}{\partial p^g} p^g$. The partial derivative of $A(p)$ to $log(p_g)$ equals $\frac{\partial A(p)}{\partial log(p^g)} = a_g + \sum_{g'} \gamma_{g'g} log(p^{g'})$. Define $\beta_0 \prod_g (p^g)^{b_k} = B(p)$ such that the partial derivative of $uB(p)$ to p^g equals $\frac{\partial uB(p)}{\partial p^g} = b_g u \beta_0 \prod_g (p^g)^{b_g} = b_g uB(p)(p^g)^{-1}$. This yields equation (3.8).

derive equation (3.9).

$$w^g = a_g + \sum_h \gamma_{g'g} log(p^{g'}) + b_g log(X) - b_g log(P) \tag{3.9}$$

Thus the budget share devoted to consumption of good g by household i is a function of a constant α_g, the log of total expenditure X_i, and prices of all goods $p^{g'}$, and the price index.[9]

The budget share of each of the consumption categories (w_i^g) is regressed on total consumption (X_i), household characteristics (H_i), a vector including eighteen fixed year effects (D_t) to control for price differences and a vector including nineteen fixed year effects for tenants only (RD_t) to control for prices for rent-controlled tenants. ε_i^g is an i.i.d. error term, see equation (3.10). Superscripts g indicate whether the consumption is on basic goods, housing, recreation or alcohol and tobacco. The β^g,ζ^g and ζ^{gR} are parameters that have to be estimated.

$$w_i^g = \beta_0^g + \beta_1^g X_i + \beta_2^g H_i + \sum_{t=1982}^{1999} \zeta_t^g D_t + \sum_{t'=1981}^{1999} \zeta_{t'}^{gR} RD_{t'} + \varepsilon_i^g \tag{3.10}$$

with $g = 1, .., 4; \quad i = 1, .., N$

On the right hand side of equation (3.10) X_i measures the log of total expenditure by household i. As the budget share has total expenditure in the denominator, X_i is instrumented using annual income Y_i. H_i is a matrix of household characteristics that might affect preferences for certain goods. The variables in H_i are age of the household head (in groups of five years), size of the household, squared size of the household, dummies for household type (single, family, family plus others), dummies for the number of children present in the household (one, two or three, or more) and the highest educational degree in the household (attained by either the head of the household or the spouse, if present).

[9] It satisfies the first property of demand (adding up), whenever $\sum_g \alpha_g = 1$ and $\sum_g \gamma_{g'g} = \sum_g \beta_g = 0$, which holds by definition. Furthermore, the conditions of homogeneity and symmetry can be tested. Homogeneity holds if and only if $\sum_g \gamma_{g'g} = 0, \forall g'$. Symmetry holds if and only if $\gamma_{g'g} = \gamma_{gg'}$. However the negativity property can not easily be reproduced by the system and cannot be controlled by restricting the values of the estimated parameters. Although $w^g = [0, 1]$ (by definition) estimating equation (3.9) might lead to predictions outside this interval, as $X = [0, \infty)$. Both drawbacks make the system 'almost ideal' (see Barten (1993) for both statements).

D_t is a vector that indicates whether the observation is in year t. It reflects the effect of year specific factors such as prices and the economic cycle. Additionally, RD_t is defined as a 'rental year' dummy. RD_t is one if the survey year equals t and the household rents controlled housing, and is zero otherwise. As a result RD_t captures the year effect that is specific to tenants. Under the assumption that homeowners and tenants have equal preferences, this RD_t captures the effect of lower rents on the consumption budget shares.

A test whether consumption of good g differs between homeowners and tenants because of rents is testing the joint hypothesis whether $\widehat{\zeta}^{gR}_{1981} = \widehat{\zeta}^{gR}_{1982} = \ldots = \widehat{\zeta}^{gR}_{1999} = 0$. Under the null hypothesis the effect of prices is equal for both homeowners and tenants. If the null hypothesis is rejected, ζ^{gT}_t contains the difference in consumption of good g in year t by tenants because of lower rents. It exactly identifies this effect if there are no other variables that are constant within a year that are different for homeowners and tenants.

Additionally, it is investigated whether consumption patterns differ within the group of rent-controlled tenants. This hypothesis can be tested under the assumption that rent-controlled tenants with a high propensity to live in owner-occupied housing are on average more restricted in their consumption of housing services than controlled tenants with a low propensity to live in owner-occupied housing. Then, equation (3.11) can be estimated. Here, the dependent variable is an indicator equal to one for being a homeowner (h_i). Explanatory variables are annual net income Y_i, its squared value Y_i^2, a matrix of explanatory variables Z_i and a set of year indicators D_t. ν_i is an i.i.d. error term. The gammas and deltas are parameters that have to be estimated. Equation (3.11) is estimated as a logistic regression to ensures that $0 < \widehat{h}_i < 1$.

$$h_i = \gamma_0 + \gamma_1 Y_i + \gamma_2 Y_i^2 + \gamma_3 Z_i + \sum_t \delta_t D_t + \nu_i \tag{3.11}$$

$$\text{with} \quad i = 1, .., N; \quad t = 1981, .., 1999$$

Explanatory variables included in Z_i are indicators of household, job and house characteristics. Household characteristics are included in the selection regression as household composition might affect the demand for housing. As rent-controlled housing is of different quality (generally smaller), this might

affect the selection into a particular type of housing. Similarly, job characteristics are included to measure the effect of income on tenure choice. Also, the type of job is a proxy reflecting ability of the household. Finally, house characteristics are included such that households in equal housing are matched. As a result, the selected households have similar revealed preferences for housing.

Each household's propensity to be a home-owner $0 < \hat{h}_i < 1$ is predicted. I include $P_i = \hat{h}_i$ and its interaction with rent-controlled tenant status P_i^R in the specification. Then, a positive and significant coefficient on P_i^R indicates that on average tenants who are more similar to home-owners overconsume the good.

$$\begin{aligned} w_i^g &= \beta_0^g + \beta_1^g X_i + \beta_2^g \mathbf{H_i} + \sum_{t=1982}^{1999} \zeta_t^g D_t + \sum_{t'=1981}^{1999} \zeta_{t'}^{gR} RD_{t'} \\ &\quad + P_i^g + P_i^{gR} + \varepsilon_i^g \qquad (3.12) \\ \text{with} \quad & g = 1,..,4; \quad i = 1,..,N; \quad t = 1981,..,1999 \end{aligned}$$

3.7 Results budget allocation model

Table 3.9 shows the base result using the full sample. Homeowners do not alter the allocation of their budget over time, as most of the year dummies are insignificant. In contrast, almost all year dummies are significant for tenants. For all consumption categories it holds that the difference between tenants and homeowners declines over time. This is in line with the fact that the difference between imputed rents and rents decreased over time. On average, tenants spend six percent of their budget less on housing, which they spend on basic goods (plus three percent), recreation (plus three percent) and alcohol and tobacco (plus 0.6 percent).[10] This indicates that, ceteris paribus, homeowners and tenants differ in the allocation of budget over consumption categories.

[10]The average coefficients do not add up to zero, because of rounding.

Table 3.9: Allocation of budget

	(1) Basic goods		(2) Housing		(3) Recreation		(4) Alcohol and tobacco	
	coef.	s.e.	coef.	s.e.	coef.	s.e.	coef.	s.e.
Ln of expenditure	-0.0020	(0.0039)	-0.1600***	(0.0029)	0.1600***	(0.0048)	0.0025*	(0.0012)
Tenant in year 1980	0.0300***	(0.0046)	-0.0710***	(0.0031)	0.0380***	(0.0050)	0.0032	(0.0017)
Tenant in year 1981	0.0270***	(0.0045)	-0.0680***	(0.0036)	0.0360***	(0.0049)	0.0058***	(0.0017)
Tenant in year 1982	0.0340***	(0.0050)	-0.0830***	(0.0039)	0.0390***	(0.0052)	0.0093***	(0.0018)
Tenant in year 1983	0.0390***	(0.0039)	-0.0710***	(0.0031)	0.0280***	(0.0043)	0.0042**	(0.0014)
Tenant in year 1984	0.0360***	(0.0038)	-0.0690***	(0.0030)	0.0240***	(0.0042)	0.0084***	(0.0014)
Tenant in year 1985	0.0350***	(0.0051)	-0.0730***	(0.0031)	0.0320***	(0.0047)	0.0058***	(0.0014)
Tenant in year 1986	0.0340***	(0.0038)	-0.0780***	(0.0028)	0.0360***	(0.0043)	0.0075***	(0.0014)
Tenant in year 1987	0.0360***	(0.0043)	-0.0830***	(0.0030)	0.0400***	(0.0048)	0.0075***	(0.0015)
Tenant in year 1988	0.0330***	(0.0060)	-0.0660***	(0.0046)	0.0240**	(0.0088)	0.0085***	(0.0018)
Tenant in year 1989	0.0320***	(0.0052)	-0.0670***	(0.0034)	0.0300***	(0.0057)	0.0055**	(0.0017)
Tenant in year 1990	0.0270***	(0.0061)	-0.0710***	(0.0039)	0.0390***	(0.0087)	0.0054***	(0.0014)
Tenant in year 1991	0.0290***	(0.0066)	-0.0730***	(0.0052)	0.0370***	(0.0072)	0.0067***	(0.0020)
Tenant in year 1992	0.0240***	(0.0051)	-0.0680***	(0.0037)	0.0370***	(0.0055)	0.0066***	(0.0017)
Tenant in year 1993	0.0220***	(0.0049)	-0.0620***	(0.0036)	0.0350***	(0.0053)	0.0040*	(0.0018)
Tenant in year 1994	0.0260***	(0.0049)	-0.0650***	(0.0037)	0.0350***	(0.0052)	0.0042*	(0.0017)
Tenant in year 1995	0.0130**	(0.0049)	-0.0440***	(0.0036)	0.0260***	(0.0051)	0.0056**	(0.0018)
Tenant in year 1996	0.0160***	(0.0049)	-0.0390***	(0.0035)	0.0170**	(0.0051)	0.0064***	(0.0018)
Tenant in year 1997	0.0190***	(0.0051)	-0.0460***	(0.0035)	0.0190***	(0.0051)	0.0083***	(0.0018)
Tenant in year 1998	0.0200***	(0.0051)	-0.0430***	(0.0037)	0.0160**	(0.0052)	0.0068***	(0.0019)
Tenant in year 1999	0.0180**	(0.0056)	-0.0330***	(0.0038)	0.0096	(0.0057)	0.0058**	(0.0019)
Year 1981	-0.0073	(0.0061)	0.0120*	(0.0049)	-0.0027	(0.0069)	-0.0022	(0.0020)
Year 1982	-0.0100	(0.0100)	0.0340***	(0.0079)	-0.0190	(0.0110)	-0.0039	(0.0032)
Year 1983	-0.0180	(0.0140)	0.0280**	(0.0110)	-0.0081	(0.0160)	-0.0014	(0.0042)
Year 1984	-0.0120	(0.0180)	0.0330*	(0.0140)	-0.0160	(0.0200)	-0.0039	(0.0055)
Year 1985	-0.0190	(0.0220)	0.0380*	(0.0170)	-0.0180	(0.0260)	-0.0020	(0.0068)
Year 1986	-0.0077	(0.0270)	0.0380	(0.0210)	-0.0270	(0.0310)	-0.0030	(0.0082)
Year 1987	0.0002	(0.0310)	0.0350	(0.0240)	-0.0320	(0.0360)	-0.0030	(0.0095)
Year 1988	0.0190	(0.0360)	0.0170	(0.0270)	-0.0330	(0.0410)	-0.0030	(0.0110)
Year 1989	0.0230	(0.0400)	0.0190	(0.0310)	-0.0400	(0.0460)	-0.0023	(0.0120)
Year 1990	0.0280	(0.0430)	0.0180	(0.0340)	-0.0440	(0.0500)	-0.0020	(0.0130)
Year 1991	0.0210	(0.0480)	0.0300	(0.0370)	-0.0470	(0.0560)	-0.0038	(0.0150)
Year 1992	0.0210	(0.0530)	0.0290	(0.0410)	-0.0470	(0.0610)	-0.0034	(0.0160)
Year 1993	0.0240	(0.0580)	0.0250	(0.0440)	-0.0490	(0.0670)	-0.0003	(0.0170)
Year 1994	0.0190	(0.0620)	0.0320	(0.0480)	-0.0520	(0.0720)	0.0009	(0.0190)
Year 1995	0.0250	(0.0660)	0.0180	(0.0510)	-0.0460	(0.0760)	0.0023	(0.0200)
Year 1996	0.0210	(0.0710)	0.0260	(0.0550)	-0.0470	(0.0820)	-<0.0001	(0.0210)
Year 1997	0.0240	(0.0750)	0.0250	(0.0580)	-0.0490	(0.0870)	-0.0002	(0.0230)
Year 1998	0.0250	(0.0800)	0.0270	(0.0610)	-0.0540	(0.0920)	0.0020	(0.0240)
Year 1999	0.0330	(0.0840)	0.0120	(0.0650)	-0.0470	(0.0970)	0.0019	(0.0250)
Age	-0.0040	(0.0045)	-0.0015	(0.0035)	0.0054	(0.0052)	-<0.0001	(0.0014)
Age squared	<0.0001	(<0.0001)	<0.0001***	(<0.0001)	-<0.0001***	(<0.0001)	-<0.0001***	(<0.0001)
Secundary, first step	-0.0074***	(0.0018)	-0.0002	(0.0014)	0.0080***	(0.0019)	-0.0004	(0.0007)
Secundary, second step	-0.0098***	(0.0020)	-0.0015	(0.0016)	0.014***	(0.0021)	-0.0024**	(0.0007)
Tertiary, first step	-0.0075**	(0.0023)	0.0013	(0.0017)	0.0100***	(0.0025)	-0.0042***	(0.0008)
Tertiary, second step	-0.0037	(0.0031)	0.0084***	(0.0023)	0.0004	(0.0034)	-0.0050***	(0.0010)
Employee	0.0049	(0.0090)	-0.0086	(0.0069)	0.0087	(0.011)	-0.0050	(0.0029)
Academic job	-0.0005	(0.0091)	-0.0016	(0.0069)	0.0022	(0.011)	-<0.0001	(0.0029)
Managerial job	0.0065	(0.0091)	0.0023	(0.0070)	-0.0088	(0.011)	0.0001	(0.0029)
Other	0.0057	(0.0090)	-0.0087	(0.0069)	-0.0011	(0.010)	0.0041	(0.0029)
adj. R^2	0.128		0.545		0.299		0.052	
Chi2 tenant year	582.8		5370.3		573.7		223.8	
P-value	<0.0001		<0.0001		<0.0001		<0.0001	
ATE tenant-year	0.03		-0.06		0.03		0.006	
Standard error ATE	0.001		0.0010		0.001		0.0005	
T-value ATE	20.8		-65.3		20.6		13.7	
Degrees model	75		75		75		75	
N	35783		35783		35783		35783	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Dependent variable: share of budget spend on each category; log expenditure instrumented using ln net income

Variables not shown: Constant, 17 cohort dummies, log household size, log household size squared, dummies for SPH, SFH MFH one dummy for not employed, three for type of job, and four for educational level

Next, the budget share equations are re-estimated using the PSM subsample to control for potential endogeneity. Estimation results based on 2SLS are given in Table 3.10. Results are similar to those for the complete sample, although the tenant-year dummies for basic goods and alcohol and tobacco are no longer significant at the end of the sample period. However, on average, tenants still spend six percent of their budget less on housing, which they spend on basic goods (plus two percent), recreation (plus three percent) and alcohol and tobacco (plus 0.6 percent). Thus the propensity score matching procedure does not significantly alter our findings with respect to the average treatment effect of living in rent-controlled or owner-occupied housing.[11]

Finally, I investigate whether the consumption pattern for restricted tenants is different compared to that of unrestricted tenants. The propensity score for being a homeowner is used as a measure of whether the household is restricted. Here I assume that rent-controlled tenants who are very likely to be a home-owner differ in their consumption patterns from households who are very unlikely to be a home-owner. Table 3.11 shows that consumption patterns of a 'more typical home-owner' differs from that of a 'typical tenant'. A head of household that is likely to be a home-owner spends more of his budget on housing, and less on recreation. However, for tenants, this effect is reduced. This indicates that especially restricted tenants spend less of their budget on housing and more on recreation.

[11]The estimates on other variables differ significantly between the PSM-sample and the full sample.

Table 3.10: Allocation of budget (PSM subsample)

	(1) Basic goods		(2) Housing		(3) Recreation		(4) Alcohol and tobacco	
	coef.	s.e.	coef.	s.e.	coef.	s.e.	coef.	s.e.
Log of expenditure	0.0050	(0.0080)	-0.2000***	(0.0050)	0.2000***	(0.0100)	0.0020	(0.0020)
Tenant in year 1980	0.0100*	(0.0070)	-0.0600***	(0.0050)	0.0400***	(0.0080)	0.0040	(0.0020)
Tenant in year 1981	0.0200**	(0.0070)	-0.0500***	(0.0050)	0.0300***	(0.0070)	0.0050*	(0.0020)
Tenant in year 1982	0.0200**	(0.0070)	-0.0700***	(0.0050)	0.0400***	(0.0070)	0.0100***	(0.0020)
Tenant in year 1983	0.0300***	(0.0060)	-0.0700***	(0.0040)	0.0300***	(0.0060)	0.0050*	(0.0020)
Tenant in year 1984	0.0300***	(0.0050)	-0.0700***	(0.0040)	0.0300***	(0.0060)	0.0100***	(0.0020)
Tenant in year 1985	0.0300***	(0.0050)	-0.0700***	(0.0040)	0.0300***	(0.0050)	0.0060**	(0.0020)
Tenant in year 1986	0.0300***	(0.0050)	-0.0700***	(0.0040)	0.0400***	(0.0060)	0.0060**	(0.0020)
Tenant in year 1987	0.0400***	(0.0060)	-0.0800***	(0.0040)	0.0400***	(0.0070)	0.0040	(0.0020)
Tenant in year 1988	0.0300***	(0.0070)	-0.0600***	(0.0050)	0.0200**	(0.0080)	0.0090***	(0.0030)
Tenant in year 1989	0.0400***	(0.0080)	-0.0700***	(0.0050)	0.0300***	(0.0080)	0.0060*	(0.0030)
Tenant in year 1990	0.0200	(0.0100)	-0.0700***	(0.0070)	0.0500**	(0.0200)	0.0060**	(0.0020)
Tenant in year 1991	0.0200*	(0.0100)	-0.0600***	(0.0070)	0.0300**	(0.0100)	0.0060	(0.0030)
Tenant in year 1992	0.0200**	(0.0070)	-0.0600***	(0.0050)	0.0300***	(0.0080)	0.0090**	(0.0030)
Tenant in year 1993	0.0200***	(0.0070)	-0.0600***	(0.0050)	0.0300***	(0.0080)	0.0020	(0.0030)
Tenant in year 1994	0.0300***	(0.0070)	-0.0600***	(0.0050)	0.0300***	(0.0070)	0.0030	(0.0030)
Tenant in year 1995	0.0100	(0.0070)	-0.0500***	(0.0050)	0.0300***	(0.0080)	0.0030	(0.0030)
Tenant in year 1996	0.0200**	(0.0070)	-0.0400***	(0.0050)	0.0200*	(0.0070)	0.0040	(0.0020)
Tenant in year 1997	0.0100	(0.0070)	-0.0400***	(0.0050)	0.0200**	(0.0080)	0.0090**	(0.0030)
Tenant in year 1998	0.0200*	(0.0070)	-0.0400***	(0.0050)	0.0200*	(0.0080)	0.0080**	(0.0030)
Tenant in year 1999	0.0060	(0.0080)	-0.0200***	(0.0050)	0.0100	(0.008)	0.0020	(0.0030)
Year 1981	-0.0100	(0.0090)	0.0060	(0.0070)	0.0040	(0.0100)	-0.0005	(0.0030)
Year 1982	-0.0040	(0.0200)	0.0300*	(0.0100)	-0.0200	(0.0200)	-0.0050	(0.0050)
Year 1983	-0.0300	(0.0200)	0.0300*	(0.0200)	-0.0050	(0.0200)	-0.0007	(0.0060)
Year 1984	-0.0200	(0.0300)	0.0400	(0.0200)	-0.0100	(0.0300)	-0.0050	(0.0080)
Year 1985	-0.0300	(0.0300)	0.0400	(0.0200)	-0.0100	(0.0400)	-0.0010	(0.0100)
Year 1986	-0.0200	(0.0400)	0.0500	(0.0300)	-0.0200	(0.0500)	0.0003	(0.0100)
Year 1987	-0.0200	(0.0500)	0.0500	(0.0300)	-0.0300	(0.0500)	0.0006	(0.0100)
Year 1988	0.0020	(0.0500)	0.0200	(0.0400)	-0.0300	(0.0600)	0.0001	(0.0200)
Year 1989	0.0010	(0.0600)	0.0400	(0.0400)	-0.0400	(0.0700)	0.0007	(0.0200)
Year 1990	0.0200	(0.0600)	0.0400	(0.0500)	-0.0500	(0.0700)	0.0005	(0.0200)
Year 1991	-0.0040	(0.0700)	0.0400	(0.0500)	-0.0400	(0.0800)	-0.0010	(0.0200)
Year 1992	-0.0050	(0.0800)	0.0500	(0.0600)	-0.0400	(0.0900)	-0.0020	(0.0200)
Year 1993	0.0010	(0.0900)	0.0500	(0.0600)	-0.0500	(0.1000)	0.0030	(0.0300)
Year 1994	-0.0090	(0.0900)	0.0500	(0.0700)	-0.0500	(0.1000)	0.0040	(0.0300)
Year 1995	0.0040	(0.1000)	0.0500	(0.0700)	-0.0600	(0.1000)	0.0060	(0.0300)
Year 1996	-0.0100	(0.1000)	0.0600	(0.0800)	-0.0500	(0.1000)	0.0020	(0.0300)
Year 1997	-0.0020	(0.1000)	0.0600	(0.0800)	-0.0600	(0.1000)	0.0020	(0.0300)
Year 1998	-0.0040	(0.1000)	0.0600	(0.0900)	-0.0600	(0.1000)	0.0020	(0.0400)
Year 1999	0.0090	(0.1000)	0.0400	(0.0900)	-0.0600	(0.1000)	0.0060	(0.0400)
Age	-0.0030	(0.0070)	-0.0030	(0.0050)	0.0060	(0.0080)	-<0.0001	(0.0020)
Age squared	<0.0001	(<0.0001)	<0.0001*	(<0.0001)	-<0.0001*	(<0.0001)	-<0.0001***	(<0.0001)
Secundary, first step	-0.0080**	(0.0030)	0.0040	(0.0020)	0.0050	(0.0030)	-0.0010	(0.0009)
Secundary, second step	-0.0100***	(0.0030)	0.0050*	(0.0020)	0.0100**	(0.0030)	-0.0040***	(0.0010)
Tertiary, first step	-0.0100**	(0.0030)	0.0100***	(0.0030)	0.0050	(0.0040)	-0.0050***	(0.0010)
Tertiary, second step	-0.0080	(0.0050)	0.0200***	(0.0040)	-0.0020	(0.0060)	-0.0070***	(0.0020)
Employee	0.0050	(0.0100)	0.0030	(0.0100)	-0.0070	(0.0200)	-0.0010	(0.0050)
Academic job	0.0060	(0.0100)	-0.0100	(0.0100)	0.0090	(0.0200)	-0.0050	(0.0050)
Managerial job	0.0100	(0.0100)	-0.0100	(0.0100)	0.0040	(0.0200)	-0.0040	(0.0050)
Other	0.0070	(0.0100)	-0.0200	(0.0100)	0.0090	(0.0200)	0.0004	(0.0050)
Constant	0.5000	(0.6000)	2.4000***	(0.4000)	-2.0000**	(0.7000)	0.1000	(0.2000)
adj. R^2	0.129		0.562		0.277		0.046	
Chi2 tenant year	284.9		3091.7		344.7		146.6	
P-value	<0.0001		<0.0001		<0.0001		<0.0001	
ATE tenant-year	0.02		-0.06		0.03		0.006	
Standard error ATE	0.002		0.001		0.002		0.0006	
T-value ATE	14.3		-51.3		17.1		10.3	
Degrees model	75		75		75		75	
N	16,386		16,386		16,386		16,386	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Dependent variable: share of budget spend on each category; log expenditure instrumented using ln net income

Variables not shown: 17 cohort dummies, log household size, log household size squared, dummies for SPH, SFH MFH one dummy for not employed, three for type of job, and four for educational level

Table 3.11: Allocation of budget (un)restricted tenants (PSM)

	(1) Basic goods		(2) Housing		(3) Recreation		(4) Alcohol and tobacco	
	coef.	s.e.	coef.	s.e.	coef.	s.e.	coef.	s.e.
Log of expenditure	0.0170*	(0.0079)	-0.2100***	(0.0055)	0.1900***	(0.0100)	0.0027	(0.0023)
Tenant in year 1980	0.0220*	(0.0087)	-0.0470***	(0.0057)	0.0220*	(0.0100)	0.0028	(0.0027)
Tenant in year 1981	0.0250**	(0.0081)	-0.0400***	(0.0060)	0.0110	(0.0094)	0.0041	(0.0028)
Tenant in year 1982	0.0280**	(0.0089)	-0.0570***	(0.0064)	0.0190	(0.0100)	0.0100***	(0.0027)
Tenant in year 1983	0.0410***	(0.0074)	-0.0550***	(0.0054)	0.0110	(0.0088)	0.0035	(0.0024)
Tenant in year 1984	0.0380***	(0.0075)	-0.0540***	(0.0055)	0.0061	(0.0091)	0.0094***	(0.0023)
Tenant in year 1985	0.0380***	(0.0074)	-0.0530***	(0.0053)	0.0110	(0.0091)	0.0046*	(0.0023)
Tenant in year 1986	0.0370***	(0.0077)	-0.0570***	(0.0055)	0.0160	(0.0097)	0.0043	(0.0024)
Tenant in year 1987	0.0460***	(0.0081)	-0.0630***	(0.0057)	0.0140	(0.0099)	0.0026	(0.0025)
Tenant in year 1988	0.0370***	(0.0086)	-0.0450***	(0.0059)	0.0003	(0.0100)	0.0082**	(0.0030)
Tenant in year 1989	0.0430***	(0.0093)	-0.0590***	(0.0059)	0.0120	(0.0110)	0.0047	(0.0029)
Tenant in year 1990	0.0250*	(0.0097)	-0.0540***	(0.0060)	0.0250	(0.0130)	0.0043	(0.0024)
Tenant in year 1991	0.0300**	(0.0110)	-0.0490***	(0.0078)	0.0140	(0.0130)	0.0044	(0.0034)
Tenant in year 1992	0.0290**	(0.0091)	-0.0470***	(0.0062)	0.0110	(0.0100)	0.0073*	(0.0031)
Tenant in year 1993	0.0320***	(0.0089)	-0.0460***	(0.0062)	0.0130	(0.0100)	0.0009	(0.0030)
Tenant in year 1994	0.0340***	(0.0088)	-0.0470***	(0.0060)	0.0120	(0.0100)	0.0021	(0.0029)
Tenant in year 1995	0.0210*	(0.0091)	-0.0360***	(0.0062)	0.0130	(0.0100)	0.0021	(0.0031)
Tenant in year 1996	0.0310***	(0.0090)	-0.0310***	(0.0058)	-0.0033	(0.0100)	0.0033	(0.0028)
Tenant in year 1997	0.0200*	(0.0090)	-0.0300***	(0.0060)	0.0027	(0.0100)	0.0073*	(0.0029)
Tenant in year 1998	0.0260**	(0.0092)	-0.0280***	(0.0062)	-0.0044	(0.0110)	0.0065*	(0.0029)
Tenant in year 1999	0.0150	(0.0098)	-0.0069	(0.0062)	-0.0085	(0.0110)	0.0009	(0.0031)
Year 1981	-0.0094	(0.0094)	0.0054	(0.0072)	0.0045	(0.0100)	-0.0005	(0.0032)
Year 1982	-0.0039	(0.0150)	0.0250*	(0.0110)	-0.0170	(0.0170)	-0.0050	(0.0048)
Year 1983	-0.0260	(0.0200)	0.0310*	(0.0150)	-0.0046	(0.0230)	-0.0007	(0.0064)
Year 1984	-0.0200	(0.0270)	0.0360	(0.0200)	-0.0110	(0.0300)	-0.0052	(0.0083)
Year 1985	-0.0270	(0.0330)	0.0400	(0.0240)	-0.0120	(0.0380)	-0.0011	(0.0100)
Year 1986	-0.0230	(0.0400)	0.0420	(0.0290)	-0.0200	(0.0460)	0.0005	(0.0120)
Year 1987	-0.0170	(0.0470)	0.0430	(0.0340)	-0.0280	(0.0540)	0.0008	(0.0140)
Year 1988	0.0013	(0.0530)	0.0200	(0.0390)	-0.0220	(0.0610)	0.0003	(0.0160)
Year 1989	0.0007	(0.0600)	0.0340	(0.0440)	-0.0360	(0.0680)	0.0010	(0.0180)
Year 1990	0.0160	(0.0640)	0.0310	(0.0470)	-0.0480	(0.0710)	0.0009	(0.0200)
Year 1991	-0.0037	(0.0730)	0.0380	(0.0530)	-0.0330	(0.0830)	-0.0010	(0.0220)
Year 1992	-0.0053	(0.0790)	0.0400	(0.0580)	-0.0330	(0.0910)	-0.0013	(0.0240)
Year 1993	0.0012	(0.0860)	0.0400	(0.0630)	-0.0440	(0.0990)	0.0033	(0.0260)
Year 1994	-0.0085	(0.0930)	0.0460	(0.0680)	-0.0420	(0.1100)	0.0044	(0.0290)
Year 1995	0.0045	(0.0990)	0.0430	(0.0720)	-0.0550	(0.1100)	0.0067	(0.0310)
Year 1996	-0.0100	(0.1100)	0.0520	(0.0770)	-0.0440	(0.1200)	0.0029	(0.0330)
Year 1997	-0.0019	(0.1100)	0.0480	(0.0820)	-0.0480	(0.1300)	0.0025	(0.0350)
Year 1998	-0.0037	(0.1200)	0.0520	(0.0870)	-0.0510	(0.1400)	0.0030	(0.0370)
Year 1999	0.0094	(0.1300)	0.0310	(0.0920)	-0.0470	(0.1400)	0.0067	(0.0390)
Age	-0.0028	(0.0068)	-0.0022	(0.0049)	0.0050	(0.0078)	-<0.0001	(0.0021)
Age squared	<0.0001	(<0.0001)	<0.0001*	(<0.0001)	-<0.0001*	(<0.0001)	-<0.0001***	(<0.0001)
Pr.score	-0.0130	(0.0072)	0.0400***	(0.0053)	-0.0260**	(0.0093)	-0.0017	(0.0020)
Pr.score and tenant	-0.0130	(0.0093)	-0.0270***	(0.0062)	0.0370**	(0.0120)	0.0023	(0.0025)
Constant	0.4200	(0.6100)	2.4900***	(0.4400)	-2.0200**	(0.7200)	0.1100	(0.1900)
adj. R^2	0.122		0.567		0.279		0.046	
Chi2 tenant year	78.3		376.6		31.1		34.5	
P-value	<0.0001		<0.0001		0.05		0.02	
ATE tenant-year	0.03		-0.05		0.010		0.005	
Standard error ATE	0.005		0.004		0.007		0.001	
T-value ATE	5.9		-12.6		1.5		3.1	
Degrees model	77		77		77		77	
N	16,386		16,386		16,386		16,386	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Dependent variable: share of budget spend on each category; log expenditure instrumented using ln net income

Variables not shown: 17 cohort dummies, log household size, log household size squared, dummies for SPH, SFH MFH one dummy for not employed, three for type of job, and four for educational level

3.8 Conclusion

In this chapter the effect of housing tenure on the level and allocation of the consumption budget has been investigated. Significant differences in consumption behavior between homeowners and (rent-controlled) tenants are found to exist. First, the relationship between housing market prices and consumption is most likely to be driven by the common factor hypothesis. I conclude this as the marginal effect of housing prices on consumption decreases with age, whereas a parabolic relationship would be expected under the wealth hypothesis.

Using a propensity score matching procedure to control for the endogeneity of housing market tenure, I find that the effect of house prices on consumption is positive for both home-owners and tenants. For both types, it is concluded that the marginal effect decreases with age, which is in line with the common factor hypothesis too. The effect of house prices is found to be smaller for tenants than for homeowners.

Second, an Almost Ideal Demand System has been estimated to see whether consumption patterns of controlled and uncontrolled households differ. It is concluded that consumption patterns of homeowners and controlled tenants are very different. Controlled tenants spend less on housing and more on basic goods, recreation and alcohol and tobacco. Evidence based on propensity score matching suggests that this difference in consumption patterns is indeed due to rent-control and not to heterogeneous preferences.

Additionally, the consumption patterns of homeowners and tenants have been converging over time. This is line with the observation that rents in the controlled housing sector have been increasing more than the imputed rents in the owner-occupied sector. Results suggest that consumption differences between restricted and unrestricted tenants exist, but they are limited. Tenants that most resemble homeowners spend less on housing and more on recreation.

It would be interesting to augment the analysis presented in this chapter in various directions. For instance, future research for the Netherlands could include local measures of housing prices to capture spatial variation. This would also allow to compute local measures of rent control benefits which could be used to test whether consumption of tenants is related to rent control. Also, it would be interesting to study the effect of housing market tenure on the consumption of durables or saving behavior.

3.A Propensity Score Matching

If owner-occupied and renting households have equal preferences for the consumption goods, the RD_t dummy variables in equations (3.10) and (3.12) capture the effect of lower rents on the consumption budget shares. However, if preferences for consumption goods differ with tenure type, part of $\widehat{RD}_t$ reflects the effect of individual preferences and parameter estimates are biased and inconsistent. This mechanism is not unlikely: Table 3.3 shows that homeowner have higher income. Research by Christensen (2007) finds that tastes are correlated with income. Let α_i^g denote individual preferences, and assume its expectation is different for households living in owner-occupied and rent-controlled housing. Now, equation (3.10) is given by

$$\begin{aligned} w_i^g &= \beta_0^g + \beta_1^g X_i + \beta_2^g \mathbf{H_i} + \sum_t \zeta_t^g D_t + \sum_t \zeta_t^{gR} RD_t + \mu_i^g \qquad (3.13) \\ \mu_i^g &= \alpha_i^g + \varepsilon_i^g \\ \text{with} \quad & g = 1,..,4; \quad i = 1,..,N^{PM}; \quad t = 1981,..,1999 \end{aligned}$$

In an ideal setting, panel data estimation techniques would be used to control for the presence of unobserved heterogeneity α_i^g. As I do not observe the observations in a panel, nearest neighbour propensity score matching (PSM) is used to control for unobserved heterogeneity. PSM constructs a $N^{pm} < N$ subsample of homeowners and tenants with similar propensity to be a homeowner using the (selection) equation (3.11). Under the assumption that $\widehat{h}_i$ and α_i^g are strongly correlated, households with equal propensity to be a homeowner no longer differ structurally in terms of preferences α_i^g.

If this is true, the parameter estimates for the PSM subsample are unbiased.[12, 13] Equation (3.12) is re-estimated as

$$w_i^g = \beta_0^g + \beta_1^g X_i + \beta_2^g \mathbf{H_i} + \sum_{t=1982}^{1999} \zeta_t^g D_t + \sum_{t'=1981}^{1999} \zeta_{t'}^{gR} RD_{t'} + \sum_{c=2}^{5} P_{ci} + \sum_{c'=1}^{5} P_{c'i}^R + \varepsilon_i^g \tag{3.14}$$

$$\text{with} \quad g = 1,..,4; \quad i = 1,..,N; \quad t = 1981,..,1999$$

Matching results

First, I present estimation results of the propensity score selection regression (Table 3.12). It follows that the propensity to be living in owner-occupied housing increases with income (and concave on the domain in the sample). Households with a head younger than 40 or older than 60 are more likely to be living in owner-occupied housing. The propensity to be home-owner increases with education. Conditional on education, the type of job is not significant at the five percent level. Finally, homeowners inhabited larger houses.

A caliper of two percent of the standard deviation of the propensity score is imposed, which results in 7,543 matched pairs. Using this caliper, the null hypothesis that the difference in group means of the variables in Z_i is zero cannot be rejected at the five percent level, see Table 3.13.[14]

Figure 3.4 shows that the propensity score matching procedure succeeds in selecting a homogeneous sample of both homeowners and tenants out of two very different subsamples. First, the solid and long-dashed line indicates that the distribution of propensity to be a home-owner is very different for

[12]The propensity score matching procedure is to estimate the propensity score $\widehat{h}_i$. Next it matches to each owner-occupied household a household that rents housing such that the difference in propensity scores is minimized. Matching is done without replacement, i.e. each renting household can be assigned to only one owner-occupied household. In order to control the quality of the match a maximum distance threshold (caliper) is defined. Matched pairs with difference in propensity score exceeding this procedure are not considered. Here, the caliper is based on the standard error of the propensity score.

[13]However, results based on PSM are less efficient than those provided by panel fixed effects. Naturally, if α_i^g is only weakly correlated with $\widehat{h}_i$, propensity score matching does not solve the estimation bias.

[14]The standard deviation of the propensity score (SDPS) equals 29.95 percent. A caliper of 2.5 percent of the SDPS (or higher) results in a statistically significant difference in group mean of (at least) the squared value of income. Contrary, an extreme caliper of .02 percent of the SDPS yields 5,879 matched pairs and gives similar results compared to those reported.

homeowners and tenants. It is skewed to the right with a peak around 0.95 for owner-occupied households and skewed to the left with peak around 0.1 for tenants. However, for the subsample of matched observations the distribution of propensity scores for the selected homeowners overlaps with that of matched tenants on almost the complete domain.[15]

Table 3.12: Propensity score selection regression

	(1) Owner-occupied coef.	s.e.
Income		
Annual net income	0.0648***	(0.0023)
Annual net income squared	-0.0000***	(0.0000)
Household characteristics		
Age	-0.3191**	(0.1094)
Age squared	0.0004***	(0.0001)
log(household size)	-0.4093	(0.4048)
log(household size) squared	-0.3179	(0.1798)
Single person household	0.7797**	(0.2417)
One family household	0.5276***	(0.1301)
Multiple family household	0.2924	(0.1985)
One child present	0.4833***	(0.0566)
Two children present	0.9254***	(0.0669)
Three children present	1.1741***	(0.1010)
Secundary, first step	0.2363***	(0.0453)
Secundary, second step	0.5616***	(0.0500)
Tertiary, first step	0.6545***	(0.0548)
Tertiary, second step	0.4225***	(0.0777)
Job characteristics		
Employee	0.0778	(0.2371)
Academic job	0.3023	(0.2386)
Managerial job	0.2582	(0.2423)
House characteristics		
Other	0.2245	(0.2358)
Detached SFH	2.4752***	(0.0738)
Apartment	-1.7544***	(0.0386)
Other	-0.8753***	(0.1148)
Prior to 1945	0.8514***	(0.0315)
After 1980	0.1250**	(0.0473)
Three or four rooms	-0.0607	(0.0817)
Five or more rooms	0.2358**	(0.0846)
Cohort dummies	YES	
Year dummies	YES	
Constant	22.0356*	(9.5325)
N	35,690	
pseudo R^2	0.293	

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[15] As should be the case, the smaller the caliper, the more the distributions of matched homeowners and tenants overlap.

Figure 3.4: Propensity score for the full and the matched sample

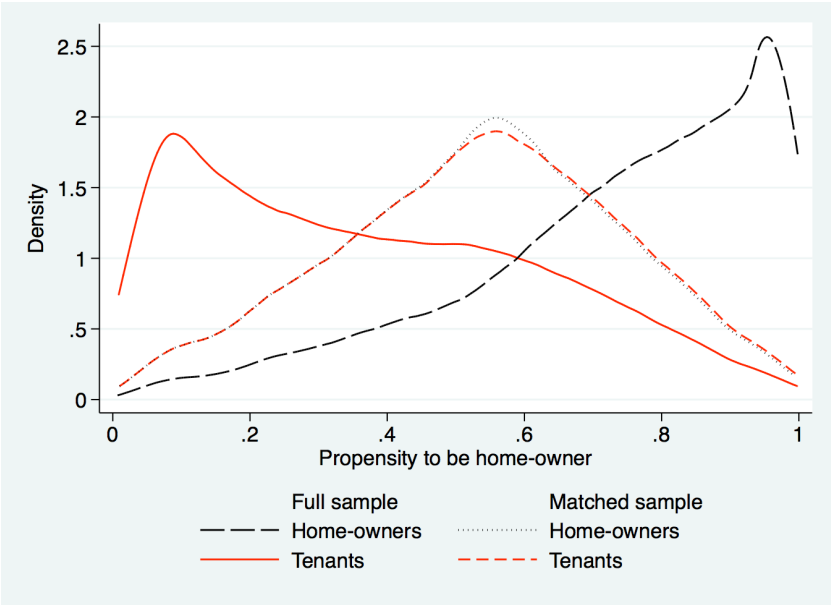


Table 3.13 shows the mean and standard deviation of several variables for tenants and owner-occupied households in the matched sample. It also shows the difference in means and the p-value that corresponds to an equality of means test. The table shows that for all households, job and house characteristics the null hypothesis of equal means for tenants and homeowners cannot be rejected. This also holds for income and the squared value of income. However, their expenditure and allocation over basic goods, housing, recreation and alcohol and tobacco differs. Table 3.13 shows that rent-control tenants spend on average 3,480 euro less than homeowners. Also, the budget share spend on housing is on average four percent lower for tenants, which they spend on basic goods (two percent more), recreation (one percent more) and alcohol and tobacco (one percent more). This suggests that housing tenure status might increase consumption and the allocation of the budget.

Table 3.13: Comparison treatment and control group PSM sample

	Tenants (1)		Owner-occupied (2)		Difference (1-2)	
	mean	std. dev.	mean	std. dev.	mean	p-value
Age	45.590	15.120	45.440	15.210	0.150	0.514
Age squared	2,307.360	1,516.390	2,295.950	1,520.730	11.410	0.631
Log of household size	0.920	0.520	0.920	0.520	0.000	0.846
Single person household	0.160	0.370	0.160	0.370	0.000	0.798
One family household	0.820	0.380	0.820	0.380	0.000	0.855
Multiple family household	0.010	0.090	0.010	0.090	0.000	0.656
One child present	0.150	0.350	0.150	0.350	0.000	0.860
Two children present	0.210	0.410	0.210	0.410	0.000	0.789
Three or more children present	0.070	0.250	0.070	0.260	0.000	0.830
Primary education	0.170	0.370	0.170	0.370	0.000	0.707
Secondary education first step	0.250	0.430	0.250	0.430	-0.010	0.312
Secondary education second step	0.350	0.480	0.350	0.480	0.000	0.844
Tertiary education first step	0.180	0.390	0.180	0.380	0.000	0.492
Tertiary education second step	0.050	0.220	0.050	0.220	0.000	0.778
Cohort head of household						
1895− <1900	0.000	0.020	0.000	0.020	0.000	0.739
1900− < 1905	0.010	0.070	0.010	0.080	0.000	0.672
1905− <1910	0.010	0.110	0.010	0.100	0.000	0.607
1910 − <1915	0.030	0.170	0.030	0.170	0.000	0.851
1915 − <1920	0.040	0.200	0.040	0.200	0.000	0.938
1920 − <1925	0.070	0.250	0.070	0.250	0.000	0.712
1925 − <1930	0.070	0.260	0.070	0.260	0.000	0.739
1930 − <1935	0.070	0.250	0.070	0.250	0.000	0.877
1935 − <1940	0.070	0.250	0.070	0.260	0.000	0.539
1940 − <1945	0.080	0.280	0.080	0.270	0.000	0.648
1945 − <1950	0.130	0.330	0.130	0.330	0.000	0.869
1950 − <1955	0.150	0.350	0.140	0.350	0.000	0.690
1955 − <1960	0.140	0.340	0.140	0.350	0.000	0.734
1960 − <1965	0.080	0.280	0.080	0.270	0.000	0.630
1965 − <1970	0.040	0.200	0.040	0.200	0.000	0.416
1970 − <1975	0.020	0.120	0.020	0.120	0.000	0.949
1975 − <1980	0.000	0.050	0.000	0.040	0.000	0.479
Job characteristics[a]						
Employee	0.670	0.470	0.670	0.470	0.000	0.740
Not employed	0.330	0.470	0.330	0.470	0.000	0.740
Academic job	0.140	0.350	0.140	0.350	0.010	0.358
Managerial job	0.050	0.220	0.050	0.210	0.000	0.384
Other	0.480	0.500	0.480	0.500	-0.010	0.492
No job	0.330	0.470	0.330	0.470	0.000	0.727
House characteristics[a]						
Detached SFH	0.030	0.160	0.030	0.180	0.000	0.072
Apartment	0.200	0.400	0.210	0.400	-0.010	0.361
Row house SFH	0.760	0.430	0.750	0.430	0.010	0.123
Constructed prior to 1945	0.370	0.480	0.380	0.480	0.000	0.735
Constructed between 1945 1979	0.520	0.500	0.520	0.500	0.000	0.815
Constructed in 1980 or later	0.110	0.310	0.100	0.300	0.000	0.356
1 or 2 rooms	0.030	0.170	0.030	0.170	0.000	0.784
3 or 4 rooms	0.350	0.480	0.370	0.480	-0.010	0.084
5 or 6 rooms	0.620	0.490	0.600	0.490	0.010	0.073
Income and expenditure[a]						
Annual net income	57,460	21,000	57,040	20,510	420	0.192
Annual net income squared	3.74e+09	3.00e+09	3.67e+09	2.93e+09	6.87e+07	0.138
Expenditure	40,108.61	14,669.42	43,590.70	1,5501.77	-3482.09	<0.0001
Basic goods	0.380	0.100	0.360	0.120	0.020	<0.0001
Housing	0.300	0.100	0.340	0.110	-0.040	<0.0001
Recreation	0.290	0.130	0.270	0.170	0.010	<0.0001
Alcohol and tobacco	0.040	0.040	0.030	0.030	0.010	<0.0001
Household characteristics[a]						

[a] Based on 8,193 renting and 8,193 owner-occupied consumers

Chapter 4

Rent control benefits and housing demand

4.1 Introduction

In many countries price schedules control the social housing market in order to guarantee access to housing for low-income households or to prevent extreme price rises.[1] Price controls set the price of housing below the market price, which leads to many different distortions in the housing market.[2] Previous studies found a negative relation between the amount of rent control and the probability of moving house.[3] These estimates are not fully informative about the size of the distortion for the demand for houses in the non-controlled

[1] In Europe various pricing schemes exist. The price ceiling might depend on construction costs (Austria, Denmark, France), income of the tenant (Germany, Netherlands, UK (England, Ireland)), negotiations between landlords and tenants (Sweden), local or central authorities decision or a combination of them (Scanlon and Whitehead, 2007, p. 16).

[2] Price controls lead to an inefficient allocation of housing (Glaeser and Luttmer, 2003) and it reduces the consumer surplus (Bulow and Klemperer, 2012). Furthermore, intertemporal consumption of housing services is affected as higher rent control leads to a lower probability of moving houses (Munch and Svarer, 2002; Simmons-Mosley and Malpezzi, 2006). Finally, rent control also affects the labor market through its influences on matching between employers and employees. Rent-controlled tenants are less likely to move out of their region for a job and more likely to accept jobs within their own region (Svarer et al., 2005).

[3] Empirical evidence from New York indicates that rent-controlled households exhibit lower overall mobility rates. The durations of tenancy is longer in the rent-controlled sector and mobility rates are lower (Gyourko and Linneman, 1989; Ault et al., 1994; Nagy, 1995; Simmons-Mosley and Malpezzi, 2006). A similar conclusion for Denmark is reached by Munch and Svarer (2002). They find that the durations of tenancy for a typical household is six years longer if the benefits of rent control are within the highest ten percent of rent-control benefits compared to the ten percent lowest.

sector, because tenants do not lose their entitlements to rent-control benefits if they move within the rent-controlled housing sector. Hence, it is likely that rent control is less distortive for transitions within the rent-controlled sector, whereas the distortion may be even more severe for transitions between both sectors. So far, no study of rent control has distinguished between the controlled and non-controlled segments of the housing market as a destination of the household's transition.

This chapter analyzes the effect of rent control on the transition by households from the controlled social housing sector to either of both destinations. Both transitions within the rent-controlled housing sector (the within transition) and transitions from the rent-controlled housing sector to the non-controlled sector (the between transition) are considered. For both types of transitions the probability that a household moves house is inversely related to the amount of rent control.

Two different forms of rent seeking are introduced that give rise to both transitions. First, tenants in rent-controlled accommodation might be less likely to move to non-controlled housing, because they want to retain the financial benefits of rent control. I will refer to this as 'rent-keeping behavior'. Second, households may increase the benefits of rent control accruing to them by transitioning within the rent-controlled housing sector. This will be denoted by 'rent seeking behavior'. For both the within transition and the between transition there is a negative effect of rent control on the probability to move house.

The empirical analysis is based on administrative information collected from Dutch households over the period 2006-2008. About one third of the housing stock in the Netherlands consists of rent-controlled social housing. Rents are regulated uniformly, which ensures that the controlled rent level is exogenous from local housing market characteristics. The measure of rent control is the controlled rent divided by the house value. The rich nature of the dataset enables us to control for confounding factors such as household composition, labor market position and local housing market characteristics. The panel dimension enables us to control for unobserved heterogeneity, which

is important as households with innate low mobility may self-select into controlled social housing.

The estimates indicate that the effect of rent control on the probability of transition is different for both destinations. With respect to the between transition only the high-income households exhibit a decreased transition rate to the non-controlled housing sector in a reaction to tighter rent controls. For the within transition all households respond to higher rent-control stringency through a decreased probability of transition. These estimates indicate that rent control has a substantial effect on demand for controlled housing. By contrast, the spillover effect on uncontrolled housing is relatively modest, which can be explained by a reduced financial attainability for the low-income households in the non-controlled sector. In other words, the negative relationship between rent control and the probability of moving is driven mainly by the decreased transition within the rent-controlled housing sector. From this it is concluded that rent control induces rent seeking behavior of Dutch households, but that rent keeping behavior is limited.

