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Homeownership, unemployment and commuting distances

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Preliminary and incomplete

Abstract
According to Oswald's thesis homeownership complicates finding a job after becoming unemployed and will therefore tend to increase unemployment rates. Empirical research on micro data has confirmed that unemployed homeowners are more reluctant than renters in accepting jobs outside their region of residence, but not the apparently trivial corollary that it takes more time for homeowners to find a new job after becoming unemployed. In particular, empirical research has repeatedly found that unemployed homeowners are better able to find a job without moving house than renters. Possible explanations are that homeowners have lower reservation wages for local jobs or search more intensively on the local labor market. However, an alternative possibility is that homeowners accept longer commutes (without changing their residential location) than renters because of their higher mobility costs. In this paper we consider this possibility in detail. At the theoretical level we show that such behavior is predicted by a model of spatial job search. At the empirical level we analyze the validity of this prediction on the basis of Dutch microdata that allow us to compare wage and commuting distances of renters and owners before and after unemployment spells.

1. Introduction

Although owner-occupied housing is generally regarded as the preferred tenure type by policy makers – who stimulate it through mortgage interest deductibility, tax exemption of capital gains, and other measures – there have also been more critical voices. Among economists, the most prominent of these is probably Oswald (1996, 1999). His thesis states that there is a causal relationship between dwelling tenure choice and high unemployment. He finds that a 10 per cent increase in the rate of homeownership is associated with 2 per cent more unemployment. If this would indeed signal a causal effect, then the increase in homeownership in many European countries in the second half of the twentieth century would be an important reason behind the increase in structural unemployment. Oswald suggested that the higher transaction costs associated with moving house are the reason why exit rates from unemployment are much lower among owner-occupiers than among tenants, or at least of tenants in the private (unregulated) part of the housing market.

Oswald's thesis appears controversial in that it contradicts much of the common sense about homeowners. In most, if not all countries, homeownership increases with income, and workers with high incomes have in general more human capital and a lower risk of becoming unemployed. Moreover, credit constraints make it difficult for those without a tenured position and a non-negligible amount of wealth to borrow the money needed to purchase a decent house. Unemployed persons are unlikely to meet that requirement. However, none of this contradicts the possibility that the probability of finding a new job can be substantially lower for homeowners than for tenants who become unemployed, and that there are substantial lock-in effects associated with homeownership. Indeed, the hypothesis that the higher costs of moving for homeowners hamper residential mobility for job reasons seems *a priori* quite plausible, and the negative effect on unemployment appears to be a natural consequence. Oswald's thesis therefore directed attention towards a neglected and potentially important effect of an increase in homeownership that makes it worthwhile to be tested empirically.

It is therefore no surprise that Oswald's (1996, 1997) papers quickly triggered additional research, for instance, Pehkonen (1997) and Partridge and Rickman (1997). In their contribution to the *Handbook of Labour Economics*, Nickel and Layard (1999) considered the correlation between unemployment and the share of homeownership for

OECD countries.[1] In their regression analyses, controlling for other variables, they find a significant coefficient for the share of homeownership on the total unemployment rate and short-term unemployment, but not on long-term unemployment. They also find a significant coefficient for the share of homeownership on the employment to population ratio of the whole working age population and working age males, but not on working age women. The authors express some doubt as to whether these relationships are due to the mobility barrier effect proposed by Oswald, since they find no correlation between the share of homeownership and regional mobility in OECD countries.

Later studies are even less favourable to Oswald's thesis. For instance, Green and Hendershott (2001), who reconsidered Oswald's evidence for the US, find that homeownership hardly restricts the mobility of heads of households. They argue that household heads have no other choice than to move to a better region when the local labour market situation deteriorates, thus implying that, for this group, the thesis is invalid. However, when their partners become unemployed, staying in the region and hoping for better times may be preferred. A second example is Barrios García and Rodríguez Hernández (2004) who take a closer look at Spain and reach a conclusion that is the complete opposite of Oswald's earlier findings: 'Spanish provinces with ownership rates that are 10 percentage points higher have an unemployment rate that is roughly 2.2 percentage points lower.'[2] More recent studies, some of them discussed in the next section, have tested Oswald's thesis on micro-data. Sometimes these analyses confirm Oswald's thesis for small groups of owner-occupiers, but the typical result is that no evidence in favour of the thesis can be found for the majority of the workers. Repeatedly, studies have reported the opposite of Oswald's thesis: unemployment durations of homeowners that are shorter than those of tenants.

This state of affairs is puzzling. On the one hand, there is strong empirical evidence that the geographical mobility of homeowners is substantially below that of tenants. Although the conclusion that homeowners will therefore experience more difficulties in finding a job when unemployed appears to be a straightforward consequence of this finding, empirically this is not the case. The paradox is resolved by the repeated finding that homeowners more often accept a job on the local labour market than tenants. However, this evokes the question what explains this difference in behaviour. Existing analyses are not always clear on what the local labour market exactly is and sometimes define a local job as one that is not associated with a change in the residential location. This comes very close to a simple restatement of the

[1] See also Nickell (1997, 1998).
[2] Barrios Garcia end Rodriguez Hernandez (2004), p. 573.

finding that the lower residential mobility of homeowners does not hamper their ability to find a job. What one would like to know is how they manage to achieve this. There are several possibilities. Conventional job search models suggest that the homeowners have lower reservation wages after they become unemployed and therefore accept job offers that would be refused by tenants that are otherwise similar. Another, related possibility is that they search more intensively on the local labour market than tenants do. Because they spent more time and effort on local job search, they receive more often acceptable job offers close to their current residential location than tenants. A third possibility that is central to this paper is that homeowners are willing to accept longer commutes. Stated differently: for homeowners the local labour market may be larger than for tenants. Owners are willing to accept jobs located at a substantial distance from their residential location that would be refused by tenants, or would induce tenants to move towards the location of the job when accepting.

This spatial dimension of job search seems to have been overlooked thus far in the literature associated with Oswald's thesis. However, in the literature on commuting it has been found repeatedly that homeowners usually have longer commutes than renters, even after controlling for other variables. As far as we know, this phenomenon has not attracted much attention from researchers. In this paper we investigate the relationship between this empirical regularity and the higher moving costs of owners.

The paper is organized as follows. In the next section we review empirical studies that investigate the validity of Oswald's thesis on micro-data. In Section 3 we propose a search model that is consistent with much of the evidence provided by these studies and discuss several features of the model. Section 4 provides empirical evidence on out-of-pocket housing expenditure of homeowners versus tenants in the Netherlands. Section 5 concludes.

