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Abstract

This paper reviews the empirical research that has been generated by Oswald's thesis, which claims that there is a causal relationship from homeownership to unemployment. The literature confirms a decreasing effect of homeownership on geographical mobility of workers, but does not in general confirm that homeowners have longer unemployment spells or higher unemployment rates. Even though this finding is related to heterogeneity in the labour force and associated selectivity effects, there are clear indications that there is also an effect of homeownership on the search for jobs on the local labour market, especially for highly leveraged homeowners. To offer an integrated representation of the various forces at work, this paper proposes an umbrella model with endogenous search intensity that is consistent with much of the empirical evidence. In particular, it predicts lower geographical mobility of homeowners as well as higher exit rates from unemployment by acceptance of jobs on the local labour market.

1. Introduction

An important branch of urban economics is formed by residential location theory. This framework is usually based on utility maximizing households who are seeking for a spatial location (including a dwelling, land and site-specific characteristics). The residential location choice implies also decisions on the journey from home to work (commuting). In a standard residential location model the attributes of the location enter as arguments in the utility model, while the dwelling prices (including land prices) and commuting costs are included in the budget constraint. In an urban land use and location equilibrium model, the locational choice and the housing and land prices are determined simultaneously.

The cornerstone of urban residential choice models can be found in the standard frameworks designed by Alonso, Mills, Muth and Henderson, where bid rents play a central role in urban development. Later on, this standard model was extended by incorporating also neighbourhood characteristics (such as congestion, air pollution, racial composition or social fragmentation). Such spatial externalities (positive and negative) play increasingly an important role in modern urban economics.

Clearly, housing has a varied set of specific and generic features: shelter, indivisible capital investment, consumption good, durability etc. The housing market is thus a complex and heterogeneous market which is hard to model in an applied context, especially when it concerns imperfectly competitive markets. In modern empirical research, micro-based approaches based on search theory play a central role (e.g., discrete choice models, conjoint choice models).

An important question in regard to the housing market is the issue of property rights of the housing asset. In the standard urban economic framework, the assumption is made that it does not matter whether a household owns or rents a house, as it is in principle possible to purchase a portfolio of dwelling assets that is equal under both modes of tenure (ownership or rent). The tenure choice however, may make a difference, if the maintenance of the housing asset is taken into consideration (Henderson and Ioannides, 1983). It seems plausible that a renter – compared to an owner – will care less about his dwelling than is efficient, as the value rise from a better maintenance accrues to the landlord. Furthermore, in an uncertain housing market but with long-

term steady financial prospects, private property of a house may create additional security and wealth to the owner.

It should be noted that the choice of housing may have serious implications for the costs of commuting. Thus, the expected wealth of housing ownership has to be corrected for the costs of journey from home to work. This means that there is an interaction between the choices on the labour market and the housing market. These choices do not only relate to the spatial choice of the location where to work and where to live, but may also have implications for the choice of ownership and rent of a dwelling. This is particularly relevant, if the possession of an own house limits a flexible adjustment on the labour market. This will be further discussed in the next section.

It should be noted that the above earlier urban economics contributions on urban shape, density and rent gradients are based on simplified monocentric city configurations, with often undifferentiated housing markets without residential submarkets, with static income distributions without socio-economic urban dynamics, and with absence of spatial externalities without (positive and negative) neighbourhood effects on residential property values or geographic mobility. These stringent assumptions have in recent years been seriously criticized, on both conceptual and empirical grounds (see e.g. Adair et al., 1996; Bourassa et al., 1999; Goodman and Thibodeau, 1998; Jud and Winkler, 2002; Parkes et al., 2002; Song and Knaap, 2003, 2004; Watkins, 2001). The complexity of urban housing markets is indeed great and calls for careful modelling experiments, with both a solid theoretical foundation and a promising scope for applied analysis. The valuation of urban residential properties is fraught with many difficulties (ranging from revealed preference market-based valuation approaches to stated preference survey-based approaches such as contingent valuation methods and conjoint analyses). The incorporation of spatial externalities, labour market choices and uncertainties (including commuting and transaction costs) and two-earner households will add to the complexity of urban housing models (see e.g., Follain and Jimenez 1985; Free and Jud, 2003; Kauko, 2003; Meens, 2001; Sultana, 2006; Wilhelmsson, 2002).

The spatial separation of housing markets and labour markets has prompted the phenomenon of commuting as a necessary consequence to bridge the gap between home and work. Commuting is often seen as a passive response to either a residential location decisions or a work decision, but ought to be considered in a broader choice context of socio-economic spatial

decision-making of households. Commuting may incur time and transport costs, but in a utility-maximising framework we know that commuting may be rational if the marginal benefits still exceed the marginal costs. Such marginal costs may – from a societal perspective – even include environmental externalities. The modern literature on commuting (in terms of trip volumes, environmental stress or 'wasteful commuting') is vast (see for a review van Ommeren, 2004). Modern commuting analysis is often cast in the framework or search theory on the labour market (see e.g., Rouwendal, 1998).

Less attention in the literature has been given to the implications of tenure conditions in urban housing markets for job mobility and commuting patterns. This issue has been addressed in some papers by Oswald (1996, 1997), who has argued that home ownership causes more inertia in spatial mobility than home rents due to the relatively higher transaction and moving costs. Consequently, home owners tend to have more stable search behaviour on the labour market than renters do. 'Their home is their castle' and forms the spatial orientation point for job search and commuting. Their limited action radius of search makes them more vulnerable, so that the average unemployment of home owners in the long run may be higher than that of renters. If home owners become unemployed and decide to stay in their residential location, then one may also expect their average duration of unemployment to be longer.