The remainder of this chapter is organized as follows. This section is followed by an explanation in section 4.2 of how rent control influences transitions from and within the rent-controlled housing sector. Section 4.3 describes the data. Section 4.4 presents evidence on the relationship between rent control and household mobility. Section 4.5 explains the estimation strategy. Estimation results are presented in section 4.6 and section 4.7 concludes.

4.2 Economic framework

Based on the economic framework below four hypotheses are formulated. The intuition behind this framework is that rent control changes demand for housing in both the controlled and non-controlled segments. However, if market rents are too high, low-income households cannot afford to purchase a house in the uncontrolled sector. Consequently, changes in rent-control benefits will not influence their transition behavior from the rent-controlled housing sector.

Housing is assigned a controlled rent r based on the physical characteristics of the house (h). The market rent p is assumed to be a function of h and the

access it provides to the local amenity level $A(\cdot)$. The level of local amenities is defined by its location in the housing market, L, and it is measured in utility terms. Thus, the rent ceiling and market rent are defined respectively as:

$$r = f(h)$$
$$p = g(h) + A(L)$$

The physical characteristics of the house and local amenity level are defined such that they are always positive, $h, A(\cdot) > 0$. Furthermore, it is assumed that the controlled rent and market rent are increasing in housing quality, although the shape of this positive relationship is not defined: $\frac{\partial r}{\partial h} > 0$, $\frac{\partial p}{\partial h} > 0$. Finally, market rents are increasing in the level of local amenities provided $\frac{\partial p}{\partial A} > 0$.[4]

Household i earns income y_i. I assume that landlords of uncontrolled housing impose financial constraints. In order to rent uncontrolled housing the tenant's income must exceed a certain threshold γ, that is based on the market rent: $\gamma = \frac{y_i}{g(h^f, L^f)}$.[5] Next, define rent-control benefits b as

$$b(h, L) = p(h, L) - r(h)$$

Households derive utility from housing services, amenities provided by the local housing market and consumption. For simplicity it is assumed that households are risk neutral, and that utility is additive separable. Let the utility derived from inhabiting a dwelling of quality h be $H(h)$, and define the utility derived from amenities in local labor market L as $A(L)$. Superscript u and s indicate uncontrolled and controlled social housing. Households that live in uncontrolled housing have utility $U^u(h, L)$ and households in controlled social housing will have utility $U^c(h, L)$:

$$U^u(h, L) = H(h) + A(L) + y - p$$
$$U^c(h, L) = H(h) + A(L) + y - r$$

[4]Note that this relation implies perfect pricing of local amenities in the uncontrolled market as for any house of quality $\tilde{h}$ the difference in market price equals the difference in utility derived from the local amenities: $p(\tilde{h}, L_i) - p(\tilde{h}, L_j) = A(L_i) - A(l_j)$.

[5]For owner-occupied housing, these financial constraints reflect income requirements set by mortgage providers.

Note that, ceteris paribus, controlled households have higher utility levels than households living in uncontrolled housing.

Households receive a costless house offer. The house offer may be for an uncontrolled house λ^u (drawn from a bivariate Poisson-distribution $\lambda^u = G^u(h, L)$) or for a rent-controlled house λ^c (drawn from a Poisson-distribution $\lambda^c = G^c(h, L)$). The house that is offered is exogenous to the characteristics of the household. Because households observe the characteristics h and location L of the house they are offered, they are able to determine the market rent of the house offer and therefore the value of the offer (in terms of their own utility).

If households in rent-controlled housing accept a house offer for an uncontrolled house λ^u, they will incur moving costs m. After moving their utility is $U(\lambda^u)$. Similarly, if they decide to move from one controlled house to another controlled house, their utility equals $U(\lambda^c)$.

$$\begin{aligned} U(\lambda^u) =& H(h^u) + A(L^u) + y - g(h^u, L^u) - m \\ U(\lambda^c) =& H(h^c) + A(L^c) + y - f(h^c) - m \end{aligned}$$

Let a transition within the rent controlled sector be denoted as $t^w = 1$ and a transition from the rent-controlled housing sector as $t^b = 1$, where superscripts w and b refer to within transfers and between transfers respectively. Households in rent-controlled housing who receive an offer for uncontrolled housing will move if the utility from the house offer minus moving costs exceeds the utility of the current dwelling. Thus, the value of t^b is given by equation (4.1), which shows that a household will move if two conditions are met. First, the change in utility from house characteristics minus the change in housing costs (measured in market rents) should exceed the benefits from rent control of the current house plus moving costs. Second, the financial threshold attached to the uncontrolled house offers should not be binding.

$$t_i^b = \begin{cases} 1 & \text{if } H(h^u) - H(h_i) + A(L^u) - A(L_i) - g(h^u, L^u) \\ & \geq b(h_i, L_i) + m \text{ and } y_i / g(h^u, L^u) > \gamma \\ 0 & \text{otherwise} \end{cases} \tag{4.1}$$

Second, households in controlled social housing, who receive an offer for controlled social housing, will move if the utility derived from this offer minus the moving costs $U(\lambda^w) - m$ exceeds the utility of the current dwelling U^c. Rearranging and using $b = p - r$ gives

$$t_i^w = \begin{cases} 1 & \text{if } H(h^c) - H(h_i) + A(L^u) - A(L_i) - g(h^u, L^u) + g(h_i, L_i) + \\ & b(h^c, L^c) \geq b(h_i, L_i) + m \\ 0 & \text{otherwise} \end{cases} \tag{4.2}$$

A household will move within the rent-controlled housing sector if the change in utility attributed to house characteristics minus the change in housing costs (in terms of market rents) exceeds the change in benefits from rent control of the current house plus moving costs. This condition is similar to the one that describes the transition from the rent-controlled to uncontrolled housing, although there are important differences.

The first difference is that financial constraints only affect transitions out of the rent-controlled housing sector, but they do not restrict transitions within the rent-controlled housing sector. Second, even in the absence of financial constraints ($y_i/g(h^u, L^u) > \gamma$), households are more likely to move within the rent-controlled housing sector than from the rent-controlled housing sector. To see this, note that if $h^c = h^u$ and $L^c = L^u$, then $P(t_i^w = 1) > P(t_i^f = 1)$.

Equations (4.1) and (4.2) are used to derive hypotheses about transition behavior from and within the rent-controlled housing sector and the size of rent control benefits. Equation (4.1) implies that, ceteris paribus, an increase in rent-control benefits $b(h_i, L_i)$ reduces the number of transitions from the rent-controlled housing sector.

Hypothesis 1: Transitions from the rent-controlled housing sector are decreasing in rent-control benefits

Provided that $Y_i/g(h^f, L^f) > \gamma$, an increase in rent-control benefits $b(h_i, L_i)$ decreases the probability that the first inequality in equation (4.1) *holds. Ceteris paribus, this reduces the probability that the utility of the (uncontrolled) house offer net of moving costs exceeds the utility from remaining in the current house.*

The same line of reasoning holds for transitions within the rent-controlled housing sector.

Hypothesis 2: Transitions within the rent-controlled housing sector are decreasing in rent-control benefits
An increase in rent-control benefits $b(h_i, L_i)$ decreases the probability that the inequality in equation (4.2) *holds. Ceteris paribus, this reduces the probability that the utility of the (rent-controlled) house offer net of moving costs exceeds the utility from living in the current house.*

The key difference between equations (4.1) and (4.2) is that an additional income restriction is imposed. In order to move from the rent-controlled housing sector, the uncontrolled house offer should be affordable ($y_i/g(h^u, L^u) > \gamma$). Suppose that for household i this restriction does not hold. In this case, a change in rent-control benefits $b(h_i, L_i)$ does not affect the probability of transition to the uncontrolled housing sector, as the household cannot move to the offered house. This leads to the following hypotheses:

Hypothesis 3: Transitions out of the rent-controlled housing sector of financially constrained households are not affected by rent-control benefits
Consider a household that receives a house offer λ^u for uncontrolled housing. The household is financially constrained, $y_i/g(h^u, L^u) \leq \gamma$. Ceteris paribus, a change in rent-control benefits does not change their probability of accepting the uncontrolled house offer, as the second condition in equation (4.1) *is not met and does not depend on rent control.*

Hypothesis 4: Transitions within the rent-controlled housing sector of financially constrained households are affected by rent-control benefits
Consider a household that receives a house offer λ^c for controlled social housing. In this case, an increase in rent-control benefits decreases the probability they will accept the controlled house offer, as it increases the RHS of equation (4.2).

4.3 Data

Empirical evidence is based on data from various administrative datasets that were provided by Statistics Netherlands over the years 2006, 2007 and 2008. The starting point is a database recording all employees (*SSB Banen*), self-employed (*SSB Zelfstandigen*) and households on rent support (*Raamwerk huurtoeslag*, provided by the Ministry of Internal Affairs) in 2006, 2007 and 2008. These data sets contain information on labor market status, and they were matched with their administrative records of municipalities (*Gemeentelijke Basis Administratie*), which allowed us to observe the address of the household as well as additional administrative information on household composition. I tracked transitions of individual households across different addresses over the three years. As employees may not be the only income source for the household, I obtained household income from the dataset *Integraal Inkomensbestand*.

To obtain a measure of the type of transition, the data sets were matched with the *WRG woonruimteregister verrijkt* which contains information on the dwelling type and the value of all houses in the Netherlands. Additional local housing market characteristics were derived from the *Volkshuisvesting InformatieSysteem* (VoIS) that is used for policy-making and monitoring by the Dutch Ministry of Internal Affairs. These additional variables provided the size of the housing stock and the share of social rental housing within the municipality.

Because of computational limitations, a random sample of five percent of the population of (self-) employed households and households on rent-support has been selected. Observations were only included in the analysis if the head of household was older than 30, and had complete records on household composition and address. For each household only the head of the household was selected. The sample contains 91,703 households that were observed over a maximum of three years. It gives us an unbalanced panel of 234,020 observations, that will be used for the empirical analyses.[6]

[6]Tenants who rent from private agents were omitted from the analysis, as they are more likely to rent uncontrolled housing at uncontrolled rents. A household is considered rent controlled if it rents from a housing agency and the value of the house is less than 300 thousand euro. Around

Table 4.1: Summary statistics

	mean	sd	av(<=p5)[a]	av(>=p95)[b]
General statistics[c]				
Transition dummy (1 if within transition or between transition)	5.25			
Within transitions (1 if within transition)	3.61			
Between transitions (1 if between transition)	1.80			
Household summary statistics[c]				
Marginal price of rent-controlled housing[d]	270.17	83.93	137.73	494.20
Market marginal price of (rent-controlled) housing[e]	433.93	56.66	349.96	587.38
House value (in 100,000 euro)	1.56	0.48	0.77	2.79
Income of households in first income decile Y_{117} (in 10,000 euro)	0.95	0.39	-0.16	1.16
Income of households in second income decile $Y_{117-129}$ (in 10,000 euro)	1.23	0.03	1.17	1.28
Income of households in third income decile $Y_{129-140}$ (in 10,000 euro)	1.34	0.03	1.29	1.39
Income of households in fourth income decile $Y_{140-150}$ (in 10,000 euro)	1.44	0.03	1.40	1.49
Income of households in fifth income decile $Y_{150-161}$ (in 10,000 euro)	1.55	0.03	1.50	1.60
Income of households in sixth income decile $Y_{161-175}$ (in 10,000 euro)	1.67	0.04	1.61	1.74
Income of households in seventh income decile $Y_{175-194}$ (in 10,000 euro)	1.83	0.05	1.75	1.93
Income of households in eight income decile $Y_{194-222}$ (in 10,000 euro)	2.07	0.08	1.94	2.21
Income of households in ninth income decile $Y_{222-267}$ (in 10,000 euro)	2.42	0.13	2.22	2.65
Income of households in tenth income decile Y_{267} (in 10,000 euro)	3.42	1.52	2.68	7.23
Age of head of household is between 30 up to 40 dummy (1 if true)	0.21			
Age of head of household is between 40 up to 50 dummy (1 if true)	0.27			
Age of head of household is between 50 up to 65 dummy (1 if true)	0.30			
Age of head of household is between 65 up to 75 dummy (1 if true)	0.10			
Age of head of household is 75 or higher (1 if true)	0.12			
Marital status dummy (1 if married)	0.33			
Multiple adults dummy (1 if there are multiple adults in the household)	0.38			
Children dummy (1 if there are children in the household)	0.37			
Nojob dummy (1 if without job)	0.36			
Self-employed dummy (1 if self-employed)	0.06			
Fixed contract dummy (1 if fixed contract type)	0.54			
Fulltime contract dummy (1 if fulltime contract)	0.40			
Fulltime and fixed contract dummy (1 if fulltime and fixed contract)	0.36			
Municipality summary statistics[f]				
Size of municipalities in sample (number of observations within municipality)	1,338.18	2,312.26	164.00	8,437.55
Size of housing stock (in units)	15,888.55	28,804.71	2,151.82	100,690.00
Size of rental housing stock (in units)	5,228.67	13,332.34	400.35	41,906.45
Percentage of housing stock that is rent-controlled (in percentages)	27.05	7.59	13.05	44.16
Median value owner-occupied housing stock (in 100,000 euro)	2.42	0.57	1.47	3.88
District summary statistics[g]				
Size of district in sample (number of observations within district)	321.29	418.24	11.37	1,707.91
Median value owner-occupied housing stock (in 100,000 euro)	1.99	0.69	0.98	3.92
Median value rent-controlled housing stock (in 100,000 euro)	1.51	0.38	0.84	2.38
Percentage of housing stock that is rent-controlled (in percentages)	0.36	0.18	0.09	0.79
Median income of employed households (in 1000 euro)	22.43	2.94	17.28	30.20
Neighborhood summary statistics[h]				
Size of neighborhood in sample (number of observations within neighborhood)	96.97	105.98	3.39	406.85
Median value owner-occupied housing stock (in 100,000 euro)	1.89	0.80	0.92	3.93
Median value rent-controlled housing stock (in 100,000 euro)	1.55	0.52	0.81	2.92
Percentage of housing stock that is rent-controlled (in percentages)	0.45	0.23	0.07	0.95
Median income of employed households (in 1000 euro)	21.95	3.66	16.15	30.47

[a] *Average value of the 0-5th percentile*
[b] *Average value of the 95-100th percentile*
[c] *Based on 234,020 observations for 91,703 households*
[d] *Measure of rent-control stringency defined as* $\frac{\textit{Monthly controlled rent}}{\textit{House value}/100{,}000}$. *Lower values imply larger rent-control benefits.*
[e] *Calibrated measure of market marginal price of housing defined as* $\frac{\textit{monthly market rent}}{\textit{House value}/100{,}000}$. *monthly market rent is defined as* $(4000 + 0.031(\textit{House value}))/12$.
[f] *433 unique municipality observations*
[g] *665 unique district observations*
[h] *2381 unique neighborhood observations*

Summary statistics for all variables used in the empirical analysis are provided in Table 4.1. The measures of within transitions and between transitions are similarly defined. The measure of within transitions equals 1 if the first transition in a particular year is to rent-controlled housing and zero elsewhere. I focus on the first transition within the calendar year, as only a small number of households move more than once in the same calender year. Similarly, the measure of between transitions equals one if the first transition in a particular year is to non-controlled housing and zero elsewhere. Using these measures for moves and their directions, the overall probability that a household decides to move equals 5.25 percent. The transition rate to non-controlled housing is lower than the transition rate to rent-controlled housing. 3.61 percent of transitions are within the rent-controlled housing sector and 1.8 percent are between transitions.

The average house value of rent-controlled tenants is 156,000 euro. Average standardized income equals 18.000 euro, which is far below the median income of 33,000 euro. This result is not surprising, given that I have selected households living in rent-controlled housing. Around one-third of the sample include a married couple, and around 37 percent of the households have children. In around 38 percent of the households multiple adults are living, indicating that the majority of households have only one adult. 53 percent of households are on rent support. 36 percent of the households do not have a wage earner residing, 54 percent of households are on fixed contracts. 40 percent of the households sampled have a fulltime contract, for 36 percent this is fixed and fulltime. Almost six percent of the population are self-employed.

The set of local housing market characteristics consists of the median house value for every municipality, district and neighborhood, where districts and neighborhoods are classified by Statistics Netherlands. In total I observe all 433 municipalities, 2099 districts and 6074 neighborhoods in 2008. However, data was not drawn from all districts and neighborhoods, because not all districts and neighborhoods contain (controlled) rental housing. All 433 municipalities are sampled. The average number of observations in a municipality

three percent of the total housing stock managed by housing agencies are non-controlled housing(CSED, 2010).

equals 1338. Furthermore, the sample contains 665 districts (339 observations on average) and 2381 neighborhoods (98 observations on average). All housing market statistics at the municipality, district and neighborhood level have been computed using the local population for each spatial region.

Measuring rent-control benefits

Next, I detail the construction of the measure of rent-control benefits. The data set *WRG woonruimteregister verrijkt* contains a variable that measures the value of the house if it were to be sold freely at the market (in Dutch: *WOZ-waarde*). The value of the house is assessed annually for both owner-occupied and rental housing. The assessment is based on the characteristics of the house and the selling price of comparable housing in the neighborhood that has been sold in the months prior to the month of assessment.[7] The data set contains only rents for tenants who are on rent support. The individual rent is proxied by the median rent of households on rent support within the neighborhood. This is a valid approach, because the rent support program is very generous, and therefore households on rent support are located across the entire spectrum of regulated housing. The stock of controlled social housing is almost homogeneous within neighborhoods and regulated rents vary little within neighborhoods.[8]

The individual benefit of living in rent-controlled housing is computed as the median rent in a neighborhood j (r_j) divided by the value of the house of the tenant (V_i), which is divided by €100,000. This measure of regulation benefits equals the marginal price of rent-controlled housing in the case that a house with value of €100,000 provides one unit of housing services. This approach is similar to the one undertaken by Munch and Svarer (2002) although these authors divide by the market rent which is assumed to be a constant fraction of the house value.[9]

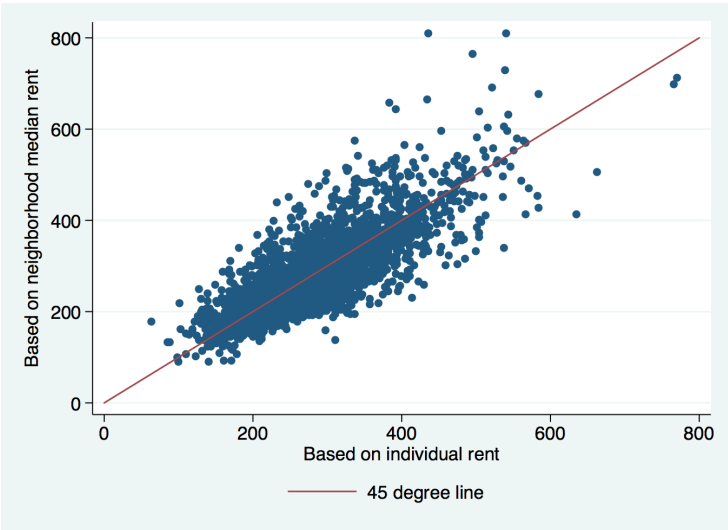
[7] Owners of housing pay taxes over the value of the house, and can comply if, according to them, the value of the house is wrongly assessed.

[8] On average about 75 percent of the observed controlled rents within a neighborhood are within 20 percent of the median value.

[9] In Denmark the yearly market rent was equal to eight percent of the house value (Munch and Svarer, 2002). If the market rent is a fraction of the house value, both methods give statistically equal results.

Figure 4.1 shows the marginal price of rent-controlled housing based on the median rent against the marginal price of rent-controlled housing based on the individual rent for 5000 tenants who receive rent support. It illustrates that both measures give similar results. A bivariate regression of the real marginal price of rent-controlled housing on the marginal price of rent-controlled housing based on the median rent yields a coefficient equal to 0.82 and is significant at the one percent level (the robust standard error equals 0.0189 based on 141.861 observations). The R^2 equals 60.7 percent.

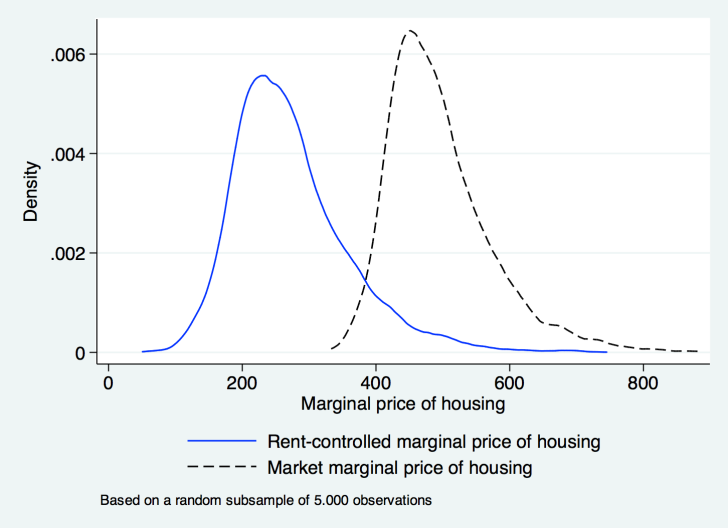
Figure 4.1: Median and observed marginal price of rent-controlled housing



The graph is based on a random subsample of 5,000 observations as Statistics Netherlands does not allow the exportation of individual observations. Therefore the house value is adjusted with a random jitter between -2,000 and 2,000 euro. As the adjustment is small compared to the house value, it does not affect Figure 4.1.

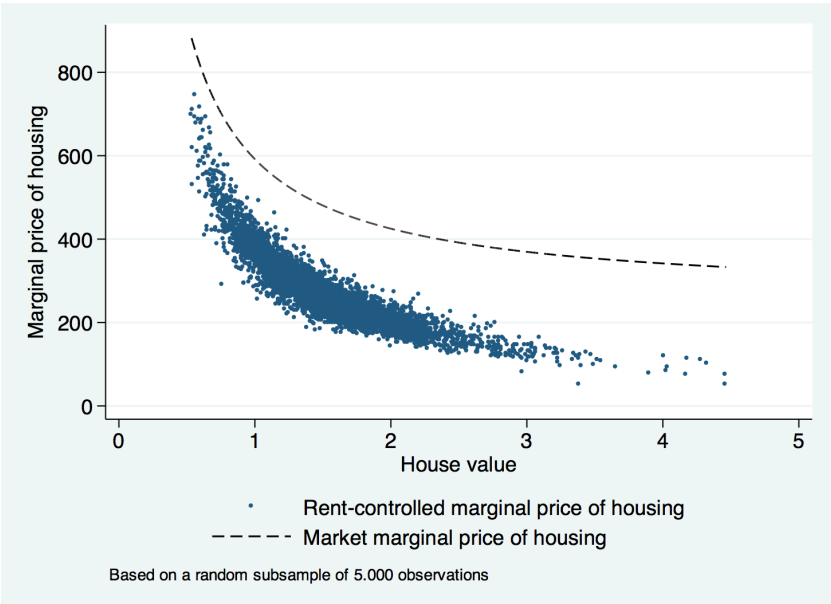
Figure 4.2 shows kernel density estimates of the observed measure of rent control benefit (marginal price of rent-controlled housing) and the market rent of rent-controlled housing (market marginal price of housing). The market marginal price of housing has been calculated by dividing the market rent by the house value measured in 100,000 euro. Here, I take as market rent the user-costs of owner-occupied housing, which has been established by Koning et al. (2006) to equal to 3,000 euro plus 3.1 percent of the value of the house annually. The left panel shows that the distribution of the marginal price of

Figure 4.2: Kernel density plot



The graph is based on a random subsample of 5,000 observations as Statistics Netherlands does not allow the exportation of individual observations. Therefore the house value is adjusted with a random jitter between -2,000 and 2,000 euro. As the adjustment is small compared to the house value, it does not affect Figure 4.2. The graph is representative for the full, non-jittered sample which is used in the regression analysis.

Figure 4.3: Marginal prices of rent-controlled housing and house value



The graph is based on a random subsample of 5,000 observations as Statistics Netherlands does not allow the exportation of individual observations. Therefore the house value is adjusted with a random jitter between -2,000 and 2,000 euro. As the adjustment is small compared to the house value, it does not affect the pattern in Figure 4.3. The graph is representative for the full, non-jittered sample which is used in the regression analysis.

rent-controlled housing is wider and to the left of the market marginal price of housing. Nearly all observations of the marginal price of rent-controlled housing are within 75 and 500 euro per unit of housing services, with a peak at around 200. By contrast, nearly all observations of the market marginal price of housing, are within 300 and 600 euro per unit of housing services, with a peak at 400.

Figure 4.3 shows the difference between the observed marginal price of rent-controlled housing and the calibrated market marginal price of housing. Each observed marginal price of rent-controlled housing is presented as a dot, while the market price of rent-controlled housing is indicated by the black line. The figure shows that both the marginal prices of housing are convex to the origin in house value. Moreover, the difference between the market marginal price of rent-controlled housing and the rent-controlled marginal price of rent-controlled housing is increasing in house value. Tenants of high-valued housing receive more rent-control benefits than tenants of low-valued housing. For a very small minority of observations the marginal price of rent-controlled housing exceeds the market price of housing.

4.4 Rent control and household mobility

Next, I focus on household transitions and relate it to the amount of rent control. Figure 4.4 shows that the probability of moving from the rent-controlled housing sector is smaller than the probability of moving within this housing sector for all levels of rent-control benefits. It seems that transitions from the rent-controlled housing sector are barely related to the marginal price of rent-controlled housing. By contrast, households that pay a high marginal price for rent-controlled housing (receiving low rent-control benefits) move more often within the rent-controlled housing sector than households that pay a low marginal price of rent-controlled housing (receiving a higher level of rent-control benefits). This is important preliminary evidence that both types of transition are fundamentally different.

Figure 4.5 indicates that both types of transition are affected differently by income. First, the probability of moving from the rent-controlled housing

sector is increasing in income, but there is no evident relationship between income and transitions within the rent-controlled housing sector. This suggests that financial constraints play a minor role in explaining transitions within the rent-controlled housing sector, but that they are important for transitions out of the rent-controlled housing sector. This is exacerbated by the finding that households with annual standardized income below 25,000 euro move more often within the rent-controlled housing sector, whereas households with a higher income are more likely to move to uncontrolled housing.

In sum, Figures 4.4 and 4.5 provide crude evidence in favor of some of the listed hypotheses. Figure 4.4 shows that the relationship between transitions from the rent-controlled housing sector and the marginal price of rent-controlled housing is unclear. At first sight, rent control benefits do not appear to influence transitions out of the rent-controlled housing sector. The data provides no evidence in favor of Hypothesis 1 that transitions from the rent-controlled sector are decreasing in rent-control benefits (increasing in the marginal price of rent-controlled housing). Figure 4.4 also shows that the probability of transition within the rent-controlled housing sector is increasing in the marginal price of rent-controlled housing, providing some evidence in support of Hypothesis 2.

Finally, Figure 4.5 shows that the probability of a transition out of the rent-controlled housing is strongly increasing in income. This indicates that affordability of housing is important for transitions from the rent-controlled housing sector, which provides evidence supporting Hypothesis 3. By contrast, it also shows that the effect of income on the probability of moving to a house within the rent-controlled sector is weak. At best, it is slightly decreasing, which can be explained by special arrangements for particular low-income groups. This evidence is conflicting with Hypothesis 4. To further investigate the hypotheses, I turn to regression analysis.

Figure 4.4: Transitions by destination and the rent-controlled marginal price of housing

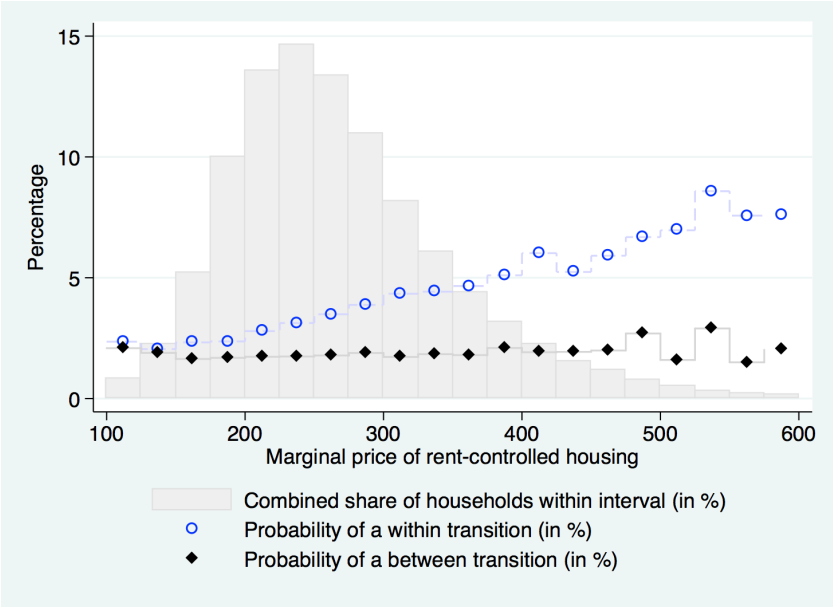
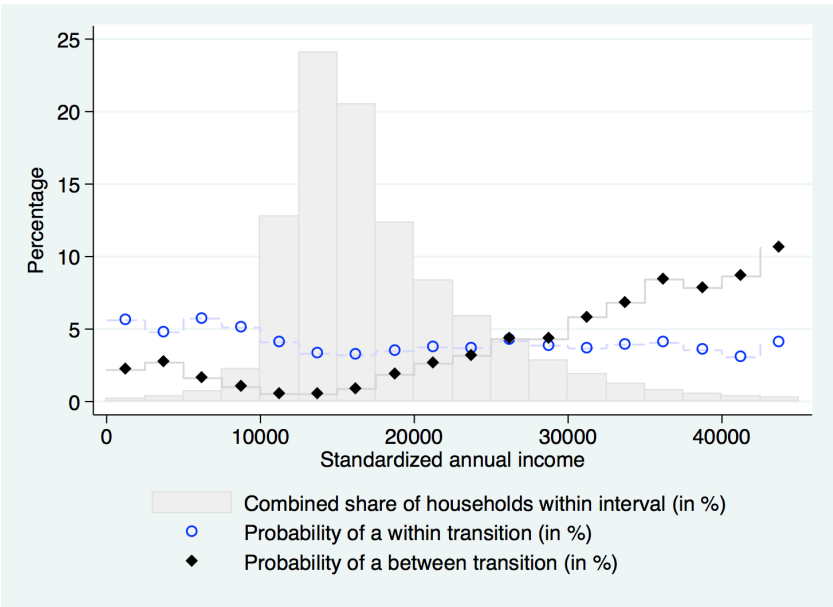


Figure 4.5: Transitions by destination and income



4.5 Empirical model

To investigate the three hypotheses more carefully three Linear Probability Models are specified. First, in order to compare the results for the Netherlands with those for the US and Denmark, I estimate how rent-control stringency influences the probability of moving. At this stage the destination of the move is neglected. The specification is

$$m_{it} = \beta_0 + \sum_{k=1}^{10} \beta_k r * Y_{k_{it}} + \sum_{l=1}^{9} \gamma_l Y_{l_{it}} + X_{it}\eta + \delta_t + a_i + \varepsilon_{it} \tag{4.3}$$
$$i = 1, \ldots, N; \quad t = 1, \ldots, T_i$$

where the dependent variable m indicates household moves; subscripts i and t refer to the i-th household and t-th year, respectively. m is explained by rent-control benefits r, where I allow the effect of rent-control on mobility to differ across ten income groups ($r * Y_k$) as in equation (4.3). Additional controls for household, job and local housing market effects are included in X. The vector X consists of variables identifying features of households, their labor market positions and the local housing market to control for confounding factors influencing housing demand, affordability and the offer rate respectively.[10] Time dummies δ_t are also included. Finally, α_i is an individual unobserved fixed effect and ε_{it} is an i.i.d. error term.

Next, I control for the destination of the move and estimate two additional empirical specifications, see equation (4.4). Both equations have different dependent variables, but their right-hand-side (RHS) variables are identical to those in equation (4.3). The first equation is for $z = b$, where b represents the between transition of the household from the controlled to the non-controlled sector. In the second equation $z = w$, where w refers to the transition of house-

[10] A list of included variables is found in Table 4.1. Many of these characteristics vary very little over the sample period. As a result, coefficients on these regressors are identified by a small group who switch status. For those that do not switch status, the effect ends up in the individual fixed effect α_i^z. Therefore, the fact that the almost time-invariant variables are identified for a small group of households does not influence the parameter estimates. In particular, as the measure of rent-control benefits is continuous, its coefficient is identified for all households in the estimation sample.

holds within the controlled sector. The specifications are

$$m_{it}^{z} = \beta_0^z + \sum_{k=1}^{10} \beta_k^z r * Y_{k_{it}} + \sum_{l=1}^{9} \gamma_l^z Y_{l_{it}} + X_{it}\eta^z + \delta_t^z + a_i^z + \varepsilon_{it}^z \tag{4.4}$$
$$z = b, w; \quad i = 1, \ldots, N; \quad t = 1, \ldots, T_i$$

For the between transition, the dependent variable m_{it}^b is an indicator that becomes one if the household moves from controlled to non-controlled housing. Similarly, for the within transition m_{it}^w is one if the household moves from controlled social housing to controlled social housing. Estimation of equation (4.4) allows us to test the hypotheses. Hypothesis 1 and Hypothesis 2 are confirmed if the estimated coefficients on rent-control stringency (β_k^z) are positive. In order to test whether rent-control benefits decrease transitions between and within the rent-controlled housing sector, I also compute the average marginal effect of a change in rent-control stringency.[11]

Hypothesis 3 states that transitions out of the rent-controlled housing sector of financially constrained households are not affected by rent-control benefits. As low-income households are more likely to be financially constrained, I would expect β_k^b to be small and insignificant if k is a low number.

Finally, Hypothesis 4 states that transitions within the rent-controlled housing sector low-income households are affected by rent-control benefits as financial constraints are absent. According to this hypothesis, β_k^w is positive and significant for all income deciles, also for those including low-income households.

Equation (4.4) is estimated as a Linear Probability Model (LPM). Some studies have made use of duration models in which competing risks have been estimated. Also, conditional fixed effects logit models have been used. Duration models can be used to control for left and right censoring of the data and to estimate competing risks models. In this chapter duration models are not used as the period of observation is very small. Estimators have been developed to estimate the contribution of individual specific effects to duration time in multiple spell data.[12] Although the LPM estimation procedure does

[11] As there are ten parameters I test whether $\zeta = \sum^k \beta_k^z / 10 = 0$.

[12] However, this estimator is not (yet) available in the remote access environment of Statistics Netherlands.

not control for duration explicitly, it does control for 'innate immobility' of the worker (by estimating the unobserved fixed effects) which are expected to be correlated with duration in the house.

Conditional fixed effects models have the advantage that the prediction of the dependent variable is between zero and one, whereas an LPM might lead to under- or overshooting. A drawback of logit models is that the parameter estimate on an interaction term does not equal the marginal effect of that variable and might even be of opposite sign (Ai and Norton, 2003, p.123). In addition, the conditional fixed effects model is identified only for workers who move. This might result in an estimation sample that is reduced in size considerably. In LPM models the parameter estimate equals the marginal effect and it can be estimated on a larger sample as only those who move to competing housing drop out the estimation sample. Results using the conditional fixed effects logit estimator are presented in section 4.A.

4.6 Results

This section discusses the estimated coefficients and their relationship with Hypotheses 1-4. First, we present estimates of equation (4.3) is estimated to determine whether estimation results for the overall transition rate are similar to those found in previous research. The estimated coefficients in Table 4.2 imply that the higher the rent-control benefits, the less likely households are to move. These results are consistent with previous empirical work. The parameter of the average marginal effect equals 0.0291 and is significant at the one percent level. Thus, a one standard deviation increase in rent-control stringency decreases the probability of moving with 2.9 percentage points. As the average transition rate equals 5.25 percent (see Table 4.1), this effect is also economically significant. In addition, rent control has a stronger effect on mobility for high-income groups compared to low-income groups.

Furthermore, households in high-value housing move less often. For each 100,000 euro increase in house value, the probability of moving decreases by 4.8 percentage points. I also find that households in high-income districts and neighborhoods move less often. Each increase of the median income in

Table 4.2: LPM of probability to move

	Dependent variable: Transition=1
Interaction terms (normalized) rent control stringency r and income group dummies [a,b]	
$r * Y_{117}$	0.0196***
	(0.0067)
$r * Y_{117-129}$	0.0185***
	(0.0066)
$r * Y_{129-140}$	0.0159**
	(0.0067)
$r * Y_{140-150}$	0.0153**
	(0.0067)
$r * Y_{150-161}$	0.0175***
	(0.0067)
$r * Y_{161-175}$	0.0212***
	(0.0068)
$r * Y_{175-194}$	0.0306***
	(0.0071)
$r * Y_{194-222}$	0.0350***
	(0.0074)
$r * Y_{222-267}$	0.0499***
	(0.0077)
$r * Y_{267}$	0.0676***
	(0.0086)
Income dummies. Base is household with annual income below 11,700 euro	
$Y_{117-129}$	0.0042
	(0.0108)
$Y_{129-140}$	0.0103
	(0.0121)
$Y_{140-150}$	0.0163
	(0.0131)
$Y_{150-161}$	0.0077
	(0.0137)
$Y_{161-175}$	0.0032
	(0.0144)
$Y_{175-194}$	-0.0139
	(0.0156)
$Y_{194-222}$	-0.0063
	(0.0169)
$Y_{222-267}$	-0.0131
	(0.0183)
Y_{267}	-0.0109
	(0.0216)
Household, house and local housing market characteristics[c]	
House value (in 100,000 euro)	-0.0482***
	(0.0150)
Median income in district (in 1,000 euro)	-0.0089*
	(0.0046)
Median income in neighborhood (in 1,000 euro)	-0.0179***
	(0.0031)
Observations	234,020
Number of households	91,703
R^2 (within)	0.024
F-test income dummies	$F_{(9, 91702)} = 0.72$
	Prob > F = 0.6871
F-test interaction terms of *r* with income dummies	$F_{(10, 91702)} = 8.67$***
	Prob > F = <0.0001
Average marginal effect of the interaction terms of *r* with the income dummies	0.0291 ***
	0.0063

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[a] *Interaction term where r is interacted with an income dummy Y_{A-B}. r measures rent control stringency and is defined as $\frac{\text{monthly controlled rent}}{\text{House value}/100{,}000}$. The mean of r equals 270 with standard deviation 84. Lower values of r imply larger rent-control benefits. Y_{A-B} is a dummy equal to one if income is greater than or equal to A and smaller than B, and is zero otherwise.*
[b] *The average marginal effect of rent control stringency -computed using the Delta method- equals 0.0291 *** and is significant at the 1 percent significance level with an standard error equal to 0.0063.*
[c] *Explanatory variables included but not shown: dummies for being on rent support, having multiple adults in the household, being married, having children, age group and indicating contract type (fixed, fulltime, fulltime and fixed or having no job), being self-employed and two year dummies. Median value of owner-occupied housing in the municipality, median house value and median house value of rent-controlled housing in the district and neighborhood. Percentage of rent-controlled housing in the district and neighborhood. Housing stock, rent-controlled housing stock and percentage of rent-controlled housing in the municipality. The inclusion of municipality dummies does not change estimated parameters.*

district by 1,000 euro decreases the probability of moving by 0.9 percentage points. This effect is even stronger at the neighborhood level. Here, each additional 1,000 euro increase in median income decreases the probability of moving by 1.8 percentage points. All three estimates indicate that households in attractive places move less often.

Next, columns one and two of Table 4.3 provide estimation results for transitions out of and within the rent-controlled housing sector separately. First, evidence is provided that rent-control benefits have a stronger effect on within transitions than on between transitions. The average marginal effect of the rent-controlled marginal price of housing on within transitions equals 0.0291 and is significant at the 1 percent level. A one standard deviation increase in the rent-controlled marginal price of housing increases the within transition rate by 2.9 percentage points. However, for between transitions this coefficient is 0.0009 and insignificant at the 10 percent level. These results provide evidence for Hypothesis 2, but not for Hypothesis 1.

Mixed evidence is found for Hypothesis 3. In line with the hypothesis, an one standard deviation decrease in the rent-controlled price of housing decreases the probability of a between transition by 2.7 percentage points for the tenth income decile.

However, a positive coefficient is found for households in the first four income deciles. The coefficients are statistically significant at the 5 percent level. Their economic significance is low: For the four lowest income groups, a one standard deviation increase in the rent-controlled marginal price of housing decreases the probability of a between transition by 0.5 percentage point. This is around one quarter of the effect on within transitions for the same income group.

I find that the probability of a within transition is increasing in the rent-controlled marginal price of housing. The lower are rent-control benefits, the more likely a household is to move house within the rent-controlled sector. moreover, this relationship is increasing in income. A one standard deviation increase in the rent-controlled marginal price of housing increases the probability of moving house within the controlled sector by 2.3 percentage points

Table 4.3: LPM of moving within and from the social housing sector

	Dependent variables: transition =1	
	Within	Between
Interaction terms (normalized) rent control stringency r and income group dummies [a,b]		
$r * Y_{117}$	0.0228***	-0.0050**
	(0.0066)	(0.0023)
$r * Y_{117-129}$	0.0217***	-0.0050**
	(0.0065)	(0.0021)
$r * Y_{129-140}$	0.0194***	-0.0049**
	(0.0066)	(0.0021)
$r * Y_{140-150}$	0.0190***	-0.0052**
	(0.0661)	(0.0022)
$r * Y_{150-161}$	0.0197***	-0.0035
	(0.0066)	(0.0023)
$r * Y_{161-175}$	0.0232***	-0.0029
	(0.0067)	(0.0024)
$r * Y_{175-194}$	0.0306***	0.0005
	(0.0069)	(0.0028)
$r * Y_{194-222}$	0.0368***	0.0001
	(0.0071)	(0.0033)
$r * Y_{222-267}$	0.0465***	0.0076*
	(0.0074)	(0.0039)
$r * Y_{267}$	0.0515***	0.0269***
	(0.0080)	(0.0054)
Income dummies. Base is household with annual income below 11,700 euro		
$Y_{117-129}$	0.0061	-0.0017
	(0.0104)	(0.0036)
$Y_{129-140}$	0.0130	-0.0035
	(0.0116)	(0.0045)
$Y_{140-150}$	0.0192	-0.0031
	(0.0125)	(0.0052)
$Y_{150-161}$	0.0152	-0.0080
	(0.0130)	(0.0057)
$Y_{161-175}$	0.0086	-0.0062
	(0.0136)	(0.0063)
$Y_{175-194}$	-0.0066	-0.0111
	(0.0146)	(0.0077)
$Y_{194-222}$	-0.0135	0.0019
	(0.0157)	(0.0094)
$Y_{222-267}$	-0.0223	0.0012
	(0.0167)	(0.0112)
Y_{267}	-0.0192	-0.0120
	(0.0190)	(0.0158)
Household, house and local housing market characteristics[c]		
House value (in 100,000 euro)	-0.0478***	0.0006
	(0.0148)	(0.0051)
Median income in district (in 1,000 euro)	-0.0097**	0.0001
	(0.0046)	(0.0013)
Median income in neighborhood (in 1,000 euro)	-0.0179***	-0.0003
	(0.0030)	(0.0009)
Observations	228,939	222,354
Number of households	89,310	89,267
R^2 (within)	0.017	0.032
F-test income dummies	$F_{(9;\,89,309)} = 1.12$	$F_{(9;\,89,266)} = 0.84$
	Prob > F = 0.3423	Prob > F = 0.5836
F-test interaction terms of *r* with income dummies	$F_{(10;\,89,309)} = 5.99$***	$F_{(10;\,89,266)} = 4.68$***
	Prob > F = <0.0001	Prob > F = <0.0001
Average marginal effect of the interaction terms of *r* with the income dummies	0.0291 ***	0.0009
	0.0063	0.0023

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[a] *Interaction term where r is interacted with an income dummy Y_{A-B}. r measures rent control stringency and is defined as $\frac{\text{monthly controlled rent}}{\text{House value}/100{,}000}$. The mean of r equals 270 with standard deviation 84. Lower values of r imply larger rent-control benefits. Y_{A-B} is a dummy equal to one if income is greater than or equal to A and smaller than B, and is zero otherwise.*

[b] *The average marginal effect of rent control stringency -computed using the Delta method- equals 0.0291 *** for transitions within the rent-controlled housing sector. It is significant at the 1 percent significance level with an standard error equal to 0.0063. The average marginal effect of rent control stringency on between transitions equals 0.0009 and is insignificant at the 10 percent significance level as its standard error equals 0.0023.*

[c] *Explanatory variables included but not shown: dummies for being on rent support, having multiple adults in the household, being married, having children, age group and indicating contract type (fixed, fulltime, fulltime and fixed or having no job), being self-employed and two year dummies. Median value of owner-occupied housing in the municipality, median house value and median house value of rent-controlled housing in the district and neighborhood. Percentage of rent-controlled housing in the district and neighborhood. Housing stock, rent-controlled housing stock and percentage of rent-controlled housing in the municipality. The inclusion of municipality dummies does not change estimated parameters.*

for the first income decile. However, for the tenth income decile this is 5.2 percentage points. This provides evidence in favor of Hypothesis 4

In additional, evidence is found that within transitions are affected by house value and local housing market characteristics. There is no evidence that these variables influence between transitions. If house value increases by 100,000 euro, the probability of making a within transition decreases by 4.8 percentage points. The estimated coefficient that measure the effect of house value on between transitions is insignificant.

Similarly, it is concluded that median income level in the district and neighborhood influence within transitions, but not between transitions. This effect is stronger at the neighborhood level. The coefficients on house value, median income in the district and median income in the neighborhood show that households are less likely to make within transitions if they consume housing of better quality, where quality refers to the house and the location. I found no evidence that between transitions are influenced by house value, median income in the district or median income in the neighborhood.

4.7 Conclusion

Price ceilings change demand for the controlled good as well as for substitute goods. The economic literature has established that rent control reduces housing demand, but did not distinguish between the effect on demand for controlled and uncontrolled housing. Two separate mechanisms why rent control might affect housing demand for controlled and uncontrolled housing differently have been presented in this chapter, exposing a deeper relationship between rent control and housing demand. Transitions out of the rent-controlled sector are explained by rent keeping behavior: the lower the benefits households receive from rent-control, the more likely they are to move to uncontrolled housing, as they give up fewer benefits from rent control. Transitions within the rent-controlled housing sector are explained by rent seeking behavior: the lower the benefits households receive from rent-control, the more likely they are to move to controlled social housing, as this might increase their rent-control benefits. The conclusions are threefold.

The first conclusion is that the negative relationship between rent control and housing demand is explained entirely by a fall in demand for rent-controlled housing. In line with the aforementioned previous empirical literature on rent control and housing demand rent control benefits are found to lower the overall transition rate. On average, a one-standard deviation increase in rent-control benefits decreases the overall transition rate with 2.9 percentage points. No evidence is found that, on average, rent control benefits influence demand for uncontrolled housing. Thus, I find evidence in favor of rent seeking, but no evidence in favor of rent keeping.

The second conclusion is that income moderates the effect of rent control on demand for uncontrolled housing. Although I do not find evidence for rent keeping behavior on average, the highest income decile engages in rent keeping behavior and postpones transitions to the uncontrolled housing sector in response to rent control. The economic model attributes this difference to the financial unattainability of uncontrolled housing for low-income households.

The third conclusion is that income moderates the effect of rent control on demand for controlled social housing. Rent-seeking behavior is increasing in income (for all ten income deciles). Thus high-income households are more likely to move house within the rent-controlled housing sector if rent-control benefits are low compared to low-income households. This empirical finding is in line with the economic framework as well.

Previous research stressed that the allocation of rent-controlled housing is often imperfect (Glaeser and Luttmer, 2003), which leads to opportunities for rent seeking (Bulow and Klemperer, 2012). By specifically considering transitions within the rent-controlled housing sector, it can be investigated empirically how rent control influences the allocation of controlled social housing.

Future research could work along this path to further investigate the mechanisms that lead to rent seeking and rent keeping behavior. A puzzling paradox arises. As households do not lose all their rent-control benefits if they move within the rent-controlled housing sector, one would expect the effect of rent control on between-transitions to be larger than the effect on within-transitions. However, as I find no effect of rent control on transitions from the rent-controlled housing sector, the evidence points in the opposite direction.

The results presented in this chapter have important consequences for the allocation of rent-controlled housing to new and existing tenants. Given a fixed supply of rent-controlled housing, new tenants can only enter the rent-controlled housing sector if existing tenants leave. It is shown that rent control only reduces the exit rate out of rent-controlled housing for the top income decile. This would imply that rent-control has a smaller negative effect on the offer rate of controlled social housing to new entrants than was previously understood.

4.A Results conditional fixed effect logit estimator

Table 4.4 shows the parameter estimates if equations (4.3) and (4.4) are estimated using a conditional fixed effect logit estimator. Results should be interpreted with care as the marginal effect of that variable and might even be of opposite sign (Ai and Norton, 2003, p.123). Nonetheless, the *pattern* that arises is similar to that of the LPM.

Again, the estimates on transitions within the social housing sector in column two are similar to the estimates on the overall transition rate in column one. Thus the conclusion that transitions within the social housing sector dominate the effect of rent-control benefits on household mobility is not specific to the LPM estimation method as it is found as well using a conditional fixed effects logit model.

Also, transitions from the social housing sector (column three) seem to be less responsive to rent-control benefits than transitions within the social housing sector (column two). Only transitions from the social housing sector by high-income households seem to be affected by rent-control benefits. In contrast, transition within the social housing sector are affected by rent-control benefits by low-income, middle and high-income workers (column two). A similar pattern has been presented in section 7.5 using the LPM model.