2. Evidence on the Housing Tenure – Unemployment Relationship

Studies using micro-data demonstrate that unemployed persons are more reluctant to accept jobs at a greater distance from their current locations (see, for instance, Van den Berg and Gorter, 1996) and that this is particularly the case when they are owner-occupiers (see Van den Berg and Van Vuuren, 1998). Even though this provides strong *a priori* endorsement of Oswald's thesis, conclusions should not be drawn too fast. Studies focusing on unemployment durations of homeowners and tenants have repeatedly found results that contradict Oswald's thesis.

The importance of the distinction between local and non-local job search for explaining this unexpected results was highlighted by Munch et al. (2005), using Danish micro-data. Their findings confirm that homeownership hampers the propensity to move residence for job reasons. Acceptance of a job outside the local labour market requires a change in the residential location, and homeowners are less likely to do so because of their higher moving costs. However, the data show that homeowners have better chances of finding a job on the local labour market when becoming unemployed, and this counteracts the negative effect of immobility on the housing market. The net result of the two effects is a negative correlation between home-ownership and unemployment duration. Again, the implication is that the group with the lowest residential mobility has the shortest unemployment duration. These findings have recently been confirmed for the Netherlands by Van Vuuren (2007).

The authors of the studies just mentioned have attempted to control for unobserved heterogeneity among workers that causes correlation between homeownership and the chance to find a new job when becoming unemployed. For instance, it is plausible that workers who have a good labour market position for reasons that cannot be observed by the researcher are more inclined to buy a house, knowing that they have better chances than others to find employment in the local labour market in the unfortunate case of becoming unemployed. The typical finding is, however, that a strong effect of homeownership on unemployment duration still remains after controlling for these effects. This suggests strongly that the intensive search efforts of the unemployed homeowners are the major determinant of their lower unemployment rate.[3] These search efforts are modelled as a willingness to accept jobs at lower wages.

These micro studies reject the Oswald thesis for some or all of the groups of workers they consider. In spite of their lower mobility on the housing market, most homeowners have better chances to escape from a situation of unemployment than tenants. The empirical evidence for the reverse of the Oswald effect calls for an explanation in terms of worker behaviour. However, the formulation of a theoretical underpinning of Oswald's thesis seems to have received little attention. Although the logic behind Oswald's thesis is straightforward and does not need a theoretical model to be understood, such a model may also be useful to provide clues about the possibility for the thesis to fail. Munch et al. (2006) develop a search

[3] A working paper by Brunet and Lesueur (2003) confirms this. They estimate a duration model and find that homeowners have lower exit rates from unemployment when controls for search intensity are included. The coefficients for the indicators of search intensity are highly significant.

theoretic model and show that it implies that homeowners have a reservation wage for local job offers that lies above that for tenants, whereas their reservation wage for non-local job offers is higher than that for tenants. However, Van Vuuren (2008) shows that in their model the hazard rate to leave unemployment for homeowners is always lower than that for tenants.[4] This implies that the search model developed by Munch et al. (2006) explains Oswald's thesis, but not the shorter unemployment durations of homeowners observed by these researchers.

Van Vuuren (2008) develops a model that differs from that of Munch et al. (2006) in that he assumes that homeowners receive an unemployment benefit for a limited period, whereas tenants do not exhaust the benefit. This introduces nonstationarity into the model, which makes it more difficult to handle. He also extends the model to include the decision to own a home. But this is not an unqualified success because, counterintuitively, his model predicts that if homeowners can have unemployment benefit for an indefinite period,[5] a higher arrival rate of job offers (which means: better employment opportunities) makes it less likely that a worker will become a homeowner. Since, in this case, the difference between Van Vuuren's model and that of Munch et al. is eliminated, this result probably also holds for the latter model. However, Van Vuuren shows that, with unemployment benefit exhaustion, this unexpected result disappears when the unemployment benefit is sufficiently high.

3. A general search model for labour market and tenure choice interactions

3.1 Job search

To analyze the impact of housing tenure on unemployment outcomes, we develop a model a job search in a spatial labor market setting.

We start with a version in which the housing market is not yet made explicit. Consider an unemployed job seeker with an instantaneous utility function $u = u(y)$, where y denotes current income. As long as this person is unemployed, income is equal to the unemployment benefit b. The searcher receives job offers at a constant arrival rate λ_l. The labor market is spatial, and jobs are characterized by a wage w and a commuting distance r. Commuting cost

[4] See their proposition 4, p. 22. The proof requires log-concavity of the wage offer distribution.
[5] In reality unemployed workers are not in this situation, but in a stationary search model they are.

are proportional to distance and the instantaneous utility associated with being employed with wage w and commute r is $u(w-tr)$, with t the full commuting cost per unit of distance.
Job offers are random draws from a simultaneous density function $f_l(w,r)$. The support of this density function is denotes as B_l. The job seeker knows the distribution and takes this knowledge into account when deciding about acceptance or refusal of job offers. The search strategy can be described by an acceptance set A_l. All combinations of wages and commutes that belong to this set are job offers that will be accepted by the searcher. In general, the job seeker will not accept all job offers and we denote the set of acceptable offers as $A_l \subseteq B_l$. When the job seeker refuses an offer, search continues. When he accepts, search stops and he will be employed in the job indefinitely.
The job seeker wants to maximize lifetime utility: the expected present value of all future utilities. We denote lifetime utility of a job seeker as U. The value of U is determined by the instantaneous utility of being unemployed $u(w-tr)$, and by the possibility of switching to employment by accepting a job. The lifetime utility associated with employment depends on the wage and commute of the job and will be denoted as $V(w,r)$. The relationship between the lifetime utilities associated with unemployment and employment follows from the asset evaluation or Bellman equation associated with this search process:

$$\rho U = u(b) + \lambda_l \int \int_{(w,r)\in A_l} (V(w,r) - U)\, f_l(w,r)\, dwdr. \qquad (1)$$

The searcher determines the acceptance set A_l in such a way that the value of U is maximized. If the acceptable set is determined optimally, the first job offer that implies a higher lifetime utility V than the 'reservation utility' U will be accepted. The acceptable set A_l thus consists of all job offers for which:

$$V(w,r) \geq U. \qquad (2)$$

Except in very special cases, a closed form solution for U is unavailable.