Oswald's (1996, 1999) thesis claims thus essentially that there is a causal relationship between dwelling tenure choice and unemployment. He finds that if the rate of homeownership is 10 percentage points higher, unemployment increases with 2%. If true, the increase in homeownership in many European countries in the second half of the twentieth century would be an important cause of the increase in structural unemployment. Oswald suggests 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 renters, or at least of renters in the private (unregulated) part of the housing market.

Oswald's thesis is at first glance paradoxical in that it seems to contradict 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 this requirement. However, this leaves open the

possibility that the probability of finding a new job can be substantially lower for homeowners than for renters 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. The thesis therefore directed attention towards a neglected and potentially important effect of increase in homeownership that makes it worthwhile to be tested empirically.

Oswald's approach is based on rather strict assumptions. The empirical basis for the inert behaviour of home owners is feeble. What would, for instance, happen if there is a very high tension (i.e., shortage) in various segments of the rental housing market (like in the Netherlands)? In addition, there is most likely not an identical income distribution for home owners and renters, so that their prospects on the labour market (and their willingness to commute or to change their commuting behaviour) may be different. These issues call for further empirical testing; in particular, of the question whether there is a positive elasticity of home ownership with respect to unemployment. The macro-economic evidence of this relationship appears to be rather weak between different countries or regions. Several authors have therefore, adopted a micro-economic (individual or panel) data approach to identify a statistical relationship between unemployed people and the probability to move (see e.g., Henley, 1998; van der Vlist, 2001). In general, the results are not conclusive for the Oswald hypothesis. For example, Goss and Phillips (1997) using panel data from the USA for examining potential labour market influences (i.e., length of unemployment) of home ownership conclude that for several categories of unemployed home ownership significantly reduces unemployment duration, mainly because mortgage payments prompt active job search and home equity aids job search through a wealth effect. This negative result on the Oswald hypothesis was further confirmed by a more recent study of Coulson and Fisher (2006) who found – using US panel data – that there is no statistical support for the Oswald hypothesis. Instead, their model showed that home owners always have better labour market outcomes than renters. These intriguing and sometimes confusing results call for a more thorough analysis of the processes at work on housing, labour and commuting markets. So there is a need to carefully examine the Oswald assumptions from both a theoretical and empirical perspective.

In the present paper we review some empirical work that has been carried out in reaction to Oswald's publication at both the macro and micro scale, and subsequently propose a search model that summarizes most of the evidence. While the reluctance of homeowners to accept job offers outside the local labour market and the associated lower residential mobility of homeowners are important features of our model, it does not predict that their unemployment rates are higher and is in fact consistent with the possibility that homeowners have lower unemployment rates than renters.

The paper is organized as follows. In the next section we review empirical studies that investigate the validity of Oswald's thesis and some related issues at both the macro and micro scale. In section 3 we propose a search model that is consistent with much of the available evidence. The model considers optimal search behaviour in a context where the searcher can influence the arrival rate of job offers by changing the intensity of search. Search can be directed at the local or the national labour market. Section 4 offers concluding and prospective research remarks.

2. Evidence on the Housing Tenure – Unemployment Relationship

2.1 Unemployment and home ownership at the macro level

Oswald's (1996) paper quickly triggered additional research. For instance, Pehkonen (1997) confirmed the relation between homeownership and unemployment for aggregate data referring to Finnish regions, and Partridge and Rickman (1997) confirmed the relationship for similar data referring to US states. More importantly, 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] Controlling for other variables, they find a significant coefficient for the share of homeownership in regressions of 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 whether these relationships are due to the mobility barrier effect proposed by

[1] See also Nickell (1997, 1998).

Oswald, since they find no correlation between the share of homeownership and regional mobility in OECD countries.

Later macro studies are less favourable to Oswald's thesis. Green and Hendershott (2001) reconsidered Oswald's evidence for the US. They confirmed Oswald's finding that changes in unemployment rates were related to changes in the share of homeownership, but note that the relationship disappears when the observations are weighted by the household population of the state to which they refer. They are also unable to find a significant coefficient for homeownership if they use unemployment shares among household heads as the dependent variable. Running similar regressions for various age groups suggests that the relationship proposed by Oswald holds for middle aged households (heads between 35 and 64 years of age) when they consider the total labour force in the relevant age class. When attention is focused on unemployment among household heads, the estimated coefficients for the change in the share of homeownership for middle aged households are at the boundary of statistical significance. Green and Hendershott interpret this as evidence that homeownership restricts especially the mobility of secondary workers in the households (that is, partners of the head). They argue that household heads have no other choice than to move to a better region when the local labour market situation deteriorates. When only their partners become unemployed, staying in the region and hoping for better times may be preferred. However, testing this hypothesis was outside the scope of their paper.

Barrios García and Rodríguez Hernández (2004) take a closer look at Spain, a country where the rates of unemployment and homeownership are both high. They develop a two equation model for homeownership and unemployment and estimate it for Spanish regions. Their conclusion is almost exactly the opposite of Oswald's 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] So, the macro-economic facts for Spain are not in favour of the Oswald hypothesis.

2.2 Unemployment and homeownership at the micro level

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,

[2] Barrios Garcia end Rodriguez Hernandez (2004), p. 573.