Table 4.4: Fixed effect logit results

	Dependent variable: Transition		
	Overal	Within	Between
Interaction terms rent control stringency r and income group dummies [a]			
$r * Y_{117}$	0.0024***	0.0020***	0.0115*
	(0.0007)	(0.0008)	(0.0066)
$r * Y_{117-129}$	0.0018**	0.0017**	-0.0012
	(0.0008)	(0.0008)	(0.0076)
$r * Y_{129-140}$	0.0010	0.0011	0.0031
	(0.0008)	(0.0008)	(0.0073)
$r * Y_{140-150}$	0.0009	0.0009	0.0003
	(0.0008)	(0.0008)	(0.0082)
$r * Y_{150-161}$	0.0017**	0.0013	0.0140**
	(0.0008)	(0.0008)	(0.0070)
$r * Y_{161-175}$	0.0018**	0.0016**	0.0089
	(0.0008)	(0.0008)	(0.0068)
$r * Y_{175-194}$	0.0033***	0.0031***	0.0089
	(0.0008)	(0.0009)	(0.0061)
$r * Y_{194-222}$	0.0032***	0.0036***	0.0097
	(0.0008)	(0.0009)	(0.0060)
$r * Y_{222-267}$	0.0044***	0.0051***	0.0084
	(0.0009)	(0.0010)	(0.0058)
$r * Y_{267}$	0.0044***	0.0047***	0.0102*
	(0.0010)	(0.0012)	(0.0062)
Income dummies. Base is household with annual income below 11,700 euro			
$Y_{117-129}$	-0.0151	0.0647	-0.3720
	(0.0724)	(0.0754)	(0.5430)
$Y_{129-140}$	-0.1260	0.0235	-0.8160
	(0.0775)	(0.0821)	(0.5110)
$Y_{140-150}$	-0.0641	0.1370	-0.7580
	(0.0835)	(0.0893)	(0.5310)
$Y_{150-161}$	-0.1790**	0.0517	-0.8590*
	(0.0853)	(0.0924)	(0.5020)
$Y_{151-175}$	-0.0940	0.1340	-0.5410
	(0.0861)	(0.0951)	(0.4760)
$Y_{175-194}$	0.0622	0.2540**	-0.2630
	(0.0875)	(0.0996)	(0.4430)
$Y_{194-222}$	0.3330***	0.5040***	-0.1060
	(0.0890)	(0.1040)	(0.4290)
$Y_{222-267}$	0.8500***	0.9930***	0.6530
	(0.0931)	(0.1100)	(0.4350)
Y_{267}	1.4760***	1.4230***	1.4270***
	(0.1030)	(0.1280)	(0.4540)
Household, house and local housing market characteristics[b]			
House value (in 100,000 euro)1	-0.6190***	-0.4890***	4.7390***
	(0.1330)	(0.1340)	(1.4050)
Median income in district (in 1,000 euro)	-0.0488	-0.0434	-0.3870
	(0.0333)	(0.0334)	(0.3810)
Median income in neighborhood (in 1,000 euro)	-0.1460***	-0.1230***	0.0244
	(0.0239)	(0.0243)	(0.2430)
Observations	24,069	19,038	4,947
Number of households	8,965	6,842	2,116

[a] *Interaction term where r is interacted with an income dummy Y_{A-B}. r measures rent control stringency and is defined as $\frac{\text{monthly controlled rent}}{\text{House value}/100{,}000}$. The mean of r equals 270 with standard deviation 84. Lower values of r imply larger rent-control benefits. Y_{A-B} is a dummy equal to one if income is greater than or equal to A and smaller than B, and is zero otherwise.*
[b] *Explanatory variables included but not shown: dummies for being on rent support, having multiple adults in the household, being married, having children, age group and indicating contract type (fixed, fulltime, fulltime and fixed or having no job), being self-employed and two year dummies. Median value of owner-occupied housing in the municipality, median house value and median house value of rent-controlled housing in the district and neighborhood. Percentage of rent-controlled housing in the district and neighborhood. Housing stock, rent-controlled housing stock and percentage of rent-controlled housing in the municipality.*

Chapter 5

Type of housing tenure and wages: Sorting or incentives?

5.1 Introduction

In the Netherlands workers living in social housing earn on average 25 percent lower wages compared to homeowners.[1] This wage differential might be the result of various sorting mechanisms as low-income households are more likely to rent social housing. Alternatively, this wage differential might be explained by a causal effect of housing tenure on wages, that occurs if housing tenure affects search behavior on the labor market. In this chapter it is studied whether housing market tenure influences wages, or whether the observed wage differentials between homeowners and tenants are the results of sorting.

The wage differential between homeowners and workers in social housing might be the result of various sorting mechanisms. Low-income workers are more likely to live in rent-controlled housing as rent-controlled housing is mostly distributed towards them. Also, workers with low wages do not want to consume better quality housing at the market rent (see chapter 2). In addition, if housing of a certain tenure is spatially concentrated, its inhabitants

[1] In contrast, tenants of private rental housing on average earn 2.5 percent lower wages.

might predominantly be working in nearby regions, and the industries, firms and jobs located therein. This might influence wages.

However, wage differentials might also be influenced by the type of housing tenure as both homeownership and rent control reduce the geographical mobility of workers (De Graaf et al., 2009).[2] On the one hand, a lower geographical mobility will weaken the labor market position, as the area in which unemployed workers look for jobs becomes smaller and the number of job offers decreases. This will negatively affect wages if workers respond by lowering their reservation wage. On the other hand, the lower geographical mobility might have a positive effect on wages: As workers are more likely to stay with the firm, they might receive more training that increases their human capital. Also, workers with lower geographical mobility might provide more effort to prevent becoming unemployed.

The literature has shown that rent-controlled households are more likely to become unemployed and to work within their local labor market.[3] Homeowners are found to have a lower probability to become unemployed, but they exhibit longer unemployment duration conditional on becoming unemployed.[4] Two studies have investigated the effect of homeownership on wages. Munch et al. (2008) use a mixed proportional hazard model to estimate the effect of homeownership on wages in Denmark. They find that that homeowners earn about 5 percent higher wages than tenants. In contrast, Coulson and Fisher (2009) use an instrumental variables on cross-sectional data for the United States. They find that homeowners in the United States earn on average 30 percent lower wages compared to tenants.

In this chapter, I consider the effect of homeownership *and* living in rent-controlled housing on wages.[5] Detailed administrative data for over one mil-

[2]Homeownership does so by increasing the transaction costs of moving. Living in rent-controlled housing does so as moving to rent-controlled housing generates high (often non-pecuniary) transaction costs such as queing. In addition, rent control creates transaction costs in the form of in kind benefits that are lost if households move to uncontrolled housing.

[3]See Hughes and McCormick (1987); Minford et al. (1988); McCormick (1997) for the UK, Flatau et al. (2003) for Australia, Munch and Svarer (2002); Svarer et al. (2005) for Denmark, and De Graaf et al. (2009) for several European countries including the Netherlands.

[4]The so-called Oswald-hypothesis, see Oswald (2009). Overviews on the relation between homeownership and unemployment are Van Ewijk and Van Leuvensteijn (2009); Havet and Penot (2010).

[5]Thus, the baseline type of housing market tenure is living in private market rental housing instead of living in (private or social) rental housing as in Munch et al. (2008) and Coulson and Fisher (2009).

lion workers is used to distinguish the sorting effect from the incentive effect of housing tenure. The panel nature of the data allows to control for the sorting effect of low-skilled workers into rent-controlled housing. Several controls for the region, industry, firm and job in which the worker works are provided, and type of housing tenure is instrumented to infer the causal effect of housing tenure on wages.

It is concluded that conditioning on worker skill is very important if one is to study the effect of housing tenure on local wage rate. In the end, no significant effect of living in rent-controlled housing (compared to being a private tenant) is found. Without instrumentation, a small statistical significant positive effect for being a homeowner is found: homeowners have a 0.3 percent higher hourly wage. Thus the coefficient is not very significant economically. After instrumenting homeownership and living in social housing there is no longer evidence that the type of housing tenure influences the wage rate.

This paper continuous as follows: In section 5.2 the literature on housing tenure and the sorting and incentives effects is discussed. Section 5.3 explains the data that are used. The empirical strategy is explained in section 5.4. Section 5.5 lists results on the effect of housing market tenure on wages. In section 5.6 evidence on the relationship between worker skill and sorting into social housing is presented. Conclusions are presented in section 5.7.

5.2 Literature

5.2.1 Framework

The sorting effect of housing tenure type arises as workers with high income are more likely to buy owner-occupied housing and workers with low-income are more likely to rent social housing. However, the incentive effect of housing tenure type entails that housing tenure reduces worker mobility, which the worker anticipates by accepting jobs that pay less or by providing more effort.

Panel data is used to distinguish the sorting effect from the incentive effect of housing tenure. Denote the log wage of worker i at time t as w_{it}, which is a function of homeownership h_{it} or living in rent-controlled social housing c_{it}. Furthermore, consider the wage rate to be influence by time-invariant (un-

observed) ability of the worker α_i and a matrix of observable worker and job characteristics X_{it}. In this specification, the housing market tenure types capture how housing market tenure type influences the wage rate (by changing incentives), whereas observed and unobserved worker characteristics take up the effect of sorting. See equation (5.1), where ε_{it} is an i.i.d. error term with zero expectation and constant variance.

$$w_{it} = \underbrace{\beta_1 h_{it} + \beta_2 c_{it}}_{Incentives} + \underbrace{\alpha_i + \beta_3 X_{it}}_{Sorting} + \varepsilon_{it} \tag{5.1}$$

The initial specification equals a multivariate regression of wages on homeownership dummy h and a dummy for living in rent-controlled housing c only. This specification is biased if ability or variables in X_{it} are correlated with homeownership or living in social housing.[6] Then, controls are provided for sorting by considering the coefficients on homeownership and living in rent-controlled housing if several indicators for the region, the industry, the firm and the job in which the worker works are included in X_{it}. Finally, α_i is estimated to control for unobserved ability of the worker. The sorting effect of housing tenure type is measured by the effect of homeownership and the effect of living in rent-controlled housing. The incentive effect of housing tenure type is given by $E[h_{it}|\alpha_i, X_{it}]$ for homeownership and $E[c_{it}|\alpha_i, X_{it}$ for living in rent-controlled housing.

5.2.2 Sorting of workers

I control for various sorting mechanisms by estimating unobserved worker characteristics that do not vary over time and by controlling for region, industry, firm and the job in which the worker is employed. The literature on agglomeration economies has shown that heterogeneous workers sort into heterogeneous places. High-skilled workers have been sorting into cities that provide more amenities (Glaeser et al., 2001), that provide higher returns to

[6] Workers with a high ability earn higher wages on average. If the correlation between homeownership and ability or variables in X_{it} is positive (as hypothesized), omitting them from equation (5.1) would bias the estimated coefficient of β_1 upwards. Similarly, if the correlation between living in rent-controlled housing and ability or variables in X_{it} is negative, omitting them would bias the coefficient of β_2 downwards.

education (Moretti, 2004) and that increase productivity from more effective face-to-face exchange of information (Glaeser and Mare, 2001). As workers sort across skill and types of housing tenures are not evenly distributed, this might create a relationship between wages and type of housing tenure that is due to sorting. This implies that a specification of the effect of housing tenure on wages should control for the worker's skill, location and characteristics of industry, firm and job in which the worker works.[7]

5.2.3 Type of housing market tenure and wages

Living in rent-controlled or owner-occupied housing increases the transaction costs of moving house. Rent control provides tenants with in kind benefits that are lost if the household moves to uncontrolled housing. Also, controlled housing is often allocated based on non-pecuniary costs such as waiting time. Homeowners face similar non-pecuniary transaction costs as they have to wait to sell their house. In addition, they often face substantial pecuniary moving costs in the form of a tax on transferring residence (as shown by Belot and Ederveen (2005) for 15 European countries).

The increased transaction cost of moving house reduce the geographical mobility of both rent-controlled and owner-occupied workers. Therefore they are less likely to accept jobs outside the local labor market. If immobile work-

[7] A large body of literature points at including these control variables. Already in the nineteenth century, the idea was put forward that asset sharing among firms could increase local productivity. Marshall (1890) argued that firms in *dense* areas could benefit from lower transportation costs, industry specific inputs, or benefit from local labor pools suitable to their industry. However, even in todays world in which falling transportation and communication costs have evoked the 'death of distance' (Cairncross, 2001; Friedman, 2006), regional wage differentials have been rising and spatial sorting of households has increased (Moretti, 2012). Todays explanations for agglomeration economies are therefore largely based on the way cities enable face-to-face contact to exchange ideas (Glaeser, 2011).

In the view of Marshall (1890), Arrow (1962) and Romer (1986) clustering allows firms to benefit from inter-knowledge spillovers. Local *specialisation* in an industry enhances the flow of ideas within industries. Following Glaeser et al. (1992), these externalities due to specialization are also referred to as MAR-externalities. On the other hand, in the view of Jacobs (1969), knowledge spills over between complementary industries as practice in the one industry lead to innovations in the other. The interaction of ideas across different industries stirs innovation and productivity. These externalities are referred to as Jacobian-externalities, and are the result of *diversification*. Finally, Porter (1998) argues that clustering of firms in a location increases information spillover, but also increases *competition*. This spurs the adaptation of new ideas as all firms have to perform better to beat their competitors.

Besides spatial heterogeneity in the productivity level of places, the local wage rate might be influenced by the spatial sorting of industries, firms and the jobs they provide. Firms in a particular industry sort into cities as dense labor markets might improve the match between job tasks and workers skills. Also, in line of the models by Melitz (2003), increased competition in dense areas might lead to the survival of high-productivity firms in cities.

ers become unemployed, their hesitation to move house to accept a job might negatively affect unemployment duration. Various studies found that immobile workers, such as homeowners and tenants of rent-controlled housing, are more likely to work within their local labor market and have increased unemployment spells.[8]

However, workers with a prolonged expected unemployment duration (conditional on becoming unemployed) might lower their reservation wage in response. Thus housing market transaction costs not only influence unemployment and job mobility, but also whether a wage offer is accepted. Munch et al. (2006) develop a theoretical search model in which unemployed workers distinct between jobs within and outside their local labor market. They show that workers with higher transaction costs of moving (homeowners) lower their reservation wage for jobs within their local labor market compared to workers with lower transaction costs of housing (tenants of private housing). Similarly, the reservation wage for jobs outside their local labor market is higher. As workers with increased transaction costs are overrepresented in jobs within their local labor market, homeowners and tenants of rent-controlled housing might earn lower wages compared to tenants of private housing, ceteris paribus.

Increased transaction costs of moving house reduces mobility and increases the expected duration of unemployment. As a result, these workers might provide more effort to prevent becoming unemployed. Individual homeowners have been found to become unemployed less often.[9] Also, their lower geographical mobility makes it more likely that homeowners stay with the firm for a long time period. This might be an incentive to both the employer and employee to increase human capital of the worker. Thus workers who are

[8] Hughes and McCormick (1987); Minford et al. (1988); Flatau et al. (2003); Munch and Svarer (2002); Svarer et al. (2005) find that rent-controlled workers are more likely to work local jobs and to be unemployed. De Graaf et al. (2009) study both homeownership and rent controlled tenants and their risk to become unemployed for fourteen European countries. On average, job-to-job mobility of rent-controlled tenants is three percentage points higher than that of private tenants, and their entry rate into unemployment is eleven percentage point higher. However, there is large varation across the sampled countries in sign of the effects.

[9] However, they have also been found to move out of unemployment faster. See among others Oswald (2009); Partridge and Rickman (1997); Green and Hendershott (2001); Flatau et al. (2003); Munch et al. (2006); Van Vuuren (2007); Battu and Phimister (2008); Munch et al. (2008). Overviews are given by Van Ewijk and Van Leuvensteijn (2009); Havet and Penot (2010).

less likely to move house, have an incentive to provide more effort and are more likely to receive training. This might increase wages.[10]

The empirical literature on the effect of housing market transaction costs on wages is small and ambiguous. So far, two papers have investigated how wages are affected by increased housing transaction costs in the form of homeownership. I did not find empirical research on the effect of rent control on wages. Munch et al. (2008) model job duration, the wage rate and the selection into homeownership simultaneously using a mixed proportional hazard model. They estimate the effect of homeownership on wages while controlling for unobserved random worker characteristics. They identify the effect of homeownership on wages using the panel dimension of their data. Also, they instrument homeownership using the local homeownership rate in the local labor market. Their results indicate that Danish homeowners receive a positive wage premium of about five percent compared to tenants of private housing.

Coulson and Fisher (2009) use cross-sectional data from the US census to test the effect of homeownership on income (not wages) using various OLS and IV specifications. They develop a theoretical search model in which the wage firms offer depends on the local homeownership rate in the local labor market. From this they conclude that the local homeownership rate, a commonly used instrument of individual homeownership, is not valid. Therefore they instrument homeownership with a dummy variable that equals one if the first two children in the households are of equal sex. Given preference of households for a boy and a girl, these households are more likely to have a third child. Consequently, these households have larger families and live in owner-occupied housing more often.[11] They find that that homeowners in the United States earn 42 percent lower wages compared to renters.

[10] Also, if unemployment benefits are means tested, the cost of unemployment might be larger for homeowners (Van Vuuren, 2007). If homeowners receive unemployment benefits for a smaller time period, whereas tenants receive unemployment benefits as long as they are unemployed, the reservation wage for homeowners might be lower compared to that of private tenants for jobs within and outside the local labor market.

[11] Also, they suggest to follow DiPasquale and Glaeser (1999) and use the local homeownership rate stratified to race or income. However, this variable is higly collinear to their homeownership variable.

5.3 Data

Several administrative data sets provided by Statistics Netherlands are combined to test whether the wage differentials between homeowners and tenants in the Netherlands is due to sorting or is the result of housing market tenure. For each worker the highest paying job that lasted for more than 28 days is selected (obtained from *SSBBanen*). The dataset *GEMSTPLBUS* contains for each worker the municipality in which his job is located. The highest paying job of each worker is matched to the municipality in which it is located. This is done for the population of workers with one job or with multiple jobs within the same municipality.

Industry, firm and job characteristics are based on *SSBBanen* as well. It is used to construct twelve sectoral indicators that correspond to groups of ISIC indicators (see section 5.B). Additionally, ten dummies for firm size are computed based on the average number of employees employed by the firm in each year. Finally, job characteristics like tenure, the type of contract, and hours worked are provided as well.

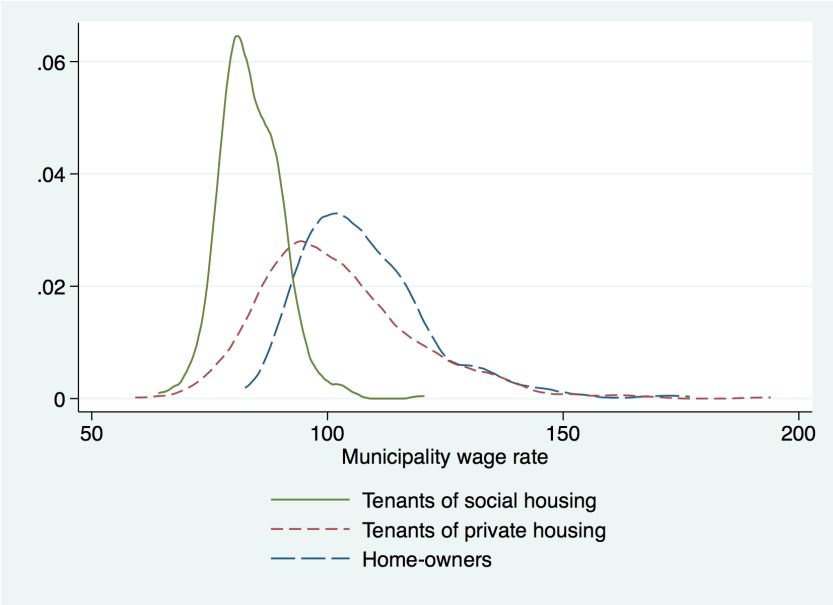
I proxy observed worker skills and effort using age-dummies, the presence of children in the household and indicators for marital status that are measured in the municipal administration *GBA*. Time-invariant indicators such as gender or belonging to a minority group cancel out in the within transformation. Also, the *GBA* data set provides a house indicator, which is merged with the file *WRG verrijkt*. This allows to distinguish homeowners from tenants living in private or rent-controlled housing.

In total there are 2,884,112 worker-year observations of which 73.3 percent is on homeowners, 22.7 percent is on rent-controlled tenants and 3.9 percent is on tenants of private housing.

Figure 5.1 shows the density of the municipal wage rate for home-owners, tenants of private rental housing and tenants of social housing. The figures indicate that the municipal wage rate of tenants of social housing is below that of tenants of private housings, which in turn is (somewhat) below that of homeowners. Figure 5.2 shows the relative municipal wage for homeowners (compared to that of tenants of private rental housing) against the relative wage of tenants of social housing. Circle size reflects municipality size. The major-

ity of observations is in the upper left quadrant, which indicates that in most municipalities homeowners earn more and tenants of rent-controlled housing earn less than tenants of private rental housing. The upper right quadrant indicates there are some (small) municipalities where both tenants of social housing and homeowners earn more than tenants of social housing. Finally, there are quite some municipalities where both homeowners and tenants of social housing earn less than tenants of private housing. These municipalities are in the bottom left quadrant.

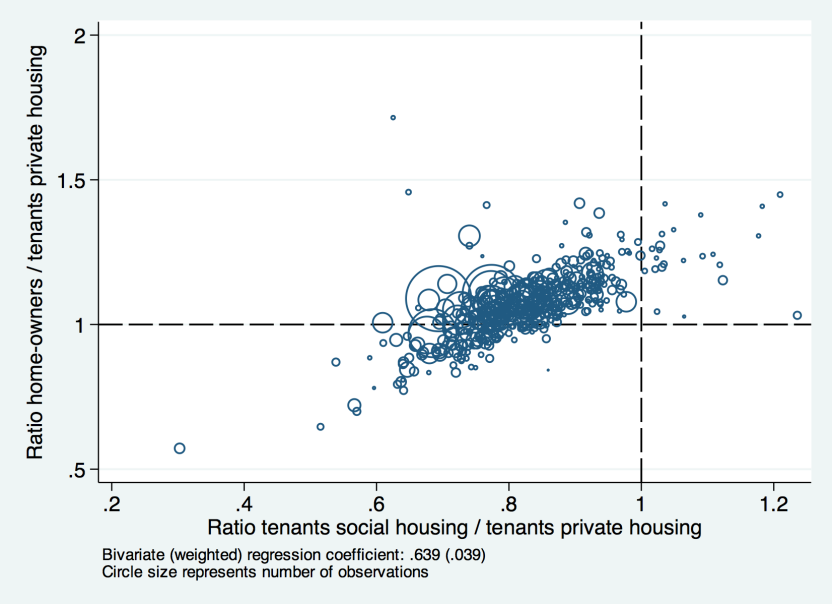
Figure 5.1: Density of municipal wages by housing tenure



Density plot of the average municipal wages earned between 2006 and 2008 for workers living in social housing, workers living in private rental housing and workers who live in owner-occupied housing.

Both tenants in rent-controlled housing and homeowners are expected to have local jobs more often. Table 5.1 shows the mean distance, measured as the crow flies, between the (centroid of) the municipality where the worker lives and the (centroid of) the municipality in which he works. Although this is a rough approximation for commuting time which defines the boundary of local labor markets, it indicates that on average tenants of private housing have longest commutes, followed by homeowners. Tenants of social housing

Figure 5.2: Relative municipal wages of homeowners and tenants of social housing



Scatter plot of the relative municipal wages earned between 2006 and 2008 by workers living in owner-occupied housing against relative municipal wages earned by workers living in social housing. Both measures are relative to the municipal wage earned by workers living in private rental housing.

Table 5.1: Average commuting distance by housing tenure

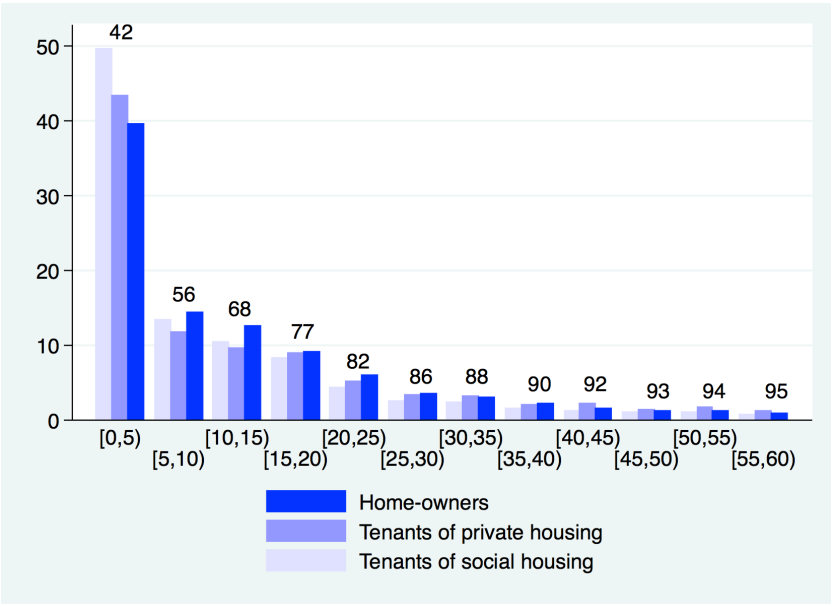
	Commuting distance[a]
Homeowners	15.91
Tenants of social housing	12.64
Tenants of private housing	17.02

[a] in kilometres as the crow flies

have the lowest commuting distance. This result is striking as it is often assumed that transaction costs are lowest for tenants of private rental housing and therefore they can lower commuting time by moving.

Figure 5.3 shows the percentage of workers within a commuting distance interval according to type of housing tenure. Thus 50 percent of all workers living in rent-controlled housing have a commuting distance that is smaller than 5 kilometer. Homeowners commute more, as about 40 percent of homeowners have a commuting distance smaller than five kilometer. Summary statistics for the variables used in the analysis are shown in Table 5.2.

Figure 5.3: Commuting distance (in km) by type of housing tenure



Commuting distance (in kilometres) for workers living in owner-occupied housing (homeowners), workers living in private rental housing and workers living in social housing. The numbers above bars indicate cumulative share of the workforce

Table 5.2: Summary statistics

Variables[a]	mean	st.dev.	av(p5)[b]	av(p95)[c]
Log daily wage	4.5655	0.4576	3.8321	5.7399
Age	42.3632	10.2750	24.6784	60.3727
Indicators housing tenure: one if...				
Tenant of social housing	0.2273	0.4191		
Homeowner	0.7332	0.4423		
Tenant of private housing	0.0394	0.1946		
Indicators worker characteristics: one if...				
Not married	0.3345	0.4718		
Widowed	0.0075	0.0861		
Divorced	0.0792	0.2700		
Female	0.3728	0.4836		
Indicators for job characteristics: one if...				
Has temporary contract	0.1113	0.3145		
Works [2-4) hours	0.0111	0.1050		
Works [4-6) hours	0.0724	0.2591		
Works [6-8) hours	0.1391	0.3461		
Works [8-10) hours	0.7760	0.4169		
Tenure equals [4-39) weeks	0.0154	0.1232		
Tenure equals [39-74) weeks	0.0748	0.2630		
Tenure equals [74-122) weeks	0.0907	0.2871		
Tenure equals [122-198) weeks	0.0952	0.2934		
Tenure equals [198-287) weeks	0.1040	0.3053		
Tenure equals [287-379) weeks	0.1113	0.3145		
Tenure equals [379-491) weeks	0.1195	0.3243		
Tenure equals [491-689) weeks	0.1227	0.3281		
Tenure equals [689-1002) weeks	0.1283	0.3344		
Indicators for firm characteristics: one if...				
Firm size equals [9-22) workers	0.0910	0.2876		
Firm size equals [23-53) workers	0.0968	0.2957		
Firm size equals [54-133) workers	0.1057	0.3074		
Firm size equals [134-311) workers	0.1097	0.3125		
Firm size equals [312-725) workers	0.1101	0.3129		
Firm size equals [726-1564) workers	0.1075	0.3098		
Firm size equals [1567-3238) workers	0.1056	0.3073		
Firm size equals [3248-10664) workers	0.1024	0.3032		
Firm size equals [10679-86840) workers	0.0913	0.2880		

[a] *Based on 2,888,441 observations*

[b] *Average value for the 5th percentile and lower*

[b] *Average value for the 95th percentile and lower*

5.4 Empirical strategy

The log of the hourly wage (w_{it}) is a linear function of worker skills (X, α_i), the region where the worker works (R), the type of industry the worker works in (S), firm productivity (F) and job characteristics (J). Dummy variables for type of tenure are included as c is equal to one if the worker is living in social housing and the dummy h is one if he is a homeowner. The default type of tenure is therefore being a tenant of uncontrolled housing. Additionally, fixed year effects δ are included. Thus equation (5.2) is estimated, where ε is an i.i.d. error term and the betas are vectors of parameters that have to be estimated.

$$\begin{aligned} w_{it} =& \alpha_i + c_{it} + h_{it} + X_{it}\beta_X + R_{rt}\beta_R + S_{st}\beta_S + F_{ft}\beta_F \\ &+ J_{it}\beta_J + \delta_t + \varepsilon_{it} \qquad (5.2) \\ i =& 1, 2, \ldots n; \quad t = 2006, 2007, 2008; \quad r = 1, 2, \ldots 443; \quad s = 1, 2, \ldots 7 \end{aligned}$$

Our measure of worker skills includes unobserved worker fixed effects such as gender and ability. It also includes observable worker characteristics for worker age, tenure at the firm and marital status.[12] I control for the municipality R in which the worker's job is located by including 430 fixed effect at the municipal level. In addition, eleven industry fixed effects S are included, together with nine dummies for firm size in F to proxy for firm productivity.

Equation (5.2) is estimated using OLS after the equation is 'within transformed' (see section 5.A). To identify the fixed industry effect S_s and the fixed part of the region effect μ_c it is required that there is enough worker mobility across sectors and municipalities such that all industries and municipalities are 'connected' by worker geographical and labor market mobility. Because of the large sample size this condition is met. The coefficient for the industry business activities and the coefficient for the municipality Amsterdam are set to zero.

[12] Age is decomposed into groups of five years (baseline: workers aged at least 35 and younger than 40). Tenure at the firm is measured in deciles (baseline being the fifth decile). Marital status is indicated using dummy variables for 'being divorced', 'being widowed' and 'never has been married' (baseline: 'being married').

Models along the lines of Roback (1982) and Moretti (2011) illustrate how wages might be set with respect to unobserved amenities. This might bias results if unobserved amenities influence the sorting of workers into regions and influences the wage rate. However, if the unobserved local amenities are invariant over the sample period, the fixed part of the regional effects R will capture both variation in exogenous productivity (say: due to location) and variation in the wage bargaining process due to local amenities. As the panel consists of three consecutive years, the assumption that local consumer amenities are fixed seems reasonable.[13]

The estimates for $\alpha_i, c_{it}, h_{it}, \delta_t$ and the β-parameters are used to decompose predicted wages into contributions of time, skills, regions, industry, firms, jobs and housing tenure to predicted wages. I follow Combes et al. (2008) who suggest to measure the conditional variance and covariance terms in one measure called "the effect". The effect of a variable equals its sample correlation coefficient with the dependent variable, multiplied by its own standard deviation. This measure can be shown to be equal to the sum of the variance of the variable divided by the variance of the dependent variable and all of the variable's covariance terms (Gibbons et al., 2013).

Identification

Equation (5.2) contains dummy variables for homeownership and renting controlled housing. They equal the average wage difference between homeowners (or tenants living in social housing) compared to tenants of private rental housing conditional on other variables included. The desired specification in equation (5.2) controls for unobserved ability of the worker using worker specific fixed effects α_i. This control variable is important as it is used to distinguish sorting in housing tenure type from the incentives these housing types provide. If α_i is excluded from the specification in equation (5.2), the coefficients on homeownership measures both the (average) skill of homeowners and the causal effect of homeownership on wages. Thus to measure the effect of skill based sorting into housing market tenure, estimates of homeowner-

[13]Combes et al. (2008) mention another endogeneity bias may occur if regions specialize into sectors *because* they pay high wages. However, this seems not to be problematic if the covered time period is small and changes in specialization rates are limited.

ship in equation (5.2) with controls for worker fixed effects are compared to those without. The same line of reasoning holds for the dummy for living in rent-controlled housing.

One might be concerned that the effect of housing tenure on the wage rate is driven by reversed causality. This would occur if shocks to the worker's wage induce him to change housing tenure. The setup of the data implies that a change in housing market tenure is measured before wages are measured. This timing of events prevents some protection against reversed causality.[14] Furthermore, the rich nature of the data set allows to include controls for changes in earning potential that are determined by (changes in) age, marital status and the presence of children, together with indicators for region, industry, firm productivity, and -potentially very important- job contract characteristics and hours worked.

As a robustness check the variables that measure housing market tenure type are instrumented. Coulson and Fisher (2009) conclude that the local homeownership rate, a commonly used instrument of individual homeownership, is not valid under wage bargaining if firms take the homeownership rate in the municipality into account in determining their wage offer. Yet, their suggested instrument would lead to a considerable reduction in sample size (to about 186 thousand observations).

Therefore, the approach suggested by DiPasquale and Glaeser (1999) is followed and the local homeownership rate stratified to income is used as an instrumental variable. To be precise, being a homeowner and living in social housing are instrumented with the homeownership rate for the first income decile in the neighborhood, and the homeownership rate among workers within the 10th and 25th percentile in the neighborhood.

Consider homeownership. The homeownership rate among these income groups at the neighborhood level is positively correlated with the probability to be a homeowner in the neighborhood because of a supply effect. Workers who move to neighborhoods with a large stock of owner-occupied housing are more likely to become homeowners. Similarly, they are less likely to rent social

[14]Housing market tenure is registered at the first of January in each year. The daily wage in each year is based on labor income over the course of the year. Thus if a worker gets a raise in year t and subsequently decides to move within the same year, the raise will be incorporated partly in the wage rate for year t.

housing. Thus the instrument is supposed to be most relevant in explaining housing tenure for workers who change tenure type. This is not problematic as the housing tenure dummies are only identified for those workers who switch tenure type.

The suggested instruments are exogenous if employers determine their wage offer based on the homeownership rate as a whole within local labor markets and do not consider homeownership among low-income households. Also, (changes in) the homeownership rate among low-income households at the neighborhood level should be 'different enough' from (changes in) the homeownership rate within the local labor market. I find some evidence suggesting that individual wage outcomes do not depend on the homeownership rate among low-income households.

5.5 Estimation results

Table 5.3 presents the main estimation results for eight nested specifications.[15] The smallest specification in column one regresses the log hourly wage on a dummy for being a homeowner and a dummy for living in social housing. One by one, control variables are included. The final specification in column eight includes the full specification as in equation (5.2).

Without additional controls, evidence is found that wages vary according to housing tenure type. The hourly wage of tenants of social housing is about 18.2 percent below that of tenants in private rental housing. Homeowners earn 7.5 percent higher wages compared to workers in private rental housing. The combined effect indicates that homeowners earn wages that are 25.7 percent higher than tenants of social housing.

In columns two to seven controls are added for the year of observation, for observed worker skills, for the location of the job, for the industry, and for firm and job characteristics. This changes parameter estimates for homeownership slightly. In general, the estimated coefficient of living in social housing remains negative around a value of minus 19 percent. The coefficient of home-

[15] Table 5.8 shows results for the same specification, including the estimates on control variables. Results are similar to those where standard errors have been clustered on the neighborhood level. Especially the conclusions with respect to the housing market tenure variables do not change.

ownership is positive at a value of about two percent. Together, the wage differential between homeowners and tenants of social housing is about 21 percent.

In the final column unobserved worker skills are estimated to control for the self-selection into housing tenure based on worker skill. The absolute value of the estimated coefficient on living in social housing drops considerably and becomes insignificant at the five percent level. From this it is concluded that the negative coefficient on the dummy for living in social housing in specifications one to seven is biased by unobserved worker skills and that low-skilled workers have been sorting into social housing. The value of the coefficient on homeownership drops as well, but it remains significant. Its value suggests that homeowners earn wages that are 0.5 percent higher than wages of tenants in private housing. This is evidence that skilled workers sort into owner-occupied housing.

The estimates in column eight suggest that the positive effects of homeownership slightly dominate its negative effects. For tenants of social housing, the two effects cancel out (or are both insignificant) and no evidence in favour of an effect of living in social housing on the wage rate is found. It is also concluded that homeowners earn wages that are 0.8 percent higher than tenants living in social housing, conditional on worker unobserved characteristics. Thus homeowners earn wages that are 0.5-0.8 percent higher than tenants, depending on type of housing the worker rents. These estimates have the same sign as that by Munch et al. (2008), however, they are considerably smaller.[16]

Table 5.4 shows the contribution of worker observed skills, time and location, industry firm and job characteristics to the explained variation in the log of hourly wages. Specification seven indicates that, without conditioning on unobserved worker skills, the largest contribution comes from "observed worker skills" (0.08), "Type of industry" (0.05) and "Living in social housing" (0.04). They have the largest effect as they correlate strongly with the log hourly wage and they contain considerable variation. In contrast, being a

[16]The baseline group of Munch et al. (2008) equals tenants. They do not distinguish between tenants of private sector housing or social housing.

homeowner is also correlated with log hourly wages, but its variation is very small.

However, column eight shows that by far the largest contribution towards the log hourly wage comes from "unobserved worker skills" (0.85), followed by job characteristics (0.01) and observed worker skills (0.01). Note that the effects of type of industry and living in social housing drop, which suggests that in estimation seven the effect of unobserved worker skills was captured by the indicators for living in social housing and the industry dummies.

Table 5.3: Estimation results

	Dependent variable: log hourly wage								
	1	2	3	4	5	6	7	8	
	coef s.e.	coef s.e.	coef s.e.	coef s.e.	coef s.e.	coef s.e.	coef s.e.	coef	s.e.
Living in social housing	-0.1824 0.0014	-0.1815 0.0014	-0.2053 0.0014	-0.2052 0.0013	-0.1894 0.0013	-0.1897 0.0013	-0.1885 0.0013	-0.0029*	0.0017
Being a homeowner	0.0750 0.0014	0.0756 0.0014	0.0100 0.0013	0.0255 0.0013	0.0223 0.0013	0.0218 0.0013	0.0201 0.0012	0.0050	0.0014
Time controls		YES	YES	YES	YES	YES	YES	YES	
Worker observed skills			YES	YES	YES	YES	YES	YES	
Regional dummies				YES	YES	YES	YES	YES	
Industry dummies					YES	YES	YES	YES	
Firm characteristics						YES	YES	YES	
Job characteristics							YES	YES	
Worker fixed effects								YES	
Worker groups								1141683	
Degrees model	3	5	19	461	472	481	491	1142173	
R^2	0.0551	0.0564	0.1300	0.1625	0.2028	0.2054	0.2114	0.8848	
Combined effect ($h_{it} - c_{it}$)	0.2574 0.0006	0.2571 0.0006	0.2153 0.0006	0.2307 0.0006	0.2117 0.0006	0.2115 0.0006	0.2086 0.0006	0.0080	0.0011

All coefficients except * significant at the 0.1 promille significance level. * significant at the 10 percent significance level. regressions based on 2,884,112 observations.

Table 5.4: Effect of indicators

	1			3			4			5			6			7			8		
	corr.	s.d.	effect	corr.	s.d.	effect	corr.	s.d.	effect	corr.	s.d.	effect	corr.	s.d.	effect	corr.	s.d.	effect	corr.	s.d.	effect
Log hourly wage	1	0.4567	1	1	0.4567	1	1	0.4567	1	1	0.4567	1	1	0.4567	1	1	0.4567	1	1	0.4567	1
Being a homeowner	0.2231	0.0332	0.0162	0.2231	0.0044	0.0022	0.2231	0.0113	0.0055	0.2231	0.0098	0.0048	0.2231	0.0096	0.0047	0.2231	0.0089	0.0044	0.2231	0.0022	0.0011
Living in social housing	0.2327	0.0764	0.0389	0.2327	0.0860	0.0438	0.2327	0.0860	0.0438	0.2327	0.0794	0.0404	0.2327	0.0795	0.0405	0.2327	.0790	0.0402	0.2327	0.0012	0.0006
Time				0.0376	0.0153	0.0013	0.0376	0.0154	0.0013	0.0376	0.0152	0.0012	0.0375	0.0152	0.0012	0.0376	0.0157	0.0013	0.0375	0.0270	0.0022
Observed worker skills				0.3010	0.1255	0.0827	0.3019	0.1251	0.0827	0.3020	0.1205	0.0797	0.3020	0.1197	0.0792	0.3022	0.1164	0.0770	0.1725	0.0286	0.0108
Location workplace							0.1610	0.0829	0.0292	0.1581	0.0716	0.0248	0.1578	0.0710	0.0245	0.1578	0.0705	0.0244	0.0165	0.0164	0.0006
Type of industry										0.2517	0.0939	0.0518	0.2511	0.0946	0.0520	0.2512	0.0941	0.0517	0.062	0.0262	0.0036
Firm characteristics													0.0597	0.0246	0.0032	0.0623	0.0245	0.0033	0.0821	0.0156	0.0028
Job characteristics																0.1158	0.0357	0.0091	0.1382	0.0394	0.0119
Worker fied effects																			0.9285	0.4187	0.8512

Specification numbers correspond to the specifications in Table 5.3. To improve readability results for specification 2 are not shown.
"corr" equals the correlation coefficient with the log of hourly wages. "s.d." equals the standard deviation.
"effect" equals $(corr)(s.d.)$ divided by the standard deviation of the log of the hourly wage. Hence, the effect in the first row is one by construction

Results for various subsamples

Table 5.5 presents the results after re-estimating equation (5.2) for different subsamples.[17] This is done to consider whether control variables in the specification can correct for subgroups of workers sorting into social or owner-occupied housing.

In column one the estimation sample contains all workers who are working 24 hours a week or more, to correct for any bias caused by the self-selection of workers with parttime jobs into social housing. A very small, statistically significant effect is found that suggest living in social housing reduces the wage earned with 0.3 percent. However, as the effect is only significant at the five percent level and the residual degrees of freedom exceed 1.4 million, the evidence is considered weak. Homeowners are found to earn 0.3 percent higher wages compared to tenants of social housing.

Column two limits the estimation sample to male workers (who work 24 hours a week or more). This might be important, as the labor market behavior of females might depend on that of their partner. However, the estimation results in this subsample are alike those in the full specification of Table 5.3.

In the third column, equation (5.2) is re-estimated for male workers who are at least thirty and who work more than 24 hours a week. This to control for all workers with parttime jobs, labor market behavior of females and the self-selection of young households into social housing. Results are similar to those found in column one, only the evidence for both tenants of social housing and owner-occupied housing is weak.

Finally, it might be that the coefficient on control variables are different for homeowners and tenants of social housing. To control for any bias that comes from omitting these covariates, equation (5.2) is estimated separately on a subsample of tenants in column four and a subsample of homeowners and tenants of private rental housing in column five. Both specifications yield parameter estimates on the type of homeownership variable that are equal to those found in column eight of Table 5.3.

Overall, the results found on the homeownership indicators in column eight of Table 5.3 are in line with the results found for various subsamples.

[17] Table 5.9 presents the results including coefficients and standard errors for control variables.

This provides evidence that these results are not biased by subgroups of workers sorting into a particular kind of housing.

Results using instrumental variables

In this section instrumental variables are used to control for the potential endogeneity of homeownership or living in social housing. The type of housing indicators are instrumented using the homeownership rate among the first decile and among workers between the first decile and the first quartile. Columns one and two of Table 5.6 show the first stage regressions. The instrumental variables are relevant as they are individually and jointly significant. The coefficients for the homeownership first stage regression are positive, whereas those for the regression for living in social housing are negative. This is conform expectations.

In column three equation (5.2) is estimated for the subsample for which instruments are available (without instrumenting the type of housing tenure variables). Results are similar to the previous estimates, with a negative albeit insignificant coefficient for living in social housing. The coefficient for being a homeowners is positive and significant with a value of 0.53 percent.

However, the coefficients become insignificant once homeownership and living in social housing are instrumented. This is in line with previous results for living in social housing. The insignificant coefficient on homeownership suggests that not too much weight should be attached to the small, positive coefficient for homeownership that was found in column eight of Table 5.3.

Table 5.5: Estimation results for various subsamples

	Dependent variable: log hourly wage				
	1	2	3	4	5
Living in social housing	-0.0026 **	-0.0021	-0.0030 *	-0.0008	
	(0.0012)	(0.0015)	(0.0018)	(0.0033)	
Being a homeowner	0.0033 ****	0.0048 ****	0.0030 **		0.0043 ***
	(0.0010)	(0.0013)	(0.0015)		(0.0016)
Time controls	YES	YES	YES	YES	YES
Worker observed skills	YES	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES	YES
Industry dummies	YES	YES	YES	YES	YES
Firm characteristics	YES	YES	YES	YES	YES
Job characteristics	YES	YES	YES	YES	YES
Worker fixed effects	YES	YES	YES	YES	YES
Observations	2,338,343	1,669,985	1,441,815	674,583	2,155,097
Worker groups	921,631	644,847	540,518	288,211	841,248
Degrees model	922,121	645,337	541,006	288,700	841,737
R^2	0.9428	0.9413	0.9404	0.8683	0.8829
Combined ($h_{it} - c_{it}$)	0.0059 *****	0.0069 *****	0.0059 *****	0.0008	0.0043 ***
	(0.0008)	(0.0010)	(0.0013)	(0.0033)	(0.0016)

Standard errors within parentheses.
*, **, ***, ****, ***** significant at the 10, 5, 1, 0.1 and 0.001 percent significance level.
Specification 1): All workers working 24 hours a week or more
Specification 2): All male workers working 24 hours a week or more
Specification 3): All male workers, aged 30 or older, working 24 hours a week or more
Specification 4): All tenants of social and private rental housing
Specification 5): All homeowners and tenants of private rental housing

Table 5.6: Estimation results instrumental variables

	Dependent variable 1): Being a homeowner Dependent variable 2): Living in social housing Dependent variable 3), 4): log hourly wage			
	1	2	3	4
Instrumental variables: local homeownership rate among:				
First decile	0.1322 *****	-0.1192 *****		
	(0.0010)	(0.0008)		
First decile and 25th percentile	0.2262 *****	-0.1998 *****		
	(0.0012)	(0.0010)		
Instrumented variables:				
Living in social housing			-0.0027	1.0602
			(0.0017)	(0.7337)
Being a homeowner			0.0053 ****	0.9477
			(0.0015)	(0.6530)
Control variables:				
Time controls	YES	YES	YES	YES
Worker observed skills	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES
Industry dummies	YES	YES	YES	YES
Firm characteristics	YES	YES	YES	YES
Job characteristics	YES	YES	YES	YES
Worker fixed effects	YES	YES	YES	YES
Observations	2,799,366	2,799,366	2,799,366	2,799,366
Worker groups	1,113,369	1,113,369	1,113,369	1,113,369
Degrees model	1,113,860	1,113,860	1,113,860	1,113,860
R^2			0.885	0.855
F	33,169.470	36,276.580		
Combined				0.1125
				(0.0809)
Stage	1	1		2

Standard errors within parentheses.
*, **, ***, ****, ***** significant at the 10, 5, 1, 0.1 and 0.001 percent significance level.

5.6 Type of housing and worker skills

Based on the estimates in column eight of Table 5.3 the predicted wage of each worker is divided into a part that depends on worker skills and a part that depends on the location of the industry and a remainder term. Worker skills are measured using the predicted value of the coefficients on observed worker skills and the unobserved worker fixed effects. Location characteristics are those indicators which vary with location in the short term, such as the fixed location effect, fixed industry effects and fixed firm effects. Also, differences in job characteristics J'_{it} are considered, which equal the job characteristics in J minus the indicators on length of tenure at the firm (which is worker-firm specific).

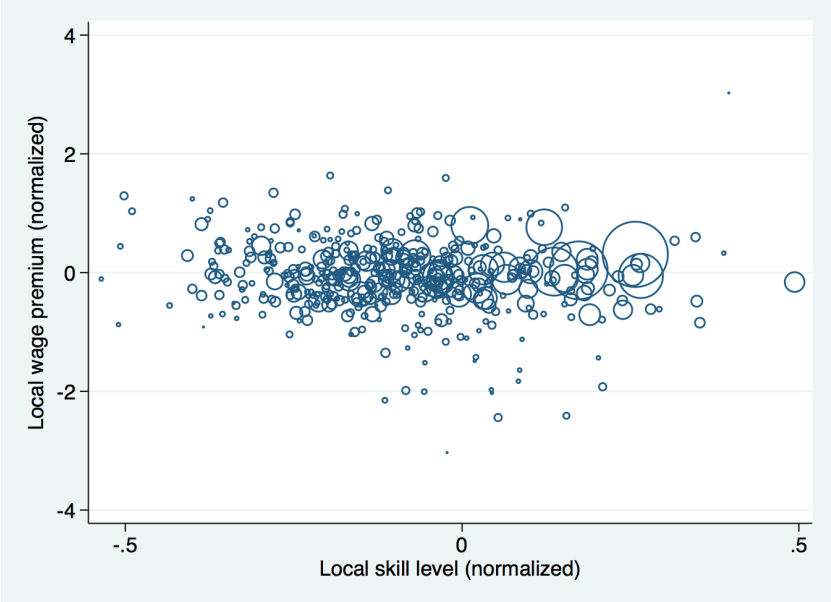
$$\begin{aligned}\hat{w}_{it} =& \underbrace{\hat{\alpha}_i + X_{it}\hat{\beta}_X}_{skills} + \underbrace{R_{rt}\hat{\beta}_R + S_{st}\hat{\beta}_S + F_{ft}\hat{\beta}_F + J'_{it}\hat{\beta}_J}_{location} + \zeta_{it} \\ \zeta_{it} =& \hat{c}_{it} + \hat{h}_{it} + \hat{\delta}_t + ft_{it}\hat{\beta}_{ft}\end{aligned}$$

Next, the municipal average of both predicted worker skills and predicted location characteristics is computed. Figure 5.4 shows the relationship between the normalized local wage premium and the local skill level. It shows no correlation between both variables. This negative relationship between local worker skills and local productivity has been found by the literature on agglomeration economies and can be explained by high productivity regions being able to set lower wages because they offer lower probabilities to become unemployed.[18] In Figure 5.5 the spatial distribution of skills and local wage premium are plotted. The left panel shows the spatial distribution of skills, which is indicative of spatial clustering according to skill. Skill levels are higher in the economic core. The spatial distribution of location premia in the right panel shows a less clearcut spatial pattern.