In the absence of mobility on the housing market, the lifetime utility of having a job is equal to:

$$V^i(w-tr) = \frac{u(w-tr)}{\rho}, \qquad (3)$$

where the superfix i indicates that the household is immobile. The reservation utility rule thus states that the first job offer whose instantaneous utility exceeds ρV_u should be accepted. It is not difficult to verify that this implies that for a given wage w there is a maximum acceptable commute $r^{max}(w)$ that is determined implicitly by:

$$u\left(w - tr^{max}(x)\right) = \rho V_u. \quad (4)$$

This maximum acceptable commute is increasing in the wage *w*, implying that the searcher is willing to accept longer commutes when the wage compensates for the commuting cost. Indeed, the set of acceptable wages can be characterized by the inequality:

$$r \leq (w - w^*)/t, \quad (5)$$

where $w^*$is the wage that would be just acceptable if the implied commute equals zero[6] (see Rouwendal, 1999).

3.2 Residential location search

To consider what changes in the model when acceptance of a job is followed by mobility on the housing market, we assume that housing market search can be described in the same way as labor market search. That is, house offers arrive at a constant rate λ_h and are random draws from a known distribution of commutes that has density $g_h(r)$. This distribution is determined by the spatial distribution of housing opportunities around the work location. As with search on the labor market, we assume that search continues until a house is accepted. The worker will then stay in the house indefinitely. We take into account that mobility is costly by subtracting annualized moving cost *c* from the income-net-of-commuting cost *w-tr* of a worker who has moved to a different residential location.

The lifetime utility $V(w,r)$ refers to the situation in which a searcher has just accepted a job, but has not yet accepted another house. The expected lifetime utility of a worker who has accepted another house is denoted by the symbol *W*:

$$W(w - tr - c) = \frac{u(w-tr-c)}{\rho}. \quad (6)$$

We can now state the Bellman equation for housing market search:

$$\rho V(w,r) = u(w - tr) + \lambda_h \int_{r' \in A_h} (W(w - tr' - c) - V(w,r) g_h(r') dr'. \quad (7)$$

In the equation A_h denotes the acceptable set of house offers. We can rewrite this equation as:

$$V(w,r) = \frac{u(w-tr) + \lambda\theta E(W | r' \in A_h)}{\rho + \lambda\theta}, \quad (8)$$

with θ the probability that a house offer will be accepted: $\theta = \int_{r' \in A_h} g_h(r') dr'$. The set of acceptable house offers is therefore a set of acceptable commutes, and it is easy to verify that it consists of all commutes that are shorter than a critical value, say r^{res}. We will refer to this critical value as the reservation commute.

[6] The value of w* is determined implicitly by the equation $\rho V_u = u(w^*)$.

Search will be useless if the acceptable set is empty. This will only happen if there is no possibility that a house offer will be received that implies a higher lifetime utility than that associated with being immobile. Whenever such a possibility exists, the searcher will benefit from search, although it may take a long time before an acceptable offer arrives.

This means that the job searcher will engage in housing market search after accepting a job with wage w and commute r from his present residential location whenever there is a possibility of being offer a commute r^* that satisfies:

$$u(w - tr) \leq u(w - tr^* - c). \quad (9)$$

This inequality can be rewritten as: $c \leq t(r - r^*)$. Stated differently: it there is a possibility to increase instantaneous utility by moving to another house, the searcher will do so. When the equality sign is relevant, we have: $r^* = r - c/t$. The reservation commute will be at most equal to this value:

$$r^{res} \leq r - c/t. \quad (10)$$

The effect of housing market search on the value of accepting a job is illustrated in Figure 1. The fat line in this picture gives the lifetime utility of accepting a job with wage w as a function of the associated commuting distance. The dashed vertical line gives the commuting distance c/t. When the actual commute is smaller than this value, there is no possibility of ever receiving an offer that brings the worker in a better position. In the figure it is assumed that this is indeed the case whenever the actual; commute is longer than this value. The solid line $W(w, r)$ then gives the expected lifetime utility of the job.

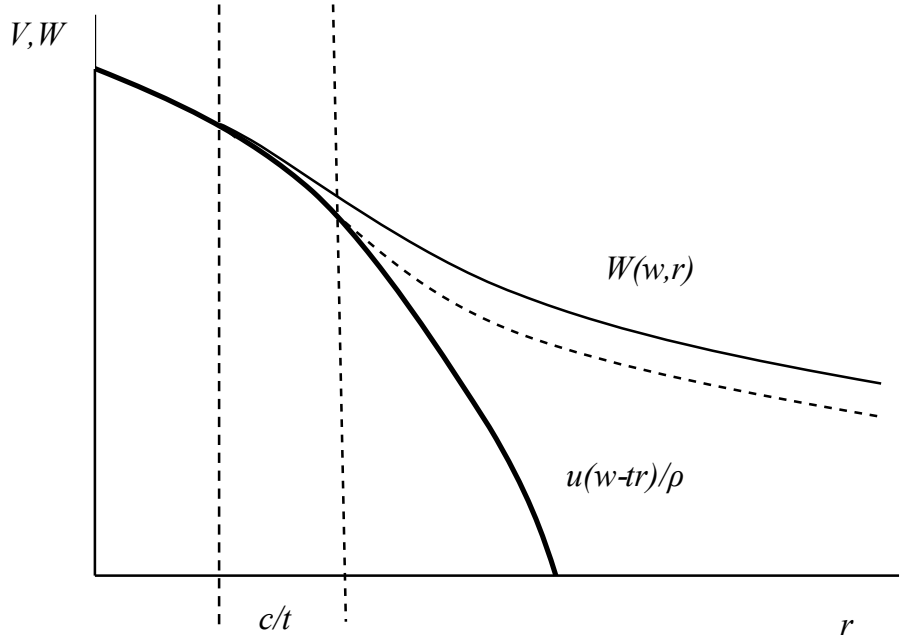

Figure 1 Housing market search and the value of a job.

The discussion given thus far makes it clear that the opportunity to engage in housing market search after accepting a job will never make a searcher worse off. Indeed, we have seen that:

$$V^i(w,r) \leq V(w,r), \quad (11)$$

for all jobs that can be offered.

Let us now consider the effect of higher moving cost on the search strategy. An increase in c implies a lower value of the expected lifetime utility $W(w-tr'-c) = u(w-tr'-c)/\rho$ for any job that can be offered. This means that the right-hand-side of (**) gets smaller for all jobs for which housing market search is attractive. For these jobs, the value of $V(w,r)$ will decrease. The increase in moving cost also means that *c/r* will increase and the set of jobs for which housing market search is not attractive will therefore increase. The dotted lines in Figure 1 show a new situation that may appear.

It is intuitive to think of jobs that do not necessitate a change in the residential location after being accepted as belonging to the local labor market, and to the others as belonging to the non-local labor market. The analysis just given shows that the size of the local labor market depends on the costs associated with a change in residential location. If these costs are small because it is often beneficial to shorten commutes by looking for another house. The local labor market is therefore also small. If the costs of residential mobility are large, the local, changing the residential location will often not benefit the worker, even if the commute is fairly long. The local labor market will therefore be larger in such cases.