1996) and that this is in particular 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. One of the first studies that examined the Oswald thesis on micro data was carried out by Goss and Phillips (1997), who found that the duration of unemployment was *shorter* for owner-occupiers, especially when a mortgage loan was present. They suggest that homeowners with weak equity positions have lower reservation wages than renters or outright owners with comparable labour market characteristics. Alternatively, the search intensity of such homeowners may be higher. In both cases the proper interpretation is probably that unemployment is more inconvenient for homeowners with (large) mortgage payments, and provides a strong incentive to search for another job. Since other evidence (see, for instance, Henley, 1998) confirms that homeowners with weak equity positions have substantially lower mobility on the housing market, it appears that they manage to realize their shorter unemployment spells without accepting jobs outside their local labour market.

Flatau et al. (2003) considered the role of leverage in the duration of unemployment of homeowners in greater detail. Using Australian data they conclude that outright owners have lower exit rates from unemployment than private renters, as hypothesized by Oswald, especially when they are female. However, the larger group of leveraged homeowners has significantly shorter unemployed durations than private renters, which contradicts Oswald's thesis. The authors interpret this as a result of the pressure on unemployed homeowners to meet the mortgage payment requirements. High mortgage payments thus have a similar effect as low replacement ratios. The rather striking implication of the analysis of Flatau et al. (2003) is that workers who are least mobile on the housing market (cf. Henley, 1998) have the shortest unemployment durations, which is an exact reversal of Oswald's thesis.

Using Danish micro data, Munch et al. (2005) confirm that homeownership hampers the propensity to move residence for job reasons. They have the possibility to distinguish moves on the local labour market (requiring no change in residence) from those outside the local labour market (requiring a change in the residential location). Homeowners are less likely to accept a job outside the local labour market than renters. However, homeowners have better chances of finding a job on the local labour market when becoming unemployed. This counteracts the negative effect of immobility on the housing market and 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.

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 empirical studies discussed above find that a strong effect of homeownership on unemployment duration remains after controlling for these effects, and therefore strongly suggest that the search efforts of the unemployed homeowners are the major determinant of their lower unemployment rate.[3] These search efforts can be a willingness to accept jobs in the local labour market at lower wages, as is suggested in the job search model used by Munch et al. (2005) to motivate their empirical specification, but also higher search intensity. The model we propose below considers the latter possibility.

2.3 Other studies

A few papers have addressed some other aspects of the relation between homeownership and labour market behaviour at the level of individual workers. A small number of other studies have considered aspects of Oswald's thesis in the context of a regional or multiregional labour market model. In this subsection we briefly discuss these two branches of the literature.

Even though Oswald (1996, 1999) stressed the negative effects of homeownership on mobility and, through this channel, on unemployment, he made clear that the proposed solution would be to increase the private rental sector. Indeed, economists have almost unanimously rejected rent control[4] because of its negative efficiency effects. In the context of the Oswald thesis, Svarer et al. (2005) find indeed that renters who experience relatively large benefits from rent control are less likely to accept a job from outside the local labour market than others. However, they also find that such renters are more likely to accept jobs in the local labour market

[3] A working paper by Brunet and Lesueur (2003) confirms this. She estimates a duration model and finds 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.

[4] See Glaeser and Luttmer (2003) for a recent study stressing the negative effects, and Arnott (1995) for a notable exception.

and their estimated models suggest that the net effect of rent control on the hazard of leaving unemployment may be positive.[5] The results are therefore similar to those of Munch et al. (2005) for the net effect of homeownership on unemployment: the renters who are less mobile on the housing market may have the shortest unemployment durations.

Munch et al. (2006) have also investigated the possible influence of homeownership on job duration. The empirical results for Danish workers confirm their hypotheses that homeowners have lower transition rates into non-local jobs, earn higher wages and are also less likely to move to other local jobs than renters. These results differ from those of Van Leuvensteijn en Koning (2004) who find that Dutch homeowners have shorter job durations than renters.

Dohmen (2005) attempts to reconcile some of the macro evidence supporting Oswald's thesis with the micro evidence that unemployment rates among homeowners are lower than among renters. He distinguishes high skilled and low skilled workers, and assumes that – all else equal - the former are more mobile than the latter. For both groups, homeownership decreases mobility. If the relative size of the private rental sector shrinks, the more mobile renters (i.e. the high skilled ones, who have higher incomes) are the first to switch to owner occupation, which results in lower mobility among owners as well as renters. Since mobility is negatively related to unemployment, this leads to the conclusion that a decrease in the amount of private rental housing leads increases the overall unemployment rate. Coulson and Fisher (2002) attempt to verify the predictions of this theoretical model.

Haavio and Kauppi (2003) develop a multiregional model and show that owner occupation results in efficiency losses if positive shocks in labour demand vary over space, whereas rental markets always reach locational efficiency. The paper does not contain empirical work.

2.4 Conclusion

The micro studies discussed in subsection 2.2 almost unanimously reject the Oswald thesis. Even though the idea that homeownership decreases mobility on the housing market is confirmed by all studies, the - at first sight very plausible - corollary that this has negative implications for unemployment duration could only be confirmed for specific subgroups of homeowners.

[5] Svarer et al. (2005, p. 2177).

Notwithstanding their lower mobility on the housing market, most homeowners have better chances to escape from a situation of unemployment than renters have. The probable explanation is that many homeowners have a strong incentive to leave unemployment because of a larger utility loss, or that they have a better labour market position. Since papers that attempt to control for the latter effect still find higher exit rates from unemployment for homeowners, the incentive effect is probably substantial. This suggests that homeownership reduces unemployment, rather than increasing it as was hypothesized by Oswald.

The evidence at the micro level is – at least as first sight – not consistent with that at the macro-level where a number of studies have confirmed the relationship suggested by Oswald. One possibility was considered by Dohmen (2005) who showed that a positive relationship between homeownership and unemployment at the macro level can be consistent with a labour market in which many homeowners are high skilled workers with shorter unemployment durations than low skilled workers who are often renters. The relationship at the macro level may therefore be quite different from that at the micro level and representative agent interpretations of the former may be completely misleading.