Figure 5.6 shows the average skill level of homeowners and tenants of social housing as a function of the number of workers in a municipality that

[18] A similar relationship is found for productivity of firms and worker skills, see Eeckhout and Kircher (2011).

Figure 5.4: Distribution skills and location premium



Relationship between the normalized local wage premium in a municipality and the normalized average skill level in the municipality. Size of the circle indicates the relative size of the workforce in the municipality.

live in social housing. First, the average skill level of homeowners exceeds that of tenants of social housing. Second, it shows a clear positive relationship between average skill level and the share of the workforce in social housing. Despite the fact that the average skill of homeowners and tenants of social housing is increasing in the share of the workforce that rents social housing, the sorting mechanism of homeowners and tenants seems to be different. Figure 5.7 shows a positive relationship between the average skills of homeowners and the average skills of homeowners in neighbouring regions. However, for workers living in social housing, this pattern is less clear-cut and seems to be reversed: the higher the average skill level of workers in social housing in a municipality, the lower is the average skill level of workers in social housing in neighbouring regions. This pattern is confirmed if the average skill of workers according to housing tenure type is regressed on the local wage premium, the number of jobs per squared kilometer, the share of the workers in social housing and a spatially lagged independent variable and error term as

Figure 5.5: Spatial distribution skills and location premium

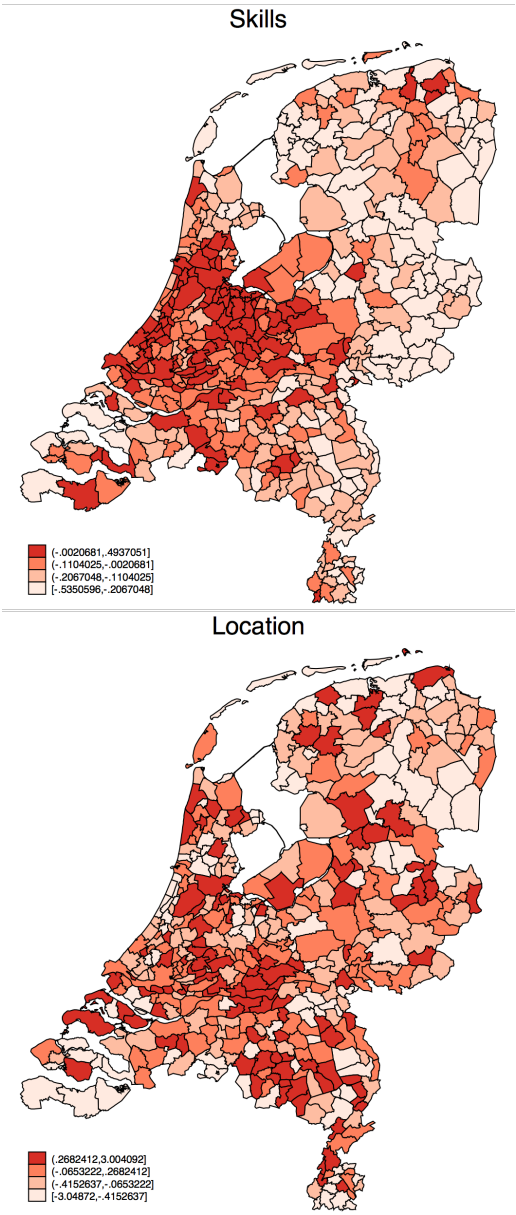
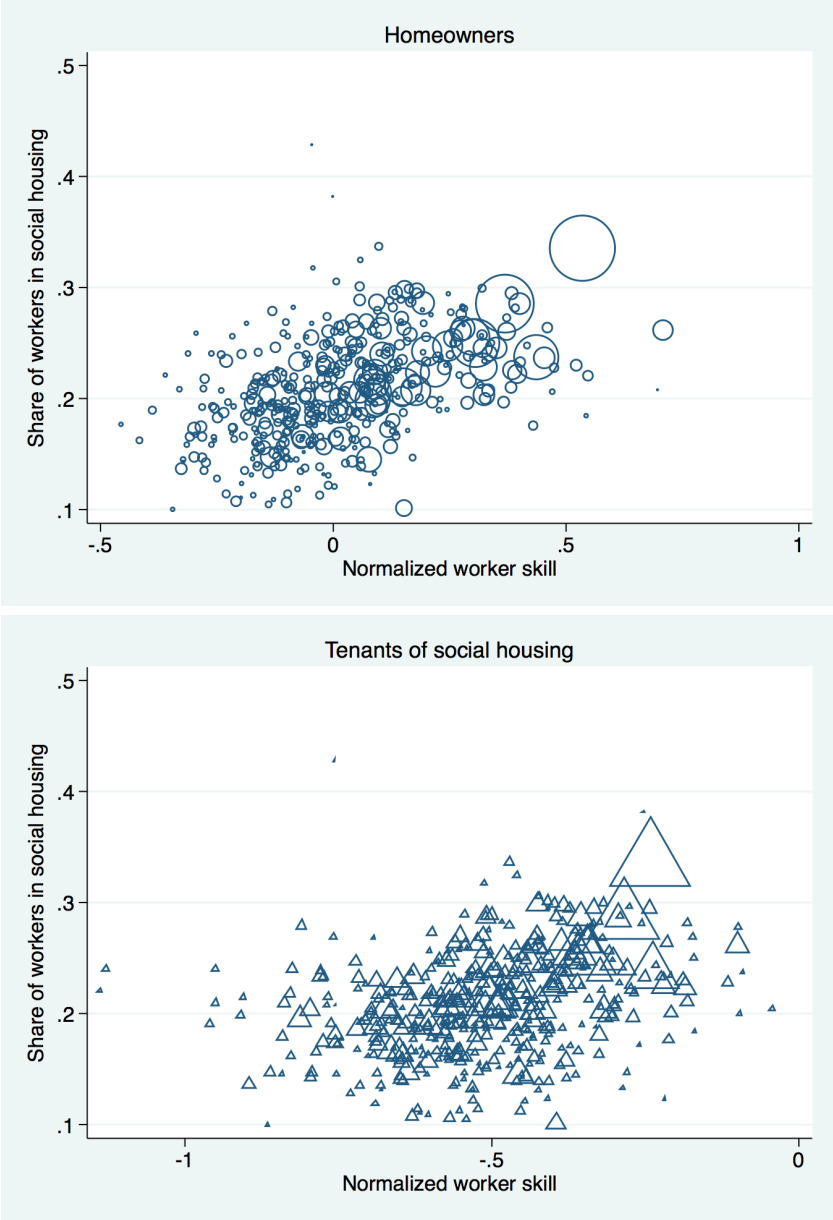
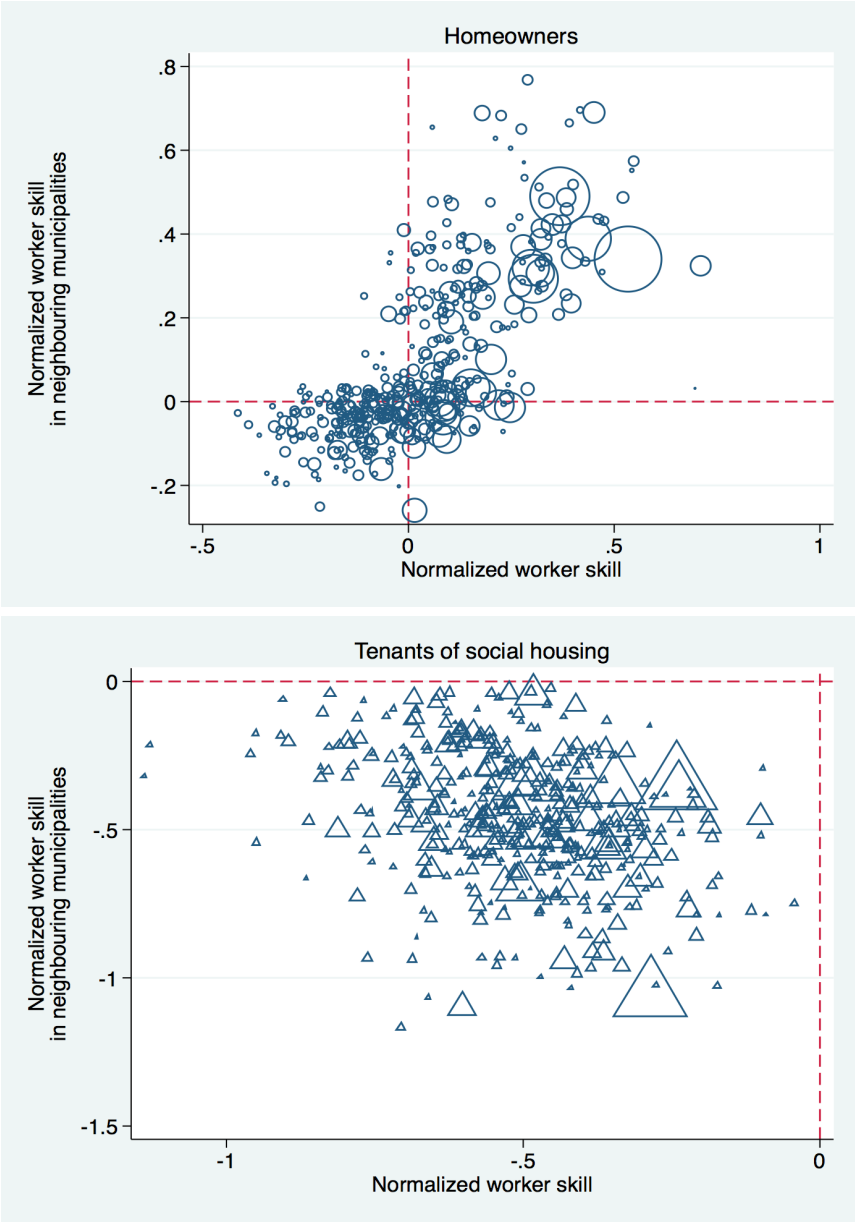


Figure 5.6: Average skills of homeowners and tenants of social housing



Relationship between the share of the workforce that lives in social housing (at the municipal level) against the average normalized skill level of homeowners and tenants of social housing at the municipal level). Size of the indicator reflects the size of the municipal workforce.

Figure 5.7: Moran's I scatterplot of municipal skill level



Moran's I scatterplot of the spatial lag of the normalized average skill in neighbouring regions against the normalized average skill of workers for workers living in owner-occupied housing (homeowners) and workers living in social housing. The average skill level in neighbouring regions is based on an inverse distance spatial weight matrix with cutoff value at 15 km. Larger cutoff-distances increase the (absolute value of) the slopes. Size of the indicator reflects the size of the municipal workforce.

in Table 5.7. For homeowners and tenants of private social housing a positive coefficient on the spatial lag of the average skill level is found. The smaller the cutoff distance in the spatial weight matrix, the stronger the parameter estimates becomes and the stronger is the sorting mechanism implied. A negative parameter estimate on the average skill level in neighbouring regions is found. Again, the absolute value of the coefficient is decreasing in the cutoff distance of the spatial weight matrix.

Differences in sorting in the social housing sector and other housing sectors are also indicated by the non-spatial coefficients. The null hypothesis that there is no relationship between the average skill of workers and the share of the workforce that lives in social housing is not rejected (for homeowners and tenants). However, the skill level of tenants (in private and social housing) and of homeowners respond differently to the local wage premium and the number of jobs in the municipality. This suggest sorting patterns differ between tenants of social housing, tenants of private housing and homeowners.

Table 5.7: Spatial sorting according to housing tenure type

	Dependent variable: Average skill level of workers		
	Cutoff distance 15 km		
	(1A) Homeowners	(2A) Social housing	(3A) Private housing
Spatial parameters: spatial lag of			
Average skill level	0.6279***	-0.4316***	0.4058*
	(0.0706)	(0.0402)	(0.1671)
Error term	0.1021	0.8185***	-0.1057
	(0.0743)	(0.0699)	(0.2151)
Main:			
Local wage premium	-0.0396*	-0.0814***	-0.0391
	(0.0196)	(0.0098)	(0.0199)
Jobs per km2	0.0321***	-0.0036	0.0505***
	(0.0077)	(0.0052)	(0.0090)
Share of workers in social housing	-0.0602	-0.2999	0.7726*
	(0.1775)	(0.1955)	(0.3410)
Constant	-0.0324	-0.6472***	-0.2732***
	(0.0340)	(0.0395)	(0.0800)
Observations	443	443	443
	Cutoff distance 25 km		
	(1B) Homeowners	(2B) Social housing	(3B) Private housing
Spatial parameters: spatial lag of			
Average skill level	0.4632***	-0.3536***	0.4262***
	(0.0481)	(0.0301)	(0.1002)
Error term	0.1552**	0.6359***	-0.1978
	(0.0514)	(0.0362)	(0.1212)
Main:			
Local wage premium	-0.0443*	-0.0859***	-0.0360
	(0.0201)	(0.0107)	(0.0203)
Jobs per km2	0.0287***	-0.0017	0.0470***
	(0.0076)	(0.0052)	(0.0091)
Share of workers in social housing	-0.2333	-0.6024**	0.4461
	(0.1656)	(0.2145)	(0.3350)
Constant	-0.0070	-0.6383***	-0.1774*
	(0.0324)	(0.0433)	(0.0807)
Observations	443	443	443
	Cutoff distance 35 km		
	(1C) Homeowners	(2C) Social housing	(3C) Private housing
Spatial parameters: spatial lag of			
Average skill level	0.3469***	-0.2881***	0.3518***
	(0.0423)	(0.0260)	(0.0786)
Error term	0.1610***	0.5011***	0.0001
	(0.0478)	(0.0482)	(0.0858)
Main			
Local wage premium	-0.0476*	-0.0862***	-0.0420*
	(0.0205)	(0.0107)	(0.0207)
Jobs per km2	0.0300***	-0.0017	0.0452***
	(0.0074)	(0.0054)	(0.0092)
Share of workers in social housing	-0.1905	-0.5605**	0.3156
	(0.1628)	(0.2074)	(0.3177)
Constant	-0.0201	-0.6870***	-0.1506*
	(0.0320)	(0.0440)	(0.0762)
Observations	443	443	443

5.7 Conclusion

In this chapter it is studied whether the observed wage differential between homeowners and tenants is the result of sorting into housing tenure type or whether type of housing tenure influences wages. It is concluded that the entire difference in wages between homeowners and tenants of private rental housing and between tenants of social and private housing can be explained by sorting.

Administrative data for the Netherlands is used to construct a panel of more than one million workers who are followed during the years 2006 to 2008. The dataset allows to regress hourly wages on worker characteristics and the region, industry, firm and job in which each worker is employed. The panel nature of the data is used to control for unobserved worker heterogeneity. These 'unobserved worker fixed effects' might reflect ability or expectations on worker ability. The results suggest that these unobserved worker characteristics are very important to control for the sorting of heterogeneous workers into housing type. Without controls on worker unobserved heterogeneity, one would conclude that wages of tenants of social housing are 20 percent lower than those of tenants of private housing. Similarly, one would conclude that wages of homeowners are two percent higher than those of tenants of private rental housing. After controlling for unobserved worker characteristics, wage differentials caused by housing tenure almost entirely disappear. Tenants of social housing do not earn lower wages than tenants of private housing, ceteris paribus. Homeowners are found to earn slightly higher wages compared to tenants of private rental housing, however, the parameter estimate is very small in economic terms: for various specifications, homeowners are found to earn 0.3-0.48 percent higher wages. The parameters on housing tenure become insignificant if they are instrumented using the homeownership rate for low-income workers in the neighborhood.

Thus it is concluded that housing tenure hardly influences wages, if controls for unobserved worker heterogeneity are included in the specification. Stated otherwise, the observed wage differentials between homeowners and tenants of social and private rental housing are entirely due to sorting of heterogeneous workers into different kinds of housing tenure.

It is concluded that spatial sorting patterns between homeowners and workers in social housing are structurally different: the average skill level of homeowners is characterized by positive spatial sorting, whereas the skill level of tenants of social housing exhibits negative spatial sorting.

5.A The within estimator with many unobserved individual effects

Because of the many individual effects α_i that have to be estimated, the within transformation of the dependent and independent variables is computed using OLS on the within transformed data. The following equation is estimated:

$$\widetilde{ln(w_{it})} = \tilde{X}_{it}\beta_X + \tilde{R}_{ct}\beta_R + \tilde{S}_{st}\beta_S + \tilde{F}_{ft}\beta_F + \tilde{J}_{it}\beta_J + \tilde{rc}_{it} + \tilde{\delta}_t + \tilde{\varepsilon}_{it}$$

Where $\tilde{}$ indicates the within transformation $\widetilde{ln(w_{it})} = ln(w_{it}) - \sum^t ln(w_{it})/T_i$, where $T_i \geq 2$ indicates the number of times the individual is observed. The 'within estimates' of the β-parameters equal the LSDV-parameters.

Next, one can obtain the value of the within transformed error term, which is consists of the constant, individual worker effect and idosyncratic error term using

$$\hat{\beta}_0 + \hat{\alpha}_i + \hat{\varepsilon}_{it} = ln(w_{it}) - X_{it}\hat{\beta}_X + R_{ct}\hat{\beta}_R + S_{st}\hat{\beta}_S + F_{ft}\hat{\beta}_F + J_{it}\hat{\beta}_J + \hat{rc}_{it} + \hat{\delta}_t$$

β_0 and α_i cannot be identified without an identifying restriction on the distribution of α_i. Use the identifying restriction that the mean of α_i is zero. Use this and the assumption that $E[\varepsilon] = 0$ to identify $\hat{\beta}_0$:

$$N^{-1}\sum^{N}\left(\hat{\beta}_0 + \hat{\alpha}_i + \hat{\varepsilon}_{it}\right) = \hat{\beta}_0$$

Define the error term minus the constant as $\hat{v}_{it}$:

$$\hat{v}_{it} = \left(\hat{\beta}_0 + \hat{\alpha}_i + \hat{\varepsilon}_{it}\right) - N^{-1}\sum^{N}\left(\hat{\beta}_0 + \hat{\alpha}_i + \hat{\varepsilon}_{it}\right) = \hat{\alpha}_i + \hat{\varepsilon}_{it}$$

Finally, α_i can be obtained as the average within individual of v_{it} and $\hat{\varepsilon}_{it}$ as the time-demeaned variation in $\hat{v}_{it}$.

$$\hat{\alpha}_i = T_i^{-1}\sum^{T_i}\hat{v}_{it}$$
$$\hat{\varepsilon}_{it} = \hat{v}_{it} - T_i^{-1}\sum^{T_i}\hat{v}_{it}$$

As said, the 'within estimates' of the β-parameters equal the LSDV-parameters. However, the standard errors are based on insufficient degrees of freedom and need to be corrected. The standard errors are corrected for having g fewer degrees of freedom. Let NT be the total number of observations for N individuals, and let k be the number of explanatory variables. LSDV computes standard errors se_{LSDV} based on $NT - (k-1)$ degrees of freedom. The fixed-effects or within estimator computes standard errors se_{FE} based on $NT - N - (k-1)$ degrees of freedom. Thus $se_{FE} = \sqrt[2]{\frac{NT-(k-1)}{NT-N-(k-1)}} se_{LSDV}$.

5.B Classification into sectors

All firms are grouped into twelve sectors based on their isic-code.

Industry[a]	Description (CBS)	Letter (CBS)	ISIC codes
1	Agriculture, Hunting and Forestry Fishing	A B	01, 02 05
2	Manufacturing	D	15–37
3	Construction	F	45
4	Wholesale and retail trade; Repair of motor verhicles, personal and household goods	G	50, 51, 52
5	Hotels and restaurants	H	55
6	Transport, storage and communication	I	60–64
7	Financial intermediation	J	65, 66, 67
8	Real estate, renting and business activities	K	70–74
9	Public administration and defence; Compulsory social security	L	75
10	Education	M	80
11	Health and social work	N	85
12	Other community, social and personal service activities; Culture, recreation and other service activities	O	90–93
. . . .	Mining and Quarrying; Electricity, gas and water supply Private households with employed persons; Extra-territorial organizations and bodies	C E P Q	10, 11, 14 40, 41 95 99

[a] "." not included (mostly because of non-occurence in some of the municipal population).

5.C Full tables

Table 5.8: Coefficients and standard errors Table 5.3

	Dependent variable: log hourly wage															
	1		2		3		4		5		6		7		8	
	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.
Housing tenure																
Living in social housing	-0.1824	0.0014	-0.1815	0.0014	-0.2053	0.0014	-0.2052	0.0013	-0.1894	0.0013	-0.1897	0.0013	-0.1885	0.0013	-0.0029*	0.0017
Being a homeowner	0.0750	0.0014	0.0756	0.0014	0.0100	0.0013	0.0255	0.0013	0.0223	0.0013	0.0218	0.0013	0.0201	0.0012	0.0050	0.0014
Fixed year effects																
Year 2006			-0.0386	0.0006	-0.0349	0.0006	-0.0354	0.0006	-0.0346	0.0006	-0.0345	0.0006	-0.0359	0.0006	-0.0646	0.0004
Year 2007			-0.0297	0.0006	-0.0288	0.0006	-0.0289	0.0006	-0.0289	0.0006	-0.0291	0.0006	-0.0294	0.0006	-0.0439	0.0003
Observed worker characteristics: one if children aged																
6 or less					0.0087	0.0007	0.0062	0.0007	0.0054	0.0006	0.0053	0.0006	0.0046	0.0006	0.0028	0.0007
between 6 and (inc.) 12					0.0172	0.0008	0.0158	0.0008	0.0162	0.0008	0.0162	0.0008	0.0161	0.0007	0.0039	0.0008
between 12 and (incl.) 16					0.0287	0.0006	0.0303	0.0006	0.0280	0.0006	0.0281	0.0006	0.0283	0.0006	0.0035	0.0007
Observed worker characteristics: one if																
Not married					-0.0146	0.0007	-0.0250	0.0007	-0.0248	0.0007	-0.0242	0.0007	-0.0241	0.0007	-0.0157	0.0015
Widowed					-0.0854	0.0029	-0.0852	0.0029	-0.0823	0.0028	-0.0822	0.0028	-0.0818	0.0028	-0.0046	0.0056
Divorced					-0.0557	0.0010	-0.0644	0.0010	-0.0629	0.0009	-0.0624	0.0009	-0.0615	0.0009	0.0006	0.0020
Aged between 20 and 25					-0.3402	0.0017	-0.3229	0.0016	-0.3078	0.0016	-0.3044	0.0016	-0.2918	0.0016	-0.0767	0.0025
Aged between 25 and 30					-0.1984	0.0011	-0.1900	0.0011	-0.1887	0.0010	-0.1872	0.0010	-0.1810	0.0010	-0.0461	0.0018
Aged between 30 and 35					-0.0690	0.0010	-0.0681	0.0010	-0.0695	0.0009	-0.0690	0.0009	-0.0674	0.0009	-0.0151	0.0012
Aged between 40 and 45					0.0368	0.0009	0.0362	0.0009	0.0370	0.0009	0.0367	0.0009	0.0356	0.0009	-0.0004	0.0011
Aged between 45 and 50					0.0739	0.0010	0.0731	0.0010	0.0696	0.0010	0.0695	0.0009	0.0671	0.0010	-0.0109	0.0015
Aged between 50 and 55					0.0999	0.0010	0.0997	0.0010	0.0903	0.0010	0.0903	0.0010	0.0870	0.0010	-0.0269	0.0019
Aged between 55 and 60					0.1153	0.0011	0.1153	0.0011	0.1052	0.0011	0.1048	0.0011	0.1007	0.0011	-0.0488	0.0023
Aged between 60 and 65					0.1597	0.0015	0.1558	0.0015	0.1427	0.0015	0.1427	0.0015	0.1393	0.0015	-0.0733	0.0028
Fixed municipality effects																
Municipality of workplace							YES		YES		YES		YES		YES	
Fixed industry effects																
Industry 1									-0.2296	0.0025	-0.2190	0.0025	-0.2203	0.0025	-0.0074	0.0051
Industry 2									-0.1154	0.0009	-0.1227	0.0009	-0.1244	0.0009	0.0084	0.0018
Industry 3									-0.1042	0.0011	-0.1001	0.0011	-0.1037	0.0011	-0.0007	0.0026
Industry 4									-0.1643	0.0009	-0.1608	0.0009	-0.1612	0.0009	-0.0099	0.0018
Industry 5									-0.3372	0.0021	-0.3331	0.0021	-0.3286	0.0021	-0.0355	0.0053
Industry 6									-0.0303	0.0011	-0.0264	0.0011	-0.0284	0.0011	0.0654	0.0023
Industry 7									0.1626	0.0012	0.1772	0.0013	0.1722	0.0013	0.0273	0.0021
Industry 9									-0.0207	0.0010	-0.0160	0.0011	-0.0172	0.0011	-0.0053	0.0026
Industry 10									0.0779	0.0011	0.0622	0.0011	0.0634	0.0011	-0.0326	0.0032
Industry 11									-0.1121	0.0009	-0.1179	0.0009	-0.1182	0.0009	-0.0411	0.0027
Industry 12									-0.1013	0.0015	-0.1041	0.0015	-0.1028	0.0015	-0.0027	0.0027
Fixed firm size effects: one if firm size equals																
9≤ size ≤ 22											-0.0132	0.0012	-0.0112	0.0012	0.0108	0.0014
23≤ size ≤53											0.0172	0.0012	0.0197	0.0012	0.0244	0.0016
54≤ size ≤133											0.0418	0.0011	0.0446	0.0011	0.0379	0.0017
134≤ size ≤311											0.0589	0.0011	0.0615	0.0011	0.0362	0.0018
312≤ size ≤725											0.0497	0.0012	0.0519	0.0012	0.0384	0.0019
726≤ size ≤1564											0.0254	0.0012	0.0278	0.0012	0.0437	0.0019
1567≤ size ≤3238											0.0137	0.0012	0.0161	0.0012	0.0459	0.0020
3248≤ size ≤10664											0.0489	0.0012	0.0511	0.0012	0.0376	0.0021
10679≤ size ≤86840											-0.0117	0.0013	-0.0064	0.0013	0.0603	0.0022
Job characteristics: one if worker holds																
Temporary contract													-0.0667	0.0009	-0.0148	0.0009
Job characteristics: one if tenure at firm in weeks equals																
4≤ tenure <39													0.2452	0.0021	0.0346	0.0022
39≤ tenure <74													-0.0175	0.0012	-0.1156	0.0018
74≤ tenure <122													-0.0028	0.0011	-0.0936	0.0018
122≤ tenure <198													0.0029	0.0011	-0.0757	0.0018
198≤ tenure <287													-0.0058	0.0011	-0.0520	0.0018
287≤ tenure <379													-0.0206	0.0010	-0.0354	0.0017
379≤ tenure <491													-0.0094	0.0010	-0.0209	0.0016
491≤ tenure <689													0.0058	0.0010	-0.0155	0.0015
689≤ tenure <1002													-0.0119	0.0010	-0.0050	0.0011
Worker fixed effects															YES	
Worker groups															1141683	
Degrees model	3		5		19		461		472		481		491		1,142,173	
R^2	0.0551		0.0564		0.1300		0.1625		0.2028		0.2054		0.2114		0.8848	
Combined effect ($h_{it} - c_{it}$)	0.2574	0.0006	0.2571	0.0006	0.2153	0.0006	0.2307	0.0006	0.2117	0.0006	0.2115	0.0006	0.2086	0.0006	0.0080	0.0011

All coefficients except * significant at the 0.1 promille significance level. * significant at the 10 percent significance level.
regressions based on 2,884,112 observations.

Table 5.9: Coefficients and standard errors Table 5.5

	Dependent variable: log hourly wage									
	1		2		3		4		5	
	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.
Housing Tenure										
Living in social housing	-0.0026**	0.0012	-0.0021	0.0015	-0.0030*	0.0018	-0.0008	0.0033	0.0000*****	0.0000
Being a homeowner	0.0033****	0.0010	0.0048****	0.0013	0.0030**	0.0015	0.0000*****	0.0000	0.0043***	0.0016
Fixed year effects										
Year 2006	-0.0753*****	0.0003	-0.0735*****	0.0003	-0.0662*****	0.0003	-0.0636*****	0.0008	-0.0640*****	0.0004
Year 2007	-0.0493*****	0.0002	-0.0485*****	0.0003	-0.0442*****	0.0003	-0.0423*****	0.0007	-0.0441*****	0.0004
Observed worker characteristics: one if children aged										
6 or less	-0.0005	0.0006	-0.0005	0.0006	-0.0020****	0.0006	0.0055***	0.0019	0.0016**	0.0008
Between 6 and (incl.) 12	0.0030*****	0.0006	0.0033*****	0.0007	0.0031*****	0.0007	-0.0014	0.0019	0.0057*****	0.0009
Between 12 and (incl.) 16	0.0032*****	0.0005	0.0038*****	0.0006	0.0050*****	0.0006	0.0013	0.0016	0.0056*****	0.0008
Observed worker characteristics: one if										
Not married	-0.0154*****	0.0011	-0.0202*****	0.0014	-0.0206*****	0.0018	-0.0100***	0.0037	-0.0172*****	0.0018
Widowed	-0.0095**	0.0041	-0.0122**	0.0052	-0.0098*	0.0052	0.0061	0.0112	-0.0054	0.0065
Divorced	0.0019	0.0014	0.0007	0.0018	0.0020	0.0018	-0.0035	0.0041	0.0000	0.0025
Aged between 20 and 25	-0.0869*****	0.0017	-0.1055*****	0.0023			-0.0677*****	0.0048	-0.0807*****	0.0030
Aged between 25 and 30	-0.0477*****	0.0013	-0.0562*****	0.0016			-0.0429*****	0.0036	-0.0475*****	0.0021
Aged between 30 and 35	-0.0162*****	0.0008	-0.0188*****	0.0010	-0.0239*****	0.0010	-0.0121*****	0.0025	-0.0155*****	0.0013
Aged between 40 and 45	0.0038*****	0.0008	0.0061*****	0.0009	0.0106*****	0.0009	-0.0070***	0.0024	0.0019	0.0012
Aged between 45 and 50	-0.0029***	0.0011	0.0004	0.0013	0.0096*****	0.0014	-0.0257*****	0.0033	-0.0054***	0.0018
Aged between 50 and 55	-0.0170*****	0.0014	-0.0134*****	0.0017	0.0007	0.0017	-0.0462*****	0.0041	-0.0189*****	0.0022
Aged between 55 and 60	-0.0395*****	0.0017	-0.0360*****	0.0020	-0.0172*****	0.0020	-0.0677*****	0.0048	-0.0398*****	0.0027
Aged between 60 and 65	-0.0630*****	0.0020	-0.0596*****	0.0024	-0.0365*****	0.0024	-0.0959*****	0.0055	-0.0620*****	0.0032
Fixed municipality effects										
Municipality of workplace	YES	YES	YES		YES	YES	YES		YES	
Fixed industry effects										
Industry 1	0.0073**	0.0035	0.0074*	0.0040	0.0154****	0.0045	-0.0085	0.0105	-0.0040	0.0060
Industry 2	0.0142*****	0.0012	0.0148*****	0.0014	0.0191*****	0.0015	0.0140****	0.0036	0.0073****	0.0021
Industry 3	0.0041**	0.0018	0.0067****	0.0019	0.0068***	0.0022	0.0053	0.0053	-0.0034	0.0031
Industry 4	-0.0042***	0.0013	-0.0032**	0.0015	0.0055****	0.0016	-0.0165*****	0.0037	-0.0081****	0.0022
Industry 5	-0.0338*****	0.0037	-0.0333*****	0.0048	-0.0192****	0.0057	-0.0447*****	0.0095	-0.0307*****	0.0067
Industry 6	0.0431*****	0.0016	0.0493*****	0.0019	0.0545*****	0.0021	0.0573*****	0.0043	0.0685*****	0.0028
Industry 7	0.0289*****	0.0015	0.0314*****	0.0019	0.0305*****	0.0020	0.0466*****	0.0048	0.0227*****	0.0023
Industry 9	0.0035*	0.0019	0.0025	0.0024	-0.0047*	0.0026	0.0210*****	0.0051	-0.0152*****	0.0031
Industry 10	-0.0270*****	0.0025	-0.0346*****	0.0032	-0.0370*****	0.0036	-0.0097	0.0064	-0.0454*****	0.0038
Industry 11	-0.0250*****	0.0021	-0.0240*****	0.0031	-0.0262*****	0.0033	-0.0200****	0.0053	-0.0508*****	0.0032
Industry 12	-0.0060***	0.0020	0.0019	0.0025	0.0021	0.0027	0.0152***	0.0049	-0.0102***	0.0033
Fixed firm size effects: one if firm size equals										
$9 \leq$ size ≤ 22	0.0095*****	0.0010	0.0116*****	0.0012	0.0117*****	0.0013	0.0114****	0.0030	0.0099*****	0.0017
$23 \leq$ size ≤ 53	0.0197*****	0.0011	0.0218*****	0.0013	0.0208*****	0.0015	0.0256*****	0.0034	0.0239*****	0.0019
$54 \leq$ size ≤ 133	0.0295*****	0.0012	0.0325*****	0.0014	0.0305*****	0.0016	0.0340*****	0.0036	0.0389*****	0.0020
$134 \leq$ size ≤ 311	0.0322*****	0.0013	0.0346*****	0.0015	0.0327*****	0.0017	0.0326*****	0.0038	0.0373*****	0.0021
$312 \leq$ size ≤ 725	0.0422*****	0.0013	0.0450*****	0.0016	0.0437*****	0.0017	0.0316*****	0.0039	0.0404*****	0.0022
$726 \leq$ size $\leq 1{,}564$	0.0380*****	0.0014	0.0406*****	0.0017	0.0383*****	0.0018	0.0392*****	0.0040	0.0451*****	0.0023
$1{,}567 \leq$ size $\leq 3{,}238$	0.0401*****	0.0014	0.0441*****	0.0018	0.0423*****	0.0019	0.0446*****	0.0041	0.0465*****	0.0024
$3{,}248 \leq$ size $\leq 10{,}664$	0.0348*****	0.0015	0.0306*****	0.0018	0.0258*****	0.0020	0.0410*****	0.0042	0.0364*****	0.0024
$10{,}6749 \leq$ size $\leq 86{,}840$	0.0575*****	0.0016	0.0585*****	0.0019	0.0526*****	0.0021	0.0560*****	0.0045	0.0610*****	0.0026
Job characteristics: one if worker holds										
Temporary contract	-0.0236*****	0.0006	-0.0245*****	0.0008	-0.0269*****	0.0009	-0.0136*****	0.0017	-0.0148*****	0.0011
Job characteristics: one if tenure at the firm in weeks equals										
$4 \leq$ tenure < 39	0.0197*****	0.0015	0.0134*****	0.0018	0.0057***	0.0019	0.0416*****	0.0046	0.0314*****	0.0025
$39 \leq$ tenure < 74	-0.1100*****	0.0013	-0.1145*****	0.0015	-0.1218*****	0.0015	-0.1122*****	0.0039	-0.1160*****	0.0020
$74 \leq$ tenure < 122	-0.0817*****	0.0013	-0.0880*****	0.0015	-0.0983*****	0.0015	-0.0818*****	0.0039	-0.0974*****	0.0020
$122 \leq$ tenure < 198	-0.0639*****	0.0013	-0.0702*****	0.0015	-0.0804*****	0.0015	-0.0668*****	0.0039	-0.0787*****	0.0020
$198 \leq$ tenure < 287	-0.0424*****	0.0013	-0.0488*****	0.0015	-0.0581*****	0.0015	-0.0470*****	0.0039	-0.0530*****	0.0020
$287 \leq$ tenure < 379	-0.0273*****	0.0012	-0.0329*****	0.0015	-0.0407*****	0.0015	-0.0329*****	0.0038	-0.0355*****	0.0020
$379 \leq$ tenure < 491	-0.0156*****	0.0012	-0.0205*****	0.0014	-0.0263*****	0.0014	-0.0221*****	0.0036	-0.0196*****	0.0019
$491 \leq$ tenure < 689	-0.0095*****	0.0011	-0.0138*****	0.0013	-0.0174*****	0.0013	-0.0153*****	0.0033	-0.0150*****	0.0017
$689 \leq$ tenure $< 1{,}002$	0.0005	0.0008	-0.0012	0.0009	-0.0040*****	0.0009	-0.0040*	0.0024	-0.0056*****	0.0012
Worker fixed effects	YES		YES		YES		YES		YES	
Observations	2,338,343		1,669,985		1,441,815		674,583		2,155,097	
Worker groups	921,631		644,847		540,518		288,211		841,248	
Degrees model	922,121		645,337		541,006		288,700		841,737	
R^2	0.9428		0.9413		0.9404		0.8683		0.8829	
Combined ($h_{it} - c_{it}$)	0.0059*****	0.0008	0.0069*****	0.0010	0.0059*****	0.0013	0.0008	0.0033	0.0043***	0.0016

*, **, ***, ****, ***** significant at the 10, 5, 1, 0.1 and 0.01 percent significance level.
Specification 1): All workers working 24 hours a week or more
Specification 2): All male workers working 24 hours a week or more
Specification 3): All male workers, aged 30 or older, working 24 hours a week or more
Specification 4): All tenants of social and private rental housing
Specification 5): All homeowners and tenants of private rental housing

Part B:

A macro-economic perspective on rent control

Chapter 6

Housing and labor market rigidities: Consequences for skill composition

6.1 Introduction

Many countries have witnessed increased sorting of high-skilled workers in cities with high productivity and house prices. Moretti (2012) calls this 'The great divide'. Urban economists explaining this sorting mechanism have emphasized the interaction of local labor and housing markets. As housing provides access to local jobs "housing supply elasticity will determine whether urban success reveals itself in the form of more people or higher incomes" (Glaeser and Gottlieb, 2009, p. 983).[1]

Consequently, both housing market and labor market price rigidities influence the equilibrium in the economy as they alter market signals. On the labor market, wage rigidities reduce the incentive to move into cities with higher

[1] Local productivity shocks stimulate the inflow of labor into a region. If the elasticity of housing supply is high, the housing stock can adapt smoothly to changes in local demand. As a result, the city grows, and many workers are hired at a rate close to the pre-existing wage rate. In contrast, if the elasticity of housing supply is low, workers cannot enter the city. This increases both wages and housing costs.

productivity. On the housing market, rent control benefits and the illiquidity of housing reduce labor mobility, as they are impediments to moving.

It has been acknowledged that outcomes on the housing and labor market are dependent. Local wage adjustments become more important to clear the labor market if labor is geographically immobile (say: due to housing market restrictions, see Hughes and McCormick 1987). In this chapter I study the combined effect of housing and labor market rigidities on local skill composition and derive conditions under which they enhance another and conditions under which they cancel out. Two price rigidities are considered: On the housing market, I allow for a share of the housing stock to be subject to rent control, which freezes the rent across the country. As a result, demand for location is no longer internalized into the controlled house prices.

On the labor market, I consider the role of equalizing wages across the country in wage negotiations between employer and employee representatives. If regions differ in productivity, this will generate local unemployment differentials. I adjust the matching framework developed by Mortensen and Pissarides (see Pissarides 2000) to model how labor demand is revealed in the local unemployment rate when wages are rigid.

In an economy with perfect labor and housing markets, a productivity shock to high-skilled labor in a region will lead to an inflow of high-skilled workers and an outflow of low-skilled workers. In this chapter I show how labor and housing market price rigidities might mitigate or amplify this relocation process.

First, the model shows that the effect of price rigidities on the housing market depends on the distribution of rent-control housing vouchers among workers of different skill. If rent-control housing vouchers are allocated mainly among low-skilled workers, the inflow of high-skilled workers and outflow of low-skilled workers after a productivity shock to high skilled labor will both be lower. The reason is that low-skilled workers with a rent-control housing voucher do not leave the core after the inflow of high-skilled workers increases market rents. The reverse occurs if rent-control housing vouchers are allocated mainly among high-skilled workers. Then, the inflow of high-skilled workers will be larger, as increasing house prices do not deter high-skilled

workers with a housing voucher from entering the region. However, they increase house prices for low-skilled workers without a housing voucher, which creates more outflow of low-skilled workers. Also, there exists an intermediate distribution such that rent-control housing vouchers increase the inflow of high-skilled workers and reduce the outflow of low-skilled workers after a productivity shock to high-skilled labor.

Second, the model indicates that labor market price rigidities mitigate the effect of a productivity shock on the relocation process. This occurs if, initially, the regions are equally productive or if the nominal wage rate is not adjusted in response to the productivity shock. The reason is that labor market price rigidities reduce the spatial expected wage rate differential that occurs due to the productivity shock.

However, if the nominal wage rate of high-skilled workers is altered in accordance to the productivity shock or if both regions differ in productivity, labor market price rigidities might amplify the relocation process. This is more likely to occur if unemployment levels are very high, the labor market matching process is vacancy intensive and wages are much larger than unemployment benefits.

A third finding is that, in general, housing market price rigidities amplify labor market price rigidities after a productivity shock to high-skilled labor, whereas they mitigate labor market price rigidities after a productivity shock to low-skilled labor. Vice versa, it is concluded that, in general, the effect of housing market price rigidities on the relocation of high- and low-skilled workers is lower if labor market price rigidities are present.[2]

This research is related to several branches of the economic literature. It augments studies of the effect of labor market rigidities on labor supply. In many European countries wages at the industry level are not set via bargaining by individual firms and workers, but in a bargaining process between (firm or) industry representatives and worker representatives. These negotiations often take place at a supra-regional (or national) level, see for instance Hartog et al. (2002). In this chapter I model wage negotiations at the supraregional level, and allow them to influence the housing market.

[2] 'In general' refers to the situation in which rent-control housing vouchers are mainly allocated among low-skilled workers and both regions are equally productive.

Wage setting regimes have been found to affect regional unemployment when wages are set according to one 'leading' labour market (Manacorda and Petrongolo, 2006); or centralized wage setting with mobile workers and government preference for immobility of workers (Caponi, 2008). These labor market outcomes might influence the housing market. For instance, Vermeulen and Van Ommeren (2009) present empirical evidence that housing markets provide compensation for regional unemployment. This chapter adds to this literature on the relationship between unemployment, wages and the housing market, as it considers the *joint* effect of housing and labor market rigidities on the location decision of workers.[3]

The remainder of this chapter is organized as follows: Section 6.2 describes the equilibrium conditions on the housing and labor market that constitutes equilibrium in the economy. Section 6.3 describes how skill and place specific productivity shock influence the location decision of workers and affect local skill composition. Next, section 6.4 shows how the equilibrium is affected by housing market price rigidities in the form of rent control. The effect of nominal wage rigidities on the equilibrium is described in section 6.5. The combined effect of housing and labor market price rigidities is derived in section 6.6. Finally, section 6.7 concludes.

6.2 The model

In this section a general equilibrium model is presented that has two regions and workers that are high-skilled or low-skilled. Utility of workers is a function of wage income (+), local amenities (+), house prices (-) and an idiosyncratic preference for either region (+). Unemployed workers move to the region that maximizes expected utility. It is assumed unemployed workers face zero moving costs, but employed workers are tied to their work and their moving costs are infinite. As a result, only unemployed workers react to labor demand shocks.

Labor markets are imperfect as skill-specific matches depend on the number of vacancies and unemployed workers in the region. Each filled job pro-

[3]See Hughes and McCormick (1987); Minford et al. (1988); McCormick (1997) for the UK, Flatau et al. (2003) for Australia, Munch and Svarer (2002); Svarer et al. (2005) for Denmark.

vides a surplus that has to be shared between the employer and the employee. I introduce price rigidities in the labor market by assuming that employer and employee-representatives bargain over a *national* wage rate. On the one hand, the national wage rate reduces the incentive to move as employed workers of type T earn equal wages in both regions. On the other hand, it sets the local unemployment rate higher or lower than the locally optimal unemployment rate.[4] Therefore *the probability* to be employed (at the national wage rate) differs between both regions.

I also introduce housing market price rigidities. Housing prices are a function of the number of residents in a city such that attractive cities have higher house prices. Part of the workforce is provided rent-control housing vouchers such that they can rent housing at the rent ceiling regardless of city size. This influences the outcomes of the model, depending on the distribution of the vouchers among high-skilled and low-skilled workers. Workers with a rent-control voucher are not subject to changing housing costs. Therefore, after a skill-specific productivity shock, rent-control vouchers affect the local skill composition in two ways: they increase the inflow of workers of that skill type, and they prevent the outflow of workers of the other skill type.

6.2.1 Labor market matching

Workers can be high-skilled or low-skilled. Let the type of labor be denoted with the superscript $T = H, L$, where H denotes high-skilled workers and L low-skilled workers. Workers live and work in the same region $c = a, b$. For simplicity, assume that the two types of labor work in firms that produce different products using only high-skilled and low-skilled labor. They sell their products at a fixed market price.

Firms post skill-specific vacancies depending on their required number of matches. Assume that the number of matches L_c^T in any period dt is a function of the number of skill-specific vacancies V_c^T, and the number of unemployed workers U_c^T. Furthermore, I assume the matching process to be Cobb-Douglas and of constant returns to skill, with general matching technology productivity μ, and vacancy intensity d. Local labor market tightness θ_c^T is defined as

[4] Except in the special case in which the national wage rate equals the local optimal wage rate.

the number of vacancies per unemployed worker of type T in city c. Use labor market tightness to define the local vacancy filling rate $m(\theta_c^T)$ and the local exit rate out of unemployment $\theta_c^T m(\theta_c^T)$.

$$L_c^T = \mu(V_c^T)^d(U_c^T)^{1-d}, \quad m(\theta_c^T) = \mu\left(\frac{V_c^T}{U_c^T}\right)^{-(1-d)}, \quad \theta_c^T m(\theta_c^T) = \mu\left(\frac{V_c^T}{U_c^T}\right)^d$$

6.2.2 Behavior of firms

All firms have to incur costs $h > 0$ each time period dt to attract labor. These costs can be thought of as resembling search costs, hiring costs, and/or intermediate costs. The return of a job of type T in c is assumed to be constant at y_c^T, whereas wage paid equals w_c^T. With the risk free interest rate r and with the probability that a filled jobs becomes vacant being equal to q, the expected profit of a filled and vacant job of type T in c in each period can be expressed as:[5]

$$\begin{aligned} r\pi_c^{Te} &= (y_c^T - w_c^T) + q(\pi_c^{Tv} - \pi_c^{Te}) \\ r\pi_c^{Tv} &= -h + m(\theta_c^T)(\pi_c^{Te} - \pi_c^{Tv}) \end{aligned}$$

Here, superscript e indicates a filled (employed) job and v a vacant job.

The free entry condition states that firms enter the market and post jobs until the expected profit of a vacant job is zero ($\pi_c^{Te} = 0$). Under this condition and using the equilibrium value for the vacancy filling rate, the unemployment rate u_c of workers of type T can be expressed as

$$u_c^T = \frac{1}{1+\alpha_c^T} \quad \text{with} \quad \alpha_c^T = \mu\left(\frac{\mu}{h}\frac{y_c^T - w_c^T}{r+q}\right)^\delta, \quad \delta = \frac{d}{1-d}$$

This equation gives the unemployment rate as determined by the matching technology, fundamental parameters h, q, r and the local productivity and wage rate for a filled job. It is a decreasing function of the surplus of a filled job $y_c^T - w_c^T$ and matching technology μ. The unemployment rate is increasing in the costs of filling a vacant job h as well as in the interest rate r and the job dis-

[5]Imposed restrictions are that $r > 0$, $0 < q < 1$ and $h > 0$. Thus firms care about future periods, there is uncertainty whether the household becomes unemployment and keeping a vacant job is costly.

solvement rate q. Finally, the unemployment rate is decreasing in the vacancy intensity of the matching process d. Note that population *size* or *number* of workers of skill-type T does not influence the local unemployment rate. This is a common feature of these types of matching models.

6.2.3 Determination of wages

Firms open up jobs in both regions such that the *expected* value of opening a vacancy is zero. Yet, each firm makes a nonzero profit on each job that *is* filled, as $y_c^T - w_c^T \geq 0$. This positive surplus has to be divided between employers and employees.

Employer and employee representatives enter a Nash bargaining process over the surplus. Simplify the bargaining process by assuming that employer representatives bargain with respect to a reference productivity level y^{Tr} and employee representatives with respect to replacement benefits z.[6] With bargaining power of employee representatives being given by β, the Nash bargaining surplus for a filled job of type T becomes:

$$S^T = \left(y^{Tr} - w^T\right)^{\beta} \left(w^T - z\right)^{1-\beta}, \quad 0 < \beta < 1$$

Taking logs and maximizing with respect to w^T shows that the negotiated optimal wage equals:

$$\max_{w^T} S^T : \quad w^T = y^{Tr} - \beta(y^{Tr} - z)$$

Therefore, the derivative of the wage rate with respect to reference productivity equals $(1-\beta)$. Note that the wage rate is independent of the local productivity level and depends solely on reference productivity and unemployment insurance. Use the expression for w_c^T to write the unemployment rate in location c as:

$$u_c^T = \frac{1}{1 + a_c^T}, \quad \text{where} \quad a_c^T = \mu \left(\frac{\mu}{h(r+q)}\right)^{\delta} \left[y_c^T - (1-\beta)y^{Tr} - \beta z\right]^{\delta}$$

[6] Thus, bargaining does not take place between individual firms and workers, but between their representatives. I explicitly assume that regional differences with respect to living conditions (amenities, house prices) are not taken into account by employee representatives.