3.3 Special cases

3.3.1 A perfect housing market

It is worthwhile to consider a few special cases. In what follows we specify u as the identity function: $u(y) = y$ and investigate some special cases. The first one refers to a situation in which the housing market is perfect in the sense that demand and supply can match (almost) immediately. This situation is approached when the arrival rate of house offers $\lambda_h \to \infty$. In this situation searches can afford to become very fastidious and accept only house offers that provide them the best possible alternative. In the present model this is a commute equal to 0.

This means that the lifetime utility $V(w,r)$ will be equal to $V^i(w,r) = u(w-tr)/\rho$ for all jobs with a commute less than c/t and to $u(w-c)/\rho$ for all other jobs. The line referring to $W(w,r)$ in Figure 1 would become flat. The opportunity to engage in housing market search therefore provides a floor to the value of accepting any offered job: the commute can always be reduced to the minimum value of 0 by searching for a different location. When the arrival rate of house offers is small, this feature of the model is not so clear, because the period of search –when the commute can be very lengthy– affects the overall lifetime utility. However, this feature of the model becomes less relevant when it is realized that very lengthy commutes can in reality always be mitigated by temporary housing (for instance, renting a room). It may therefore be argued that the model with (literally) a perfect housing market, may be regarded as a reasonable approximation to a situation in which the housing market is not really perfect. This model is a bit easier to handle than the more general one we discussed above.

The Bellman equation (1) can now be written as:

$$\rho U = b + \lambda_l \int\int \left(max\left(V^i(w,r), V^m(w,r), U\right) - U\right) f(w,r) dw\, dr. \quad (12)$$

The term ρV^U can be considered as the expected return for unemployment and in the theoretical sections hereafter it is extensively used. By plugging in the relevant employment asset values from equations **Error! Reference source not found.** and **Error! Reference source not found.** the equation becomes

$$\rho U = b + \lambda_l \int\int \left(max\left(\frac{w-r}{\rho}, \frac{wcr}{\rho}, U\right) - U\right) f(w,r) dw\, dr. \quad (13)$$

The *max* expression represents the best choice for the individual for any offered job (accept and stay, accept and move or remain unemployed). Note, however, that for jobs with commuting costs between 0 and c, the net wage with commuting $w-D$ is always higher than the net wage after relocating $w-c$. Essentially, workers would never relocate when commuting is cheaper and would never commute to work when relocation is cheaper. Therefore, equation **Error! Reference source not found.** can be written as

$$\rho U = b + \lambda_l \int_0^c \int_0^\infty max\left(\frac{w-r}{\rho}, U\right) f(w,r)\, dw dr +$$

$$\lambda_l \int_c^\infty \int_0^\infty max\left(\frac{w-c}{\rho}, U\right) f(w,r) dw dr. \quad (14)$$

Denote the reservation net wage as ω^*. It can be defined as the minimum wage of an acceptable job with commuting cost r=0. The asset value of such a job is $W(\omega^*,0) = \omega^*/\rho$. For the wage to be just high enough for the job to be accepted, $W(\omega^*,0)$ should be equal to

the asset value of unemployment *U*, which implies $\omega^* = \rho U$. Hence, in the range $0 \leq r \leq c$ of the first term in the square brackets, it holds that $\frac{w-r}{\rho} - U \geq 0$ only if $w \geq \omega^* + r$. Similarly, in the range $r \geq c$ of the second term in the square brackets, it holds that $\frac{w-c}{\rho} - U \geq 0$ when $w \geq \omega^* + c$. Rewriting equation (14), the asset value of unemployment can finally be derived from

$$\rho U = b + \lambda_l \left[\int_0^c \int_0^\infty \left(\frac{w-r}{\rho} - U \right) f(w,r) dw dr + \int_c^\infty \int_0^\infty \left(\frac{w-c}{\rho} - U \right) f(w,r) dw dr \right]. \qquad (15)$$

2 A Model without Commuting

It is interesting to examine whether and how the general model developed above relates to other models present in the literature. More specifically, it will now be shown that the two-region search model by Munch et al. (2006) can be regarded as nested in the general model. To do so, we consider the situation in which jobs are either local and imply a negligible commute (r=0) or non-local, in which case a residential move is necessary. We maintain the assumption of a perfect housing market. We can formalize the assumption just stated as implying:

$$f_l(w,r) = \begin{cases} f_{loc}(w|r=0) \text{with probability } \pi \\ f_{nat}(w|r > \hat{r}) \text{ with probability } (1-\pi) \end{cases}$$

The authors concentrate on the comparison between owners – who have large costs of mobility - and renters – who have lower costs of mobility.

In its essence, their model assumes moving costs for homeowners c_o, whereas renters do not incur costs when changing residence $c_r = 0$. They define an arrival rate for offers of *local jobs*, which in the context of the general model would be defined as jobs whose commuting costs are zero, and an arrival rate of *national jobs*, which in what follows would be defined as jobs that involve relocation due to their commuting costs being at least as high as the moving costs. Jobs that are close enough for commuting are not offered. Their model entails that the reservation wage for local jobs of homeowners is lower than the reservation wage of renters for all jobs, which is lower than the reservation wage of homeowners for national jobs. This eventually implies that homeowners perform better than renters in finding local jobs and worse in finding national jobs.

Let c denote the moving costs for homeowners. The chance of receiving a local job offer ($D=0$) is α_l and of receiving a national job offer $(D=c)$ is α_n (note that $\alpha_l+\alpha_n=\lambda$). Conditional on an arrival of a job offer, the distribution of commuting costs of the job offer is defined by $P(D=0)=\frac{\alpha_l}{\lambda}, P(D=c)=\frac{\alpha_n}{\lambda}$. w is distributed independently of D and its distribution is denoted $F(w)$, where $dF(w)=f(w)dw$. ω^* denotes the renters' reservation wage (both gross or net, since commuting and moving costs are zero).

The unemployment asset value equation **Error! Reference source not found.** for renters becomes the same as equation (2) in Munch et al. (2006) [7]:

$$\rho V^U = b+(\alpha_l+\alpha_n)\int_{\omega^*}^{\infty}\left(\frac{w}{\rho}-V^U\right)dF(w)$$

Let ω_l^* denote the reservation wage for homeowners for jobs in the vicinity of home. Homeowners will also accept jobs that require moving if the wage offered is at least $\omega_n^*=\omega_l^*+c_o$. Using equation **Error! Reference source not found.**, the asset value of unemployment for homeowners $\tilde{V}^U$ becomes almost the same as equation (4) in Munch et al. (2006)[8] (The moving costs are annualized in the framework of this paper whereas those of Munch et al. (2006) are a one-time payment):

$$\rho\tilde{V}^U = b+\alpha_l\int_{\omega_l^*}^{\infty}\left(\frac{w}{\rho}-\tilde{V}^U\right)dF(w)+\alpha_n\int_{\omega_n^*}^{\infty}\left(\frac{w-c_o}{\rho}-\tilde{V}^U\right)dF(w)$$

It has been shown that the model of Munch et al. (2006) can be regarded as nested in the general model. Since the same basic equations have been derived, all the conclusions that follow in their paper hold in this case as well.