3. An Umbrella Search Model for Labour Market and Tenure Choice Interactions

The empirical research discussed in the previous section is puzzling. On the one hand it seems to confirm the basic idea behind Oswald's thesis, that homeownership hampers residential mobility. On the other hand, many results are at variance with the a priori plausible consequence that this will have adverse effects on unemployment. This prompts the question whether conventional economic reasoning can be consistent with the basic idea as well as with the empirical facts. To shed some light on this question, we present in this section a simple model for individual job search on a local or national labour market and consider the consequences of owning one's house. The purpose of the model is to provide us with an integrative analytical tool that helps to summarize and interpret the empirical evidence provided by the various studies discussed above.

3.1 Development of the model

The basic model

We start with a simple job search model of the type discussed, for instance, in Pissarides (2000). Consider an unemployed job searcher who receives acceptable job offers with intensity q. As long as he is unemployed, he experiences an instantaneous utility u_u. The instantaneous utility when employed is u_w. An employed worker faces a separation risk σ and returns to unemployment after loosing his job. The Bellman equations associated with this simple model are:

$$\rho V = u_u + q(W - V), \tag{1}$$

$$\rho W = u_w + \sigma(V - W), \tag{2}$$

where V denotes the value of unemployment and W that of being employed. Solving for these values gives:

$$V = \frac{1}{\rho}\frac{q u_w + (\sigma + \rho)u_u}{q + \sigma + \rho} \tag{3}$$

and

$$W = \frac{1}{\rho}\frac{(q + \rho)u_w + \sigma u_u}{q + \sigma + \rho}. \tag{4}$$

In this model housing tenure and transaction costs associated with the possible need to move to another region after acceptance of a job do not yet play a role. The expected duration of unemployment is equal to $1/q$ and the expected duration of employment $1/\sigma$. If all the workers are identical, the unemployment rate u is equal to:

$$\begin{aligned} unem &= \frac{1/q}{1/q + 1/\sigma} \\ &= \frac{\sigma}{\sigma + q}. \end{aligned} \tag{5}$$

Below we extend this model with issues that play a significant role in the literature generated by Oswald's thesis.

Search intensity

The review of the previous section strongly suggests that the generation of job offers differs over workers in relation to their housing circumstances. Our aim is to capture these effects into the model. To do so, we start with endogenizing the arrival rate of job offers. The model of the

previous subsection is intended to provide a stylized description of search behaviour, i.e. of activities of the searcher that result in job offers. The search process that leads to the arrival of job offers can be made explicit by incorporating the costs of search into the model. We do so in a simple way by specifying the instantaneous utility u_u of the unemployed agent as the difference between utility experienced when no search is undertaken, denoted as u_u' and search cost $a(q;u_u')$. The first Bellman equation, (1), thus becomes:

$$\rho V = u_u' - a(q;u_u') + q(W - V), \tag{6}$$

The function *a* indicates the cost of generating an arrival rate with an intensity *q* to the searcher. In order to reflect the opportunity cost of the resources involved, this cost is made dependent on u_u'. For instance, search cost could be specified as the amount of time involved in job search times the value of time. The arrival rate generated by the searcher depends on the amount of time spent searching and the opportunity cost of time depends on the utility of being unemployed. This reasoning suggests a multiplicative specification of search cost:

$$a(q,u_u') = a_1(q)\,a_2(u_u') \tag{7}$$

In what follows, we assume that (7) is valid. In addition, we assume that a_1 is a continuous twice differentiable function with the following properties:

$$a_1(q) \geq 0 \text{ for al } q \geq 0, \tag{8a}$$

$$\frac{\partial a_1}{\partial q} > 0 \tag{8b}$$

$$\frac{\partial^2 a_1}{\partial q^2} > 0. \tag{8c}$$

Assumption (8) states that search cost are never negative, that no offers will be generated unless some costly action is undertaken, that the arrival rate of job offers can only be increased if additional costly search is undertaken and that the marginal cost of an generating job offers increases with the arrival rate, that is, increases in the arrival rate become increasingly difficult to realize. It is assumed that a_2 is a continuously differentiable non-decreasing function of u_u'.[6]

[6] In later subsections we follow a slightly different specification in which a_2 depends on one component of the instantaneous utility of being unemployed.

The searcher chooses q, while taking into account the associated cost, so as to maximize the value of unemployment V, which can be derived on the basis of the Bellman equations (6) and (2) as:

$$V = \frac{1}{\rho}\frac{q\,u_w + (\sigma+\rho)(u_u' - a(q))}{q+\sigma+\rho} \tag{9}$$

The first order condition of this maximization problem can be written as:

$$\frac{da}{dq} = \frac{u_w - u_u' + a(q)}{q+\sigma+\rho}\,. \tag{10}$$

The left-hand-side of (10) is increasing in q by assumption (8c). Both the numerator and the denominator of the right-hand-side are increasing functions of q. It is not difficult to verify that the right-hand-side is decreasing in the arrival rate q when it is small, reaches a minimum and then becomes increasing. Equation (10) is satisfied at the arrival rate for which the right-hand side reaches its minimum. There is a unique arrival rate, q^*, for which V is maximized. Figure 1 illustrates the determination of the optimal arrival rate, as a consequence of the optimal amount of search. In the diagram it is assumed that the search cost function is quadratic, and therefore that marginal search cost is an increasing linear function of the arrival rate.