Unemployment differentials between city a and b can only come from differentials in productivity, as all other variables are assumed to be equal across the country. For reasons that become apparent later, write the first derivatives of the local unemployment rate with respect to the local productivity level and the reference productivity level as functions of the unemployment level:[7]

$$\frac{\partial u_c^T}{\partial y_c^T} = -f(u_c^T)\zeta\delta; \quad \frac{\partial u_c^T}{\partial y^{Tr}} = -(1-\beta)f(u_c^T)\zeta\delta \tag{6.1}$$
$$f(u_c^T) = \left(1-u_c^T\right)^{1-1/\delta}\left(u_c^T\right)^{1+1/\delta}, \quad \zeta = \mu^{1/\delta}\tfrac{\mu}{h(r+q)}$$

The shape of $f\left(u_c^T\right)$ depends on the local unemployment rate u_c^T and vacancy-intensity of the matching process d. Figure 6.7 in section 6.A shows how $f\left(u_c^T\right)$ changes with u_c^T for different values of δ. If matching is vacancy neutral or vacancy intensive ($d \geq 0.5$) the function will be smaller or equal to one. $f\left(u_c^T\right)$ might exceed one if matching is vacancy extensive (or: unemployed worker intensive, $d < 0.5$), but this only occurs if the unemployment rate is 60 percent or more.

6.2.4 Behavior of workers

Assume workers live infinite lives and are risk neutral. Employed workers of type T earn w^T, whereas unemployed workers receive replacement benefits $z < w^T$. Housing costs are given by p_c. The value of local amenities is denoted A_c, whereas individual preference for location c is e_{ic}. Housing costs, local amenities and individual preferences for a location do not depend on employment status. I assume $z, w > p_c$, such that unemployed workers can locate in either region. Unemployed workers are always in search of jobs. The expected utility of being unemployed equals:

$$rV_{ic}^{Tu} = (w^T - p_c) - \tfrac{r+q}{r+q+\alpha_c^T}(w^T - z) + A_c + e_{ic} \tag{6.2}$$

Unemployed workers of type T decide to look for jobs in b if $U_{ib}^{Tu} > U_{ia}^{Tu}$. Equating (6.2) for location a and b and rearranging gives (6.3). The marginal

[7] Where I used $\frac{a_c^T}{\left(1+a_c^T\right)^2} = u_c^T\left(1-u_c^T\right)$ and $\left(y_c^T - (1-\beta)y^{Tr} - \beta z\right)^{-1} = \left(1-u_c^T\right)^{-1/\delta}\left(u_c^T\right)^{1/\delta}\mu^{1/\delta}\frac{\mu}{h(r+q)}$.

unemployed worker of type T is indifferent between moving or not and for him the equality holds.

$$(e_{ia} - e_{ib}) \leq \left[\frac{r+q}{r+q+\alpha_a^T} - \frac{r+q}{r+q+\alpha_b^T}\right](w^T - z) + (p_a - p_b) + (A_b - A_a) \qquad (6.3)$$

Preferences for location a over b are i.i.d. uniformly distributed on the domain $[-s, s]$, independent from skill type.

$$e_{ia} - e_{ib} \sim [-s, s]$$

The size of s determines the number of workers in b. Assume that the value of s is large enough to restrict the decision to relocate for at least one unemployed household.[8] Then in the long run the share of workers of type T in location b equals

$$N_b^T \frac{2s}{N^T} = \left[\frac{r+q}{r+q+\alpha_a^T} - \frac{r+q}{r+q+\alpha_b^T}\right](w^T - z) + (p_a - p_b) + (A_b - A_a) + s \qquad (6.4)$$

Equation (6.4) indicates how population size of workers of type T is determined by employment conditions and the wage rate for its skill, local house prices and the local level of amenities. Note that equation (6.4) also equals housing demand in b by workers of skill type T. As the labor market is in equilibrium if equation (6.4) holds, replacing p_c by its value determined by housing market supply will solve the model.

6.2.5 The housing market

Assume all housing is owned by profit maximizing agents abroad with deep pockets. They rent out housing at the market price to uncontrolled tenants. The price of uncontrolled housing is an increasing function of demand. Thus

[8] This restriction is met if $s \geq \left[\frac{r+q}{r+q+\alpha_a^T} - \frac{r+q}{r+q+\alpha_b^T}\right](w^T - z) + (p_a - p_b) + (A_b - A_a)$. It has a similar role as the 'no black hole condition' in the New Economic Geography literature. The 'no black hole condition' ensures that the entire economy does not collapse into one point, see Fujita et al. (1999). Similarly, the restriction that s is large enough, ensures that unemployed workers of type T do not locate in only one region.

both types of workers compete for the same uncontrolled housing.

$$p_c = \rho + k_c N_c$$

However, some workers are in the possession of a voucher that enables them to rent housing at ρ regardless of location. γN with $0 \leq \gamma \leq 1$ equals the stock of housing vouchers in the economy. $\alpha^L \gamma N$ and $\alpha^H \gamma N$ are the number of low-skilled and high-skilled workers with a housing voucher, where $\alpha^L = 1 - \alpha^H$. It is assumed that the rent-control housing vouchers are randomly allocated within the two skill groups.

Consider the location decision of rent-controlled workers. They locate according to equation (6.4) with $p_a = p_b = \rho$. Therefore, their location is driven by the difference in real wage and amenities in a and b and localization preference only. City size or housing demand by other households do *not* influence their decision to live in a or b. However, by living in a city, they influence the price of uncontrolled housing. Therefore, they affect the location decision of workers without a housing voucher.

It follows that the number of high and low-skilled workers in b is given by equation (6.5). For notational convenience, I used the simplifying assumption $r + q = 1$. Section 6.A.4 shows the derivations and also shows the number of controlled and market tenants by skill type.

$$\begin{aligned} N_b^T = & \frac{N^T}{2} + \left[\frac{\sigma + N^{T'} - \alpha^{T'}\gamma N}{\sigma + (1-\gamma)N}\right] \frac{N^T}{2s} \left(u_a^T - u_b^T\right) \left(w^T - z\right) \\ & - \frac{N^T - \alpha^T \gamma N}{\sigma + (1-\gamma)N} \frac{N^{T'}}{2s} \left(u_a^{T'} - u_b^{T'}\right) \left(w^{T'} - z\right) \\ & + \left[\frac{N^T}{N} - \frac{N^T - \alpha^T \gamma N}{\sigma + (1-\gamma)N}\right] \frac{N}{2s} (A_b - A_a) \\ & + \frac{N^T - \alpha^T \gamma N}{\sigma + (1-\gamma)N} \frac{N}{2(k_a + k_b)} (k_a - k_b) \end{aligned} \tag{6.5}$$

6.3 Effect of an idiosyncratic productivity shock on labor relocation

This section describes the comparative statics of our model with two types of labor, nominal wage rigidities and rent-controlled housing if an idiosyncratic

productivity shocks occurs. Without loss of generality, I consider the case when the productivity of high-skilled workers in b increases. It is assumed both regions are identical in the price elasticity of housing supply ($k_a = k_b$), local amenities ($A_a = A_b$) and, initially, in local productivity levels as well ($y_a^T = y_b^T$). Assume that the productivity level in b is the reference productivity level for both types of labor.

If a productivity shock to high-skilled labor occurs in b only, such that $y_{b2}^H - y_{b1}^H = \Delta > 0$, this will influence the location of labor via its effect on relative employment conditions. Denote relative employment conditions for workers of skill type T in location b as E_b^T. Relative employment conditions are a function of the national skill-specific wage rate and local unemployment rates. Define them as $E_b^T = (1-u_b^T)(w^T - z) - (1-u_a^T)(w^T - z)$, which equals the first line of equation 6.5. Then, the effect of the idiosyncratic productivity shock might manifest itself via an effect on the wage of all high-skilled workers w^H and an effect on the local unemployment rates. More specifically, the unemployment level in b falls as the region becomes more productive, whereas the unemployment rate in a rises.

Starting from equation (6.5), write the change in the number of high and low-skilled workers in b because of the change in productivity as:

$$\frac{\partial N_b^H}{\partial y^{H_b}}\Delta = \frac{\sigma+(N-N^H)-(1-\alpha^H)\gamma N}{\sigma+(1-\gamma)N}\frac{N^H}{2s}\nabla E_b^H\Delta > 0 \tag{6.6}$$

$$\frac{\partial N_b^L}{\partial y^{H_b}}\Delta = -\frac{(N-N^H)-(1-\alpha^H)\gamma N}{\sigma+(1-\gamma)N}\frac{N^H}{2s}\nabla E_b^H\Delta \leq 0 \tag{6.7}$$

Here, I used ∇E_b^H to define the change in relative employment conditions of high-skilled workers due to the productivity shock in b under rigid wages.[9]

$$\begin{aligned}\nabla E_b^H &= \frac{dE_b^H}{dy_b^H} = \frac{\partial E_b^H}{\partial y_b^H} + \frac{\partial E_b^H}{\partial y^{Hr}}\frac{\partial Y^{Hr}}{\partial Y_b^H} \\ &= \left[1 + (1-\beta)\frac{\partial y^{Hr}}{\partial y_b^H}\left(1 - \frac{f(u_a^H)}{f(u_b^H)}\right)\right]\zeta\delta f(u_b^H)\left(w^H - z\right) + \\ &\quad (1-\beta)\frac{\partial y^{Hr}}{\partial y_b^H}(u_a^H - u_b^H)\end{aligned} \tag{6.8}$$

[9]Note that the assumption that the initial unemployment levels in a and b are equal ensures that any change in the reference productivity level does not affect ∇E_b^H. Under this condition ∇E_b^H simplifies to $\nabla E_b^H = \zeta\delta f(u_b^H)\left(w^H - z\right)$.

Equations (6.6) shows that an increase in productivity of high-skilled workers in b makes city b more attractive for high-skilled workers compared to city a. As a result, high-skilled workers move to b, which increases house prices. As productivity of low-skilled workers in b has not changed, whereas house prices increase, low-skilled workers are made worse off. Therefore some low-skilled workers move to a. There is one exception to this rule: If all low-skilled workers are on rent-control such that $(1 - \alpha^H)\gamma N = N - N^H$, then housing prices will not increase for low-skilled workers. As a result, a shock to the productivity of high-skilled labor does not lead to an outflow of low-skilled workers.

6.4 Rent control and labor relocation

Here I highlight the role of rent-control on the allocation of high-skilled and low-skilled workers. Equations (6.6) and (6.7) show that the change in the population of workers depends on the size of the rent-controlled housing stock and its distribution among high and low-skilled workers.

Basically, there are four types of allocations, see Table 6.1. In the baseline situation, there are no rent-controlled housing vouchers ($\gamma = 0$). As there are no vouchers to allocate, the value of α^H is irrelevant. In the other type of situations, the stock of rent-control housing vouchers γ is nonzero. In the one extreme, all housing vouchers are in the possession of low-skilled workers and $\alpha^H = 0$. This is the top right cell in Table 6.1. Another extreme allocation would be the one in which all housing vouchers are the property of high-skilled workers ($\alpha^H = 1$, the bottom left cell). Finally, the cell in the middle of Table 6.1 refers to the situation in which the stock of rent-controlled housing is nonzero and are distributed among both high and low-skilled workers.

Table 6.1: Allocation of rent-control housing vouchers

		Among low-skilled		
		none	some	all
	none	$0 \leq \alpha^H \leq 1$ $\gamma = 0$		$\alpha^H = 0$ $\gamma > 0$
Among high-skilled	some		$0 < \alpha^H < 1$ $\gamma > 0$	
	all	$\alpha^H = 1$ $\gamma > 0$		

α and γ are such that $\alpha\gamma N \leq N^H$ and $(1-\alpha)\gamma N \leq N - N^H$

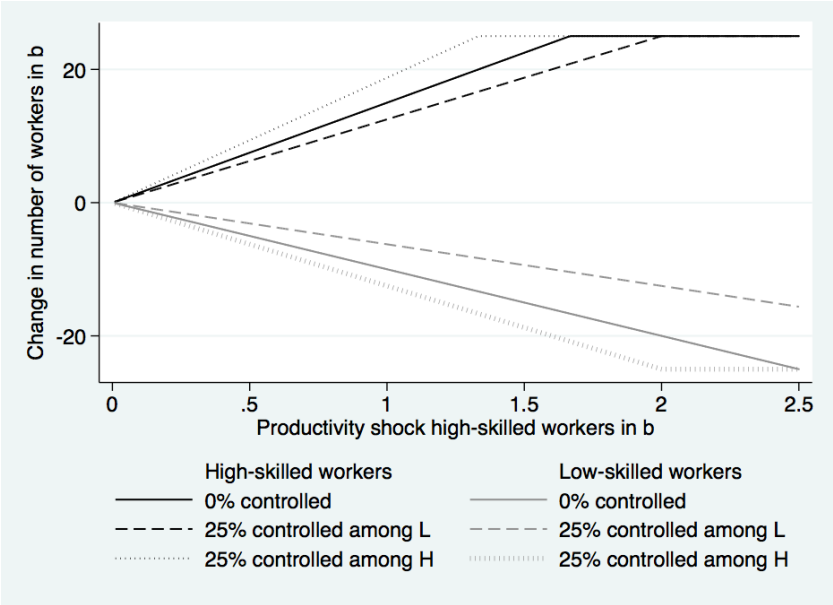
Figure 6.1 shows the change in number of high-skilled and low-skilled workers after an increase in productivity of high-skilled workers in b. The upward sloping lines represent the change in the number of high-skilled workers, the downward sloping lines are the change in the number of low-skilled workers in b. This is done for the baseline situation and the situations in which all rent-control housing vouchers are in the possession of high-skilled workers or low skilled workers.

The baseline situation in which there are no rent-control housing vouchers is illustrated with the solid black lines. The upward sloping solid black line shows the inflow of high-skilled workers in b after a productivity shock (to high-skilled workers in b). It is linear and becomes horizontal when all the high-skilled workers in the economy live in b. As high-skilled workers enter city b, house prices go up, and some low-skilled workers leave b. This is represented by the downward sloping solid line, which becomes horizontal when all low-skilled workers have left b. Note that city b is growing, as the slope parameter for high-skilled workers exceeds the absolute value of the slope parameter for low-skilled workers.

Next, consider the situation in which there are some rent-control housing vouchers in the economy, and they are all held by low-skilled workers ($\alpha^H = 0, \gamma > 0$ in the top right cell). Then the inflow of high-skilled workers is lower compared to the baseline situation.[10] At the same time, equation (6.7) shows that the flow of low-skilled workers out of b is lower compared to the baseline

[10]This is because $\frac{\sigma+(N-N^H)-\gamma N}{\sigma+N-\gamma N} < \frac{\sigma+(N-N^H)}{\sigma+N}$.

Figure 6.1: Rent control and the change in population in b



The graph shows the situation outlined above where the local amenities, the unemployment rates of low-skilled labor and housing market elasticities are equal across both cities. Furthermore, $W_b^H/2s = 4$, $\sigma = 500/20 = 25$, population size $N = 100$ and number of high-skilled workers $N^H = 50$. Positive values on the y-axis represent the inflow of high-skilled workers into b after a shock to high-skilled productivity in b (on the x-axis). Negative values on the y-axis indicate the outflow of low-skilled workers out of b.

situation.[11] This situation is shown in Figure 6.1 using the dashed lines (for $\gamma = 0.25$). The increase in productivity of high-skilled workers increases the number of high-skilled workers in b and the number of low-skilled workers decreases. However, the increase in high-skilled workers and the decrease in low-skilled workers are lower compared to the baseline situation. The higher the stock of rent-control housing vouchers, the more the lines rotate towards the x-axis. In the extreme case in which all low-skilled workers receive rent-control housing vouchers, the productivity increase of high-skilled workers slightly increases the number of high-skilled workers, without leading to an outflow of low-skilled workers. This implies that city b is still growing. Also, the skill composition changes in favor of high-skilled workers, however, the change is less profound.

Consider the effect of rent-control housing vouchers on the presence of high and low-skilled workers in b if all housing vouchers are in the possession of high-skilled workers ($\alpha^H = 1$). Now, the shock in the productivity of high-skilled workers *raises* the inflow of high-skilled workers compared to the baseline model in which there are no rent-controlled housing vouchers. Similarly, the outflow of low-skilled workers is larger than the outflow under the baseline model. The upward sloping dotted line in Figure 6.1 shows the inflow of high-skilled workers into b in this situation. As housing prices do not hold back their entrance of high-skilled workers into b, the line is steeper compared to the baseline situation without rent-control housing vouchers. Similarly, the outflow of low-skilled workers in this scenario is larger.

Finally, consider the effect of rent-control on the inflow and outflow of workers after the productivity shock if rent-control housing vouchers are allocated to both low and high-skilled workers ($0 < \alpha^H < 1$). First, note there exists a special value for α^H for which the relocation of high-skilled workers is *not* influenced by rent-control. This value equals $\alpha^H = N^H/(\sigma + N)$.[12] For values of α^H that are smaller, an increase in the stock of rent-control housing vouchers γ will decrease the inflow of high-skilled workers into b after

[11] This is because $\frac{(N-N^H)-\gamma N}{\sigma+N-\gamma N} < \frac{(N-N^H)}{\sigma+N}$.

[12] Write $\sigma = sN$ and $N - N^H = lN$. Then equate the multiplier for high-skilled workers if $0 \leq \alpha^H \leq 1$ and $\gamma > 0$ to the multiplier if $\gamma = 0$. Cross-multiplication gives $\alpha^H = \frac{1-l}{(s+1)} = \frac{N^H}{\sigma+N}$.

the described productivity shock. Likewise, rent-control housing vouchers do *not* influence the outflow of low-skilled workers in the special case that $\alpha^H = (\sigma + N^H)/(\sigma + N)$.[13] For values of α^H that are smaller, an increase in the stock of rent-control housing vouchers γ will decrease the flow of low-skilled workers out of b after the described productivity shock.

The left panel of Figure 6.2 shows how parameter values for α^H and γ change the inflow of high-skilled workers. For all values of α^H and γ the inflow of high-skilled workers is positive. For the chosen parameterization in Figure 6.2, the number of high-skilled workers increases more than the baseline model if more than 40 percent of the rent-control housing vouchers is in the possession of high-skilled workers ($\alpha^H > 0.4$). The upward sloping arrow indicates the difference with the baseline situation is increasing in the number of rent-control housing vouchers in the economy.

If less than 40 percent of the rent-control housing vouchers is in the possession of high-skilled workers ($\alpha^H < 0.4$) the inflow of high-skilled workers is smaller compared to the baseline model. In this situation, the gap between the inflow of high-skilled workers under a situation with rent-control and under the baseline situation is increasing in the number of rent-control housing vouchers in the economy.

The right panel of Figure 6.2 shows the outflow of low-skilled workers after the productivity shock in b for different parameter values of α^H and γ. For all values of α^H and γ the outflow is larger than or equal to zero.[14] The outflow of low-skilled workers is larger than the baseline model if more than 60 percent of the housing vouchers are allocated to high-skilled workers ($\alpha^H > 0.6$). This excess outflow is increasing in the number of rent-control housing vouchers in the economy, as indicated by the upward sloping arrow in the right panel.

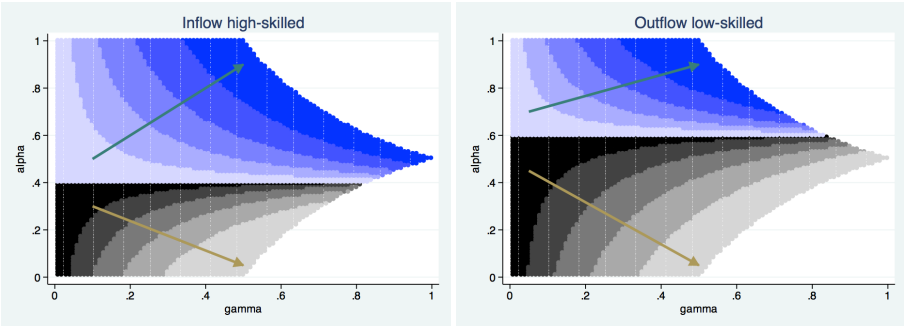
In the case that less than 60 percent of the housing vouchers is in the possession of high-skilled workers ($\alpha^H < 0.6$), the outflow of low-skilled workers is smaller compared to the baseline situation. Again, the difference with the

[13] Write $\sigma = sN$ and $N - N^H = lN$. Then equate the multiplier for low-skilled workers if $0 \leq \alpha^H \leq 1$ and $\gamma > 0$ to the multiplier if $\gamma = 0$. Cross-multiplication gives: $\alpha^H = \frac{s+1-l}{s+1} = \frac{\sigma+N^H}{\sigma+N}$

[14] The outflow equals zero if all low-skilled workers in b possess a rent-control housing voucher.

baseline situation in which there are no rent-control housing vouchers in the economy is increasing in the number of rent-control housing vouchers, as the downward sloping arrow indicates.

Figure 6.2: Inflow and outflow of workers for intermediate values of α



Upward sloping arrow: alpha>0.4 (left panel) or alpha>0.6 (right panel): Inflow high-skilled larger than baseline
Downward sloping arrow, α^H<0.4 (left panel) or α^H<0.6 (right panel): Inflow high-skilled smaller than baseline
The direction of the arrows indicate rising absolute values for the gap with the baseline model. The graph shows the situation where I have set $\sigma = 500/20 = 25$, population size $N = 100$ and number of high-skilled workers $N^H = 50$.

Figure 6.2 illustrates that the effect of increasing the rent-controlled housing stock γ on local skill composition depends on the allocation of rent-control housing vouchers among high and low-skilled workers. It shows that if rent-control housing vouchers are mainly distributed among low-skilled workers (such that α^H is smaller than the value of the special cases), increasing the rent-control housing stock will reduce the inflow of high-skilled workers into b after a positive productivity shock to high-skilled labor. Similarly, it will reduce the outflow of low-skilled workers out of b after the positive productivity shock to high-skilled labor in b.

6.5 Wage rigidities and labor relocation

Wage rigidities influence the relocation of high-skilled and low-skilled workers as they constitute the term ∇E_b^H in equations (6.6) and (6.7). Under rigid wages, ∇E_b^H is given by equation (6.8). However, under flexible wages ∇E_b^H is determined differently.

If wages can vary locally, the surplus-maximizing wage rate in c is equal to

$$\tilde{w}_c^T = y_c^T - \beta(y_c^T - z)$$

Use this to write the surplus maximizing unemployment rate for workers of type T in c as

$$\tilde{u}_c^T = \frac{1}{1+\tilde{a}_c^T} \quad \text{with} \quad \tilde{a}_c^T = \mu \left(\frac{\mu}{h(r+q)}\right)^{\delta} \left[\beta(y_c^T - z)\right]^{\delta}$$

Under flexible wages the productivity shock to high-skilled workers in b only affects the local wage rate of high-skilled workers in b. The unemployment rate of high-skilled workers in b decreases, but the unemployment rate of high-skilled workers in a and the unemployment rates of low-skilled workers do not change. The change in the local unemployment rate in b after a productivity shock to high-skilled workers in b equals:

$$\frac{\partial \tilde{u}_c^T}{\partial y_{c'}^{T'}} = \begin{cases} -f(\tilde{u}_c^T)\zeta\delta & \text{if} \quad c = c' \quad \text{and} \quad T = T' \\ 0 & \text{otherwise} \end{cases} \tag{6.9}$$
$$f(\tilde{u}_c^T) = \left(1 - \tilde{u}_c^T\right)^{1-1/\delta} \left(u_c^T\right)^{1+1/\delta}, \quad \zeta = \mu^{1/\delta} \frac{\mu}{h(r+q)}$$

Define $\tilde{E}_B^H$ as the relative employment conditions of high-skilled workers in b. Next, denote as $\nabla \tilde{E}_b^H$ the change in relative employment conditions of high-skilled workers due to the productivity shock of high-skilled workers in b.[15]

$$\begin{aligned} \tilde{E}_b^H &= (1 - \tilde{u}_b^H)(\tilde{w}_b^H - z) - (1 - \tilde{u}_a^H)(\tilde{w}_a^H - z) \\ \nabla \tilde{E}^H &= \frac{d\tilde{E}_b^H}{dy_b^H} = \frac{\partial(1-\tilde{u}_b^H)}{\partial y_b^H}(\tilde{w}_b^H - z) + \frac{\partial(\tilde{w}_b^H - z)}{\partial y_b^H}(1 - u_b^H) \\ &= f(\tilde{u}_b^H)\zeta\delta\left(\tilde{w}_b^H - z\right) + (1-\beta)\left(1 - u_b^H\right) \end{aligned} \tag{6.10}$$

Let the number of workers of skill type T under flexible wage determination be given by $\tilde{N}_b^T$. Then it follows that the effect of an increase of the productivity of high-skilled workers in b equal to Δ changes the number of high-skilled

[15] Where I used $(1 - u_c^T) = \frac{a_c^T}{1+a_c^T}$ and $\tilde{w}_c^T - z = (1-\beta)(y_c^T - z)$.

and low-skilled workers with

$$\frac{\partial \tilde{N}_b^H}{\partial y_b^H}\Delta = \frac{\sigma+N-N^H-(1-\alpha^H)\gamma N}{\sigma+(1-\gamma)N}\frac{N^H}{2s}\nabla \tilde{E}_b^H \Delta \tag{6.11}$$

$$\frac{\partial \tilde{N}_b^L}{\partial y_b^H}\Delta = -\frac{N-N^H-(1-\alpha^H)\gamma N}{\sigma+(1-\gamma)N}\frac{N^H}{2s}\nabla \tilde{E}_b^H \Delta \tag{6.12}$$

These are equal to the expression found under rigid wages, except for the replacement of ∇E_b^H with $\nabla \tilde{E}_b^H$. N_{c1}^T equals $\tilde{N}_{c1}^T$ if it is assumed that the initial local productivity levels in a and b equal the reference productivity level. This allows to write the difference in the number of workers of skill type T in city b under flexible and rigid wages as:

$$\left(\frac{\partial \tilde{N}_b^H}{\partial y_b^H} - \frac{\partial N_b^H}{\partial y_b^H}\right)\Delta = \frac{\sigma+N-N^H-(1-\alpha^H)\gamma N}{\sigma+(1-\gamma)N}\frac{N^H}{2s}\Delta\left(\nabla \tilde{E}_b^H - \nabla E_b^H\right)$$

$$\left(\frac{\partial \tilde{N}_b^L}{\partial y_b^H} - \frac{\partial N_b^L}{\partial y_b^H}\right)\Delta = -\frac{N-N^H-(1-\alpha^H)\gamma N}{\sigma+(1-\gamma)N}\frac{N^H}{2s}\Delta\left(\nabla \tilde{E}_b^H - \nabla E_b^H\right)$$

Thus, whether wage rigidities reduce or increase the adaptation in the number of high-skilled workers depends on the sign of $\nabla \tilde{E}_b^H - \nabla E_b^H$. Equation (6.13) shows that wage rigidities always *reduce* the response of city size and the number of high-skilled workers in the city if the reference rate is not adopted in response to the productivity shock *or* if the initial unemployment rates in a and b are equal.

$$\begin{aligned}\nabla \tilde{E}_b^H - \nabla E_b^H = (1-\beta)&\left[1-\left(\frac{\partial y^{Hr}}{\partial y_b^H}u_a^H + (1-\frac{\partial y^{Hr}}{\partial y_b^H})u_b^H\right)\right]\\ &-(1-\beta)\frac{\partial y^{Hr}}{\partial y_b^H}\left(1-\frac{f(u_a^H)}{f(u_b^H)}\right)\zeta\delta f(u_b^H)\left(w^H - z\right)\end{aligned} \tag{6.13}$$

$$\nabla \tilde{E}_b^H - \nabla E_b^H = (1-\beta)\left(1-u_b^H\right) \geq 0 \quad \text{if} \quad u_a^H = u_b^H \quad \text{or} \quad \frac{\partial y^{Hr}}{\partial y_b^H} = 0$$

Consider the situation in which the reference productivity level is not altered such that $\frac{\partial y^{Hr}}{\partial y_b^H} = 0$. Under rigid wages, the wage rate for high-skilled workers does not change, and therefore the unemployment level in a is not affected by the productivity shock in b. However, the unemployment rate of high-skilled workers in b falls as demand for high-skilled workers goes up with their productivity. Therefore region b becomes more attractive for high-skilled

workers and workers move to b. However, the inflow of high-skilled workers is smaller compared to the situation with flexible wages as the wage rate is determined by the reference productivity level (the initial productivity level in b) and does not reflect the increase in productivity of high-skilled workers in b. This shows the increase in employment conditions for high-skilled workers is smaller under rigid wages. Also, wage rigidities reduce the response in the number of workers if the initial unemployment values in a and b are equal. This holds even if the reference productivity level is adjusted.

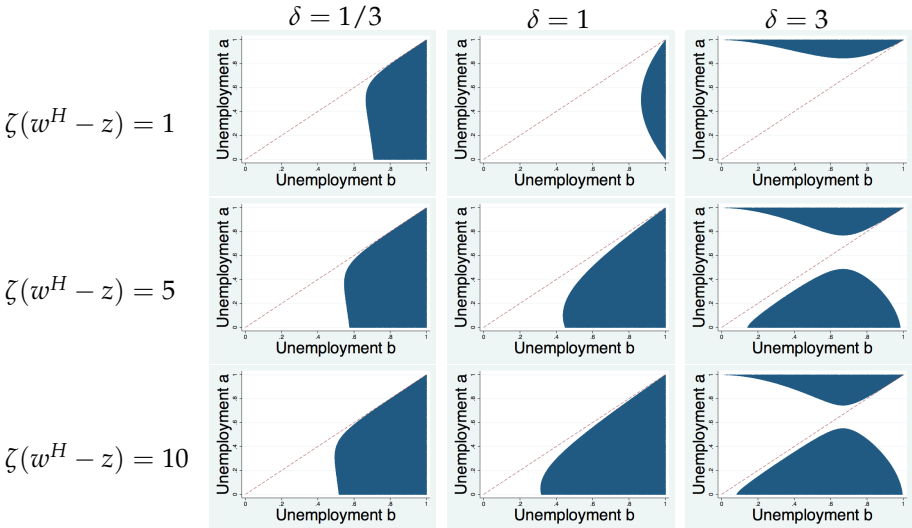
On the one hand, wage rigidities reduce mobility of high-skilled workers as they do not have to move to b to benefit from a wage increase. On the other hand, the wages in a are too high with respect to its productivity level, which increases the unemployment level in a over the optimal unemployment level. Note that the unemployment level in a depends on the productivity in a and the reference productivity level, whereas the wage rate depends only on the reference productivity level. Therefore, if the reference productivity level changes with the productivity in b and the productivity levels in a and b are equal, the increase in u_a^H is smaller than the increase in wages and wage rigidities lead to less mobility.

However, if the local unemployment levels are not equal and δ is large, the change in adjustment of labor *might* be larger under rigid wages. Rigid wages *increase* the change in city size and skill-composition if equation (6.14) holds.[16] The colored areas in Figure 6.3 show for which values of the unemployment rate in a and b this condition is met. They are drawn for several values of the vacancy intensity of the matching process (recall that $\delta > 1$ if the vacancy intensity parameter of matching $d > .5$) and several values for the rescaled wages $\zeta\left(w^H - z\right)$ under the assumption that $\partial y^{Hr}/\partial y_b^H = 1$.

$$\frac{1 - \left[\frac{\partial y^{Hr}}{\partial y_b^H} u_a^H + \left(1 - \frac{\partial y^{Hr}}{\partial y_b^H}\right) u_b^H\right]}{\frac{\partial y^{Hr}}{\partial y_b^H}\left(f(u_b^H) - f(u_a^H)\right)} < \zeta\delta\left(w^H - z\right) \tag{6.14}$$

[16]Note that equation (6.14) is not defined if the local unemployment levels for high-skilled workers are equal or if the reference productivity level for high-skilled workers is not changed after the productivity shock.

Figure 6.3: Increasing labor relocation under wage rigidities



Colored: range of values for u_a^H and u_b^H for which wage rigidities increase *labor relocation after a positive shock to productivity of high-skilled workers in b ($\nabla \tilde{u}^H - \nabla u^H < 0$). Outcomes based on $\frac{\partial y^{Hr}}{\partial y_b^H} = 1$ and on different values of $\delta = d/(1-d)$ and $\zeta(w^H - z)$.*

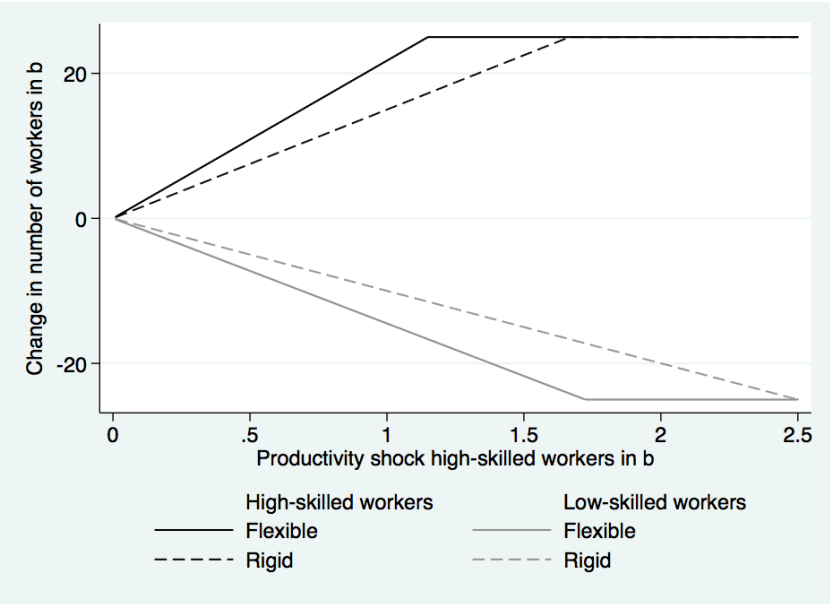
From Figure 6.3 I conclude that in general $\nabla \tilde{E}^H - \nabla E^H > 0$. Thus, in general, local nominal wage rigidities *reduce* the relocation of workers in the economy. This implies that after a positive shock to labor productivity of high-skilled workers in b, less high-skilled workers will move into city b compared to a situation where wages are flexible. Likewise, the outflow of low-skilled workers out of b is lower as well.

Figure 6.4 shows the adjustment of high-skilled and low-skilled workers in response to the idiosyncratic productivity shock. If wages would be flexible the change in the number of high-skilled workers is given by the upwards sloping solid line, which becomes horizontal if all high-skilled workers are living in b. The change in the number of high-skilled workers in b if wages are rigid is shown using the upward sloping dashed line. Together, the lines indicate that wage rigidities lower the increase in high-skilled workers after a productivity shock of high-skilled workers in b.

Similarly, the solid decreasing line shows the change in number of low-skilled workers in b under flexible wages. As more high-skilled workers enter b, house prices in b increase and some low-skilled workers leave b. The line runs horizontal if all low-skilled workers have left b. However, if wages

are rigid, less high-skilled workers enter b in general, and therefore less low-skilled workers leave b, as is indicated with the dashed, less-steeply downward sloping line.

Figure 6.4: Wage rigidities and the change in population in b



The graph shows the situation outlined above where the local amenities, the unemployment rates of low-skilled labor and housing market elasticities are equal across both cities. Furthermore, $W_b^H/2s = 4$, $\sigma = 500/20 = 25$, population size $N = 100$ and number of high-skilled workers $N^H = 50$. Positive values on the y-axis represent the inflow of high-skilled workers into b after a shock to high-skilled productivity in b (on the x-axis). Negative values on the y-axis indicate the outflow of low-skilled workers out of b.

6.6 Rent control and wage rigidities combined

The previous analysis showed that rent-control housing vouchers reduce the inflow of high-skilled workers and the outflow of low-skilled workers if the vouchers are targeted towards low-skilled workers (see Figure 6.2). For wage rigidities, I found that wage rigidities reduce the inflow of high-skilled workers and the outflow of low-skilled workers after the increase of productivity of high-skilled workers in b if unemployment levels are not too far apart (see Figure 6.3).

As both partial effects point in the same direction and their combined effect is a multiplicative function, housing market rent rigidities and labor market

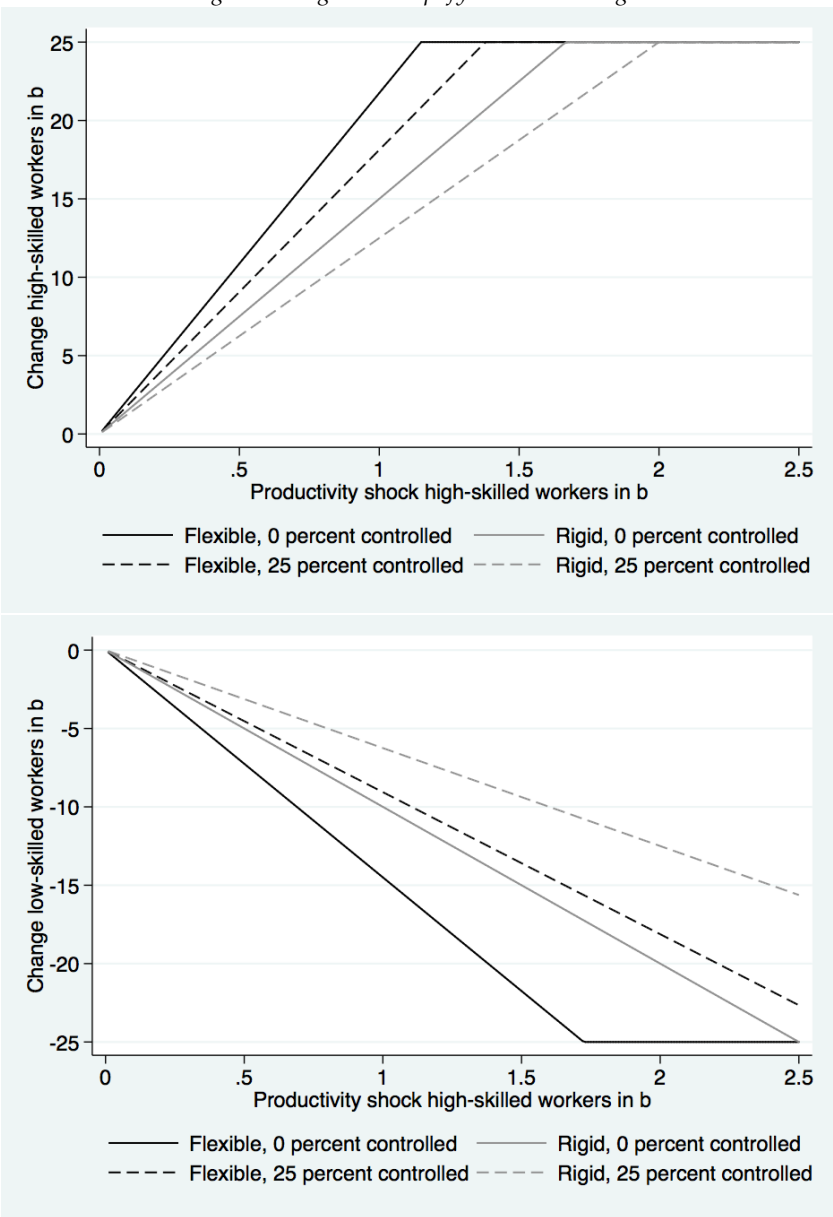
wage rigidities enforce one another. Figure 6.5 shows this when the initial productivity levels of high-skilled workers in *a* and *b* are equal, 25 percent of the housing stock is rent-controlled and all rent-control vouchers are allocated towards low-skilled workers. The top panel illustrates the change in the population of high-skilled workers. Having flexible wages and 25 percent housing vouchers in the economy allocated to low-skilled workers reduces the inflow of high-skilled workers about as much as having rigid wages without rent-control housing vouchers. Also, the gray dashed line shows that having both rigid wages *and* rent-control housing vouchers reduces the inflow of high-skilled workers the most.

The bottom panel shows the outflow of low-skilled workers after the increase in productivity of high-skilled workers. The effects of rent-control housing vouchers and rigid wages point in the same direction, and they are similar in size: In an economy with flexible wages and with 25 percent rent-controlled housing vouchers allocated to low-skilled workers, the outflow of low-skilled workers is smaller compared to an economy with rigid wages and no rent-control housing vouchers. Again, in an economy with both rigid wages and rent-control housing vouchers, the outflow of low-skilled workers is mitigated the most.

Finally, Figure 6.6 illustrates a case in which housing and labor market price rigidities mitigate one another. Here, labor market wage rigidities have the effect of lowering the inflow of high-skilled into and the outflow of low-skilled workers out of *b*: If wages are rigid a larger increase in productivity is required for a certain change in the number of high-skilled or low-skilled workers. However, if rent-control housing vouchers are allocated to high-skilled workers, the negative effect of wage rigidities on labor relocation is partly offset by increased labor relocation due to housing market rigidities. Note that wage rigidities do still negatively affect labor relocation, as can be seen by comparing the situation with and without rent-control housing vouchers under flexible and rigid wages.

Figure 6.5: Housing and labor market rigidities combined (I)

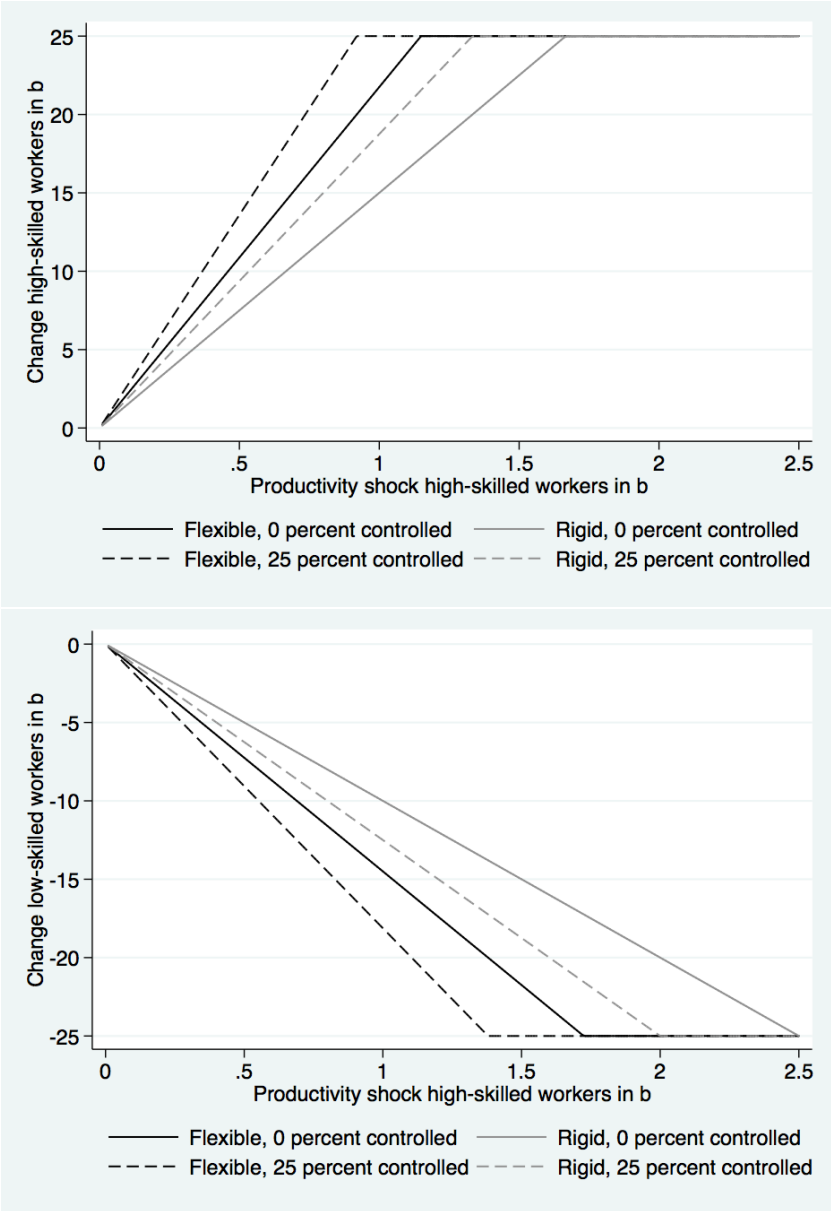
All housing vouchers allocated to low skilled:
housing market rigidities amplify labor market rigidities



The graph shows the situation outlined above where the local amenities, the unemployment rates of low-skilled labor and housing market elasticities are equal across both cities. Furthermore, $\alpha^H = 0$ (such that all housing vouchers are owned by low-skilled workers), $W_b^H/2s = 4$, $\sigma = 500/20 = 25$, population size $N = 100$ and number of high-skilled workers $N^H = 50$. Positive values on the y-axis represent the inflow of high-skilled workers after a shock to high-skilled productivity (on the x-axis). Negative values on the y-axis indicate the outflow of low-skilled workers.

Figure 6.6: Housing and labor market rigidities combined (II)

All housing vouchers allocated to high-skilled:
housing market rigidities mitigate labor market rigidities



The graph shows the situation outlined above where the local amenities, the unemployment rates of low-skilled labor and housing market elasticities are equal across both cities. Furthermore, $\alpha^H = 1$ (such that all housing vouchers are owned by high-skilled workers), $W_b^H/2s = 4$, $\sigma = 500/20 = 25$, population size $N = 100$ and number of high-skilled workers $N^H = 50$. Positive values on the y-axis represent the inflow of high-skilled workers after a shock to high-skilled productivity (on the x-axis). Negative values on the y-axis indicate the outflow of low-skilled workers

6.7 Conclusion

I have presented a model based on Moretti (2011) that integrates both the housing market and labor market in a general equilibrium framework. It has several new features. First, it is based on the assumption that labor markets are characterized by labor market search as developed by Mortensen and Pissarides (Pissarides, 2000). As a result, the location decision of households not only depends on the local wage rate, but also on the local unemployment rate. This feature makes the model consistent with empirical observations such as the wage curve (Blanchflower and Oswald, 1995).

The model considers the effect of price rigidities at both the housing and the labor market on location behavior of workers. On the labor market, the effect of nominal wage rigidities are modeled. I show that wage rigidities reduce the adjustment of the labor force with respect to local productivity changes if the reference rate is not adjusted or both regions have equal initial unemployment levels. Thus, the increase in the number of high-skilled workers after a productivity shock to high-skilled labor in b is lowered if wages are negotiated at a national level without taking local productivity into account. As a result, the outflow of low-skilled workers is smaller as well.

On the housing market, I introduce housing price rigidities in the form of rent-control housing vouchers. I show that the *sign* of the response of high and low-skilled workers to changes in local productivity depends on the *allocation* of housing vouchers among high and low-skilled workers. The size of the rent-controlled housing sector influences the size of the effect, but it cannot alter the sign. If rent-control housing vouchers are mainly distributed among low-skilled workers, the adjustment in the number of high-skilled workers after a productivity shock to high-skilled labor is lower. This occurs because fewer low-skilled workers leave the city if they possess more rent-control housing vouchers. As a result, housing prices remain high and the inflow of high-skilled workers is low compared to the situation without rent control.

Finally, I consider the joint effect of housing market and labor market price rigidities. I show that housing market rigidities and labor market rigidities can be amplifying or mitigating, depending on the distribution of rent-control housing vouchers. From our analysis one could also conclude that although housing market and labor market rigidities influence the equilibrium allocation of high-skilled and low-skilled workers across the economy, an equilibrium still exists.

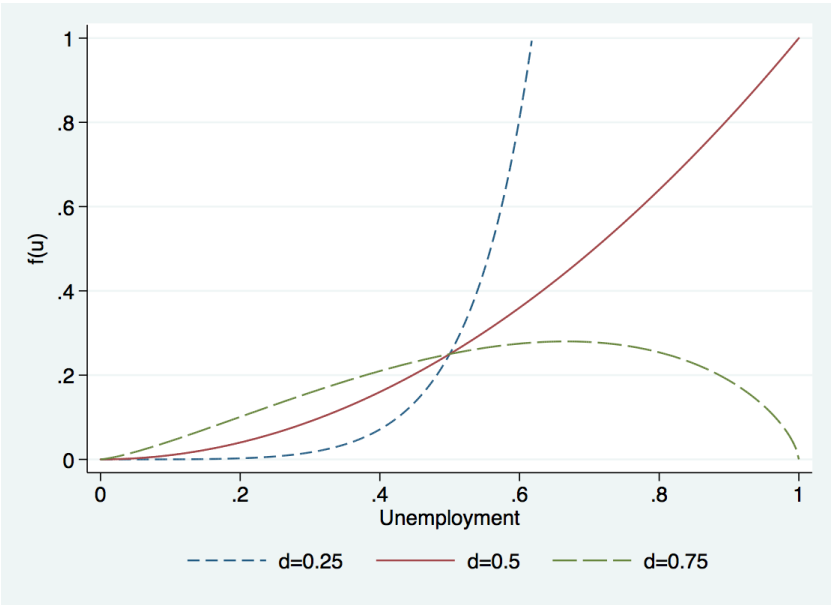
In the final chapter, I study the relationship between local housing and labor markets in the Netherlands from an empirical perspective. The Dutch system of rent regulation does not provide housing vouchers. Instead, some share of the local housing stock is declared to be rent-controlled. These differences in organization of the housing market prevent a one-to-one mapping of the results in this chapter to the situation in the Netherlands. Nonetheless, the model provides valuable insights on the interaction between local housing and labor markets for the Netherlands as well.

The insight that workers in rent-controlled housing do not leave a city if house prices increase still holds. In addition, given the correlation between income and education and the fact that rent-controlled housing is mainly allocated to low-income households, it is expected that rent-controlled housing reduces the percentage of high-skilled workers in a city.