3 Simple Model with Fixed Wages

Next we will consider a simple model that ignores variation in offered wages, so as to concentrate on the commuting distance.

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[7] It can first be rewritten as $\rho V^U = b+\lambda\left[\frac{\alpha_l}{\lambda}\int_{\omega^*}^{\infty}\left(\frac{w}{\rho}-V^U\right)dF(w)+\frac{\alpha_n}{\lambda}\int_{\omega^*}^{\infty}\left(\frac{w}{\rho}-V^U\right)dF(w)\right]$

[8] It can first be rewritten as $\rho\tilde{V}^U = b+\lambda\left[\frac{\alpha_l}{\lambda}\int_{\omega_l^*}^{\infty}\left(\frac{w}{\rho}-\tilde{V}^U\right)dF(w)+\frac{\alpha_n}{\lambda}\int_{\omega_l^*+c}^{\infty}\left(\frac{w-c}{\rho}-\tilde{V}^U\right)dF(w)\right]$

In order to investigate the implications of the difference in moving costs on the willingness of renters and homeowners to commute, a simpler version of the general model is considered. To achieve this simplicity, wages are assumed to be equal across all job offers, denoting the wage w_0 so that $P(w = w_0) = 1$. This strong assumption can be justified in cases of wage bargaining at the national level. A person of a particular occupation, e.g. a teacher, can expect to be offered the same wage in schools across the country, a wage that was set by bargaining between the teachers unions and the government. The analysis henceforth is organized in a way similar to the construction of the model in Munch et al. (2006).

The distribution of job offers is denoted $F(D)$, where $dF(D) = f(D)\,dD$. Let c_r, c_o be the moving costs of renters and homeowners respectively, such that $0 < c_r < c_o$. Renters are assumed to have positive moving costs, since assuming otherwise – as in Munch et al. (2006) – unrealistically implies they relocate upon accepting any job (unless the commuting costs are zero). Rewriting equation **Error! Reference source not found.**, the unemployment asset value[9] V_i for an individual of type $i, i \in \{o, r\}$ can be derived from

$$\rho V_i = b + \frac{\lambda}{\rho}\left[\int_0^{c_i} \max\left(w_0 - D - \rho V_i, 0\right) dF(D) + \int_{c_i}^{\infty} \max\left(w_0 - c_i - \rho V_i, 0\right) dF(D)\right]$$

The equation can get one of two simpler forms, conditional on the values of w_0 and c_i:

$$\rho V_i = \begin{cases} b + \frac{\lambda}{\rho}\left[\int_0^{w_0 - \rho V_i} \left(w_0 - D - \rho V_i\right) dF(D)\right] & w_0 - c_i < \rho V_i \\ b + \frac{\lambda}{\rho}\left[\int_0^{c_i} \left(w_0 - D - \rho V_i\right) dF(D) + \int_{c_i}^{\infty} \left(w_0 - c_i - \rho V_i\right) dF(D)\right] & w_0 - c_i \geq \rho V_i \end{cases}$$

In the first case, $w_0 - c_i < \rho V_i$, the wage is too low, or the moving costs are too high, for the individual to accept a job with high commuting costs. More accurately, the expected return for unemployment ρV_i is larger than the net wage. The expression $w_0 - D - \rho V_i > 0$ holds true only up to commuting costs $D = w_0 - \rho V_i$, and since these are smaller than c_i, the range of the first term in the square brackets of equation (..) is narrowed accordingly. Furthermore, the second term is always zero, and so relocation will never occur. Therefore, in what follows, this case is referred to as the "stationary state".

In the second case, $w_0 - c_i \geq \rho V_i$, the wage is high enough, or the moving costs are low enough, for the individual to accept the first job offer regardless of the commuting costs

[9] In what follows, the superscript U for V^U is omitted.

associated with it. The expression $w_0 - D - \rho V_i > 0$ holds true for the whole range of the first integral in equation (..). In addition, in the second term $w_0 - c - \rho V_i \geq 0$, and so relocation always occurs when receiving a job offer with associated commuting costs that are larger than the moving costs. Therefore, in what follows, this case is referred to as the "mobile state".

In the analysis that follows, the expected return for unemployment ρV_i is used extensively. Therefore, consider its dependency on the variable of interest, the costs of moving c. Intuitively, the expected discounted future income of an employed individual V_i is likely to decrease with any increase in costs. When moving costs rise, a mobile individual would be less willing to relocate when accepting a distant job, thus paying higher commuting costs. When she does decide to relocate, the higher moving costs will be incurred. However, when moving costs rise so high that an individual becomes stationary, a further increase would not matter to her, as relocation never occurs.

PROPOSITION 1 ρV_i is a continuous, monotonically decreasing function of c_i.

Refer to Appendix A for a proof.

It is important to identify in which of the states (mobile or stationary) renters and homeowners can be considering their relative moving costs. Trivially, both types can be jointly mobile or jointly stationary, for instance in cases with very high or very low wages, respectively. Can renters be mobile while homeowners are stationary? Intuitively, due to the lower moving costs of renters, this situation is possible. Can renters be stationary while homeowners are mobile? Applying the same reasoning, this does not seem likely. The stationary case is defined as $w_0 - c_i < \rho V_i$, which can alternatively be written as $w_0 - c_i - \rho V_i < 0$. Similarly, the mobile case can be written as $w_0 - c_i - \rho V_i \geq 0$. Showing that $w_0 - c_i - \rho V_i$ decreases in c_i would imply that the intuitive conclusions are correct.

PROPOSITION 2 $w_0 - c_i - \rho V_i$ is decreasing in c_i.

Refer to Appendix A for a proof.

This proposition, then, implies that renters might be mobile when homeowners are not, whereas the reverse situation is impossible.