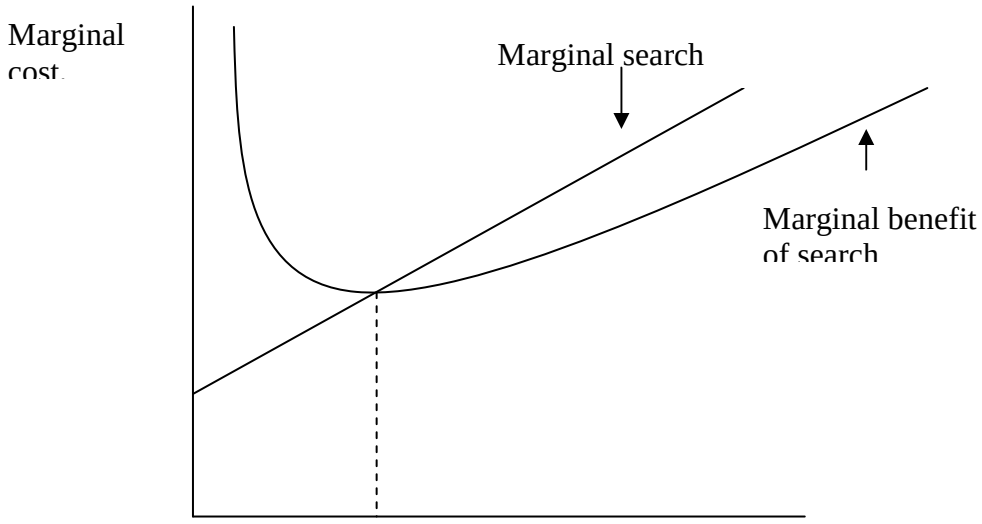

Figure 1 Determination of the optimal arrival rate.

It can be shown that the optimal arrival rate is increasing in the instantaneous utility of work u_w, decreasing in the instantaneous utility of being unemployed u_v, in the separation rate σ, and in the rate of discount ρ. The first order condition (10) says that in the optimum the marginal cost of search should be equal to the marginal benefits and this facilitates the interpretation of these results. If the instantaneous utility of work increases, the marginal benefits from search increase. If the instantaneous utility of being unemployed goes up, the attractiveness of ending unemployment decreases and search becomes less intense. Also, if the separation rate increases, search becomes less rewarding and therefore the optimal search intensity decreases. Finally if the rate of discount increases, the future becomes less important and this has a decreasing effect on the perceived benefits from search.

In the previous subsection we showed that the expected duration of unemployment is the inverse of the arrival rate of job offers, and with the extension of the model just discussed we can say that it is the inverse of the optimal arrival rate as it is determined by the worker. Oswald's thesis can now be interpreted as saying that the optimal search intensity of homeowners is lower than that of renters, but since we have not yet introduced housing into the model this issue cannot be addressed in the present version of the model. However, the model in its present form suggests a number of important potential determinants of difference in unemployment rates among groups of workers. In particular, it implies that the gap between the utility of being employed and unemployed and the risk of losing one's job influences the search intensity, and therefore the unemployment rates of workers. In the subsections that follow we will see how this can be related to homeownership.

Housing

It is conventional in the job search literature to use the income of a worker for his instantaneous (money metric) utility. In order to link the model to the worker's housing situation, we will use a slightly different function that specifies utility as the sum of cash-on-hand and a term referring to housing. Cash-on-hand is defined as the difference between income and out-of-pocket housing costs. The idea is that utility per period depends on the amount of money that can be spent on

(non-durable) consumption goods and on the available stock of durables. For simplicity, the latter is represented only by housing, which is certainly the most important durable for most, if not all, households. We use an additive formulation, i.e. we specify utility as the sum of cash in hand and the utility derived from the stock of durable goods.

Income is equal to an unemployment benefit *b* or a wage *w*. Housing costs are equal to the rent *r* for renters and to out of pocket user costs *c* (mainly mortgage payments) for owner-occupiers. Since housing costs are fixed in the short run (that is, they cannot be changed except by a costly move to another residence), the difference between income and housing costs indeed represents something like cash-on-hand for the worker. The benefits of the house depend on the worker's housing situation. We will scale them to zero for renters and the value for owner occupiers will therefore reflect the utility premium associated with owning.[7] The difference between the housing benefits associated with owning or renting will be denoted as *h*.[8]

We will also assume that the cost of search is dependent on the amount of cash-on-hand of the unemployed worker, but not on the component of instantaneous utility that refers to durable goods. The reason is that the opportunity costs of search increase with the amount of cash-on-hand available to the searcher.[9] This means that cash-on-hand, denoted as *x*, is now the argument of the opportunity cost of search a_2 , so that we assume:

$$\frac{\partial a_2(x)}{\partial x} > 0 \qquad (11)$$

This inequality says that the cost of generating an increase in the arrival rate of job offers is increasing in the amount of cash-on-hand. Cash in hand equals *b*-*r* for renters and *b*-*c* for homeowners.

In the extended model a worker's utility does not only depend on his employment situation, but also on housing tenure. We write:

$$u_{u|r} = b - r - a(q; b - r) \qquad (12a)$$

$$u_{u|o} = b - c + h - a(q; b - c) \qquad (12b)$$

for unemployed renters and owners, respectively. Similarly, we write for owner-occupiers:

[7] It may also be interpreted as reflecting the effect of wealth creation associated with owning through amortization of the mortgage and possible increases in house prices.
[8] Below we discuss how they depend on the worker's employment situation through tax facilities.
[9] In search models without housing it is conventional to make search costs depend on the unemployment benefit. See e.g. Pissarides (2000, chapter 5).

$$u_{w|r} = w - r \tag{13a}$$

$$u_{w|o} = w - c + h\,. \tag{13b}$$

We assume that an increase in the unemployment benefit will always increase the instantaneous utility of being unemployed (at given arrival rates of job offers), that is:

$$1 - \frac{\partial a(q;x)}{\partial x} > 0 \tag{14}$$

where *x* denotes cash-on-hand, as before.