6.A Mathematical derivations

6.A.1 $f(u_c^H)$ for different values of u_c^T and δ

Figure 6.7: $f(u_c^H)$ for different values of u_c^T and δ



6.A.2 Derivation rV_{ic}^{Tu}

Solve rV_{ic}^{Te} for V_{ic}^{Te}

$$
\begin{aligned}
rV_{ic}^{Te} &= w^T - p_c + q(V_{ic}^{Tu} - V_{ic}^{Te}) + A_c + e_{ic} \\
V_{ic}^{Te} &= \frac{w^T - p_c}{r+q} + \frac{q}{r+q} V_{ic}^{Tu} + \frac{A_c + e_{eic}}{r+q}
\end{aligned}
$$

Substitute into rV_{ic}^{Tu} and collect terms for $(A_c + e_{ic})$ and V_{ic}^{u}

$$
\begin{aligned}
rV_{ic}^{Tu} &= z - p_c + \theta_c^T m(\theta_c^T)(V_{ic}^{Te} - V_{ic}^{Tu}) + A_c + e_{ic} \\
rV_{ic}^{Tu} &= (z - p_c) + (A_c + e_{ic}) + \theta_c^T m(\theta_c^T) \left(\frac{w^T - p_c}{r+q} + \frac{A_c + e_{ic}}{r+q} + \frac{q}{r+q} V_{ic}^{Tu} - V_{ic}^{Tu} \right) \\
rV_{ic}^{Tu} &= (z - p_c) + (A_c + e_{ic}) \left(1 + \frac{\theta_c^T m(\theta_c^T)}{r+q} \right) + \theta_c^T m(\theta_c^T) \left(\frac{w^T - p_c}{r+q} - \frac{1}{r+q} rV_{ic}^{Tu} \right)
\end{aligned}
$$

Solve for rV_{ic}^{Tu}

$$rV_{ic}^{Tu} = \frac{r+q}{r+q+\theta_c^T m(\theta_c^T)}(z-p_c) + (A_c + e_{ic}) + \frac{\theta_c^T m(\theta_c^T)}{r+q+\theta_c^T m(\theta_c^T)}(w^T - p_c)$$

Define $\Phi(\theta_c^T) = \frac{\theta_c^T m(\theta_c^T)}{r+q+\theta_c^T m(\theta_c^T)}$.

$$rV_{ic}^{Tu} = (1-\Phi(\theta_c^T))(z-p_c) + A_c + e_{ic} + \Phi(\theta_c^T)(w^T - p_c)$$
$$rV_{ic}^{Tu} = (z-p_c) + \Phi(\theta_c^T)(w^T - z) + A_c + e_{ic}$$

6.A.3 Derivation rV_{ic}^{Te}

Solve rV_{ic}^{Tu} for V_{ic}^{Tu}

$$rV_{ic}^{Tu} = z - p_c + \theta_c^T m(\theta_c^T)(V_{ic}^{Te} - V_{ic}^{Tu}) + A_c + e_{ic}$$
$$V_{ic}^{Tu} = \frac{1}{r+\theta_c^T m(\theta_c^T)}(z-p_c) + \frac{\theta_c^T m(\theta_c^T)}{r+\theta_c^T m(\theta_c^T)}V_{ic}^{Te} + \frac{1}{r+\theta_c^T m(\theta_c^T)}(A_c + e_{ic})$$

Substitute into rV_{ic}^{Te} and solve for rV_{ic}^{Te}

$$rV_{ic}^{Te} = w^T - p_c + q(V_{ic}^{Tu} - V_{ic}^{Te}) + A_c + e_{ic}$$
$$rV_{ic}^{Te} = w^T + \frac{q}{r+\theta_c^T m(\theta_c^T)}z - p_c\left(\frac{q}{r+\theta_c^T m(\theta_c^T)} + 1\right) - \frac{q}{r+\theta_c^T m(\theta_c^T)}rV_{ic}^{Te} + \left(\frac{q}{r+\theta_c^T m(\theta_c^T)} + 1\right)(A_c + e_{ic})$$
$$rV_{ic}^{Te} = \frac{r+\theta_c^T m(\theta_c^T)}{r+q+\theta_c^T m(\theta_c^T)}w^T + \frac{q}{r+q+\theta_c^T m(\theta_c^T)}z - p_c + (A_c + e_{ic})$$

Rearrange to obtain

$$rV_{ic}^{Te} = (z-p_c) + \frac{r+\theta_c^T m(\theta_c^T)}{r+q+\theta_c^T m(\theta_c^T)}(w^T - z) + A_c + e_{ic}$$
$$rV_{ic}^{Te} = (z-p_c) + \left(\frac{r}{r+q+\theta_c^T m(\theta_c^T)} + \Phi(\theta_c^T)\right)(w^T - z) + A_c + e_{ic}$$

6.A.4 Workers located in b in market housing by type

To ease the notational burden define $W_a^T - W_b^T = \frac{r+q}{r+q+\alpha_a^T}(w^T - z) - \frac{r+q}{r+q+\alpha_b^T}(w^T - z)$. The location decision of rent-controlled tenants does not depend on house prices, as they pay ρ regardless of location. Therefore, the location decision

for each skill type is given by:

$$
\begin{aligned}
s\frac{N_b^{TC}-N_a^{TC}}{N^{TC}} &= W_a^T - W_b^T + (A_b - A_a) \\
N_b^{TC} &= \frac{N^{TC}}{2s}\left[W_a^T - W_b^T + (A_b - A_a) + s\right] \\
N_b^{HC} + N_b^{LC} &= \frac{N^{HC}}{2s}\left(W_a^H - W_b^H\right) + \frac{N^{LC}}{2s}\left(W_a^L - W_b^L\right) + \frac{N^C}{2s}\left[(A_b - A_a) + s\right]
\end{aligned}
$$

The location decision of high-skilled and low-skilled workers in the market segment is given by:

$$
s\frac{N_b^{TM}-N_a^{TM}}{N^{TM}} = W_a^T - W_b^T + (p_a - p_b) + (A_b - A_a)
$$

House prices in c are given by $p_c = \rho + k_c N_c$. Substitute in p_c. Because house prices are determined by demand for location, the share of workers of skill type T in b is a function of total workers in b. Thus I have to solve for N_b. Workers in b can be of the high or low skill type, and both can rent market or controlled housing: $N_b = N_b^{HC} + N_b^{LC} + N_b^{HM} + N_b^{LM}$.

$$
2s\frac{N_b^{TM}}{N^{TM}} = W_a^T - W_b^T + k_a N - (k_a + k_b)N_b + (A_b - A_a) + s
$$

Plug this in into the location decision to derive

$$
\begin{aligned}
N_b^{TM} &= \phi^{TM}\left(1 - \sigma^{-1}N^{TC}\right)\left(W_a^T - W_b^T\right) \\
&\quad - \phi^{TM}\sigma^{-1}N^{T'C}\left(W_a^{T'} - W_b^{T'}\right) \\
&\quad + \phi^{TM}(1 - \sigma^{-1}N^C)\left((A_b - A_a) + s\right) + \phi^{TM}k_a N \\
&\quad - \phi^{TM}(k_a + k_b)N_b^{T'M} \\
\text{with} \quad \phi^{TM} &= \frac{N^{TM}}{2s + (k_a + k_b)N^{TM}}, \quad \sigma = \tfrac{2s}{k_a + k_b}
\end{aligned}
$$

Fill in the definition of $N^{T'M}$ into the definition for N^{TM}.
Use $\left(1 - (k_a + k_b)\phi^{TM}\right) = \frac{\sigma(k_a+k_b)}{2s+(k_a+k_b)N^{TM}}$ to express al parts as functions of

$\phi^{TM}\phi^{T'M}/N^{T'M}$

$$
\begin{aligned}
N_b^{TM} = & \frac{\phi^{TM}\phi^{T'M}}{N^{T'M}}\left[2s + (k_a + k_b)(N^M - N^T)\right]\left(W_a^T - W_b^T\right) \\
& - \frac{\phi^{TM}\phi^{T'M}}{N^{T'M}}(k_a + k_b)(N - N^T)\left(W_a^{T'} - W_b^{T'}\right) \\
& + \frac{\phi^{TM}\phi^{T'M}}{N^{T'M}}(k_a + k_b)\left(\sigma - N^C\right)[(A_b - A_a) + s] + \frac{\phi^{TM}\phi^{T'M}}{N^{T'M}}\sigma(k_a + k_b)k_a N \\
& + \phi^{TM}(k_a + k_b)\phi^{T'M}(k_a + k_b)N_b^{TM}
\end{aligned}
$$

Note that $\frac{\phi^{TM}\phi^{T'M}/N^{T'M}}{1-(k_a+k_b)\phi^{TM}(k_a+k_b)\phi^{T'M}}$ conveniently reduces to $\frac{N^{TM}}{2s+(k_a+k_b)N^M}\frac{1}{2s}$. From here, it is straightforward to solve for N_b^{HM} and N_b^{LM}.

$$
\begin{aligned}
N_b^{TM} = & N^{TM}\mu\left[1 + \sigma^{-1}(N^M - N^T)\right]\left(W_a^T - W_b^T\right) \\
& - N^{TM}\mu\sigma^{-1}(N - N^T)\left(W_a^{T'} - W_b^{T'}\right) \\
& + N^{TM}\mu\left(1 - \sigma^{-1}N^C\right)[(A_b - A_a) + s] + N^{TM}\mu k_a N \\
\mu = & \frac{1}{2s+(k_a+k_b)(1-\gamma)N}
\end{aligned}
$$

Furthermore, I define $N^C = \gamma N$, where $0 \leq \gamma \leq 1$, to express the housing stock that is rent-controlled. The final step is to replace $\left(W_a^T - W_b^T\right) = \left(u_a^T - u_b^T\right)\left(W^T - z\right)$ by imposing $r + q = 1$.

$$
\begin{aligned}
N_b^{HM} = & N^{HM}\left[\mu + \mu\sigma^{-1}\left((1-\gamma)N - N^H\right)\right]\left(u_a^H - u_b^H\right)\left(w_b^H - z\right) \\
& - N^{HM}\mu\sigma^{-1}(N - N^H)\left(u_a^L - u_b^L\right)\left(w_b^L - z\right) \\
& + N^{HM}\mu\left(1 - \sigma^{-1}\gamma N\right)[(A_b - A_a) + s] + N^{HM}\mu k_a N
\end{aligned} \tag{6.15}
$$

$$
\begin{aligned}
N_b^{LM} = & N^{LM}\left[\mu + \mu\sigma^{-1}\left((1-\gamma)N - (N - N^H)\right)\right]\left(u_a^L - u_b^L\right)\left(w_b^L - z\right) \\
& - N^{LM}\mu\sigma^{-1}(N^H)\left(u_a^H - u_b^H\right)\left(w_b^H - z\right) \\
& + N^{LM}\mu\left(1 - \sigma^{-1}\gamma N\right)[(A_b - A_a) + s] + N^{LM}\mu k_a N
\end{aligned} \tag{6.16}
$$

Recall that number of rent-controlled high- and low-skilled workers in b are given by:

$$N_b^{HC} = \frac{N^{HC}}{2s}\left(u_a^H - u_b^H\right)(w^H - z) + \frac{N^{HC}}{2s}\left[(A_b - A_a) + s\right] \tag{6.17}$$

$$N_b^{LC} = \frac{N^{LC}}{2s}\left(u_a^L - u_b^L\right)(w^L - z) + \frac{N^{LC}}{2s}\left[(A_b - A_a) + s\right] \tag{6.18}$$

These can be used to compute the total number of high and low-skilled workers in b. Note that $\mu(k_a + k_b)(\sigma + (N - N^C) = 1$. Use $N^{HC} = \alpha\gamma N$ to denote the number of high-skilled workers on rent control, with $0 \leq \alpha \leq 1$ such that $\alpha\gamma N^H \leq N^H$.

$$\begin{aligned}
N_b^H &= N_b^{HC} + N_b^{HM} \\
N_b^H &= \frac{N^H}{2} + \left[1 - \frac{N^H - \alpha\gamma N}{\sigma + (1-\gamma)N}\right]\frac{N^H}{2s}\left(u_a^H - u_b^H\right)\left(W^H - z\right) \\
&\quad - \frac{N^H - \alpha\gamma N}{\sigma + (1-\gamma)N}\frac{N - N^H}{2s}\left(u_a^L - u_b^L\right)\left(W^L - z\right) \\
&\quad + \left[N^H - N\frac{N^H - \alpha\gamma N}{\sigma + (1-\gamma)N}\right]\frac{1}{2s}(A_b - A_a) \\
&\quad + N\frac{N^H - \alpha\gamma N}{\sigma + (1-\gamma)N}\left(\frac{k_a}{k_a + k_b} - \frac{1}{2}\right)
\end{aligned} \tag{6.19}$$

$$\begin{aligned}
N_b^L &= N_b^{LC} + N_b^{LM} \\
N_b^L &= \frac{N - N^H}{2} + \left[1 - \frac{(1-\gamma)N - (N^H - \alpha\gamma N)}{\sigma + (1-\gamma)N}\right]\frac{N - N^H}{2s}\left(u_a^L - u_b^L\right)\left(W^L - z\right) \\
&\quad - \frac{(1-\gamma)N - (N^H - \alpha\gamma N)}{\sigma + (1-\gamma)N}\frac{N^H}{2s}\left(u_a^H - u_b^H\right)\left(W^H - z\right) \\
&\quad + \left[(N - N^H) - N\frac{(1-\gamma)N - (N^H - \alpha\gamma N)}{\sigma + (1-\gamma)N}\right]\frac{1}{2s}(A_b - A_a) \\
&\quad + N\frac{(1-\gamma)N - (N^H - \alpha\gamma N)}{\sigma + (1-\gamma)N}\left(\frac{k_a}{k_a + k_b} - \frac{1}{2}\right)
\end{aligned} \tag{6.20}$$

and therefore the number of workers in b is given by:

$$
\begin{aligned}
N_b &= N_b^H + N_b^L = \\
N_b &= \frac{N}{2} + \frac{\sigma}{\sigma + (1-\gamma)N} \frac{N^H}{2s} \left(u_a^H - u_b^H\right) \left(W^H - z\right) \\
&\quad \frac{\sigma}{\sigma + (1-\gamma)N} \frac{N - N^H}{2s} \left(u_a^L - u_b^L\right) \left(W^L - z\right) \\
&\quad + \left(\frac{\sigma}{\sigma + (1-\gamma)N}\right) \frac{N}{2s} (A_b - A_a) \\
&\quad + \frac{(1-\gamma)N}{\sigma + (1-\gamma)N} \left(\frac{k_a}{k_a + k_b} - \frac{1}{2}\right) N
\end{aligned} \tag{6.21}
$$

6.A.5 Effect productivity of high-skilled workers on their unemployment rates

The first full derivative of u_b^H towards y_b^H equals:

$$
\begin{aligned}
\frac{du_b^H}{dy_b^H} &= \frac{\partial u_b^H}{\partial a_b^H} \frac{\partial a_b^H}{\partial y_b^H} + \frac{\partial u_b^H}{\partial a_b^H} \frac{\partial a_b^H}{\partial y^{Hr}} \\
&= \frac{\partial u_b^H}{\partial a_b^H} \left(\frac{\partial a_b^H}{\partial y_b^H} + \frac{\partial a_b^H}{\partial y^{Hr}}\right) < 0
\end{aligned}
$$

with

$$
\begin{aligned}
\frac{\partial u_b^H}{\partial a_b^H} &= -(1 - a_b^H)^{-2} < 0 \\
\left(\frac{\partial a_b^H}{\partial y_b^H} + \frac{\partial a_b^H}{\partial y^{Hr}}\right) &= \beta \frac{\partial a_b^H}{\partial y_b^H} > 0 \\
\frac{\partial a_b^H}{\partial y_b^H} &= \tfrac{d}{1-d} \mu \left[\tfrac{\mu}{h} \left(y_c^H - (1-\beta) y^{Hr} - \beta z\right)\right]^{\frac{2d-1}{1-d}} \tfrac{\mu}{h} > 0
\end{aligned}
$$

The first full derivative of u_a^H towards y_b^H equals:

$$\begin{aligned}\frac{du_a^H}{dy_b^H} &= \frac{\partial u_a^H}{\partial a_a^H}\frac{\partial a_a^H}{\partial y_a^H} + \frac{\partial u_a^H}{\partial a_a^H}\frac{\partial a_a^H}{\partial y^{Hr}} \\ &= \frac{\partial u_a^H}{\partial a_a^H}\frac{\partial a_a^H}{\partial y^{Hr}} > 0\end{aligned}$$

with

$$\frac{\partial u_a^H}{\partial a_a^H} = -(1-a_b^H)^{-2} < 0$$

$$\frac{\partial a^{H_a}}{\partial y^{Hr}} = -(1-\beta)\tfrac{\mu}{h}\tfrac{d}{1-d}\mu\left[\tfrac{\mu}{h}\left(y_a^H - (1-\beta)y^{Hr} - \beta z\right)\right]^{\frac{2d-1}{1-d}} < 0$$

Chapter 7

Rent control and local skill composition[1]

7.1 Introduction

As rent control prevents the adjustment of housing costs for controlled (and typically low-skilled) tenants, the growth of cities and their skill composition could be affected by rent control. This effect on local labor supply might reduce agglomeration externalities that find their origin in the clustering of high-skilled workers.[2] If so, this provides a new channel by which rent control distorts outcomes on the local labor market, besides the effect on local unemployment (Svarer et al., 2005). Additionally, as the main goal of rent control is to provide affordable housing to workers who are typically low-skilled, knowledge whether rent control improves the access of low-skilled workers is informative on its efficacy.[3]

[1]This chapter uses data on the sectoral production and labor force for forty NUTS 3 regions in the Netherlands over the years 1981-2006. This data has been collected by TNO. I am grateful to TNO for sharing their data with me.

[2]Moretti (2004) presents evidence that clustering of high-skilled workers increases nominal wages of all skill types. For the Netherlands, De Groot et al. (2013) find that the wage elasticity to the percentage of high-skilled workers equals 2.9-5 percent (depending on skill-type).

[3]Rent control is widespread especially in Europe (Scanlon and Whitehead, 2007, 2008). Worldwide about forty percent of the population lives in rental housing being subject to some controls (Malpezzi, 1993). Scanlon and Whitehead (2007) mention there is a general public concern in Europe that without social housing low-income household cannot afford to live in expensive cities.

Moretti (2011, 2013) has shown how local skill composition is driven by the local wage rate net of local housing costs. Rent-controlled social housing distorts this mechanism, as it changes the local housing costs. Under the assumption that social housing is allocated mainly to low-skilled workers, it enhances the entrance of low-skilled workers after a generic increase in productivity and prevents the outflow of low-skilled workers after a high-skilled specific productivity increase. Thus rent control is expected to negatively influence the share of high-skilled workers in a region.

However, the effect of rent control on local skill composition might be negligible from an economic perspective. This might occur for instance, if rent-controlled housing is poorly targeted towards low-skilled workers. In the extreme, if the probability to rent controlled or uncontrolled housing does not differ between high-skilled and low-skilled workers, increasing the rent-controlled housing stock will not alter local skill composition.

The effect of rent control on skill composition is analyzed using panel data on fourty NUTS 3 regions in the Netherlands (in Dutch: *COROPs*). An advantage of the data is that all NUTS 3 regions in the Netherlands have a substantial share of housing that is rent-controlled. Skill composition, skill premium, house prices and rent-controlled housing stock for each region have been measured using the national housing surveys in the years 1981, 1985, 1989, 1993, 1998, 2002 and 2006 (the so-called *WBO* and *WoON* surveys). This data is augmented with information on productivity and employment for eight sectors in these years at the NUTS 3 level.

Of these variables, the local wage ratio and local house prices might be correlated with changes in unobserved local amenities. This creates an endogeneity problem. Using the data on sectoral productivity and employment and using data on historic housing density these endogenous variables can be instrumented.

Evidence is found that rent control reduces the percentage of high-skilled workers in a region. Ceteris paribus a ten percentage point increase of the rent-controlled housing stock is found to reduce the percentage of high-skilled workers in a region with 1.5 percentage points. This is equivalent to an increase in house prices with about 8,800 euro.

This chapter contributes to two branches of the economic literature. First, it contributes to economic research on the interaction between local housing markets and local labor markets. Housing markets can create mobility constraints that might influence unemployment. Svarer et al. (2005) find that rent-controlled tenants are more likely to become unemployed. Our contribution is that the framework of Moretti (2011, 2013) is augmented with a (non-competitive) rent-controlled housing sector and derive the implications for local skill composition. This highlights a new labor market distortion created by rent control.

Second, our research contributes to the literature on economic segregation. The way rent control affects social segregation depends on local market conditions, see (Glaeser, 2003; Sims, 2011; Öst et al., 2013). In this chapter the effect of rent control on local composition is studied for an entire country over a long time-period of 25 years, while controlling for labor demand and local consumer amenities.

The remainder of this chapter is organized as follows. Section 7.2 presents our theoretical model how rent-controlled housing might affect local skill composition. A description of the data is presented in section 7.3. The estimation strategy is presented in section 7.4, section 7.5 gives the estimation results. Conclusions and implications for further research are presented in section 7.6.

7.2 Theoretical model

To see how rent control influences the skill composition in a general equilibrium setting, the model by Moretti (2011) is augmented with housing vouchers that provide access to rent-controlled housing. Consider an economy with two cities a and b and high-skilled workers N^H and low-skilled workers N^L. Log indirect utility of workers in city $c = a, b$ is a function of local wages w, local housing costs p_{ic} (that might differ across workers), the pecuniary valuation of local amenities A_c and a worker specific preference for city c.

$$u_{ic}^T = w_c^T - p_{ic} + A_c^T + e_{ic}^T, \quad T = H, L \tag{7.1}$$

For simplicity, it is assumed that high and low-skilled workers work in separated firms.[4] Assume that production is Cobb-Douglas. The wage workers earn equals the marginal productivity of labor. Assume the supply of capital is infinitely elastic and capital is applied such that the marginal productivity of capital equals the rent r. Thus the production function and the marginal returns to labor equal:[5]

$$\begin{aligned} y_c^T =& X_c^T + hN_c^T + (1-h)K_c^T \\ w_c^T =& X_c^T - (1-h)N_c^T + (1-h)K_c^T + h \end{aligned}$$

Housing is rented out to workers by profit-maximizing landlords with deep pockets who reside outside the economy. Housing supply equals the number of workers in the city and is an increasing function of the price:

$$p_c = \rho + k_c(N_c^H + N_c^{Lm} + N_c^{Lv})$$

All housing is rented out against market rents p_c, however N^v workers receive a housing voucher which enables them to rent housing at the controlled rent ρ in any city. Assume housing vouchers are randomly distributed among low-skilled workers only.[6] Thus all N^H high-skilled workers and some N^{Lm} low-skilled workers rent against the market rent. N^{Lv} low-skilled workers rent against the controlled rent.

Local amenities are valued differently by low-skilled and high-skilled workers. Finally, it is assumed that the relative worker specific preference for city a over city b is i.i.d. uniformly distributed on the domain $-s, s$ (regardless of skill).

Equilibrium

Workers locate in city b if $u_{ib} > u_{ia}$, which depends on the relative local wage rate, the relative presence of local amenities and on relative worker spe-

[4]Thus, substitution between skill types in production is assumed away. This simplifies the model, but it is not crucial for its outcome.

[5]Similarly, in equilibrium the marginal product of capital equals marginal costs $r = X_c^T + hN_c^T - hK_c^T + (1-h)$.

[6]Chapter 5 presents a similar model that shows an extended version of this model in which rent-control housing vouchers can be allocated among high-skilled workers.

cific preference. Location depends on local house prices only if the worker does not have a housing voucher. The larger the difference between the skill-specific wage net of housing costs and local amenities in the cities, the more unequal workers of a certain skill will be distributed. The economy contains three marginal workers who are indifferent between living in city a or b: one high-skilled worker, one low-skilled worker without a housing voucher and one low-skilled worker with a housing voucher. As $e^T_{ia} - e^T_{ib}$ is uniformly distributed on the domain $[-s, s]$ it is possible to solve for the number of people of type T in both cities using:[7]

$$N^{Lv}_c = \frac{N^{Lv}}{2s}\left[(w^L_c - w^L_{c'}) + (A^L_c - A^L_{c'}) + s\right] \tag{7.2a}$$

$$N^{Lm}_c = \frac{N^{Lm}}{2s}\left[(w^L_c - w^L_{c'}) - (p_c - p_{c'}) + (A^L_c - A^L_{c'}) + s\right] \tag{7.2b}$$

$$N^{H}_c = \frac{N^{H}}{2s}\left[(w^H_c - w^H_{c'}) - (p_c - p_{c'}) + (A^H_c - A^H_{c'}) + s\right] \tag{7.2c}$$

Solving for w^L_c and w^H_c yields labor supply of low-skilled and high-skilled workers. Equilibrium at the labor market requires that each worker earns his marginal productivity. Note that the wage rate does *not* depend on the local supply of the labor force as capital is attracted such that labor earns its marginal product.

Labor supply

$$w^H_c = w^H_{c'} + \tfrac{2s}{N^H} N^H_c + (p_c - p_{c'}) - (A^H_c - A^H_{c'}) - s \tag{7.3}$$

$$w^L_c = \tfrac{2s}{N^{Lm}+N^{Lv}} N^L_c + w^L_{c'} - (A^L_c - A^L_{c'}) - s + \tfrac{N^{Lm}}{N^{Lm}+N^{Lv}}(p_c - p_{c'}) \tag{7.4}$$

Labor demand

$$w^T_c = \tfrac{1}{h} X^T_c + \tfrac{1-h}{h}\left[(1-h) - r\right] + h \tag{7.5}$$

Housing supply is a positive function of the housing price. Equilibrium at the housing market is reached if local housing demand equals local housing supply. Sum equations (7.2a) to (7.2c) and rewrite as a function of p_c to obtain

[7] See section 7.A for its derivation. It is assumed that s is large enough such that there are always workers with a housing voucher living in a and b. Think of this condition as resembling the "no black hole condition" in New Economic Geography, as it prevents that workers of a particular skill concentrate in one region (see Fujita et al. 1999).

inverse housing demand:

housing supply

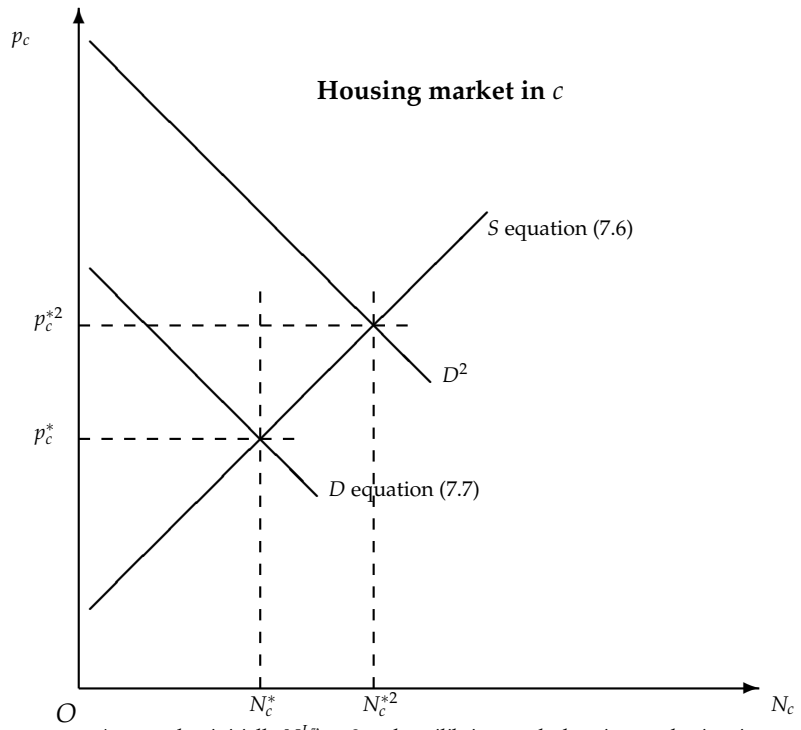
$$p_c = \rho + k_c(N_c^H + N_c^{Lm} + N_c^{Lv}) \tag{7.6}$$

housing demand

$$p_c = p_{c'} - \frac{2s}{N^H+N^{Lm}} N_c + \left(1 + \frac{N^{Lv}}{N^H+N^{Lm}}\right) s + \frac{N^{Lv}+N^{Lm}}{N^H+N^{Lm}} \left(w_c^L - w_{c'}^L + A_c^L - A_{c'}^L\right) + \frac{N^H}{N^H+N^{Lm}} \left(w_c^H - w_{c'}^H + A_c^H - A_{c'}^H\right) \tag{7.7}$$

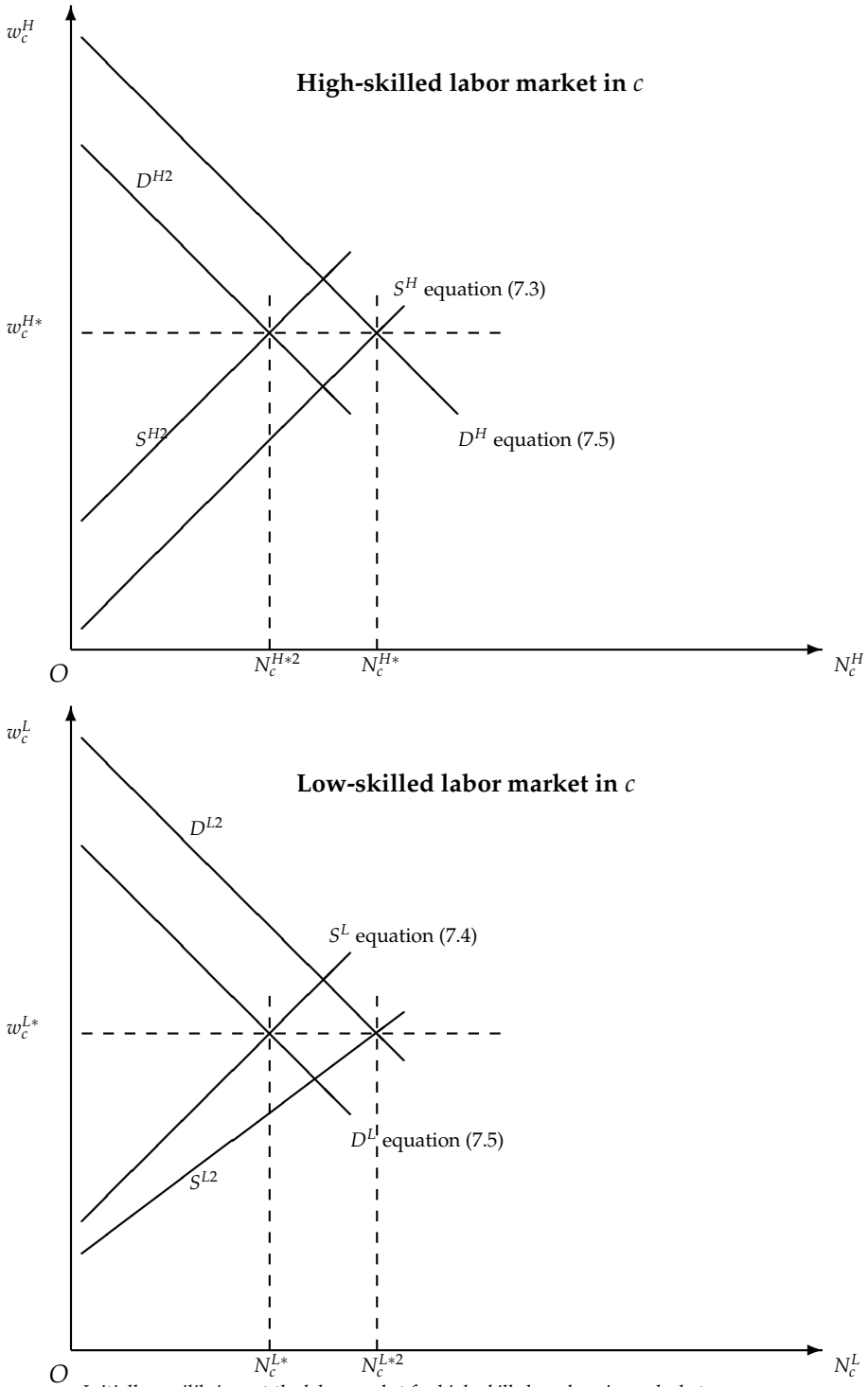
Figures 7.1 and 7.2 illustrate the equilibrium at the housing and labor market. If c is the more desirable place to live in for low-skilled workers ($w_c^L + A_c^L > w_{c'}^L + A_{c'}^L$), then an *increase* in the number of housing vouchers in the economy *decreases* the number of high-skilled workers and *increases* the number of low skilled workers in c.

Figure 7.1: Equilibrium at the housing market



Assume that initially $N^{Lv} = 0$ and equilibrium at the housing market in c is established at the intersection of D^H and S^H in the point (N_c^*, p_c^*). Then low-skilled workers with rent-control housing vouchers are introduced (N^{Lm} does not change). If $(w_c^L + A_c^L) > (w_{c'}^L + A_{c'}^L)$ this shifts the demand curve upwards and equilibrium is restored at the intersection of D2 and S in (N_c^{*2}, p_c^{*2}). Thus introducing rent-controlled workers increases the workforce and house prices in c, and decreases them in c'.

Figure 7.2: Equilibrium at the labor markets



Initially equilibrium at the labor market for high-skilled workers is reached at (N_c^{H*}, w_c^{H*}). The introduction of low-skilled workers with rent-control housing vouchers increases prices in c and decreases them in c′ (see Figure 7.1). This decreases supply of high-skilled workers in c. As supply of capital K is infinitely elastic, capital is increased to K' and the new equilibrium at the high-skilled labor market is at (N^{H*2}, w_c^{H*}), with $N^{H*2} < N^{H*}$. At the low-skilled labor market the equilibrium shifts from (N_c^{L*}, w_c^{L*}) to (N_c^{L*2}, w_c^{L*}), with $N_c^{L*2} > N_c^{L*}$. The introduction of low-skilled workers with rent-controlled housing vouchers decreases the slope and decreases the final term of the labor supply function (note that N^{Lv}, p_c and p_{c2} change). As a result firms using low-skilled labor increase the level of capital such that the labor demand curve shifts to the left.

The relative wage differential for each skill type depends on the labor intensity of production h and local general productivity parameter X_c^T, as in equation (7.8). Relative housing costs for workers without a housing voucher are a function of workers in b, all workers in the economy N and the parameters k_a and k_b that reflect the price-elasticity of housing supply.

$$w_b^T - w_a^T = \tfrac{1}{h}\left(X_b^T - X_a^T\right) \tag{7.8}$$

$$p_b - p_a = (k_a + k_b)(N_b^H + N_b^{Lm} + N_b^{Lv}) - k_a N \tag{7.9}$$

To solve the model, add equations (7.2a) to (7.2b). Next plug in equations (7.8) and (7.9) and do the same for equation (7.2c). Express the number of workers of each skill type with and without a housing voucher as a function of exogenous parameters and N_b^L and N_b^H. Next substitute the equations for low-skilled workers into that of high-skilled workers (or vice versa) to derive the equilibrium number of high-skilled workers (equation 7.10).[8] For completeness, the number of low-skilled workers in b is given as well.

$$\begin{aligned} N_b^H = &\left(\sigma + N - N^H - N^{Lv}\right) N^H \delta \left[\tfrac{1}{h}\left(X_b^H - X_a^H\right) + (A_b^H - A_a^H)\right] \\ &- (N - N^H) N^H \delta \left[\tfrac{1}{h}\left(X_b^L - X_a^L\right) + (A_b^L - A_a^L)\right] \\ &+ (\sigma - N^{Lv}) N^H \delta s + \sigma N^H \delta k_a N \\ \delta = &\frac{1}{2s}\frac{1}{\sigma + (N - N^{Lv})}, \quad \sigma = \tfrac{2s}{k_a + k_b} \end{aligned} \tag{7.10}$$

Similarly, N_b^L becomes:

$$\begin{aligned} N_b^L = &-(N - N^H - N^{Lv}) N^H \delta \left[\tfrac{1}{h}\left(X_b^H - X_a^H\right) + (A_b^H - A_a^H)\right] \\ &+ (N - N^H)(\sigma + N^H)\delta \left[\tfrac{1}{h}\left(X_b^L - X_a^L\right) + (A_b^L - A_a^L)\right] \\ &+ \delta s \left[\sigma(N - N^H) + N^H N^{Lv}\right] + \sigma(N - N^H - N^{Lv})\delta k_a N \end{aligned}$$

Equation (7.10) shows that the number of high-skilled workers in b depends positively on the relative local productivity of high-skilled workers ($X_b^H - X_a^H$) and the valuation of relative local amenities by high skilled workers ($A_b^H -$

[8] See section 7.A for a step by step approach.

A_a^H). Similarly, it depends negatively on relative productivity and valuation of relative amenities by low-skilled workers. A special case of this model in which there are no housing vouchers distributed to low-skilled workers ($N^{Lv} = 0$). This yields the same equation as Moretti (2011).

Equation (7.10) shows that rent-control negatively influences the number of high-skilled workers in the most attractive region in terms of productivity and amenities. Suppose that for both skill types, city b is the more attractive city to live, such that for both skill types $T = L, H$ it holds that $\frac{1}{h}\left(X_b^T - X_a^T\right) + \left(A_b^T - A_a^T\right) > 0$. The fraction that weights the relative valuation of local productivity and amenities by high-skilled workers is positive and decreasing (concave to the origin) in the number of rent-control vouchers in the economy. Thus *rent-control vouchers reduce the increase in high-skilled workers in* b *after a positive demand shock for high-skilled workers.*

Furthermore, the presence of high-skilled workers in city b depends negatively on the relative valuation of wages and amenities by low-skilled workers. This is because the inflow of low-skilled workers increases house prices without changing the productivity of high-skilled workers. The fraction that weights the relative valuation of local productivity and amenities by low-skilled workers increases with the stock of housing vouchers. Thus *rent-control vouchers augment the increase in low-skilled workers in* b *after a positive demand shock for low-skilled workers.*

To sum up, in this chapter a general equilibrium model is described that connects the labor and housing market when rent-control vouchers are allocated among low skilled workers. This has two important effects on the presence of low and high-skilled workers. First, as workers with a housing voucher have equal housing costs in a and b, ceteris paribus rent control housing vouchers increase the number of low-skilled workers if the attractiveness of a city to low-skilled workers increases. Second, the same mechanism ensures that rent control reduces the inflow of high-skilled workers after an increase in attractiveness of city b to high-skilled workers.

Application to the Netherlands

The model describes how in relatively attractive cities rent control housing vouchers reduce the number of high-skilled workers. It is based on several simplifications. First, in the Netherlands housing vouchers are not allocated to workers, but a percentage of the housing stock is rent-controlled. These houses in turn are assigned to workers according to a set of allocation rules that favors low-income households, who are typically low-skilled. Thus the model does not reflect that low-income households in controlled housing who move to another region are not entitled to rent-controlled housing. However, low-income households do have a larger probability to be allocated controlled housing.

A second simplification of the model is that it assumes that high-skilled workers do not receive housing vouchers. If this would be modeled, the effects of rent-controlled housing on the location decision of high and low-skilled workers would become smaller without changing sign. This holds as long as more housing vouchers are allocated to high-skilled workers than to low-skilled workers.

Despite these simplifications, the model yields useful predictions. As the majority of rent-controlled tenants is low-skilled and as the share of housing that is rent-controlled is higher in dense areas, an average *negative* effect of rent control on the percentage of the population that is high-skilled can be expected.

7.3 Data

I test the influence of rent control on local skill composition using longitudinal data for 40 NUTS 3 regions in the Netherlands. The nationwide surveys WBO and WoON are used to construct measures for local wage premium, local housing costs, the percentage of the population that is high-skilled and the percentage of the population that lives in rent-controlled housing. The waves conducted in the years 1981, 1985, 1989, 1993, 1998, 2002 and 2006 are available. All monetary amounts have been converted to 2006 euro using national inflation figures.

A worker is considered high-skilled if he has obtained a degree from university, including universities of applied sciences (in Dutch: has a *HBO* or *WO*-diploma). If not, the worker is considered low-skilled. Based on this variable the percentage of the population that is high-skilled is computed.

Additionally, the survey contains information on the type of landlord if the worker is renting housing. This allows to indicate whether the landlord is a social housing organization and is used to construct our measure of social housing at the regional level.

Next, local skill premia for high and low-skilled workers have been computed based on (gross) income (in Dutch: *bruto inkomen*) of the households. To compute the local wage premium in each sample year, income is regressed on employment status (dummy equal to one if unemployed), household composition (single person household, couple with children, other type of household and couple without children as base household), the number of children younger than six, twelve and fifteen in the household, and nine age category dummies (all heads of households are at least aged twenty and the age of the baseline head of household is between 30 and 39), a dummy-variable equal to one if the head of household is female and 39 NUTS 3 region dummies (relative to Zeeuws-Vlaanderen). This is done for high-skilled workers and low-skilled workers separately. After estimation, the local skill-premium for each skill type has been computed by adding the coefficients on each of NUTS 3 regional dummies to the constant.

The local house price premium is computed similarly based on the house price for which homeowners expect to sell their house. For each year in the sample, the house price is regressed on variables indicating the number of rooms, the size of the living room, the size of the kitchen, the presence of a garden (or similar attribute), the bathroom facilities in the house and 39 regional dummies. The baseline house is located in Zeeuws-Vlaanderen, has four rooms, a living room of 30-40 square metres, a kitchen of five to seven square metres, and contains a shower and a garden. The local house price-premium has been computed by adding the coefficients on each of the NUTS 3 regional dummies to the constant.

Next, the percentage of people that is high-skilled, the percentage of housing that is rent-controlled and local skill premium and local house prices are merged with information on regional labor productivity and jobs for eight sectors.[9] For each region, there is information on the number of FTE in each sector as well as total productivity. This allows to compute the Gross Regional Product per worker at the sectoral level. Table 7.1 provides summary statistics of these variables.

Table 7.1: Summary statistics

	mean	sd	min	max
Percentage of workers that is high-skilled	16.15	11.48	1.00	44.00
Perc. of housing stock that is rent-controlled	43.35	7.29	24.50	65.60
Local house prices (in €10,000)	10.58	3.39	4.78	25.63
Local high-skill premium (w_c^H/w_c^L)	1.31	0.16	0.49	1.69
Jobs per km^2	184.11	201.61	12.02	1249.61
Spatial lag of				
Perc. of housing stock that is rent-controlled	42.67	3.95	32.20	52.55
Jobs per km^2	177.36	87.69	27.18	481.11
log GDP per worker	10.77	0.34	10.01	11.82
Local productivity share sector 1 (B_1)	1.49	0.55	0.65	3.67
Local productivity share sector 2 (B_2)	0.10	0.08	0.00	0.30
Local productivity share sector 3 (B_3)	1.87	0.35	0.76	2.75
Local productivity share sector 4 (B_4)	0.23	0.23	0.00	1.39
Local productivity share sector 5 (B_5)	3.29	0.93	1.03	5.66
Local productivity share sector 6 (B_6)	1.66	0.43	0.73	3.28
Local productivity share sector 7 (B_7)	1.50	0.45	0.82	3.23
Local productivity share sector 8 (B_8)	0.63	0.23	0.23	1.63
Surface	103815.43	70324.12	12818.00	342884.00
Housing density in 1947	81.12	104.93	1.00	574.00
Housing density in 1947 $\times$ log GDP per worker	873.63	1135.28	10.29	6499.92

7.3.1 Clustering of high-skilled workers and rent control

Compared to other European countries, the share of housing that is rent-controlled in the Netherlands is substantial, see Scanlon and Whitehead (2007). Although the share of rent-controlled housing has been falling over time, about

[9] The eight sectors are: banking (in Dutch: *banken en zakelijke dienstverlening*), real estate (in Dutch: *exploitatie onroerend goed*), trade and catering (in Dutch: *handel en horeca*), agriculture and fisheries (in Dutch: *landbouw en visserij*), industry (in Dutch: *nijverheid*), non profit and other services (in Dutch: *non-profit en overige dienstverlening*), government (in Dutch: *rijksoverheid*, transport and communications (in Dutch: *transport en communicatie*).

one-third of the total housing stock was rent-controlled in 2008.[10,11] However, the share of housing that is owner-occupied is not so different from other European countries. Thus the Dutch housing market is characterized by a dual market with owner-occupied (market) housing and rent-controlled (social) housing. The market for uncontrolled rental housing exists, but is very small (Scanlon and Whitehead, 2007).

Table 7.2 presents development of high-skilled workers and rent-controlled housing over time. For each year the average and standard deviation is listed for the NUTS 3 regions. The average percentage of high-skilled workers in the population has increased from in 6.8 percent in 1981 to 32 percent in 2006. The standard deviation over this time period has doubled. Note that between 1989 and 1998 the percentage of the population that is high-skilled has increased from almost 9 to almost 21 percent. This increase is substantial, but can be explained partly by two cohort effects.

First, the cohorts 1920-1930 and 1930-1940 are skewed towards low-skilled workers. These workers are expected to retire around 1989 creating a relatively large outflow of low-skilled workers. Second, attendance rates of universities and universities of applied science have increased exponentially over the period 1950-1980. This has generated a relatively large inflow of high-skilled workers. Thus a strong increase around 1989-1993 is expected. However, the data shows an exceptional sharp increase in the number of high-skilled workers between 1993 (7.5 percent) and 1998 (20.9 percent). This seems to be a development that is too large in a too short time-period to be explained by the cohort effects alone. Therefore, fixed year effects are used to control for the development of high-skilled workers over time.

The development of the average share of housing that is rent-controlled is very different. It slightly decreases over time from 46 percent in 1981 to below 39 percent in 2006, but the change is very gradual. Figure 7.3 shows

[10] See Romijn and Besseling (2008); Donders et al. (2010); Regeer and Van Daalen (2011); Van Daalen et al. (2012) for several recent indicators.

[11] Rent-controlled housing distorts the housing market as controlled rents do not reflect the local marginal price of housing. This leads to an inefficient allocation of controlled housing (Glaeser and Luttmer, 2003). On the other hand, the size of the controlled housing stock is arguably not very inefficient as the marginal willingness to pay for rent-controlled housing quality is close to its marginal costs (Van Ommeren and Koopman, 2011; Van Ommeren and De Graaf-Zijl, 2013).

Table 7.2: Share of high-skilled workers and social housing over time

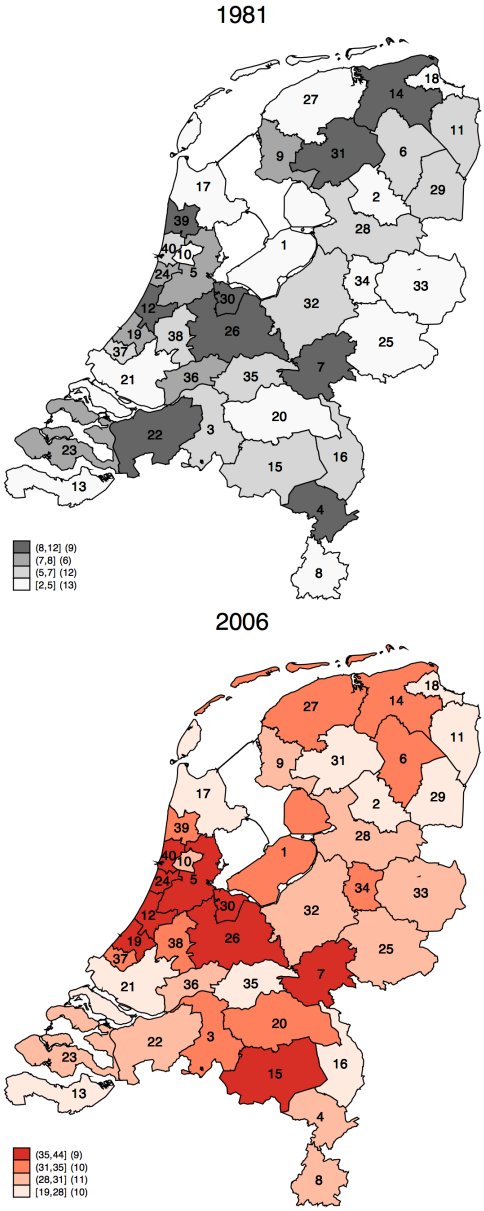
	High-skilled		Social housing	
	mean	sd	mean	sd
1981	6.80	2.58	45.99	7.34
1985	6.58	2.90	47.21	6.83
1989	8.95	3.90	45.32	6.73
1993	7.47	4.29	43.87	6.29
1998	20.90	6.14	42.32	6.27
2002	30.32	5.39	40.10	6.81
2006	32.00	5.15	38.65	6.93

the spatial distribution of high-skilled workers in 1981 and 2006. It shows that in 1981 the spatial distribution of high-skilled workers over the country did not follow a clear-cut pattern as regions with the most high-skilled workers are found in the north, middle and south of the country. Also, regions with the highest and lowest percentage of high-skilled workers are often located near each other. However, in 2006 this has changed. High-skilled workers are now concentrated in the west of the country. In the literature clustering of high-skilled workers over time has been explained from the agglomeration externalities and the creation of consumer amenities.

Consider the relationship between high-skilled workers and wages of high-skilled workers. Figure 7.4 shows a positive relationship in favour of the hypothesis that high-skilled workers have been clustering in regions with high wages. Also, the clustering of high-skilled might be explained by consumer amenities for which high-skilled workers have a higher willingness to pay.[12] Consumer amenities are not directly observed, but as they are correlated with house prices insight into this mechanism can be given by plotting the percentage of high-skilled workers against local house prices for a standard house. In line with this, Figure 7.5 indicates that high-skilled workers have been clustering in regions with high house prices. Figure 7.6 shows the spatial distribution of rent-controlled housing in 1981 and 2006. In 2006, the share of housing that is rent-controlled is among the highest in the three largest largest cities Ams-

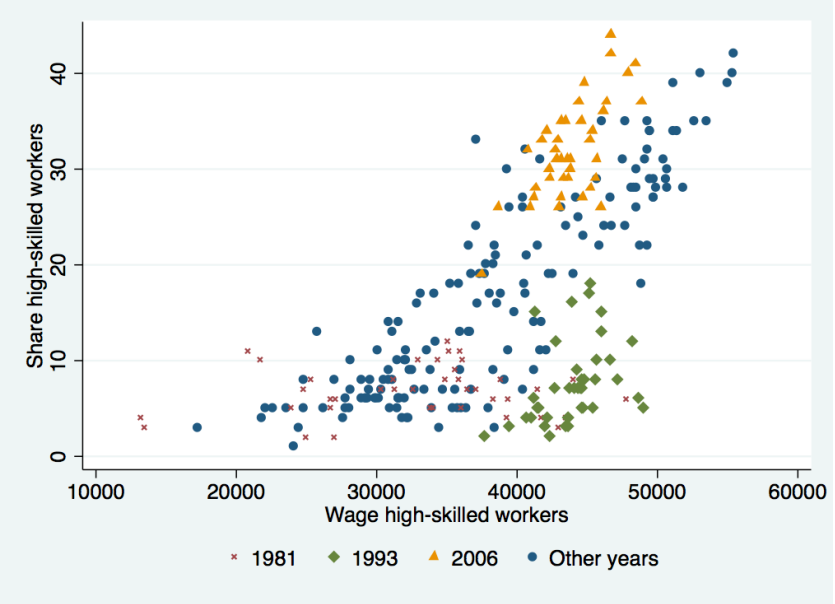
[12]See Brueckner et al. (1999) for this idea applied to the monocentric city model.