It is now finally possible to discuss the difference in the willingness to commute between homeowners and renters. The willingness to commute D_i^* is the maximum commuting costs an individual can incur when accepting a job offer that does not involve moving (remember that moving eliminates the commuting costs). In the stationary case, jobs are accepted as long as the net wage is larger than the return from unemployment $w_o - D \geq \rho V_i$. In the mobile case, jobs are accepted without relocating as long as the net wage in larger than the net wage attained by accepting and moving $w_0 - D \geq w_0 - c$. Therefore, the willingness to commute is

$$D_i^* = \begin{cases} w_0 - \rho V_i & w_0 - c_i < \rho V_i \\ c_i & w_0 - c_i \geq \rho V_i \end{cases}$$

The difference between D_i^* of renters and that of homeowners is

$$D_o^* - D_r^* = \begin{cases} w_0 - \rho V_o - w_0 + \rho V_r & \begin{matrix} w_0 - c_r < \rho V_r \\ w_0 - c_o < \rho V_o \end{matrix} \\ w_0 - \rho V_o - c_r & \begin{matrix} w_0 - c_r \geq \rho V_r \\ w_0 - c_o < \rho V_o \end{matrix} \\ c_o - c_r & \begin{matrix} w_0 - c_r \geq \rho V_r \\ w_0 - c_o \geq \rho V_o \end{matrix} \end{cases}$$

In the first case, in which renters and homeowners are stationary,

$$D_o^* - D_r^* = \rho V_r - \rho V_o = 0 .$$

In the second case, in which renters are mobile and homeowners are stationary,

$$D_o^* - D_r^* = w_0 - \rho V_o - c_r \underset{c_r \leq w_0 - \rho V_r}{\geq} w_0 - \rho V_o - \left(w_0 - \rho V_r \right) = \rho V_r - \rho V_o \underset{\text{Prop.1}}{\geq} 0$$

holding strictly if job offers with commuting costs in the range $\left[c_r , w_r - \rho V_r \right]$ might be received.

The third case, that of joint mobility, trivially implies $D_o^* - D_r^* > 0$. In either of the cases, then, $D_o^* \geq D_r^*$, holding strictly if renters are mobile. The maximum commuting costs that homeowners are willing to incur are at least as high as those that renters are ready to accept. Consider now the implications of the different moving costs on the performance of renters and homeowners when searching for a job. If homeowners are willing to accept more costly commutes, it is likely that they accept jobs without moving more often than renters. This intuition can be examined in terms of hazard rates, the chances of an unemployed individual

to become employed, given that she is still unemployed at the time of transition to employment. The hazard rates for accepting a job and staying θ_i^S, accepting a job and moving, θ_i^M, and for generally accepting a job, θ_i, are considered.

$$\theta_i^S = \lambda F\left(D_i^*\right)$$

The hazard rate of becoming employed without moving, θ_i^S, is a product of the chance of receiving a job offer and the chance that it is a job offer that is accepted without moving. Since $D_o^* \geq D_r^*$, it follows that $\theta_o^S \geq \theta_r^S$. If renters are mobile and if there is a chance of receiving job offers with commuting costs between D_o^* and D_r^*, then $\theta_o^S > \theta_r^S$. In this case, unemployed homeowners have better chances than renters to find unemployment without moving.

$$\theta_i^M = \begin{cases} \lambda\left(1-F\left(c_i\right)\right) & w_0 - c_i \geq \rho V_i \\ 0 & w_0 - c_i < \rho V_i \end{cases}$$

The chance of receiving a job offer, accepting it and relocating depends on whether the individual is stationary or mobile. In the former case, this chance is zero since relocation is impossible, while in the latter it is a product of the chance of receiving a job offer and the chance that it is a job offer that is accepted with moving. Since renters have lower moving costs, it is likely that they are more willing than homeowners to accept an offer and move. This intuition is tested by examining the differential between the relevant hazard rates:

$$\theta_r^M - \theta_o^M = \begin{cases} 0 & \begin{matrix} w_0 - c_r < \rho V_r \\ w_0 - c_o < \rho V_o \end{matrix} \\ \lambda\left(1-F\left(c_r\right)\right) & \begin{matrix} w_0 - c_r \geq \rho V_r \\ w_0 - c_o < \rho V_o \end{matrix} \\ \lambda\left(F\left(c_o\right)-F\left(c_r\right)\right) & \begin{matrix} w_0 - c_r \geq \rho V_r \\ w_0 - c_o \geq \rho V_o \end{matrix} \end{cases}$$

In the first case, renters and homeowners are stationary, and neither would move when accepting an offer. In the second case, only homeowners are stationary, and so it follows trivially that renters are more likely to accept an offer and move. In the third case, the differential is proportional to the chance of receiving a job offer with commuting costs between c_r and c_o, which is positive if such jobs exist. In any case, renters perform at least as

good as homeowners in accepting a job and moving, $\theta_o^M \leq \theta_r^M$, while they perform strictly better if they are mobile and if relevant job offers might arrive.

Lastly, the hazard rate of accepting any kind of job is the sum of the hazard rate of accepting a job and staying and the hazard rate of accepting a job and moving.

$$\theta_i = \theta_i^M + \theta_i^S = \begin{cases} \lambda & w_0 - c_i \geq \rho V_i \\ \lambda F\left(D_i^*\right) = \lambda F\left(w_0 - \rho V_i\right) & w_0 - c_i < \rho V_i \end{cases}$$

Following the same method as before, the differential between θ of renters and θ of homeowners is

$$\theta_r - \theta_o = \begin{cases} 0 & \begin{matrix} w_0 - c_r < \rho V_r \\ w_0 - c_o < \rho V_o \end{matrix} \left(\rho V_r = \rho V_o \text{ in this range}\right) \\ \lambda\left(1 - F\left(w_0 - \rho V_o\right)\right) & \begin{matrix} w_0 - c_r \geq \rho V_r \\ w_0 - c_o < \rho V_o \end{matrix} \\ 0 & \begin{matrix} w_0 - c_r \geq \rho V_r \\ w_0 - c_o \geq \rho V_o \end{matrix} \end{cases}$$

It follows that $\theta_r \geq \theta_o$, implying that renters perform at least as good as homeowners in the job market. However, when examined carefully, it can be stated that renters perform better than homeowners only in the case in which renters are mobile and homeowners are stationary. In other cases, the two types of individuals perform equally well.

According to Oswald's hypothesis, the rate of homeownership has a positive, causal effect on the level of unemployment. In the individual level, this implies that homeowners are expected to have lower hazard rates into employment than renters. However, that is only the case when renters are mobile and homeowners are stationary. Whether this case holds is a matter of the parameters used $(w_0, b, F\left(D\right), \rho, \lambda)$ and the specific costs of moving set for renters and homeowners. Otherwise, if renters and homeowners are jointly mobile or jointly stationary, the Oswald's hypothesis is not supported by the results of this model.