The value of the unemployment *V* for permanent renters is now:

$$\begin{aligned} V_r &= \frac{1}{\rho}\frac{q(w-r)+(\sigma+\rho)(b-r-a(q;b-r))}{q+\sigma+\rho} \\ &= \frac{1}{\rho}\left[\frac{qw+(\sigma+\rho)(b-a(q;b-r))}{q+\sigma+\rho} - r\right] \end{aligned} \tag{15}$$

while for owner-occupiers we find:

$$\begin{aligned} V_o &= \frac{1}{\rho}\frac{q(w-c+h)+(\sigma+\rho)(b-c+h-a(q;b-c))}{q+\sigma+\rho} \\ &= \frac{1}{\rho}\left[\frac{qw+(\sigma+\rho)(b-a(q;b-c))}{q+\sigma+\rho} - (c+h)\right] \end{aligned} \tag{16}$$

Equations (13) and (14) show that the introduction of housing into the model results in the addition of a term reflecting net housing costs into the value of unemployment *V*. If the arrival rate of job offers is independent of housing tenure, the preferred tenure is determined by a comparison between the rent *r* and the difference *c-h* between out-of-pocket cost and the ownership premium. However, we should note that the intensity of search is an endogenous variable, and we will return to the housing tenure decision later in this section.

Optimal determination of the amount of search will only result in identical arrival rates if the amount of cash-on-hand is equal for the two tenure types. When this amount differs, there will be more search for the type with the lowest cash-on-hand. If owners have more cash-on-hand when unemployed, they will have the lowest amount of search and therefore the highest unemployment rate, which would confirm Oswald's thesis, even though mobility is not yet introduced into the model. Note, however, that it is not evident that owner-occupiers have the highest amount of cash-on-hand. Young households who just entered homeownership often have high monthly mortgage payments and this may well result in relatively low amounts of cash-on-

hand after becoming unemployed. In the present model, this would result in a higher search intensity and a lower unemployment rate compared to renters. Hence, the present model provides an explanation for Flatau et al.'s (2003) finding that homeowners with large amounts of mortgage debt have low unemployment rates in comparison to renters and outright homeowners.

Moving costs

In this subsection we extend the model by taking into account that offered jobs could be located in the labour market area where the searcher lives, as well as elsewhere in the country. In the latter case, acceptance of a job implies that a new residence has to be found elsewhere. This is similar to Munch et al. (2005), except for the fact that they consider a model in which arrival rates of job offers are fixed.

We now distinguish jobs from the local labour market, which arrive with intensity q_l and jobs from the rest of the country, which arrive with intensity q_n. Both arrival rates are determined by the efforts of the searcher. The expected wage after acceptance of a job is still equal to *w*. When the accepted job is located outside the local labour market, the worker has to move to a different region and the associated cost is denoted as *mc*.

In order to generate job offers, the worker has to search and we assume that search costs are determined by both intensities and by the amount of cash-on-hand the searcher has available. Generalizing (7), we write:

$$\begin{aligned} a &= a(q_l, q_n; x) \\ &= a_1(q_l, q_n) a_2(x) \end{aligned} \tag{17}$$

where *x* denotes cash-on-hand. It is now assumed that

$$a_1(q_l, q_n) \geq 0 \text{ for all } q_l, q_n \geq 0, a_2(x) > 0 \text{ for all } x \geq 0. \tag{18a}$$

$$\frac{\partial a_1}{\partial q_l} > 0, \frac{\partial a_1}{\partial q_n} > 0 \tag{18b}$$

$$\frac{\partial^2 a_1}{\partial q_n^2} > \frac{\partial^2 a}{\partial q_l^2} > \frac{\partial^2 a}{\partial q_l \partial q_n} \geq 0. \tag{18c}$$

$$\frac{\partial a_1}{\partial q_n} > \frac{\partial a_1}{\partial q_n} \text{ if } q_n = q_l \tag{18d}$$

These assumptions say that the costs of local and non-local search are both increasing convex functions of the arrival rate of job offers. Moreover, additional search on the local market will never decrease the marginal cost of search outside the local labour market and vice versa. When the arrival rates of job offers from inside and outside the local labour markets are equal, the marginal cost of local search is smaller than that of search outside the local labour market. An example of a cost function that satisfies (18) is the quadratic specification $a = \alpha_1 q_n^{\,2} + \alpha_2 q_l^{\,2} + \alpha_3 q_n q_l$ with $\alpha_1 > \alpha_2 > \alpha_3$.