Figure 7.3: Share of high-skilled workers by region, 1981 and 2006



Numbers correspond to numbers in Table 7.B

Figure 7.4: High-skilled workers and local high-skilled wages



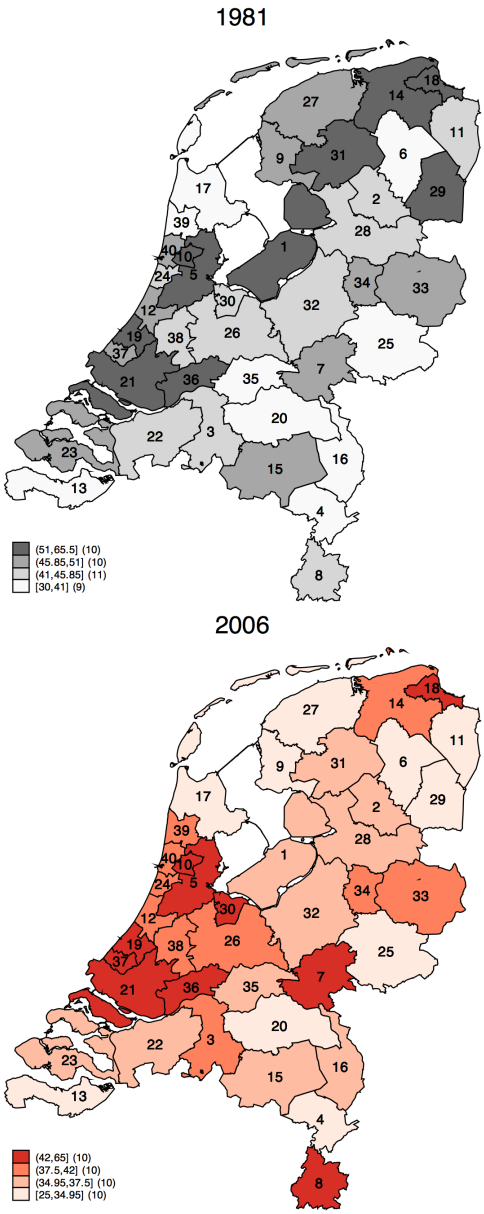
Relation between share of high-skilled workers in a region and the absolute wage of high-skilled workers (measured in 2006 euros) in that region.

Figure 7.5: High-skilled workers and local house prices

Relation between share of high-skilled workers in a region and the local house prices (measured in 10,000 euros in 2006) in that region.

terdam (5), Rotterdam (21) and The Hague (19). Other regions where the share of the housing stock that is rent-controlled is high are regions with 'historic cities' like Maastricht (8) and Nijmegen (7).

Figure 7.6: Rent-controlled housing by region, 1981 and 2006



Numbers correspond to numbers in Table 7.B

Table 7.3 and Figure 7.7 provide rudimentary evidence on the relationship between the share of the workforce that is high-skilled and percentage of housing that is rent-controlled over time.

The data shows a positive correlation between the share of rent-controlled housing and percentage of high-skilled workers *at the cross-sectional level* since the 1990s. This might have to do with the fact that the share of rent-controlled housing is higher in more urban regions and these regions are also more likely to contain a university or university of applied sciences. In contrast, the *overall* correlation between the share of high-skilled workers in a region and the share of housing that is rent-controlled is found to be negative. The change in sign of the correlation coefficients over time and in the cross-section highlights the importance of studying the relationship between rent control and local skill composition from a longitudinal panel perspective controlling for fixed region effects.

Table 7.3: Correlation high-skilled workers and rent controlled housing

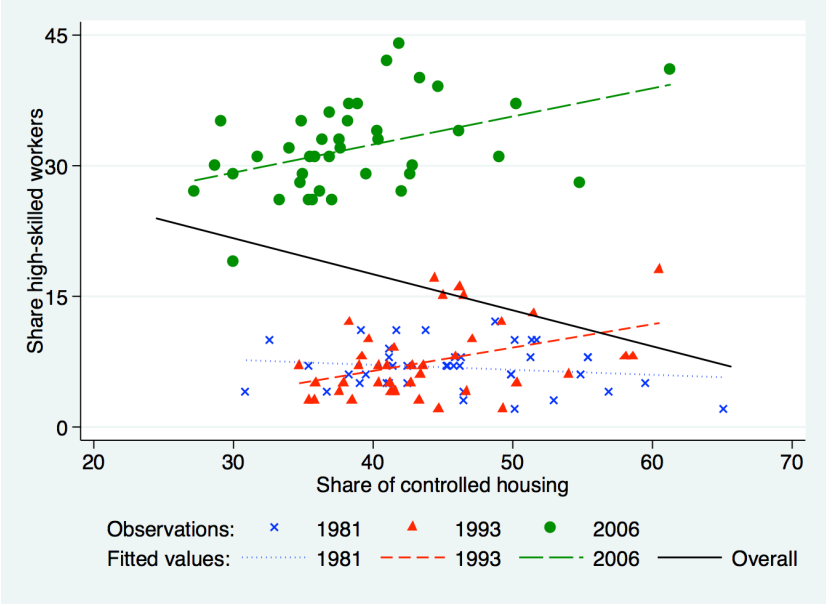
	Correlation coefficients[a]
Overall	-0.26***
1981	-0.16
1985	-0.07
1989	0.15
1993	0.39**
1998	0.28*
2002	0.46***
2006	0.43***

[a] *Pairwise correlation coefficients are based on 280 observations for the overall correlation and on 40 observations per year. Significance level denoted with stars,* $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

However, the negative relationship between rent-controlled housing and the share of high-skilled workers might reflect a spurious relation if the local stock of rent-controlled housing is adjusted according to local labor market conditions that drive the location of high-skilled workers.[13] Figure 7.8 suggests the rent-controlled housing stock is not adjusted in relation to labor market density. It shows the long run changes in the share of housing that

[13]The regression specification controls for this by including fixed region effect, fixed year effects and explanatory variables that measure local economic conditions.

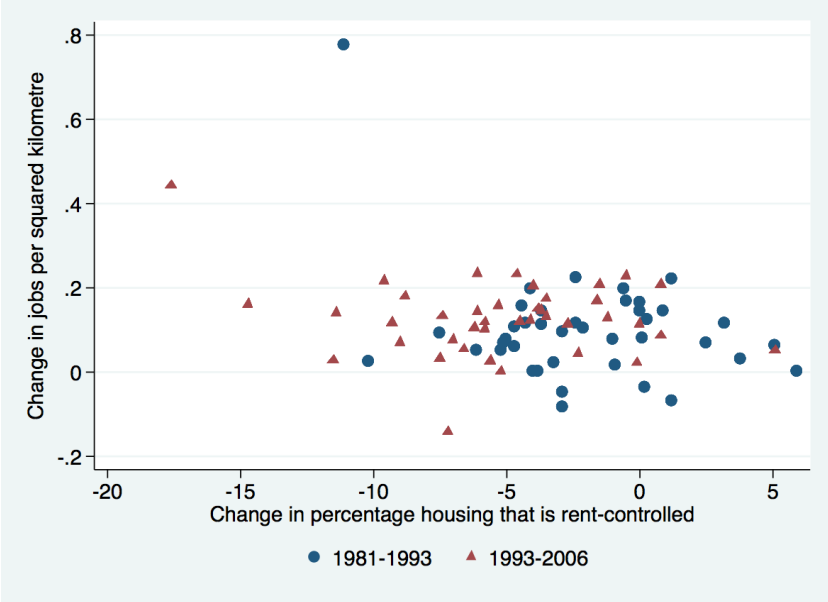
Figure 7.7: Rent control and high-skilled workers



Relation between share of high-skilled workers in a region and the share of the housig stock that is social housing in 1981, 1993 and 2006.

is rent-controlled against long run changes in jobs per squared kilometer. No clear-cut patterns arises. The observations are distributed over virtually the entire interval of long run changes of rent-controlled housing stock.

Figure 7.8: Rent-controlled housing and labor market density



Relation between long term changes in the number of jobs per squared kilometre and the long term change in the share of housing that is social housing.

7.4 Empirical strategy

Equation (7.11) is estimated to investigate the effect of rent control on the presence of high-skilled workers. The dependent variable is the percentage of the population that is high-skilled in city c at time t, denoted H_{ct}. Independent variables are a region specific fixed effect α_c, a set of time dummies to account for non-linear time effects δ_t. The share of housing that is rented out by housing agencies S_{ct} and the number of jobs per squared kilometer J_{ct} are included as well. Other independent variables are the ratio of local skill-premia $w_{ct} = w^H_{ct}/w^L_{ct}$ and local house prices p_{ct}. A_{ct} are unobserved local amenities and ε_{ct} is an idiosyncratic error term.

$$H_{ct} = \alpha_c + \beta_1 S_{ct} + \beta_2 w_{ct} + \beta_3 p_{ct} + \beta_4 J_{ct} + \delta_t + \nu_{ct} \tag{7.11}$$

$$\nu_{ct} = A_{ct} + \varepsilon_{ct}$$

$$c = 1, \ldots, 40, \quad t = 1981, 1985, 1989, 1993, 1998, 2002, 2006$$

However, local amenities A_{ct} might influence the high-skill premium w_{ct} as households are willing to accept a lower wage if they live in attractive regions. Local amenities are directly internalized in local house prices p_{ct}. Thus local house prices and wages are endogenous variables that should be instrumented. Note that *economic amenities* like job density and the local wage rate are included in the specification. The excluded measure for amenities A_{ct} refers to *consumer amenities* like national parks, open space and so on. Local house prices and local skill premium can then be instrumented with a variable that is correlated with local house prices and the local skill premium, but that is not correlated with the local consumer amenities.

I instrument the local wage premium with the local expected productivity share B_{cst}. B_{cst} is defined using productivity of each of the eight sectors s in year t, and multiply this measure with the local employment share of this sector. Denoting employment in sector s in region c at time t with E_{cat}, and with C being the number of regions, this measure is defined as:

$$B_{cst} = \frac{\sum^c GDP_{cst}}{C} \frac{E_{cst}}{\sum^s E_{cst}}$$

Next, local house prices are instrumented with the number of houses per km^2 in 1947, multiplied with local GDP.[14] The idea is that in historically dense areas house construction costs are higher because the low-cost options for construction of housing have already been executed. This measure is multiplied with GDP as to acknowledge that high housing costs only reduce supply if there is increased demand (see also Diamond (2011)). With S denoting the total number of sectors in the city, this measure is defined as:

$$H_{1947} = \frac{\text{Housing stock 1947}}{\text{km}^2} \frac{\sum^s GDP_{cst}}{S}$$

[14]There is no official statistic on the housing stock in 1947 for COROP regions, as the regions have been created in 1971 only. The housing stock in 1947 by COROP-region has therefore been constructed based on several data sets provided by Statistics Netherlands and manually taking into account 'adjustments in municipal boundaries' (in Dutch: *gemeentelijke herindelingen*) over the period 1947-1988. Section 7.B lists the COROP regions and the housing stock in 1947.

Control for commuting and replacement

As the Netherlands is a small country, workers do not have to work in the region of residence but can commute to nearby work-locations. Therefore, the percentage of high-skilled workers in a region is expected to be influenced by employment conditions in the home-region as well as nearby regions. To control for commuting by workers measures of the number of jobs in nearby regions are included.

If rent-control reduces the presence of high-skilled workers, one would expect that high-skilled workers who cannot enter a city because of its large rent-controlled housing stock are more likely to settle in nearby cities. Thus the effect of rent control on the percentage of high-skilled workers, might spillover to nearby regions as well. To derive consistent estimates, this cross-sectional dependence should be explicitly modeled.

To control for commuting and spatial spillovers of the social housing stock, the so-called spatial lag is computed by pre-multiplying the variable with a spatial weight matrix W.[15] Let W_{ct} be the cth row of the spatial weight matrix W at time t.[16] Thus it is tested whether the share of housing that is rent-controlled in neighboring regions affects the percentage of workers that is high-skilled by including the spatial lag of rent-controlled housing stock ($W_{ct}S_{ct}$). Similarly, to consider the effect of jobs in neighboring regions on the share of workers that is high-skilled, the spatial lag of jobs ($W_{ct}J_{ct}$) is included. Thus equation (7.11) is extended with these spatially lagged variables and estimate equation (7.12).[17]

[15] W is a $N \times N$ matrix that has element $w_{ij} = 1$ if j is an adjacent neighbor of i and zero elements otherwise (including the main diagonal). W is row-normalized such that all elements on a row sum up to 1. Furthermore restriction on the nonzero elements w_{ij} are imposed such that the spatial interactions fade out with distance. Restrictions are that the row and column sums of W and $(I - \rho W)^{-1}$,$(I - \lambda W)^{-1}$ should be bound in absolute value as N goes to infinity. See Kelejian and Prucha (1998, 1999); Lee (2004).

[16] The specification of W influences the parameter estimates on the spatial lags and in empirical work different specifications of W are often tested. See (Harris et al., 2011) for a discussion on formulating W. However, according to LeSage and Pace (2010), the effect of the specification of W on the marginal effects of a (spatially lagged) variable is negligible.

[17] I have also included a spatial lag of the independent variable, which was insignificant. Results available upon request.

$$
\begin{aligned}
H_{ct} &= \alpha_c + \beta_1 S_{ct} + \beta_2 w_{ct} + \beta_3 p_{ct} + \beta_4 J_{ct} + \delta_t \\
&\quad + \gamma_1 W_{ct} S_t + \gamma_2 W_{ct} J_t + \nu_{ct} \\
\nu_{ct} &= A_{ct} + \varepsilon_{ct} \\
c &= 1, \ldots, 40, \quad t = 1981, 1985, 1989, 1993, 1998, 2002, 2006
\end{aligned}
\tag{7.12}
$$

Measurement of spatial spillovers

It is important to realize that the estimated parameters on the spatially lagged variable do not necessarily equal the marginal effects of the independent variables. Therefore, significant parameters are not sufficient to prove the existence of spatial spillovers (Elhorst, 2010; LeSage and Pace, 2009). Let y be a vector containing the dependent variable. y is explained by the matrix of independent variables X, a vector Wy containing the spatially lagged dependent and matrix WX containing the spatially lagged independent variables. ε is a vector containing an i.i.d. error term with expectation zero and constant variance. ρ, β and θ are scalars that have to be estimated.

$$
y = \rho W y + X\beta + WX\theta + \varepsilon \tag{7.13}
$$

The reduced form becomes

$$
y = (I - \rho W)^{-1} X \left[\beta + W\theta\right] + (I - \rho W)^{-1} \varepsilon \tag{7.14}
$$

From which it follows that the derivative of y towards any variable x_k in X equals:[18]

$$
\begin{pmatrix}
\frac{\partial y_1}{\partial x_{k1}} & \frac{\partial y_1}{\partial x_{k2}} & \cdots & \frac{\partial y_1}{\partial x_{kN}} \\
\frac{\partial y_2}{\partial x_{k1}} & \frac{\partial y_2}{\partial x_{k2}} & \cdots & \frac{\partial y_2}{\partial x_{kN}} \\
\vdots & \vdots & \ddots & \vdots \\
\frac{\partial y_N}{\partial x_{k1}} & \frac{\partial y_N}{\partial x_{k2}} & \cdots & \frac{\partial y_N}{\partial x_{kN}}
\end{pmatrix}
= (I - \rho W)^{-1}
\begin{pmatrix}
\beta_k & w_{1,2}\theta_k & \cdots & w_{1,40}\theta_k \\
w_{2,1}\theta_k & \beta_k & \cdots & w_{2,40}\theta_k \\
\vdots & \vdots & \ddots & \vdots \\
w_{40,1}\theta_k & w_{40,2}\theta_k & \cdots & \beta_k
\end{pmatrix}
\tag{7.15}
$$

[18] Where $\frac{\partial y_a}{\partial x_{kb}}$ is the derivative of the y in region a to a shock to x_k in region b.

Of which the RHS can be written in matrix notation as $(I - \rho W)^{-1}(\beta_k I + W\theta_k)$.

As direct and indirect effects are different for each spatial unit, LeSage and Pace (2009) suggest to compute the average (in)direct effect and consider its distribution under the null of an (in)direct effect equal to zero. In matrix notation, the average direct and average indirect effect are given by:

$$\text{Average direct effect}: \quad trace[(I - \rho W)^{-1} I\beta]/N \tag{7.16}$$

$$\text{Average indirect effect}: \quad i'_N[(I - \rho W)^{-1}\theta W]i_N \tfrac{1}{N(N-1)} \tag{7.17}$$

where i_n is a N-dimensional vector of ones. The direct effect and indirect effect are divided by N and $N(N-1)$ as there are N regions with each $N-1$ potential neighbors.

7.5 Results

The model in equation (7.12) is estimated to test whether rent-controlled housing influences the percentage of high-skilled workers. Table 7.4 shows the regression results. Column one presents the second stage regression, first stage regression results are presented in columns two an three.

I find evidence at the five percent significance level in favor of a negative relationship between the share of rent-controlled housing and the share of high-skilled workers. Ceteris paribus, a ten percentage point increase in the share of rent-controlled housing reduces the percentage of high-skilled workers with 1.5 percentage points.

I also find evidence that the share of high-skilled workers is larger in regions characterized by high house prices. The coefficient on local house prices indicates that ceteris paribus an increase in house prices with 10,000 euro increases the share of high-skilled workers with 1.33 percentage points.

Estimates on both the share of rent-controlled housing and local house prices are credible. A ten percentage point increase in the share of housing that is rent-controlled has the same effect on the percentage of high-skilled

Table 7.4: Results spatial LSDV

	(1) Percentage high-skilled	(2) Wage ratio	(3) House prices
Share of social housing	-0.1510**	0.0023	0.1080***
	(0.0665)	(0.0048)	(0.0251)
Spatial lag share of social housing	-0.1060	-0.0115	0.0178
	(0.1210)	(0.0100)	(0.0479)
Jobs per squared kilometer	0.0112	0.0004	-0.0024
	(0.0096)	(0.0004)	(0.0069)
Spatial lag jobs per squared kilometer	0.0546**	0.0035	-0.01990**
	(0.0246)	(0.0023)	(0.0082)
Local house prices	1.3310***		
	(0.3110)		
Local high-skill premium	-1.2130		
	(4.4180)		
Year 1985	3.8900***	0.0322	-2.7850***
	(0.9860)	(0.0580)	(0.2370)
Year 1989	4.0090***	-0.0227	-2.0170***
	(0.7040)	(0.0598)	(0.2760)
Year 1993	0.2150	0.0586	-0.7250*
	(0.7620)	(0.0866)	(0.4250)
Year 1998	8.3100***	-0.0573	1.4280**
	(1.5010)	(0.1470)	(0.6890)
Year 2002	17.5500***	-0.0114	1.5000*
	(1.6050)	(0.1950)	(0.8700)
Year 2006	15.1300***	-0.1930	4.2230***
	(2.4070)	(0.2220)	(1.0200)
Local productivity share sector 1		0.1540*	1.8480***
		(0.0911)	(0.5700)
Local productivity share sector 2		-0.0507	-1.2400
		(0.1510)	(1.3900)
Local productivity share sector 3		0.1190	-0.5590
		(0.1040)	(0.7070)
Local productivity share sector 4		-0.2540	-2.0300**
		(0.1610)	(0.8170)
Local productivity share sector 5		0.1910**	-0.9980*
		(0.0846)	(0.5890)
Local productivity share sector 6		0.1890	-1.9720***
		(0.1530)	(0.7330)
Local productivity share sector 7		0.2410*	-1.9910***
		(0.1230)	(0.7440)
Local productivity share sector 8		0.1270	-1.6010**
		(0.1120)	(0.7420)
GDP and historic house density		-<0.0001	0.0073*
		(0.0003)	(0.0038)
Observations	280	280	280
adj. R^2	0.949	0.235	0.915
Degrees model	51	58	58
χ^2 (F) value 2nd (1st) stage	10873.5	(5.8)	(58.7)
Robust score χ^2 statistic p-value	0.03		
Robust regression F-statistic p-value	0.04		
Overidentification χ^2 statistic p-value	0.3		

Robust standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$
Variables not shown: 39 region dummies, constant

workers as a decrease in local house prices with 8,800 euro.[19] Thus the estimated parameters on local house prices and rent-controlled housing (and also their relative size) are plausible from an economic perspective.

The number of jobs per squared kilometer in neighboring regions is significant at the five percent level. I do not find evidence that the the share of high-skilled workers in a region is influenced by the share of housing that is rent-controlled in neighboring regions, the local job density or the local high-skilled wage premium.

As a robustness check the effect of rent-controlled housing on the share of high-skilled workers is allowed to be nonlinear. Dummies have been generated for the five quintiles of S_{ct}, and the first four quintiles are compared with the quintile that has the highest share of rent-controlled housing. Results in column one of Table 7.5 indicate that the share of high-skilled workers decreases with rent-controlled housing. The share of high-skilled workers in the time-region quintile with the lowest share of rent-controlled housing is 2.6 percentage point higher than in the time-region with the most rent-controlled housing, ceteris paribus. This is about 1.9 for the second and 1.8 for the third quintile, whereas the fourth quintile is not significantly different from the fifth quintile, ceteris paribus. This specification provides evidence that the result in columns one and two is not driven by outliers as all categories are significant at at least ten percent and they follow a consistent pattern. Under this specification, the parameter on house prices remains significant at the one percent level whereas it parameters decreases slightly in absolute value. The significance of the parameter on jobs in neighboring regions also slightly decreases, but remains significant at the five percent level.

Spatial spillover of rent-controlled housing and jobs per km^2

This subsection considers the spatial spillover effects using the parameter estimates of the first columns in Tables 7.4 and 7.5. One thousand realizations indexed $i = 1, \ldots, 1000$ for the relevant parameters β and θ have been gener-

[19] The estimated coefficient on house prices (measured in €10,000) equals 1.331, while that on percentage of housing that is rent-controlled equals -0.150. To compare both estimates compute (1.331) (€10,000)/(-0.15*10) $\approx$ €8,800.

Table 7.5: Results spatial LSDV (dummy specification)

	(1) Percentage high-skilled	(2) Wage ratio	(3) House prices
First quintile share of social housing	2.6430**	0.0734	-1.3750***
	(1.0560)	(0.0701)	(0.4990)
Second quintile share of social housing	1.9230**	-0.0127	-0.8850**
	(0.8290)	(0.0525)	(0.3760)
Third quintile share of social housing	1.8180**	0.0426	-0.5740
	(0.7990)	(0.0489)	(0.3510)
Fourth quintile share of social housing	1.4510*	-0.0177	-0.2580
	(0.7490)	(0.0405)	(0.2790)
Spatial lag first quintile share of social housing	0.2710	0.1790	-0.2220
	(2.4860)	(0.1490)	(1.0460)
Spatial lag second quintile share of social housing	-0.7520	0.2440**	0.4090
	(2.1440)	(0.1130)	(0.7300)
Spatial lag third quintile share of social housing	0.6660	0.1850*	0.6150
	(2.1790)	(0.1090)	(0.7760)
Spatial lag fourth quintile share of social housing	-1.7470	0.0772	1.0200*
	(1.8890)	(0.0885)	(0.6050)
Jobs per squared kilometer	0.0136	0.0005	-0.0050
	(0.0097)	(0.0005)	(0.0074)
Spatial lag jobs per squared kilometer	0.0495**	0.0037	-0.0278***
	(0.0246)	(0.0025)	(0.0098)
Local house prices	1.2580***		
	(0.2760)		
Local high-skill premium	-0.1750		
	(3.7480)		
Local productivity share sector 1		0.1870**	1.7000***
		(0.0931)	(0.6400)
Local productivity share sector 2		0.0074	-1.5680
		(0.1540)	(1.4180)
Local productivity share sector 3		0.1260	-0.9150
		(0.0996)	(0.7420)
Local productivity share sector 4		-0.2920*	-2.3650***
		(0.1570)	(0.8760)
Local productivity share sector 5		0.2110***	-1.2580**
		(0.0810)	(0.6350)
Local productivity share sector 6		0.2060	-2.7500***
		(0.1470)	(0.8260)
Local productivity share sector 7		0.2470**	-2.2390***
		(0.1200)	(0.8470)
Local productivity share sector 8		0.1440	-1.6390**
		(0.1080)	(0.8000)
GDP and historic house density		0.0002	0.0079*
		(0.0004)	(0.0042)
Observations	280	280	280
adj. R^2	0.950	0.258	0.910
Degrees model	57	64	64
χ^2 (F) value 2nd (1st) stage		5.6	51.1
Robust score χ^2 statistic p-value	0.03		
Robust regression F statistic p-value	0.05		
Overidentification χ^2 statistic p-value	0.4		

Robust standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$
Variables not shown: 39 region dummies, 6 year dummies, constant

ated, where each realization β_i, θ_i has been drawn from an independent random normal distribution with mean $\widehat{\beta}, \widehat{\theta}$ and standard deviation $\widehat{se(\beta_i)}, \widehat{se(\theta_i)}$ respectively. Next, the direct and indirect spillover effects have been computed according to equations 7.16 and 7.17. Table 7.6 shows the result.

In the preferred specification in which the share of rent-controlled housing is treated as a continuous variable (column one of Table 7.4), I find that a change in the number of rent-controlled housing with ten percentage points reduces the number of high-skilled workers in the region with 1.56 percentage points. However, the indirect spillover effect is insignificant as indicated by the 95% confidence interval and therefore it is concluded that rent-controlled housing does not influence the percentage of high-skilled workers in neighboring regions on average. If one allows for a nonlinear effect of the share of housing that is rent-controlled on the percentage of high-skilled workers, regions with a smaller share of rent-controlled housing are found to have more rent-controlled workers. However, also here no evidence in favor of spatial spillover effects to neighboring regions is found.

Next, it is concluded that an increase in the number of jobs per squared kilometer in a region does not influence the number of high-skilled workers in a region, but has spatial spillover effects to neighboring regions. The direct and combined effect are insignificant at the five percent significance level. The average indirect spatial spillover effect equals 0.0014, which suggests that a one standard deviation increase in the number of jobs increases the number of high-skilled in neighboring region with about 0.30 percentage points.[20] Using dummies to allow the effect of the share of housing that is rent-controlled to be nonlinear does not change conclusions on the spatial spillover effects of the number of jobs per squared kilometer.

Spatial correlation in the error term

Up to now, spatial dependence of the error term has not been considered. The robust standard errors developed by White (1980) and Newey and West

[20]The standard deviation of the number of jobs in a region equals 201.61 and $201.61(0.0014) \approx 0.28$.

Table 7.6: Spatial spillover effects

Variable	Table 7.4 , column 1 Type[a]	Mean	lb 95%CI	ub 95%CI
Share of social housing	Direct	-0.1561	-0.2900	-0.0221
	Indirect	-0.0028	-0.0088	0.0032
	Combined	-0.1589	-0.2931	-0.0246
Jobs per squared kilometer	Direct	0.0105	-0.0089	0.0298
	Indirect	0.0014	0.0002	0.0026
	Combined	0.0119	-0.0076	0.0313

Variable	Table 7.5 , column 1 Type[a]	Mean	lb 95%CI	ub 95%CI
Share of social housing, first quintile	Direct	2.5680	0.4400	4.6960
	Indirect	0.0053	-0.1178	0.1285
	Combined	2.5734	0.4389	4.7078
Share of social housing, second quintile	Direct	1.8639	0.1931	3.5348
	Indirect	-0.0207	-0.1269	0.0855
	Combined	1.8432	0.1665	3.5200
Share of social housing, third quintile	Direct	1.761	0.1520	3.3702
	Indirect	0.0157	-0.0923	0.1236
	Combined	1.7768	0.1615	3.3920
Share of social housing, fourth quintile	Direct	1.3980	-0.1104	2.9063
	Indirect	-0.0460	-0.1395	0.0475
	Combined	1.3520	-0.1615	2.8654
Jobs per squared kilometer	Direct	0.0129	-0.0067	0.0326
	Indirect	0.0013	0.0000	0.0025
	Combined	0.0142	-0.0055	0.0339

[a] Direct, indirect and combined effect based on 1000 random and independent realizations according to equations 7.16 and 7.17.

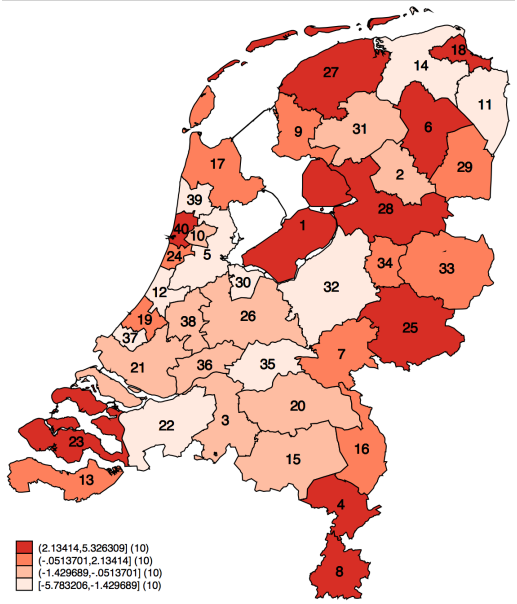
(1987) are robust to heteroskedasticity under the assumption that each relation of the error is independent within and between regions.[21] Thus both methods require that the error term is spatially independent.

Driscoll and Kraay (1998) adjust the Newey and West (1987) standard errors to allow general spatial dependence of the error term. However, estimators that allow the computation of Driscoll and Kraay standard errors can only handle cross-sectional data or cannot handle endogenous independent variables. Therefore, it is not possible to control for spatial dependency in the error term in our setup.

However, no evidence is found that the error term is spatially correlated. Figure 7.9 shows the spatial distribution of the residual (specification in column one of Table 7.4) in 2006. Many negative outliers are next to positive outliers. For all years, a scatterplot of the residuals against their spatial lags shows no concrete pattern, see Figure 7.10. Also an OLS regression of the spatial lag of the residual on the residual yields a parameter estimate that is insignificant at the ten percent level. As there is no concrete evidence for spatially correlation in the residuals, controlling for heteroskedasticity using clustered and robust standard errors seems to be valid.

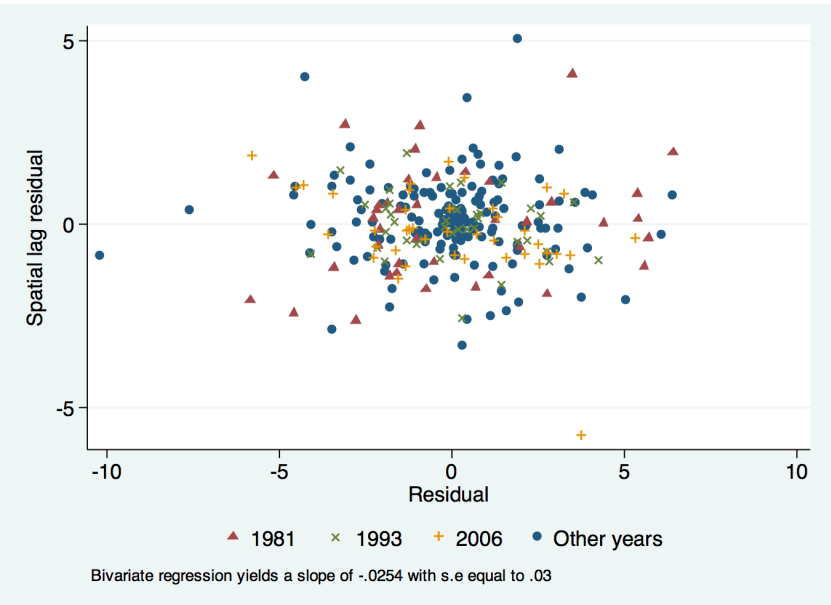
[21] It is possible to estimate clustered standard errors that are robust to heteroskedasticity under the assumption that the error term is only independent across regions.

Figure 7.9: Spatial plot of residuals



Spatial plot of residuals of the specification of column one of Table 7.4 in 2006. Numbers correspond to numbers in Table 7.B.

Figure 7.10: Spatial dependence in the residuals



Scatter plot of spatial lag of the residual against the residuals of the specification of column one of Table 7.4.

7.6 Conclusion

Over the last two decades, high-skilled workers in the United States and the Netherlands have been found to cluster in cities characterized by high productivity, high wages and high housing costs. This generates substantial productivity externalities to low-skilled and high-skilled workers. Rent-controlled housing distorts this mechanism as it is mainly allocated to workers with low-income at the time of entry. Also, it reduces skill substitution within a city by preventing the internalization of housing demand in the controlled rent. This effect on local skill composition provides a new channel by which rent control distorts outcomes on the local labor market, besides the effect on worker mobility and unemployment duration.

In this chapter the framework of Moretti (2011, 2013) is augmented with a (non-competitive) rent-controlled housing sector. This highlights the mechanisms by which rent-control housing vouchers influence local skill composition in an economy with two regions, two types of labor and idiosyncratic preference for a region. Next, the influence of rent-controlled housing on the local skill composition of regions is tested using a longitudinal panel of forty NUTS 3 regions in the Netherlands over the years 1981-2006.

Evidence is found that ceteris paribus a decrease of the rent-controlled housing stock with ten percentage points increases the percentage of high-skilled workers with 1.5 percentage points. Our results are conditional on fixed region effects and fixed time effects, the local skill-premium, local house prices and local job density. Local house prices and the local skill-premium are instrumented using historic housing density and indicators for local labor demand. Also, the estimation procedure allowed for spatial dependence in the data, although this has been shown to be of minor importance.

Our results suggest that rent control not only influences local labor markets as it reduces the mobility of workers, but also alters local skill composition. This implies that the distortional effects of rent control on the labor market have been larger than previously thought.

The parameter size on the percentage of rent-controlled housing illustrates that rent control has an economically significant effect on skill composition. The estimated coefficients suggest that a decrease of the rent-controlled hous-

ing stock with ten percentage points has a similar effect on skill composition as an increase of local house prices with about 8,800 euro.

The size of the effect of rent-controlled housing on the percentage of workers that is high-skilled seems limited. Suppose the social housing stock of Utrecht would be halved from forty to twenty percent. Based on our results, one would expect the share of workers that are high-skilled to increase with three percentage points (to 46 percent). An explanation for the limited size of this effect might be that Dutch entry regulations based on income cannot prevent that high-skilled worker remain living in social housing if house prices are high.

7.A Derivations number of workers in a city

To solve the model write the number low-skilled workers (with and without housing voucher) as

$$
\begin{aligned}
N_b^{Lv} &= \frac{N^{Lv}}{2s}\left[w_b^L - w_a^L + (A_b^L - A_a^L) + s\right] \\
N_b^{Lm} &= \frac{N^{Lm}}{2s}\left[\left(w_b^L - w_a^L\right) - (p_b - p_a) + (A_b^L - A_a^L) + s\right] \\
N_b^{H} &= \frac{N^{H}}{2s}\left[\left(w_b^H - w_a^H\right) - (p_b - p_a) + (A_b^H - A_a^H) + s\right]
\end{aligned}
$$

Therefore the number of high and low-skilled workers in b equals

$$
\begin{aligned}
N_b^H &= \frac{N^H}{2s}\left[\left(w_b^H - w_a^H\right) - (p_b - p_a) + (A_b^H - A_a^H) + s\right] \\
N_b^L &= N_b^{Lm} + N_b^{Lv} \\
&= \frac{N^L}{2s}\left[\left(w_b^L - w_a^L\right) + (A_b^L - A_a^L) + s\right] - \tfrac{N^{Lm}}{2s}(p_b - p_a)
\end{aligned}
$$

Use equations (7.8) and (7.9) to express the number of workers of each skill type as

$$
\begin{aligned}
N_b^H =& \frac{N^H}{2s}\left[\tfrac{1}{h}\left(X_b^H - X_a^H\right) - (k_a + k_b)(N_b^H + N_b^L) + (A_b^H - A_a^H) + s + k_a N\right] \\
N_b^L =& \frac{N^L}{2s}\left[\tfrac{1}{h}\left(X_b^L - X_a^L\right) + (A_b^L - A_a^L) + s\right] - \frac{N^{Lm}}{2s}(k_a + k_b)(N_b^H + N_b^L) + \\
& \frac{N^{Lm}}{2s}k_a N
\end{aligned}
$$

Define $Z^T = \frac{1}{h}\left(X_b^T - X_a^T\right) + (A_b^T - A_a^T) + s + k_a N$ to reduce the notational burden and rearrange. Note that all parameters that occur on the right hand side only are exogenous.

$$
N_b^H = \phi^H \frac{N^H}{2s} Z^H - \phi^H \frac{N^H}{2s}(k_a + k_b) N_b^L \tag{7.18}
$$

$$
N_b^L = \phi^L \frac{N^L}{2s} Z^L - \phi^L \frac{N^{Lm}}{2s}(k_a + k_b) N_b^H - \phi^L \frac{N^{Lv}}{2s} k_a N \tag{7.19}
$$

$$
\phi^L = \frac{2s}{2s + N^{Lm}(k_a + k_b)}, \quad \phi^H = \frac{2s}{2s + N^H(k_a + k_b)}
$$

Substitute equation (7.19) into equation (7.18) to solve for N_b^H:

$$N_b^H = \Phi\phi^H \frac{N^H}{2s} Z^H - \Phi\phi^H \frac{N^H}{2s}(k_a + k_b)\phi^L \frac{N^L}{2s} Z^L + \Phi\phi^H \frac{N^H}{2s}(k_a + k_b)\phi^L \frac{N^{Lv}}{2s} k_a N$$
$$\Phi = \frac{2s + (k_a + k_b)N^H}{2s + (k_a + k_b)N^H \frac{2s}{2s + (k_a + k_b)N^{Lm}}}$$

which simplifies to:

$$\begin{aligned} N_b^H &= \left(\sigma + N - N^H - N^{Lv}\right) N^H \delta \left[\tfrac{1}{h}\left(X_b^H - X_a^H\right) + (A_b^H - A_a^H)\right] \\ &\quad - (N - N^H) N^H \delta \left[\tfrac{1}{h}\left(X_b^L - X_a^L\right) + (A_b^L - A_a^L)\right] \\ &\quad + (\sigma - N^{Lv}) N^H \delta s + \sigma N^H \delta k_a N \\ \delta &= \frac{1}{2s} \frac{1}{\sigma + (N - N^{Lv})}, \quad \sigma = \tfrac{2s}{k_a + k_b} \end{aligned}$$

Plug in the values of δ and σ to derive equation (7.10).

To solve for N_b^L, substitute equation (7.18) into equation (7.19):

$$\begin{aligned} N_b^L &= -(N - N^H - N^{Lv}) N^H \delta \left[\tfrac{1}{h}\left(X_b^H - X_a^H\right) + (A_b^H - A_a^H)\right] \\ &\quad + (N - N^H)(\sigma + N^H)\delta \left[\tfrac{1}{h}\left(X_b^L - X_a^L\right) + (A_b^L - A_a^L)\right] \\ &\quad + \delta s \left[\sigma(N - N^H) + N^H N^{Lv}\right] + \sigma(N - N^H - N^{Lv})\delta k_a N \end{aligned}$$

From which it follows that $N_b = N_b^H + N_b^L$ is given by:

$$\begin{aligned} N_b &= N^H \delta\sigma \left[\tfrac{1}{h}\left(X_b^H - X_a^H\right) + (A_b^H - A_a^H)\right] \\ &\quad + (N - N^H)\delta\sigma \left[\tfrac{1}{h}\left(X_b^L - X_a^L\right) + (A_b^L - A_a^L)\right] \\ &\quad + \delta\sigma N s + (N - N^{Lv})\delta\sigma k_a N \\ \delta &= \frac{1}{2s} \frac{1}{\sigma + (N - N^{Lv})}, \quad \sigma = \tfrac{2s}{k_a + k_b} \end{aligned}$$

7.B Housing in 1947

ID	corop	housing stock 1947
1	Flevoland	1,281
2	Zuidwest-Drenthe	17,849
3	Midden-Noord-Brabant	47,239
4	Midden-Limburg	19,307
5	Groot-Amsterdam	251,037
6	Noord-Drenthe	18,807
7	Arnhem/Nijmegen	74,935
8	Zuid-Limburg	71,574
9	Zuidwest-Friesland	21,570
10	Zaanstreek	22,166
11	Oost-Groningen	31,692
12	Agglomeratie Leiden en Bollenstreek	42,581
13	Zeeuws-Vlaanderen	20,850
14	Overig Groningen	68,581
15	Zuidoost-Noord-Brabant	56,832
16	Noord-Limburg	22,674
17	Kop van Noord-Holland	39,633
18	Delfzijl en omgeving	9,223
19	Agglomeratie 's-Gravenhage	146,151
20	Noordoost-Noord-Brabant	45,125
21	Groot-Rijnmond	233,872
22	West-Noord-Brabant	60,596
23	Overig Zeeland	40,179
24	Agglomeratie Haarlem	50,329
25	Achterhoek	44,773
26	Utrecht	120,352
27	Noord-Friesland	61,674
28	Noord-Overijssel	43,581
29	Zuidoost-Drenthe	17,356
30	Het Gooi en Vechtstreek	39,434
31	Zuidoost-Friesland	28,097
32	Veluwe	60,478
33	Twente	71,053
34	Zuidwest-Overijssel	16,989
35	Zuidwest-Gelderland	25,640
36	Zuidoost-Zuid-Holland	48,785
37	Delft en Westland	24,991
38	Oost-Zuid-Holland	33,109
39	Alkmaar en omgeving	22,176
40	IJmond	18,573

Chapter 8

Summary

The objective of social housing is to provide affordable housing to low-income households. To guarantee the affordability of the dwelling the rent is often controlled. This changes the costs and benefits of living, which in turn alters the behavior of tenants of social housing and other agents. These economic effects of social housing are the subject of this dissertation.

In this dissertation I present two theoretical and four empirical studies. The first part considers social housing from a microeconomic perspective and looks at the self-selection into social housing (chapter two), as well as at how this influences consumption patterns (chapter three), the relocation behavior of household within and from the social housing sector (chapter four) and the wage rates workers earn (chapter five). The second part is macroeconomic in nature and considers the joint effect of housing and labor market price rigidities on the skill composition of cities (chapter six). I study the effect social housing on the local skill composition by empirically testing whether a large social housing stock reduces the percentage of high-skilled workers in the labor force (chapter seven).

8.1 Summary of this dissertation

Microeconomic framework

Evidence exists to suggest that social housing is not allocated randomly to (low-skilled) workers. Tenants of social housing with high incomes benefit more from rent control than tenants with low incomes (Gyourko and Linneman, 1989). What's more, the average incomes of tenants living in social housing are found to be higher in regions with higher house prices (Van Daalen et al., 2012). In chapter two I present a microeconomic framework that explains both observations by the way in which local amenities influence the self-selection into controlled or uncontrolled housing.

Local amenities such as the presence of jobs, historic scenery or natural areas (or other local public goods) are internalized into the local house prices, but not into the controlled rent of social housing. This allows the tenant of social housing to consume those location amenities for free. Therefore, social housing in regions with a high level of local amenities will be inhabited by high-income tenants, whereas tenants with such incomes would rent uncontrolled housing in other regions.

The microeconomic framework that is developed assumes that workers derive utility from consuming housing quality, a composite good and location amenities. Workers maximize utility by choosing to consume uncontrolled or social housing. As a result, living in rent-controlled housing (and its quality) becomes a decision.

The model shows that rent control changes the allocation of the budget to housing quality and consumption of the composite good. It moreover demonstrates that workers in social housing can be subdivided into those who consume the optimal quality of social housing given their income and the controlled rent (unrestricted tenants of social housing) and those who would want to consume social housing of better quality but are unable to (restricted tenants of social housing). Tenants of social housing spend a larger budget share on the composite good. We show this holds even stronger for restricted tenants of social housing.

Chapter two points out that the 'unrestricted tenants of social housing' are those workers in social housing with income equal or below the income threshold Y^s. The other tenants of social housing make up the 'unrestricted tenants of social housing'. Tenants with incomes exceeding another threshold (Y^{A_l}) will rent uncontrolled housing. The income threshold Y^{A_l} varies with the level of location amenities. This implies that the maximum income level at which one is willing to live in social housing varies with the local amenity level.

It is shown that entry regulations based on income are unable to prevent the self-selection of high-income tenants into social housing if incomes are dynamic. This weakens the contribution of rent control to mixed neighborhoods: In growing cities with many local amenities, rent-controlled tenants will have a higher incomes, thereby reducing social mixing.

An important contribution of chapter two is its study of the welfare effects of social housing. Social housing is always inefficient as the costs born by the lessor always exceed the benefits enjoyed by the tenants. This provides scope for welfare improvement as winners from the decontrol of social housing can compensate losers in such a way that both are better off compared to the current situation. However, such compensation schemes might be politically unfeasible to accomplish.

The welfare analysis in this chapter shows that the contribution of a worker to the total welfare loss of social housing increases with income and the market rent. This implies that the welfare loss of social housing can be reduced by reallocating social housing from high-income workers to low-income workers. Such schemes might provide a (second best) welfare improvement that is politically more feasible.

Consumption differs with housing tenure type

It can be argued that the consumption of tenants of social housing differs from that of homeowners because of two reasons. First, the property rights that come with homeownership ensure that movements in house prices influence (future) wealth of homeowners, but not that of tenants. The propensity to consume out of income might therefore be different for homeowners as compared

to tenants. Second, the microeconomic framework has shown that rent control of social housing influences the budget share devoted to the composite good. Both effects of housing market tenure are studied in chapter three.

I start with testing whether house prices influence consumption as a result of the increased wealth of homeowners (wealth hypothesis) or whether both variables move together because of a common driver (common factor hypothesis). Both hypotheses are identified by a different marginal effect of house prices on consumption for different age groups.

I test whether housing tenure influences the level of consumption by estimating a lifecycle consumption model based on data from the Dutch budget survey (in Dutch: *Budget Onderzoek*) that has been collected by Statistics Netherlands for the years 1980-1999. The national house price index for the period 1980-1999 is used to test whether the consumption levels of homeowners and tenants respond differently to house prices.[1] Along the lines of Attanasio et al. (2009) identification occurs according to the interaction with age, although propensity score matching (PSM) is applied as a robustness check.

The evidence is in line with the common factor hypothesis: The marginal effect of house prices on consumption is positive and decreases with age. Results from the PSM-procedure confirm this for both homeowners and tenants.

Currently, the Dutch economy is characterized by both a low level of household consumption and decreasing house prices. It has been argued that a recovery of the housing market is required in order to raise consumption. However, my findings suggest that both the low prices on the housing market and low consumption are caused by other factors.

The second part of chapter three studies the effect of housing market tenure on the allocation of the budget. Using the same consumption data Engel curves are estimated for four expenditure categories: 'Basic goods', 'Housing', 'Recreation' and 'Alcohol and tobacco'. These four categories on average contain 80 percent of total household expenditure.

It is concluded that housing market tenure has an effect on the allocation of the budget: Tenants in social housing spend less on housing and more on

[1] The data does not allow for the consideration of house prices across regions.

basic goods, recreation and alcohol and tobacco. This difference in budget allocation remains is PSM is used. The analysis shows that the difference in the allocation of budget to consumption goods between homeowners and tenants of social housing has been falling over time. This is in line with the observation that rents in the controlled housing sector have been increasing more than the imputed rents in the owner-occupied sector.

Finally, I test consumption patterns of tenants who are similar in characteristics to homeowners differ from those of other tenants of social housing. Under the assumption that social housing tenants with similar characteristics as homeowners are restricted tenants of social housing, I find some evidence pointing to the existence of consumption differences between restricted and unrestricted tenants. Restricted tenants of social housing are found to spend less on housing and more on recreation, although the size of the effect is limited.

Social housing reduces mobility and housing demand

The prediction following from the microeconomic framework is that the income at which workers leave the social housing sector increases with the price difference between the market rent and controlled rent. Chapter four tests this hypothesis by considering how rent control benefits influence the decision to move from and within the social housing sector. Rent control might influence these types of transitions differently, as moving from the social housing sector eliminates the benefits of rent control, whereas transitions within the rent control housing sector do not and might in fact increase them.

Previous empirical research concludes that rent control reduces the overall propensity to move house.[2] However, this research did not make a distinction between transitions from and within the social housing sector.

Estimation results are based on a unique household panel dataset for the years 2006 through 2008 that has been constructed from administrative records provided by Statistics Netherlands. It contains individual household information, job characteristics, local housing market characteristics and an indicator

[2]See, for instance, Gyourko and Linneman (1989); Ault et al. (1994); Nagy (1995); Munch and Svarer (2002); Simmons-Mosley and Malpezzi (2006) for empirical results using various estimation methods such as OLS, logistic regression, and duration models.

of whether the house one lives in is social housing or owner-occupied housing. Rent control benefits are measured as the median rent at the neighborhood level divided by individual house value.

The results indicate that the effect of rent control benefits on household mobility is large for transitions within the social housing sector, whereas it is limited for transitions from the social housing sector. In line with the model presented in chapter two the probability to move from the social housing sector decreases with rent control benefits for high-income workers only. In contrast, all tenants of social housing reduce the transitions within the social housing sector if rent control benefits increase.

These results suggest that rent control has a limited effect on the demand for owner-occupied housing. In the short run rent-controlled housing only becomes available for new entrants if current inhabitants move. Our results suggest that less housing becomes available as rent control of social housing reduces mobility within the social housing sector.

Housing market tenure does not influence wages

On average, workers in owner-occupied housing earn 25 percent higher wages compared to tenants of social housing. This wage differential might reflect the sorting mechanism as described in the economic framework. In contrast, as both homeownership and living in social housing reduce labor mobility (De Graaf et al., 2009), wages might be affected by housing market tenure.