4. Empirical Work

In our empirical work we use register data provided by Statistics Netherlands (CBS). These register data are known as SSB and based on municipal administrations. They cover the whole Dutch population and contain information about sex, gender and household composition. The data are enriched by some socio-economic variables. For the purposes of

this paper we need to know the location of the employment location, which is not included in the SSB. However, we can combine the SSB we surveys conducted by CBS, and one of these, the Labor Force Survey (abbreviated in Dutch as EBB) contains this information. We therefore used the intersection of SSB and EBB.

We selected respondents who were unemployed for a period of at least three weeks. The data inform us about the wage and the commuting time of these workers before and after the unemployment spells. This gives us direct information about two relevant aspects of the unemployment durations of owners and tenants: the possibly lower reservation wages and longer commutes of owners. The data do not provide direct information about search intensity, but that data are also useful with respect to this possible explanation: if owners would receive more offers with comparable wages and commutes than renters (under ceteris paribus conditions) this strongly suggests that they search more intensively.

5. Conclusion

To be completed.

References

Barrios García, J.A. and J.E. Rodríguez Hernández (2004), User Cost Changes, Unemployment and Home-ownership: Evidence from Spain. *Urban Studies*, vol. 41, pp. 563-578.

Brunet, C. and J.-Y. Lesueur (2003), Do Homeowners Stay Unemployed Longer? A French Microeconometric Study. CNRS/GATE working paper.

Card, D., R. Chetty and A. Weber (2007) Cash-on-Hand and Competing Models of Intertemporal Behavior: New Evidence from the Labor Market. *Quarterly Journal of Economics*, **122**, 1511-1560.

Chetty, R. (2004) Consumption Commitments, Unemployment Durations and Local Risk Aversion. NBER working paper 10211.

Chetty, R. (2008) Moral Hazard vs Liquidity and Optimal Unemployment Insurance. *Journal of Political Economy*, **116**, 173-234.

Flatau, P., M. Forbes, P.H. Hendershott and G. Wood (2003), Homeownership and Unemployment: The Roles of Leverage and Public Housing. NBER working paper 10021

Goss, E.P., and J.M. Phillips (1997), The Impact of Home Ownership on the Duration of Unemployment, *Review of Regional Studies*, vol. 27, no. 1, pp. 9-27.

Green, R. and P. Hendershott (2001), Homeownership and Unemployment in the US, *Urban Studies*, vol. 38, pp. 1501-1520.

Gruber, J. (1998) Unemployment Insurance, Consumption Smoothing, and Private Insurance: Evidence from PSID and CEX. *Research in Employment Policy*, **1**, 3-31.

Henley, A. (1998), Residential Mobility, Housing Equity and the Labour Market, *The Economic Journal*, vol. 108, 1998, pp. 414-427.

Lentz, R. and T, Tranæs (2005) Job Search and Savings: Wealth Effects and Duration Dependence. *Journal of Labor Economics*, **23**, 467-489.

Munch, J.R., M. Rosholm and M. Svarer (2005), Are Home Owners Really More Unemployed?, Department of Economics, University of Aarhus, working paper.

Munch, J.R., M. Rosholm and M. Svarer (2006), Home Ownership, Job Duration and Wages CAM working paper 2006-08.

Nickell, S.J. (1997), Unemployment and Labor market Rigidities: Europe versus North America. *Journal of Economic Perspectives*, vol. 11, pp. 55-74.

Nickel, S.J. (1998), Unemployment: Questions and some Answers. *Economic Journal*, vol. 108, pp. 802-816.

Nickell, S.J. and R. Layard (1999), Labour Market Institutions and Economic Performance. In: A. Ashenfelter and D. Card (eds.) *Handbook of Labor Economics*, vol. 3, North Holland, Amsterdam, pp. 3030-3084.

Oswald, A.J. (1996), A Conjecture on the Explanation for High Unemployment in the Industrialized Nations: Part I. working paper.

Oswald, A. (1997), Thoughts on Nairu, *Journal of Economic Perspectives*, vol. 11, no. 1, pp. 227-228.

Oswald, A. J. (1999), The Housing market and Europe's Unemployment: A Non-Technical Paper. Working paper.

Partridge, M.D. and D.S. Rickman (1997), The Dispersion of US State Unemployment Rates: The Role of Market and Non-Market Equilibrium Factors, *Regional Studies*, vol. 31, pp. 593-606.

Pehkonen, J. (1997), Unemployment and Homeownership, *Applied Economic Letters*, vol. 6, pp. 263-265.

Taylor, M.P., D.J. Pevalin and J. Todd (2006) The Psychological Cost of Unsustainable Housing Commitments. ISER working paper 08.

Van den Berg, G.J. and C. Gorter (1996), Job Search and Commuting Time, *Journal of Business Economics and Statistics*, vol. 15, pp. 269-281

Van den Berg, G.J. and A. van Vuuren (1998), Job Search and the Non-Monetary Cost of Moving to a New Residence, Unpublished working paper, Free University

Van Vuuren, A. (2008) The Relationship Between Expectations of Labor Market Status, Homeownership and the Duration of Unemployment. Working paper, VU Amsterdam.

Vlist, A.J. van der (2001), *Residential Mobility and Commuting*, Tinbergen Institute, Amsterdam

Appendix A – Proofs

Proof of Proposition 1

PROPOSITION 1 ρV_i is a continuous, monotonically decreasing function of c_i.

Let r, o be two types of unemployed individuals such that $c_r < c_o$.

Consider first two cases: 1. r, o are both stationary. 2. r, o are both mobile. For convenience, equation (..) is presented again:

$$\rho V_i = \begin{cases} b + \frac{\lambda}{\rho}\left[\int_0^{w_0-\rho V_i}\left(w_0 - D - \rho V_i\right)dF\left(D\right)\right] & w_0 - c_i < \rho V_i \\ b + \frac{\lambda}{\rho}\left[\int_0^{c_i}\left(w_0 - D - \rho V_i\right)dF\left(D\right) + \int_{c_i}^{\infty}\left(w_0 - c_i - \rho V_i\right)dF\left(D\right)\right] & w_0 - c_i \geq \rho V_i \end{cases}$$

1. In the case where $w_0 - c_r < \rho V_r$ and $w_0 - c_o < \rho V_o$, the value ρV_i is independent of c_i. Therefore, $\rho V_r = \rho V_o$ in the given range.