The Bellman equations for renters are now:

$$\rho V_r = b - r - a(q_l, q_n, b-r) + q_l(W_r - V_r) + q_n(W_r - V_r - mc_r), \tag{19}$$

$$\rho W_r = w - r + \sigma(V_r - W_r). \tag{20}$$

Solving these equations for the value of unemployment gives:

$$V_r = \frac{1}{\rho}\left[\frac{(q_l + q_n)w + (\sigma+\rho)(b - a(q_l, q_n; b-r)) - (\sigma+\rho)q_n mc_r}{q_l + q_n + \sigma + \rho} - r\right]. \tag{21}$$

Maximization with respect to the two arrival rates results in the first order conditions:

$$\frac{\partial a(q_l, q_r; b-r)}{\partial q_n} = \frac{w - (b-a) - (q_l + \sigma + \rho)mc_r}{q_l + q_n + \sigma + \rho} \tag{22}$$

$$\frac{\partial a(q_l, q_r; b-r)}{\partial q_l} = \frac{w - (b-a) + q_n mc_r}{q_l + q_n + \sigma + \rho} \tag{23}$$

These first-order conditions are generalizations of (9). Moving costs decrease the marginal benefit from search outside the local labour market and increase that of search on the local labour market. Equations (22) and (23) imply that in equilibrium the marginal cost of search on the local labour is higher than the marginal cost of search outside that market. Assumption (18d) shows that this is incompatible with equal arrival rates from the local and other labour markets. Since the marginal costs of the two arrival rates are increasing, the arrival rate of local job offers must in equilibrium be higher than that of job offers from elsewhere. Note that this is true, even if there would be no cost associated with geographical mobility (i.e. $mc_r = 0$).

Subtraction of (22) from (23) gives:

$$\frac{\partial a}{\partial q_l} - \frac{\partial a}{\partial q_n} = mc_r, \tag{24}$$

where we suppressed the arguments of *a* for notational convenience. This equation says that the difference between the marginal costs of increasing the local and the national arrival rate with one unit must be equal to the full cost of making a residential move. Since this cost is considerable, the equation shows clearly that residential moving costs provide a strong incentive to search more intensively on the local labour market than in the rest of the country.

The Bellman equations for owner-occupiers are similar to those of the renters and result in a value of unemployment:

$$V_o = \frac{1}{\rho}\left[\frac{(q_l + q_n)w + (\sigma+\rho)(b - a(q_l, q_n; b-c)) - (\sigma+\rho)q_n mc_o}{q_l + q_n + \sigma + \rho} - c + h\right] \tag{25}$$

Maximization with respect to the two arrival rates of job offers results in first-order conditions:

$$\frac{\partial a(q_l, q_r; b-c)}{\partial q_n} = \frac{w - (b-a) - (q_l + \sigma + \rho)mc_o}{q_l + q_n + \sigma + \rho} \tag{26}$$

$$\frac{\partial a(q_l, q_r; b-c)}{\partial q_l} = \frac{w - (b-a) + q_n mc_o}{q_l + q_n + \sigma + \rho} \tag{27}$$

and instead of (22) we have:

$$\frac{\partial a}{\partial q_l} - \frac{\partial a}{\partial q_n} = mc_o . \tag{28}$$

Since residential moving costs of homeowners are considerably larger than those of renters, it follows that homeowners will direct their search activities even more to the local labour markets than renters. This is consistent with the empirical evidence provided by Munch et al. (2005).

Comparative static results are derived in Appendix. A higher wage increases the benefits from search and implies more search and therefore higher arrival rates for local as well as other jobs. A higher unemployment benefit has a negative effect on the arrival rate of local job offers, but the sign of its effect on the arrival rate of other job offers, and on the sum of the two arrival rates is not determined. Similarly, a higher rent or higher out-of-pocket housing costs, has a positive effect on the search intensity for local jobs. Also here, the effect on the arrival rate for non-local job offers and that on the sum of the two arrival rates is not determined. The model is therefore consistent with Flateau et al.'s finding that homeowners with a mortgage have on average shorter unemployment spells, even though it does not predict this as a necessary outcome.

Higher moving costs increase the intensity of search for local jobs, and decrease that for non-local jobs. The effect on the sum of the two arrival rates is, again, not determined.

A higher separation rate and a higher rate of discount decrease search intensity for local as well as non-local jobs.

Housing tenure choice and its effect on labour market search

An unemployed worker will own his home if the value of being an unemployed renter is less than that of being an unemployed owner:

$$V_r^o < V_o^o \tag{29}$$

A choice for homeownership is a choice for the associated benefit *h*, which does not affect search behaviour, and for higher moving cost *mc* and different out-of-pocket housing cost.

The first thing to observe is that the model does not unambiguously generate the predictions associated with the Oswald thesis, even though it explicitly incorporates moving cost. Even if the out-of-pocket cost of owner-occupied housing are lower than the rent, the higher moving cost has a positive effect on the search intensity of local job offers that may be strong enough to compensate for the negative effects of lower housing cost and lower intensity of search for non-local jobs. Unemployment rates of homeowners may therefore still be lower than those of renters.

Second, if the out-of-pocket housing cost of owner-occupied housing are higher than that of renting, our model predicts that the arrival rate of job offers on the local labour market is higher for homeowners than for renters. The arrival rate of non-local job offers for homeowners may be lower as well as higher than that of renters. In this case there is no prediction of lower geographical mobility of homeowners.

It can therefore be concluded that a relatively simple search theoretic model of labour market behaviour that explicitly takes into account the higher moving cost of unemployed homeowners does not generate the predictions of Oswald's thesis and is consistent with much of the available empirical evidence.

Discussion

The model developed in the present section uses search theory to study the relationship between homeownership and unemployment. It takes the intensity of search as an endogenous variable,

which is determined by the job searcher so as to maximize utility. In this model the higher cost of moving associated with homeownership has an increasing effect on the intensity of search outside the local labour market. However, the total effect on the arrival rate of job offers is not determined by the model. This implies that Oswald's thesis, according to which homeownership has a negative influence on unemployment, is a possible outcome. However, the same is true for the opposite effect, which was empirically observed by Munch et al. (2005). Both possibilities are consistent with optimizing behaviour of rational agents. In the context of our model Oswald's thesis is not a proposition that necessarily follows from it, but it can be interpreted as a hypothesis concerning the sign of an effect that is not determined by the theory. The evidence suggests that it is empirically falsified.