Although it has been documented that tenants of social housing have a weaker labor market position than homeowners, the effect of social housing on wages has not previously been investigated. And while two studies have investigated the effect of homeownership on wages, however, they are inconclusive on the sign and magnitude of its effect. Munch et al. (2008) use Danish data from administrative records to find that homeowners earn about five percent higher wages than tenants. In contrast, Coulson and Fisher (2009) use survey data for the United States and find that homeowners in the United States earn on average 30 percent lower wages compared to tenants. Both studies do not distinguish between tenants of private housing and tenants of social housing.

Chapter five tests whether homeowners and tenants of social housing earn different wages compared to tenants of private rental housing. This is done using a large panel for the years 2006 through 2008 based on administrative records. This enables controlling for the sorting of low-skilled workers into social housing.

It follows from the analysis that conditioning on worker skill is very important: Without controlling for the sorting mechanism of low-skilled workers into social housing one would conclude that social housing reduces the wage rate with 17 percent compared to the wage rate of private tenants. Similarly, homeowners are found to earn seven percent higher wages than tenants of private rental housing. In contrast, if one controls for sorting according to skill, there is no evidence that homeowners or tenants living in social housing earn different wages compared to tenants of private housing.

Macroeconomic framework

The macroeconomic framework of this dissertation is presented in chapter six. Because workers compete for housing a demand shock to high-skilled labor increases the number of high-skilled workers in a city and decreases the number of low-skilled workers in it. Because house prices depend on the price elasticity of the housing supply, the housing market determines how skill-specific productivity shocks change the composition of a city (Roback, 1982; Moretti, 2011).[3] These types of equilibrium models describe the interaction between local housing and labor markets under the assumption that both markets are perfectly competitive. In chapter six, I present a macroeconomic framework that analyzes the location decision of low-skilled and high-skilled workers if labor and housing markets are characterized by imperfections in the form of price rigidities.

Price rigidities on the labor market are modeled in the form of nominal wage rigidities that are the result of a national wage bargaining process. Local labor markets are characterized by the matching framework in developed by

[3] If labor demand in a city increases, this might attract labor. If the price elasticity of housing supply is high, the increase in population will be modest and the increase in local wages and house prices will be large. However, if the price elasticity of housing is low, many workers can enter the city and the increase in local wages and house prices will be low.

Pissarides (2000). I show that these price rigidities in the labor market reduce the mobility of labor if there are limited spatial differentials in unemployment rates or if wages are not adjusted in response to local changes in productivity. This is due to the fact that moving to another labor market would in these cases not pay off.

Price rigidities in the housing market enter in the form of housing vouchers that enable the holder to rent housing at the rent ceiling. I show that the effect of these housing market vouchers on the size and composition of cities is critically dependent on its distribution among workers: If the housing vouchers are held mainly by low-skilled workers, the inflow of high-skilled workers and outflow of low-skilled workers after a productivity shock to high-skilled labor will both be lower. In contrast, if rent control housing vouchers are held mainly by high-skilled workers the inflow of high-skilled workers and outflow of low-skilled workers will be larger.

Interestingly, I show the existence of an intermediate distribution of rent control housing vouchers among high-skilled and low-skilled workers, such that rent control housing vouchers both *increases* the inflow of high-skilled workers and *reduces* the outflow of low-skilled workers after a productivity shock to high-skilled labor.

The analysis shows that the effect of housing market and labor market price rigidities on local skill composition is skill-specific. In general, both housing market price rigidities and labor market price rigidities have an amplified effect on city composition after a shock to the productivity of high-skilled labor. However, rent control housing vouchers mitigate the effect of nominal wage rigidities if the productivity of low-skilled workers changes.

Rent-controlled housing reduces local skill level

The macroeconomic framework illustrates how low-skilled workers in social housing do not leave the city if the productivity of high-skilled workers increases, whereas low-skilled workers in uncontrolled housing do. In addition, as these low-skilled workers do not leave the city, house prices increase for high-skilled workers who want to enter. These two mechanisms imply that the percentage of high-skilled workers in a city decreases with the stock

of rent-controlled housing. On the other hand, chapter two has shown that entry regulations are unable to prevent the self-selection of high-skilled workers into social housing if the income of a worker might increase over time.

It is important to know whether the social housing stock reduces the skill composition of local labor markets, as this might reduce the positive externalities from agglomeration economies.[4] If it does, this would be a channel by which rent control distorts outcomes on the local labor market that has not been studied before. In chapter seven I test whether the stock of rent-controlled housing influences the local skill composition of regions and, if so, to what extent.

It test whether the stock of rent-controlled housing influences local skill composition using a longitudinal panel of forty NUTS 3 regions in the Netherlands. The data is constructed from the WBO and WoON national housing surveys in the years between 1981 and 2006 and augmented with information on productivity and employment for eight sectors in these years at the NUTS 3 level for the same period.

I use an instrumental variables approach to control for the endogeneity of explanatory variables such as the high-skilled wage premium and local house prices. Rent control is found to reduce the percentage of high-skilled workers in a region. A ten percentage point increase of the rent-controlled housing stock is found, ceteris paribus, to reduce the percentage of high-skilled workers in a region with 1.5 percentage points. This is equivalent to an increase in house prices with about €8,800, ceteris paribus. The size of the effect is modest. If the social housing stock of Utrecht would be decreased by half (from forty to twenty percent of the housing stock), the percentage of high-skilled workers in Utrecht is expected to increase with three percentage points (to 46 percent). As mentioned the limited effect of the share of rent-controlled housing on local skill composition might be explained by the self-selection of high-skilled workers into social housing in attractive cities, the topic of study in chapter two.

[4]Moretti (2004) presents evidence that clustering of high-skilled workers increases nominal wages of all skill types.

8.2 Limitations and directions for future research

This dissertation has shown that social housing has many economic effects on the housing and labor market. However, the economic effects are more subtle than the canonical "rent-controlled social housing reduces transitions to uncontrolled housing, which worsens the labor market position of inhabitants of social housing". In contrast, this dissertation has shown that rent control mainly reduces transitions to controlled housing, whereas transitions to the uncontrolled (owner-occupied) housing sector are only limitedly affected. These results call for the development of dynamic theoretical models in which household choose to move within or from the social housing sector.

Moreover, although I did not study the direct effect of social housing on the labor market position, no evidence is found that social housing reduces the wages of its inhabitants. This is surprising as a negative effect on wages is expected if social housing worsens the labor market position. Research on housing tenure type and labor mobility has focused mainly on the effect of homeownership on the probability to become unemployment, the probability to leave unemployment, and the probability to switch jobs (Van Ewijk and Van Leuvensteijn, 2009). An interesting exception is De Graaf et al. (2009), who find no evidence for a worsened labor market position of tenants of social housing compared to tenants of private rental housing in the Netherlands. It remains an open question why ceteris paribus inhabitants of social housing do not earn lower wages and do not have a worsened labor market position, when they are found to be less mobile and to commute less.

With regard to economic theory it would be interesting to consider the joint welfare implications of social housing on the housing and labor markets. It has been shown that the reallocation of social housing from high-income to low-income workers reduces the welfare loss created by social housing at the housing market, but might increase labor market distortions on the labor market. Future research could focus on further exploring this efficiency vs. efficiency trade-off and on developing strategies to quantify it.

Also, the models in this dissertation consider the behavior of tenants of social housing and of tenants of uncontrolled housing, whereas the empirical sections make a comparison between tenants of social housing and homeown-

ers most of the time. The reason is that homeownership influences equity and therefore the long-term income of households which is more complicated to model. Although simple and straightforward models are a benefit in itself, future research on the interactions of the labor and housing markets might explicitly model the effects of ownership when comparing homeowners to tenants.

There are several aspects of the Dutch housing market that merit study in future research. I highlighted why there are so many high-skilled workers to be found in social housing in the economic core. I also explained why this makes high-skilled workers benefit more from social housing than low-skilled workers. However, I did not explicitly consider the implications this self-selection of high-skilled workers into social housing has for redistribution.

Also, I ignored the effect of the Dutch rent support program on housing demand. Given the size of the program, both in number of households and the total amount of subsidy received, it would be interesting to investigate how this program impacts the demand for housing services. Koning and Ridder (1997) conclude that the Dutch rent support program increases demand for housing services. It would be worthwhile to consider whether individual rent support affects wages (poverty trap) and whether it influences the self-selection into social housing, household mobility and labor market position.

The conclusions of any empirical study are restricted by the data that have been used. This dissertation is no different. In several chapters it would be interesting to use other types of data to see whether the conclusions of this dissertation hold. For instance, the study on the consumption of homeowners and tenants of social housing in chapter three uses a pooled cross-section for twenty consecutive years and a national house price index. With available panel data on consumption and local house price indices, it would be possible to control for unobserved worker characteristics (preferences, skills) that are found to be important drivers of selection into social housing (see chapter five). Now, while this concern is dealt with using propensity score matching, panel data techniques are always consistent (and at least more efficient), as is

explained in chapter three. Local house price indices might clearly be better able to capture the wealth shocks homeowners face compared to the national house price index, and are the preferred avenue to improve the efficiency of this analysis.

In chapters four and five I use a panel based on administrative records. It would be interesting to extent the panel to include a longer time span. Not only would this improve the analysis by reducing the incidental parameter problem, it would also allow for the investigation of the effect of the crisis on the Dutch (owner-occupied) housing market that started in 2008 and as of today has not yet come to an end. Since the crisis, house prices have been falling, thereby reducing the benefits of rent control. This might influence household transitions and self-selection into social housing as social housing might be considered a save haven.

The analysis in chapter seven considers the effect of social housing on local skill composition based on NUTS 3 regions. Because of aggregation issues, a lower geographical scale such as the municipal level might provide a better level to measure both the share of the housing stock that is rent-controlled and the percentage of the labor force that is high-skilled. While it is true that an analysis at a lower geographical scale presents issues of spatial dependence of the data, these can be dealt with using spatial econometric techniques.

8.3 Policy implications

This dissertation has shown that social housing has several economic effects which should be taken into consideration when designing policy for the Dutch social housing sector. Social housing has been shown to influences consumption and geographical mobility without reducing the earned wage. Also, social housing somewhat reduces the share of high-skilled workers in the local labor market, although the magnitude of this effect is limited.

The aim of social housing is to provide dwellings to households who typically have a low-income. It has been shown that entry-regulations based on income are unable to prevent that social housing is inhabited by high-income

households. As a result social housing in the Netherlands is badly targeted to low-income households especially in regions where house prices are high and keeping housing affordable is most needed. Thus from an equity perspective regulations that change the allocation of social housing are called for.

A similar conclusion is reached if one is concerned with the efficiency of the housing market. The contribution to the welfare loss from social housing has been shown to be larger for high-income workers than for low-income workers. Thus reallocating social housing from high-income workers to low-income workers will reduce the welfare loss at the housing market, especially if this occurs in places where house prices are high.[5] As most high-income workers live in social housing in locations where rent control benefits are high, social housing will especially become available to low-income households in those regions where transitions within the social housing sector are lowest and where entering the social housing sector is hardest.

Thus reallocating social housing from high-income to low-income households might be considered fair and will reduce the welfare loss at the housing market. The Dutch administration has taken several steps to adjust the allocation of social housing away from high-income households.[6] The framework in chapter two suggest that these measures will reduce the share of social housing inhabited by high-income households. However, targeting of social housing to low-income tenants is expected to remain less efficient in regions with high house prices, as long as there exists a wedge between market and social housing prices and only entry-regulations are imposed.

It should be noted that legislation that ensures that social housing will only be inhabited by low-income households will increase local labor market distortions by reducing the share of high-skilled workers. This 'efficiency vs. ef-

[5]Reallocation of social housing from high-income to low-income households is unable to eliminate the welfare loss. It can be eliminated by decontrolling all social housing and letting the winners compensate the losers. However, such a policy is likely to be unfeasible.

[6]As of July 2011, the rent of new contracts is allowed to increase more in attractive locations in the country (the so-called *schaarstegebieden*). As of July 2013 rents in the social housing sector were made dependent on income. Rents were allowed to increase with the inflation rate plus 2.5, 3.5 and 4 percent maximums for low-, middle-, and high-income households. Here, middle-income households are defined as earning an annual income between €33,614 and €43,000. Finally, the government aims to introduce a new pricing mechanism on 1 July 2014 in which rents of social housing are based on house values, see BZK (2013).

ficiency trade-off' is an important mechanism policymakers should be aware off, if they introduce new policy on social housing.

The 'efficiency vs. efficiency trade-off' implies that if legislation that increases the allocation of social housing to low-income households is introduced, then it should be accompanied by a reduction of the social housing stock: The reallocation will reduce the efficiency loss at the housing market, whereas the reduced size of the social housing stock will reduce labor market distortions. If the latter does not occur, the efficiency vs. efficiency trade-off implies that distortions on the labor market will be amplified. As social housing is poorly targeted to low-income households, this suggest that low-income workers need not necessarily be worse off. If so, a more efficient outcome might be realized without harming the people for whom social housing is designed.

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Samenvatting

De economie van sociale woningbouw

Sociale huurwoningen stellen mensen in staat om een kwalitatief goede woning te huren tegen een betaalbare huur. Om ervoor te zorgen dat de huur betaalbaar blijft, wordt deze gereguleerd. Veel economen menen dat huurregulering nadelige gevolgen heeft. Huurregulering vermindert de welvaart. Ook zou het leiden tot een vermindering van het aantal sociale huurwoningen en een verschraling van hun kwaliteit. Daarnaast profiteren de bewoners van sociale huurwoningen van een huur die lager is dan de markthuur. Omdat ze dit voordeel verliezen als ze naar een koopwoning verhuizen, zouden bewoners van sociale huurwoningen minder vaak verhuizen. Dit zou hun arbeidsmarktpositie kunnen verzwakken en de duur van werkloosheid verlengen.

Het is echter onduidelijk of deze onbedoelde economische gevolgen van sociale woningbouw optreden binnen Nederland, onder andere omdat de regelgeving op de woningmarkt verder gaat dan enkel het reguleren van de huur. Zo voorziet de institutionele context van de Nederlandse woningmarkt bijvoorbeeld in afspraken over het aantal en de kwaliteit van huurwoningen, waardoor er relatief veel sociale huurwoningen zijn en de kwaliteit goed is (zie ter illustratie de Figuren 1.1 en 1.2).[1] Daarnaast kan een verminderde arbeidsmarktmobiliteit ook leiden tot een grotere bereidheid om te pendelen tussen huis en werkplek.

[1] In de literatuur wordt naar dit soort institutionele arrangementen verwezen als 'tweede generatie huurregulering' ter onderscheid van een 'eerste generatie huurplafond' (Arnott, 1995; Lind, 2001). Dit soort tweede generatie arrangementen zijn divers (Fallis1988; Lind 2001; Scanlon en Whitehead, 2007, 2008).

Daarom wordt in dit proefschrift onderzocht hoe de sociale woningbouw de lokale economie beïnvloedt en richt zich daarbij met name op gevolgen voor de arbeidsmarkt. Het onderzoek bestaat uit een micro-economisch en macro-economisch deel. In hoofdstuk twee wordt een micro-economisch kader ontwikkeld dat de keuze om in een sociale huurwoning te wonen verklaart uit locatievoordelen. Ook worden de welvaartseffecten hiervan geanalyseerd. In hoofdstuk drie, vier en vijf wordt dit model getest: Ik onderzoek in hoofdstuk drie of huurders in een sociale huurwoning een ander consumptiepatroon hebben. In hoofdstuk vier wordt onderzocht of het wonen in een sociale huurwoning de verhuisgeneigdheid beïnvloedt. Hierbij wordt onderscheid gemaakt tussen verhuizingen binnen en uit de sociale huursector. In hoofdstuk vijf wordt gekeken of het verschil in inkomen tussen huurders van sociale huurwoningen en huiseigenaren verklaard wordt door de zelfselectie van mensen met een laag inkomen in sociale huurwoningen of dat het type woning van invloed is op de hoogte van het inkomen.

In het macro-economische deel worden de gevolgen van sociale woningbouw voor de opbouw van de lokale beroepsbevolking besproken. Ik ontwikkel een theoretisch kader in hoofdstuk zes dat laat zien hoe loononderhandelingen op de arbeidsmarkt en het reguleren van huurwoningen zorgen voor prijsrigiditeiten, die elkaar kunnen versterken of verzwakken afhankelijk van het type werknemer dat toegang heeft tot huurregulering. In hoofdstuk zeven wordt getest of de grootte van de sociale huurwoningvoorraad van invloed is op het percentage hoogopgeleide werknemers in een gebied.

Deze onderwerpen worden onderzocht vanuit een drietal invalshoeken. Ten eerste wordt er tijdens het onderzoek rekening mee gehouden dat de positie op de arbeidsmarkt en de woningmarkt niet onafhankelijk van elkaar zijn. Mensen hebben verschillende waargenomen kenmerken (zoals leeftijd, geslacht, gezinssituatie en type baan), maar hebben ook verschillende niet-waargenomen, 'zachte' kenmerken zoals preferenties, vaardigheden en karakter. Juist deze 'zachte' kenmerken zouden heel belangrijk kunnen zijn voor zowel de zelfselectie in een sociale huur- of koopwoning als de positie op de arbeidsmarkt en een gedegen analyse dient hiervoor te corrigeren. In

dit proefschrift probeer ik te doen door middel van *propensity score matching*[2], paneldata-schatters en het gebruik van instrumentele variabelen.

Een tweede invalshoek is dat locaties van elkaar verschillen. Economische activiteit zoals banen en het type bedrijf en industrie zijn niet gelijkmatig verdeeld over het land. Dit geldt ook voor locatievoordelen, zoals lokale publieke goederen (bijvoorbeeld parken, natuurreservaten, open ruimte) en consumentenvoordelen zoals de aanwezigheid van een historisch stadscentrum of recreatiemogelijkheden. De nabijheid van zulke locatievoordelen wordt verdisconteerd in de marktprijs van woningen, maar niet in de gereguleerde huur.[3] Hierdoor profiteren de bewoners van sociale huurwoningen in het economische centrum meer van huurregulering dan bewoners van sociale huurwoningen in de economische periferie. Dit heeft als gevolg dat de economische effecten van sociale woningbouw regionaal verschillen.

Een derde invalshoek betreft de ruimtelijke afhankelijkheid van (met name) geaggregeerde economische variabelen. Ruimtelijke afhankelijkheid wordt samengevat in de wet van Tobler: "Alles is gerelateerd aan alles, maar zaken dichterbij zijn meer gerelateerd dan zaken ver weg" (Tobler, 1970). De vele banen in Amsterdam verhogen bijvoorbeeld niet alleen de woningprijzen in Amsterdam, maar ook die in nabijgelegen gebieden. Ruimtelijk econometrische technieken worden gebruikt om voor de ruimtelijke afhankelijkheid van variabelen te corrigeren.

Belangrijkste conclusies

Micro-economisch kader

Sociale huurwoningen worden niet-willekeurig bewoond. Huurders van sociale huurwoningen met een hoog inkomen genieten meer huurvoordeel (Gyourko and Linneman, 1989). Ook wonen er meer huishoudens met een hoog inkomen in sociale huurwoningen als de huizenprijs hoog is (Van Daalen et

[2]Het construeren van een homogene steekproef uit twee verschillende groepen door het koppelen van subjecten in groep *a* aan vergelijkbare subjecten in groep *b* op basis van de voorspelde kans om in groep *a* (of *b*) te horen.

[3]Dit is recentelijk aangepast. Sinds juli 2011 mag de gereguleerde huur in zogeheten schaarstegebieden verhoogd worden met 25 punten als een nieuw contract wordt aangegaan.

al., 2012). In hoofdstuk twee wordt een micro-economisch kader gepresenteerd dat deze zelfselectie in sociale huurwoningen verklaart uit locatievoordelen: Omdat een sociale huurwoning de bewoner in staat stelt om deze locatievoordelen gratis te consumeren (ze worden immers niet verwerkt in de huur) blijven huishoudens met een hoog inkomen in sociale huurwoningen zitten in gebieden met veel locatievoordelen. Hierdoor wordt het bewonen of verlaten van een sociale huurwoning een keuze die afhangt van de locatie.

Het micro-economisch kader veronderstelt dat huiseigenaren hun nut maximaliseren door de consumptie van locatievoordelen, de kwaliteit van de woning en alle andere goederen (*composite good*). Verder kan een ongecontroleerde huurwoning iedere gewenste kwaliteit hebben, maar is de kwaliteit van een sociale huurwoning aan een maximum gebonden. Uit het micro-economisch kader volgt dat huurregulering de verdeling van het budget over de goederen beïnvloedt. Ook illustreert het dat de werknemers opgedeeld kunnen worden in huiseigenaren, en gerestricteerde en niet-gerestricteerde bewoners van sociale huurwoningen. Niet-gerestricteerde huurders van sociale huurwoningen kunnen de ideale woningkwaliteit consumeren[4], terwijl gerestricteerde huurders liever een sociale huurwoning van betere kwaliteit zouden consumeren. Echter, zij zijn beter af in een sociale huurwoning, omdat zij het geld dat ze uitsparen aan huur kunnen besteden aan de overige goederen. De groep werknemers met het hoogste inkomen besluit om ongecontroleerde woningen te huren.

De hoogte van het inkomen waarop men besluit om een ongecontroleerde woning te huren neemt toe met de locatievoordelen in het gebied, hetgeen de empirische verbanden tussen het inkomen van huurders van sociale huurwoningen en de woningprijzen en het huurvoordeel verklaart. Ook laat het micro-economisch kader zien dat de zelfselectie van werknemers met een hoog inkomen in sociale huurwoningen niet tegengegaan kan worden met selectie aan de poort op basis van inkomen als het inkomen aan (positieve) verandering onderhevig is.

Hoofdstuk twee kan gebruikt worden om de welvaartseffecten van de *allocatie* van sociale huurwoningen aan te geven. De bijdrage aan het welvaarts-

[4]Namelijk die woningkwaliteit die het hoogst haalbare nut oplevert gegeven het inkomen.

verlies van huurregulering van de sociale woningbouw is groter voor werknemers met een hoog inkomen dan voor werknemers met een laag inkomen. Dit impliceert dat het welvaartsverlies van het sociale woningbouw verminderd kan worden door sociale huurwoningen te herverdelen van bewoners met een hoog inkomen naar bewoners met een laag inkomen. Deze maatregel is een *second best* maatregel vanuit het oogpunt van efficiëntie: het welvaartsverlies kan er niet door verdwijnen. Echter, het is mogelijk een maatregel die politiek beter haalbaar is dan de *first best* welvaartsverhogende beleidsaanbeveling om de sociale huursector af te schaffen (al dan niet met een compensatieregeling voor de benadeelden).

Consumptiepatronen verschillen met type woning

Er zijn meerdere redenen om te veronderstellen dat consumptiepatronen van huiseigenaren anders zijn dan de consumptiepatronen van bewoners van sociale huurwoningen. Bewoners van een sociale huurwoning delen niet in de groei (of daling) van het vermogen die veroorzaakt wordt door prijsfluctuaties op de woningmarkt. Daarnaast heeft het micro-economisch kader laten zien dat huiseigenaren en bewoners van sociale huurwoningen hun budget anders over de goederen verdelen.

In hoofdstuk drie test ik of verschillen in consumptie tussen huiseigenaren en huurders in sociale huurwoningen inderdaad veroorzaakt worden doordat huizenprijzen het vermogen beïnvloeden (de 'vermogenshypothese') of dat er sprake is van gelijktijdige beïnvloeding van consumptie en woningprijzen door eenzelfde variabele (de 'gemeenschappelijke-factorhypothese'). Ik schat daartoe een levensloop-consumptiemodel met behulp van data van het Budget Onderzoek verzameld door het CBS over de periode 1980 tot en met 1999. De nationale woningprijsindex is gebruikt om te testen via welke hypothese woningprijzen consumptie beïnvloeden.[5] Beide hypothesen worden van elkaar onderscheiden door gebruik te maken van de interactie van woningprijzen met leeftijd volgens de methode van Attanasio et al. (2009). Als

[5]Het is hiermee niet mogelijk om na te gaan hoe lokale woningprijzen consumptie beïnvloeden.

een controle op de robuustheid van de resultaten pas ik ook *propensity score matching* toe.

De schattingsresultaten leveren bewijs voor de gemeenschappelijke-factor-analyse: Het marginale effect van woningprijzen op consumptie is positief en daalt met leeftijd. De resultaten van de *propensity score matching* bevestigen deze conclusie. Dit zou betekenen dat het huidige lage niveau van de binnenlandse besteding niet veroorzaakt wordt door de crisis op de woningmarkt, maar dat beide beïnvloed worden door een gemeenschappelijke factor.

Tenslotte bestudeer ik in hoofdstuk drie het effect van het type woning op de allocatie van het budget over consumptiegoederen. Gebaseerd op het Budget Onderzoek 1980-1999 worden Engelcurves geschat voor de categorieën 'alledaagse goederen', 'wonen', 'recreatie' en 'alcohol en tabak'. Deze vier categorieën vormen 80 procent van de totale bestedingen.

Uit de geschatte Engelcurves volgt dat bewoners van sociale huurwoningen minder uitgeven aan 'wonen' en meer aan 'alledaagse goederen', 'recreatie' en 'alcohol en tabak', maar het verschil is afgenomen over tijd. Deze conclusie volgt ook uit de robuustheidsanalyse. Tenslotte blijkt uit de analyse dat bewoners van sociale huurwoningen, die meer op huiseigenaren lijken wat betreft karakteristieken (zoals leeftijd, gezinssamenstelling, inkomen, etc.), een groter gedeelte van hun budget besteden aan 'recreatie' en minder aan 'wonen' vergeleken met de overige bewoners van sociale huurwoningen. Dit is in overeenstemming met het micro-economisch kader uit hoofdstuk twee. De grootte van het gevonden effect is echter beperkt.

Huurregulering beïnvloedt de verhuismobiliteit

Het micro-economisch kader voorspelt dat het inkomensniveau waarbij bewoners van een sociale huurwoning naar de koopsector verhuizen, toeneemt als het huurvoordeel, het verschil tussen de markthuur en de gereguleerde huur, toeneemt. Deze hypothese wordt getest in hoofdstuk vier door te schatten hoe het huurvoordeel de kans om binnen of uit de sociale huursector te verhuizen beïnvloedt.

Eerder empirisch onderzoek heeft uitgewezen dat het wonen in een sociale huurwoning de verhuismobiliteit vermindert.[6] Er is echter geen onderscheid gemaakt tussen transities binnen en uit de sociale huursector. De verwachting is dat huurregulering beide transities anders beïnvloedt, omdat bewoners hun huurvoordeel verliezen als ze naar een koopwoning verhuizen, maar deze deels behouden (en zelfs kunnen vergroten) als ze verhuizen naar een sociale huurwoning.

De schattingen zijn gebaseerd op een paneldataset gebaseerd op administratieve bestanden die beschikbaar zijn gesteld door het CBS. De data bevatten gegevens over het type en de waarde van de woning. Ook bevatten ze kenmerken van het huishouden, de baan en de lokale woningmarkt. Huurvoordeel wordt gemeten op basis van de mediane huur in een wijk gedeeld door de individuele WOZ-waarde van de woning.

De resultaten laten zien dat het effect van het huurvoordeel op de mobiliteit met name groot is voor transities binnen de sociale huursector, maar dat het effect op transities naar de koopsector beperkt is. In overeenstemming met het micro-economisch kader verhuizen alleen bewoners van een sociale huurwoning met een hoog inkomen minder snel naar de koopsector. Dit geeft aan dat de verstoring van de koopsector door huurregulering beperkt is en dat de negatieve effecten zich concentreren binnen de sociale huursector zelf.

Het type woning heeft geen invloed op het loon

Het gemiddelde loon van huiseigenaren is 25 procent hoger dan dat van bewoners van sociale huurwoningen. Dit verschil in loon kan komen door zelfselectie van werknemers met een laag loon in sociale huurwoningen (zie hoofdstuk twee). Echter, gezien de verminderde mobiliteit van bewoners in een sociale huurwoning (zie hoofdstuk drie), is het mogelijk dat het loonverschil tussen beide groepen werknemers veroorzaakt wordt door het woningtype.[7]

Empirische studies tonen aan dat bewoners van sociale huurwoningen een minder goede arbeidsmarktpositie hebben dan huiseigenaren: ze werken va-

[6] Gyourko en Linneman (1989), Ault et al. (1994); Nagy (1995), Munch en Svarer (2002), Simmons-Mosley en Malpezzi (2006) vinden empirisch bewijs hiervoor gebaseerd op schattingsmethoden zoals OLS, logistische regressies en duurmodellen.

[7] Eigenwoningbezit vermindert ook de mobiliteit van werknemers. Dit kan ook invloed hebben op de baanmobiliteit van en werkloosheid onder huiseigenaren.

ker in de lokale arbeidsmarkt en zijn vaker werkloos. Er zijn echter geen studies die onderzocht hebben of deze negatieve arbeidsmarktpositie doorwerkt in het verdiende loon. In twee studies is onderzoek gedaan naar het loon van huiseigenaren ten opzichte van alle huurders: Munch et al. (2008) gebruiken een panel gebaseerd op administratieve bestanden uit Denemarken en concluderen dat huiseigenaren een vijf procent hoger loon verdienen, ceteris paribus. Daartegenover staat het onderzoek van Coulson en Fisher (2009) gebaseerd op survey data. Zij concluderen dat huiseigenaren in de Verenigde Staten gemiddeld 30 procent minder loon verdienen dan huurders, ceteris paribus. Beide onderzoeken verschillen dus significant in de richting en de orde van grootte van het effect.

In hoofdstuk vijf wordt onderzocht of eigenwoningbezit of het wonen in een sociale huurwoning van invloed is op het loon door deze typen werknemers te vergelijken met werknemers in een private huurwoning. De schattingen zijn gebaseerd op een groot paneldatabestand gebaseerd op administratieve gegevens verzameld over de periode 2006 tot 2008. Omdat meer dan één miljoen werknemers gevolgd worden gedurende drie jaar, is het mogelijk om te corrigeren voor de selectie van werknemers met veel of weinig vaardigheden ('worker skills') in sociale huur- of koopwoningen.

De schattingsresultaten geven aan dat het corrigeren voor de vaardigheden van werknemers uitermate belangrijk is: zonder de correctie voor de vaardigheden van werknemers zou men concluderen dat bewoners van sociale huurwoningen 17 procent minder verdienen dan inwoners van private huurwoningen, doordat ze in een sociale huurwoning wonen. Idem dito zou men concluderen dat huizenbezitters 7 procent meer verdienen dan huurders van private woningen, doordat ze in een koopwoning wonen. Echter, na de correctie voor vaardigheden van de werknemer is er geen bewijs dat het verschil in inkomen tussen huurders in een sociale huurwoning of huiseigenaren (vergeleken met huurders van private huurwoningen) veroorzaakt wordt door het type woning.

Macro-economisch kader

Heterogene werknemers beconcurreren elkaar om dezelfde woningen. Hierdoor hebben veranderingen in de productiviteit van hoog- en laagopgeleide werknemers invloed op de compositie van de beroepsbevolking: Een productiviteitsschok voor hoogopgeleide werknemers zal leiden tot een hogere vraag naar deze werknemers. Gegeven de woningprijs veroorzaakt dit een instroom van hoogopgeleide werknemers. De prijselasticiteit van het woningaanbod bepaalt in hoeverre dit leidt tot veel hogere woningprijzen en een kleine instroom van hoogopgeleide werknemers, of enigszins hogere woningprijzen en een grote instroom.

De verandering in de woningprijzen beïnvloedt ook de locatiekeuze van laagopgeleide werknemers. Een deel van hen zal de regio verlaten, omdat de woonkosten stijgen terwijl hun inkomen niet verandert. Veranderingen in het (opleidingspecifieke) loon en de woningprijs zijn dus van belang voor de compositie van de lokale arbeidsmarkt en er vinden *spillovers* plaats tussen beide typen arbeid via de prijselasticiteit van het woningaanbod.

Dit soort modellen van de arbeids- en woningmarkt is gebaseerd op de premisse dat de arbeidsmarkt en woningmarkt perfect competitief zijn.[8] In hoofdstuk zes analyseren we hoe de beide markten elkaar beïnvloeden als deze gekenmerkt worden door marktimperfecties in de vorm van prijsrigiditeiten.

Prijsrigiditeiten op de arbeidsmarkt worden gemodelleerd in de vorm van nominale loonrigiditeiten die het gevolg zijn van nationale loononderhandelingen. Lokale arbeidsmarkten worden gekenmerkt door imperfecte koppeling van vacatures aan werkzoekenden (*labor market matching*) zoals beschreven in Pissarides (2000). Ik geef in hoofdstuk zes aan dat arbeidsmarktrigiditeiten de mobiliteit van werknemers beperkt als ruimtelijke verschillen in werkloosheid gering zijn, of als het loon niet aangepast wordt na een productiviteitsschok. De verklaring is dat het verhuizen naar een andere regio in deze gevallen geen hoger verwacht loon oplevert.

Prijsrigiditeiten op de arbeidsmarkt worden gemodelleerd in de vorm van het recht om woningen tegen een vaststaand tarief te huren ongeacht de markt-

[8] Zie Roback (1982); Moretti (2011) voor zulke modellen van de arbeids- en woningmarkt.

huur (*rent control housing vouchers*). Ik toon aan dat het effect van deze rechten op de compositie van de arbeidsmarkt (na een toename van de productiviteit van hoogopgeleide werknemers) afhangt van de verdeling ervan over hoog- en laagopgeleide werknemers: Als zij in het bezit zijn van met name laagopgeleide werknemers, leiden ze tot een verminderde instroom van hoogopgeleide werknemers en een verminderde uitstroom van laagopgeleide werknemers. Als zij daarentegen in het bezit zijn van voornamelijk hoogopgeleide werknemers, leiden deze rechten ertoe dat de instroom van hoogopgeleide werknemers en de uitstroom van laagopgeleide werknemers groter is.

De analyse geeft aan dat het effect van rigiditeiten op de arbeids- en woningmarkt afhangt van het opleidingsniveau. In het algemeen versterken rigiditeiten op de arbeids- en woningmarkt elkaar na een toename van de productiviteit van hoogopgeleide werknemers. Echter, prijsrigiditeiten op de arbeidsmarkt verhelpen deels de prijsrigiditeiten op de arbeidsmarkt als de productiviteit van laagopgeleide werknemers verandert.

Sociale woningbouw beïnvloedt het opleidingsniveau van het lokale arbeidsaanbod

Het macro-economisch kader geeft aan dat laagopgeleide werknemers in een sociale huurwoning de stad niet verlaten als huizenprijzen stijgen door een toename van hoogopgeleide werknemers. Daarnaast worden sociale huurwoningen voornamelijk toegewezen aan huishoudens met een laag inkomen. Dit zijn twee redenen om te veronderstellen dat sociale woningbouw in Nederland leidt tot een lager percentage hoogopgeleide werknemers. Daar staat tegenover dat het Nederlandse systeem van het toekennen van sociale huurwoningen aan huishoudens met een laag inkomen (ten tijde van het tekenen van het contract), niet kan verhinderen dat sociale huurwoningen op den duur bewoond worden door werknemers met een hoog inkomen (zoals besproken in hoofdstuk twee). In extremo kan deze zelfselectie van werknemers met een hoog inkomen in sociale huurwoningen er voor zorgen dat er een beperkt of zelfs geen effect is van de sociale woningbouw op het opleidingsniveau van het lokale arbeidsaanbod.

Het is van belang om te weten of sociale woningbouw gevolgen heeft voor de opbouw van de lokale beroepsbevolking, omdat dit de positieve externaliteiten die het gevolg zijn van agglomeratievoordelen teniet kan doen.[9] In hoofdstuk zeven test ik of de sociale woningbouw van invloed is op het percentage hoogopgeleide werknemers in een gebied. Als dit het geval is, toont dit aan dat de sociale woningbouw de lokale arbeidsmarkt beïnvloedt via een voorheen niet bestudeerd kanaal.

De schattingen zijn gebaseerd op een longitudinaal panel van de veertig COROPs in Nederland. De regionale variabelen zijn geconstrueerd op basis van het WBO en WoON in de periode 1981 tot en met 2006. Deze zijn uitgebreid met gegevens over de regionale productiviteit en werkgelegenheid voor acht sectoren over de steekproefperiode.

Uit de schattingen blijkt dat sociale woningbouw een negatief effect heeft op het percentage hoogopgeleiden in een COROP: Een vergroting van de sociale huurwoningvoorraad met tien percentage punten verkleint het percentage hoogopgeleide werknemers in de regio met 1.5 percentage punten, ceteris paribus. Dit effect is even groot als een stijging van de woningprijzen met €8.800. Bij deze schattingen is gecorrigeerd voor het aantal banen in de COROP en omliggende COROPs, en de endogeniteit van het relatieve loon van hoogopgeleide werknemers en de woningprijzen.

De grootte van het effect van sociale woningbouw op de opbouw van de lokale arbeidsmarkt is beperkt. Ter illustratie: Als de sociale huurwoningsector in Utrecht gehalveerd wordt van 40 naar 20 procent, dan stijgt het percentage hoogopgeleiden in Utrecht met (slechts) 3 percentage punten tot 46 procent.

Beperkingen en richtingen voor vervolgonderzoek

In dit proefschrift worden enkele economische effecten van sociale woningbouw behandeld. Ik geef aan dat deze economische effecten subtieler zijn dan het mantra "sociale huur vermindert de mobiliteit (naar de koopsector), hetgeen slecht is voor de arbeidsmarkpositie" doet vermoeden. In mijn proef-

[9] Zo toont Moretti (2004) aan dat de concentratie van hoogopgeleide werknemers in stedelijke gebieden zorgt voor hogere lonen voor zowel hoog- als laagopgeleide werknemers.

schrift wordt immers aangetoond dat met name transities binnen de huursector gereduceerd worden, terwijl transities van huur naar koop amper beïnvloed worden. Deze bevindingen vragen om dynamische, theoretische modellen van het verhuisgedrag van werknemers die de transities binnen en uit de sociale huursector kunnen verklaren.

In mijn proefschrift wordt geen bewijs gevonden dat bewoners van sociale huurwoningen een lager loon verdienen, ceteris paribus. Dit is opmerkelijk, omdat bewoners van sociale huurwoningen minder mobiel zijn op de woningmarkt en vaker werkzaam zijn in de lokale arbeidsmarkt (ceteris paribus), hetgeen hun positie op de arbeidsmarkt zou moeten verzwakken. Onderzoek naar de relatie tussen woningtype en positie op de arbeidsmarkt heeft zich voornamelijk gericht op de rol van eigenwoningbezit (Van Ewijk en Van Leuvensteijn, 2009). Een interessante uitzondering zijn De Graaf et al. (2009). Zij concluderen dat in Nederland bewoners van sociale huurwoningen geen slechtere arbeidsmarktpositie hebben dan bewoners van private huurwoningen, ceteris paribus. Het is vooralsnog onduidelijk hoe het mogelijk is dat bewoners van sociale huurwoningen wel minder mobiel zijn en vaker in de lokale woningmarkt werken, zonder dat dit nadelige gevolgen heeft voor hun loon of mobiliteit binnen de arbeidsmarkt.

Ook wordt in dit proefschrift aangegeven dat de allocatie van sociale huurwoningen welvaartseffecten met zich meedraagt. Zo wordt in hoofdstuk twee aangetoond dat de bijdrage aan het totale welvaartsverlies van sociale woningbouw groter is voor huishoudens met een hoog inkomen dan voor huishoudens met een laag inkomen. Dit impliceert dat een strengere toedeling van sociale huurwoningen aan (alleen) huishoudens met een laag inkomen leidt tot minder welvaartsverlies op de woningmarkt.[10] Echter, het strenger toekennen van sociale huurwoningen aan huishoudens met een laag inkomen leidt tot een kunstmatige reductie van het percentage hoogopgeleiden, en vergroot daarmee de verstoring van huurregulering op de lokale arbeidsmarkt. Toekomstig onderzoek zou zich kunnen richten op het analyseren en kwantificeren van deze uitruil van efficiëntie op de arbeidsmarkt en de woningmarkt.

[10] Het toekenningsbeleid is aangescherpt sinds de Europese Commissie gebiedt dat 90 procent van alle vrijgekomen sociale huurwoningen toegekend wordt aan huishoudens met een inkomen lager dan €34.678 (prijspeil 2014). De EC doet dit om staatssteun tegen te gaan.

De theoretische modellen in dit proefschrift modelleren het gedrag van huurders van sociale huurwoningen en huurders van private huurwoningen. Dit gebeurt, omdat het modelleren van eigenwoningbezit (en de daarmee samenhangende gevolgen voor het vermogen in de toekomst) een dynamisch en dus ingewikkelder model vereist. Hoewel het nuttig is om theoretische modellen simpel te houden, zouden toekomstige modellen van de interactie tussen de arbeidsmarkt en de woningmarkt zich kunnen richten op de gevolgen van het bezit van de woning voor het gedrag van huiseigenaren.

Er zijn verschillende aspecten van de Nederlandse woningmarkt die in dit proefschrift wellicht onvoldoende aan het licht gekomen zijn. In het proefschrift wordt verklaard waarom, met name in de Randstad, werknemers met een hoog inkomen in sociale huurwoningen wonen. Dit verklaard waarom werknemers met een hoog inkomen meer profiteren van huurregulering dan werknemers met een laag inkomen. De gevolgen die dit heeft voor de herverdelende functie van de sociale woningbouw komen echter niet expliciet aan bod.

Ook richt ik mij in dit proefschrift niet op de gevolgen van de individuele huurtoeslag voor de vraag naar woningen. Koning en Ridder (1997) concluderen dat de (toen nog) individuele huursubsidie de vraag naar woningdiensten vergrootte. Gegeven de grootte van het programma (zowel in het aantal toegekende subsidies als het totale subsidiebedrag) is het interessant om na te gaan of de huidige individuele huurtoeslag de vraag naar woningdiensten beïnvloedt en of het gevolgen heeft voor het loon (armoedeval), de zelfselectie van huurders in sociale huurwoningen en de mobiliteit van huishoudens.

Voor al het empirisch onderzoek geldt dat de kracht van de resultaten afhankelijk is van de kwaliteit van de data. Dat geldt ook voor dit proefschrift. De analyse in dit proefschrift kan in de toekomst uitgebreid worden door de analyse op een gedetailleerder niveau uit te voeren. Zo maakt de analyse van het consumptiegedrag gebruik van gecombineerde cross-sectionele gegevensbestanden over een periode van twintig jaar en van een nationale woningprijsindex. Met panel data zou gecorrigeerd kunnen worden voor niet waargenomen 'zachte' kenmerken van de werknemer (zoals preferenties en vaardigheden)

en hoe die de selectie in een huur- of koopwoning beïnvloeden. Hoofdstuk drie probeert dit te ondervangen door middel van *propensity score matching*. Dit biedt echter minder zekerheid dan paneldata (en is een minder efficiënte techniek). Met behulp van lokale woningprijsindices zou het effect van woningprijzen op vermogen nauwkeuriger geïdentificeerd kunnen worden.

In de hoofdstukken vier en vijf wordt gebruik gemaakt van panel data op basis van administratieve gegevens die verzameld zijn over de periode 2006 tot en met 2008. Het zou interessant zijn om de gegevens van het panel over een langere periode te meten. Dit komt de analyse ten goede, omdat er meer observaties per individu zijn. Ook wordt het dan mogelijk om het effect van de woningmarktcrisis te analyseren. Gedurende de crisis zijn de prijzen op de woningmarkt voortdurend gedaald. Dit kan van invloed zijn op de transities binnen en uit de sociale huursector, zeker wanneer sociale huurwoningen beschouwd worden als een 'veilige haven' waar men beschermd is tegen prijsschommelingen op de koopmarkt.

In hoofdstuk zeven wordt het effect van sociale woningbouw op de opbouw van de lokale beroepsbevolking bestudeerd op COROP-niveau. Een lagere geografische schaal zou een nauwkeurigere analyse opleveren, omdat COROP-gebieden vanwege hun grootte aggregatienadelen ondervinden. Daar staat tegenover dat een analyse op een lager aggregatieniveau vermoedelijk meer problemen kent door de ruimtelijke afhankelijkheid van de data (bijvoorbeeld door pendel), maar hier kan voor gecorrigeerd worden door middel van ruimtelijke econometrische technieken.

Beleidsimplicaties

In het proefschrift is aangetoond dat sociale woningbouw verschillende economische effecten heeft die van belang zijn bij het ontwikkelen van beleid. Zo is laten zien dat sociale woningbouw de consumptie en geografische mobiliteit van huishoudens beïnvloedt zonder dat het gevolgen heeft voor het loon dat verdiend wordt. Ook verlaagt het percentage sociale huurwoningen in een regio het percentage hoogopgeleide werknemers, al is de grootte van het effect beperkt.

Het doel van de sociale woningbouw is om betaalbare woningen aan te bieden aan (voornamelijk) huishoudens met een laag inkomen. Ik heb laten zien waarom het toekennen van sociale huurwoningen op basis van inkomen bij het aangaan van het huurcontract niet kan voorkomen dat sociale huurwoningen bewoond worden door huishoudens met een hoog inkomen. Dit heeft tot gevolg dat er relatief minder huishoudens met een laag inkomen in sociale huurwoningen wonen juist als de woningprijzen hoog zijn. Dit gaat tegen het doel van sociale woningbouw in. Vanuit rechtvaardigheidsoverwegingen is additioneel beleid daarom gewenst.

Deze conclusie wordt ook getrokken als sociale woningbouw vanuit het perspectief van efficiëntie op de woningmarkt bekeken wordt. In het proefschrift wordt aangetoond dat de bijdrage van huishoudens met een hoog inkomen aan het welvaartsverlies van sociale woningbouw groter is dan dat van huishoudens met een laag inkomen. Het herverdelen van sociale huurwoningen van rijke inkomens naar lage inkomens verkleint daarom het welvaartsverlies dat optreedt op de woningmarkt, met name als dit gebeurt waar woningprijzen hoog zijn.[11] De meeste bewoners van sociale huurwoningen met een hoog inkomen wonen op die plekken waar woningprijzen het hoogst zijn. Er zullen dan dus meer sociale huurwoningen beschikbaar komen voor huishoudens met een laag inkomen, in die buurten waar de transities binnen de sociale huursector het laagst zijn en het betreden van de sociale huursector het moeilijkst is.

Dus het herverdelen van sociale huurwoningen van huishoudens met een hoog naar huishoudens met een laag inkomen kan gezien worden als rechtvaardig en verkleint bovendien het welvaartsverlies op de woningmarkt. De Nederlandse regering heeft verschillende maatregelen genomen om het bewonen van sociale huurwoningen door huishoudens met een hoog inkomen tegen te gaan.[12] Volgens het theoretisch kader in hoofdstuk twee verminderen deze maatregelen waarschijnlijk het aandeel huishoudens met een hoog inko-

[11] Door het herverdelen van sociale huurwoningen van huishoudens met een hoog naar huishoudens met een laag inkomen kan het welvaartsverlies nooit elimineren. Dit kan alleen als sociale woningbouw afgeschaft wordt. De winnaars van deze maatregelen kunnen de verliezers compenseren. Echter, zo'n ingreep is politiek waarschijnlijk niet haalbaar.

[12] Per 1 juli 2011 is de maximum toegestane huur in de zogeheten schaarstegebieden verhoogt. Per 1 juli 2013 zijn de huren in de sociale huursector inkomensafhankelijk. De huur mag verhoogd worden met de inflatie plus 2,5, 3,5 en 4 procent voor huurders met een laag, midden- of hoog inkomen. Huishoudens met een middeninkomen verdienen tussen de €33,614 en €43,000. Ten-

men dat in een sociale huurwoning woont. Echter, zolang de gereguleerde huur lager is dan de markthuur en inkomenseisen alleen bij het betreden van de sociale huurwoning gesteld worden, zullen er altijd relatief minder huishoudens met een laag inkomen in een sociale huurwoning wonen in gebieden waar de woningprijs hoog is.

Men dient zich er echter bewust van te zijn dat het strenger toekennen van sociale huurwoningen aan huishoudens met een laag inkomen de verstoring van de lokale arbeidsmarkt door sociale woningbouw vergroot doordat het aandeel hoogopgeleide werknemers hierdoor verkleind wordt. Deze 'uitruil van efficiëntie' is een belangrijk mechanisme waarvan beleidsmakers zich bewust moeten zijn als zij beleid maken met betrekking tot de sociale woningbouw.

De uitruil van efficiëntie impliceert dat beleid dat ervoor zorgt dat meer sociale huurwoningen bewoond worden door huishoudens met een laag inkomen gepaard dient te gaan met een verkleining van de sociale huurwoningvoorraad: Het strenger toekennen van sociale huurwoningen aan huishoudens met een laag inkomen verkleint het welvaartsverlies op de woningmarkt, terwijl het verkleinen van de sociale woningvoorraad de verstoring op de arbeidsmarkt vermindert. Als dat laatste niet gebeurt en de grootte van de sociale woningvoorraad intact blijft, dan volgt uit de uitruil van efficiëntie dat de verstoring op de arbeidsmarkt vergroot wordt. Ik wil benadrukken dat door de huidige slechte toedeling van sociale huurwoningen aan huishoudens met een laag inkomen, deze huishoudens niet noodzakelijkerwijs slechter af zijn als men de sociale huurwoningvoorraad verkleint en tegelijkertijd de toekenning aan lage inkomens verbetert. In dit geval kan een efficiëntere woniningmarkt gerealiseerd worden, zonder dat de mensen, voor wie sociale woningbouw bedoeld is, benadeeld worden.

slotte streeft de regering er naar om per 1 juli 2014 de huur van sociale huurwoningen afhankelijk te maken van de WOZ-waarde van de woning, zie BZK (2013).

Curriculum Vitae

Mark Kattenberg obtained his master degree in economics at the Free University in Amsterdam in 2008 (cum laude) and his research master degree in Multidisciplinary Economics at Utrecht University in 2010. In September of that year he started his PhD at the chair of Applied Econometrics of Utrecht *University* School of Economics, the project being cofinanced by the Netherlands Ministry of the Interior and Kingdom Relations.

Mark Kattenberg's research interests are in applied econometrics and policy evaluation. As of January 2014 he is employed by the CPB Netherlands Bureau for Economic Policy Analysis in The Hague.

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