2. In the case where $w_0 - c_r \geq \rho V_r$ and $w_0 - c_o \geq \rho V_o$, consider the sign of $\rho V_r - \rho V_o$:

$$\begin{aligned} \rho V_r - \rho V_o = \frac{\lambda}{\rho}\Bigg[& \int_0^{c_r}\left(w_0 - D - \rho V_r\right)dF\left(D\right) + \int_{c_r}^{\infty}\left(w_0 - c_r - \rho V_r\right)dF\left(D\right) \\ & - \int_0^{c_o}\left(w_0 - D - \rho V_o\right)dF\left(D\right) - \int_{c_o}^{\infty}\left(w_0 - c_o - \rho V_o\right)dF\left(D\right)\Bigg] \\ = \frac{\lambda}{\rho}\Bigg[& \left(w_0 - \rho V_r\right)\underbrace{\int_0^{\infty}dF\left(D\right)}_{1} - \int_0^{c_r} D dF\left(D\right) - \int_{c_r}^{\infty} c_r dF\left(D\right) \\ & - \left(w_0 - \rho V_o\right)\int_0^{\infty}dF\left(D\right) + \int_0^{c_o} D dF\left(D\right) + \int_{c_o}^{\infty} c_o dF\left(D\right)\Bigg] \\ = \frac{\lambda}{\rho}\Bigg[& \left(\rho V_o - \rho V_r\right) - \cancel{\int_0^{c_r} D dF\left(D\right)} - \int_{c_r}^{c_o} c_r dF\left(D\right) - \int_{c_o}^{\infty} c_r dF\left(D\right) \\ & + \cancel{\int_0^{c_r} D dF\left(D\right)} + \int_{c_r}^{c_o} D dF\left(D\right) + \int_{c_o}^{\infty} c_o dF\left(D\right)\Bigg] \\ = \frac{\lambda}{\rho}\Bigg[& \left(\rho V_o - \rho V_r\right) + \int_{c_r}^{c_o}\left(D - c_r\right)dF\left(D\right) + \int_{c_o}^{\infty}\left(c_o - c_r\right)dF\left(D\right)\Bigg] \end{aligned}$$

$$\left(\rho V_r - \rho V_o\right)\left(1 + \frac{\lambda}{\rho}\right) = \frac{\lambda}{\rho}\left[\int_{c_r}^{c_o}\left(D - c_r\right)dF\left(D\right) + \left(c_o - c_r\right)\int_{c_o}^{\infty}dF\left(D\right)\right]$$

$$\left(\rho V_r - \rho V_o\right) = \frac{\lambda}{\rho + \lambda}\left[\int_{c_r}^{c_o}\left(D - c_r\right)dF\left(D\right) + \left(c_o - c_r\right)\int_{c_o}^{\infty}dF\left(D\right)\right] \quad \text{(A1)}$$

The first term in the square brackets is an integral of a function which is not negative in the integral range. It is positive if there is a chance of receiving job offers with commuting costs that are between c_r and c_o. The second term is not negative either, and it is positive if there is a chance of receiving job offers with $D \geq c_o$. Therefore, $\rho V_r \geq \rho V_o$ under the given conditions.

So far it has been shown that the ρV_i is monotonically decreasing in c_i when $w_0 - c_i < \rho V_i$ and when $w_0 - c_i > \rho V_i$. If the function is continuous in the point where $w_0 - c_i = \rho V_i$, then it

can be considered monotonically declining in all of its range. Indeed, the function is continuous at the examined point:

$$\lim_{\substack{c_i \to w_0-\rho V_i \\ c_i > w_0-\rho V_i}} \rho V_i = b + \frac{\lambda}{\rho}\left[\int_0^{c_i}\left(w_0 - D - \rho V_i\right)dF\left(D\right)\right] = \lim_{\substack{c_i \to w_0-\rho V_i \\ c_i < w_0-\rho V}} \rho V_i = \rho V_i\Big|_{c_i = w_0-\rho V_i}$$

This concludes the proof.

Proof of Proposition 2

PROPOSITION 2 $w_0 - c_i - \rho V_i$ is decreasing in c_i.

Let r, o be two types of unemployed individuals such that $c_r < c_o$. Hence, the proposition states that $w_0 - c_r - \rho V_r - \left(w_0 - c_o - \rho V_o\right) \geq 0$. Assume $w_0 - c_r - \rho V_r - \left(w_0 - c_o - \rho V_o\right) < 0$.

$$w_0 - c_r - \rho V_r - \left(w_0 - c_o - \rho V_o\right) < 0$$
$$-c_r - \rho V_r + c_o + \rho V_o < 0$$
$$c_o - c_r < \rho V_r - \rho V_o$$

Using equation (A1) and denoting $dF\left(D\right)$ as $F'\left(D\right)dD$,

$$\begin{aligned} c_o - c_r &< \frac{\lambda}{\rho+\lambda}\left[\int_{c_r}^{c_o}\left(D - c_r\right)F'\left(D\right)dD + \left(c_o - c_r\right)\int_{c_o}^{\infty}F'\left(D\right)dD\right] \\ &= \frac{\lambda}{\rho+\lambda}\left[\int_{c_r}^{c_o}DF'\left(D\right)dD - c_r\int_{c_r}^{c_o}F'\left(D\right)dD + \left(c_o - c_r\right)\int_{c_o}^{\infty}F'\left(D\right)dD\right] \\ &= \frac{\lambda}{\rho+\lambda}\left[\int_{c_r}^{c_o}DF'\left(D\right)dD - c_r\left(F\left(c_o\right) - F\left(c_r\right)\right) + \left(c_o - c_r\right)\left(1 - F\left(c_o\right)\right)\right] \end{aligned}$$

Solving the first term using integration by parts,

$$\int_{c_r}^{c_o}DF'\left(D\right)dD = \left[DF\left(D\right)\right]_{c_r}^{c_o} - \int_{c_r}^{c_o}1\cdot F\left(D\right)dD = c_oF\left(c_o\right) - c_rF\left(c_r\right) - \int_{c_r}^{c_o}F\left(D\right)dD$$

And plugging back,

$$c_o - c_r < \frac{\lambda}{\rho+\lambda}\left[c_oF\left(c_o\right) - c_rF\left(c_r\right) - \int_{c_r}^{c_o}F\left(D\right)dD - c_r\left(F\left(c_o\right) - F\left(c_r\right)\right) + \left(c_o - c_r\right)\left(1 - F\left(c_o\right)\right)\right]$$

$$c_o - c_r < \frac{\lambda}{\rho+\lambda}\left[\left(c_o - c_r\right) - \int_{c_r}^{c_o}F\left(D\right)dD\right]$$

Since the term in the brackets is smaller than $c_o - c_r$ and then multiplied by $\frac{\lambda}{\rho+\lambda}$ which is surely smaller than 1, the right side of the inequality cannot possibly be larger than the left side. A contradiction is reached and the proposition is proven.