Moreover, the model also sheds light on the empirical results of Flatau et al. (2003) that highly leveraged homeowners have lower unemployment rates and shorter unemployment duration than outright owners and renters. It does so by considering cash-on-hand, that is the amount of money available for nondurable consumption, as an indicator of the homeowner's well being. For highly leveraged homeowners mortgage payments are often larger than rents that have to be paid for comparable rental housing, implying that cash in hand is lower. In our model, this implies that the search intensity on the local labour market of such highly leveraged owners exceeds that of the renters. Even though the effect on search intensity outside the local labour market is indeterminate, the net result of the higher housing cost may well be that unemployment spells of such highly leverage homeowners are lower than those of renters, as observed by Flatau et al. (2003).

The model can be extended so as to cover even more of the available empirical results. For instance, costs associated with losing the gains from rent control can be introduced into the model by including them as a component of the moving cost of renters. This would result in the prediction of more intense local labour market search by such renters as found by Svarer et al. (2006).

Another extension would be to introduce housing market policy measures into the model. A means-dependent housing subsidy for renters would have similar effects as a higher unemployment benefit and may also result in higher moving cost for renters if the rental segment of the housing market is rent controlled. Fiscal deductibility of mortgage interest payments has similar effects as a higher wage rate under progressive income taxation. A tax on housing sales,

as is currently in effect in the Netherlands, increases moving cost and therefore has a negative effect on geographical labour mobility.

4. Empirical Evidence from the Netherlands

Introduction

In this section we report some preliminary results of empirical work that is inspired by the model developed in the previous section. We used the Housing Needs Survey (abbreviated in Dutch as WBO) of the year 2002. It provides information about the housing situation and a large number of related variables for about 75,000 Dutch households.

The WBO is a cross section and for this reason we focus on the probability of unemployment and its relationship with homeownership. The model developed in the previous section refers to the duration of unemployment spells as well as to unemployment rates of workers. The purpose of our estimations is to consider the relationship between homeownership and unemployment for the Netherlands. We noted in section 2 that empirical work has often rejected Oswald's thesis, even though the theoretical model developed in section 3 does not predict the sign of the effect of homeownership on unemployment rates. Our empirical investigation addresses the question whether the empirical evidence for the Netherlands is in line with that found in earlier work, or is more favorable to Oswald's thesis.

We concentrate attention on cases in the WBO where the respondent is one of the 'main inhabitants' of the house, which means that the respondent is renter or owner-occupier or the partner of the renter or owner occupier. The questionnaire distinguishes between the respondent and his or her partner (if there is one in the household), but for our purposes it is more natural to make a distinction between males and females. For this reason we defined new variables that refer to the male and female main inhabitants.[10]

Our interest is in the relationship between unemployment and homeownership. We define the labor force as consisting of all the persons between 20 and 60 years old who are either working for at least 12 hours per week or receiving an unemployment benefit. Since the WBO

[10] It is possible that answers top questions referring to the respondent's partner have more measurement errors than those referring to the respondent him- of herself, but we ignore this issue here.

contains the relevant information, we can compute unemployment rates for male and female main inhabitants per province and compare these figures with the unemployment figures provided by Statistics Netherlands. The correlation between the unemployment rates among main occupiers and the official figures is far from perfect: the correlation coefficient equals .53 for males and .56 for females. Average unemployment rates among main inhabitants are lower than in the total labor force, as should be expected.

Table 1 Provincial unemployment shares

	Official figure	Male main inhabitants	Female main inhabitants
Groningen	6.8	4.3	4.1
Friesland	4.9	2.6	4.1
Drenthe	5.3	2.8	3.2
Overijssel	4.0	2.7	2.4
Gelderland	5.0	1.4	2.9
Utrecht	3.6	1.8	2.7
Noord-Holland	4.1	1.4	2.3
Zuid-Holland	3.9	2.3	2.8
Zeeland	4.2	2.7	3.0
Noord-Brabant	3.2.	3.0	3.3
Limburg	3.4	2.6	3.0
Flevoland	4.9	3.2	4.7
Nederland			

Source: Statistics Netherlands for the official figures, own computations based on WBO 2002 for the other two columns.

We use the WBO to compute the share of owner occupiers per province. There appears to be no relationship between unemployment and the share of owner-occupiers at this aggregate level. A simple regression of the unemployment rate on the share of owner-occupiers results in small and insignificant coefficients.

Analysis at the micro level

We use linear regression on the variable that indicates that a member of the labor force (as defined above) is working. Even though our dependent variable only takes on the values 0 and 1, OLS is usually very informative in a first analysis. We start with using only one explanatory variable: a dummy indicating homeownership. The results, reported under (1) in Table 2, show that unemployment is higher among renter than among owner-occupiers, as is usually observed. Part of the difference disappears when we control for a number of personal and household characteristics as is shown in the second regressions.

To deal with the possible endogeneity of the homeownership variable, we adopt an instrumental variables approach. We use the provincial share of homeowners, the average value of owner-occupied houses and the average rent as instruments. The regional share of homeowners has also been used by Koning and Van Leuvensteijn. We interpret the average value of houses as a (crude) indicator of the price of housing services provided by owner occupied housing and the average rent as a similar indicator for its main substitute: housing services provided by rental housing. Both prices should, according to economic theory be relevant to tenure choice.

Table 2 Estimation results for probability of being employed

	Males				Females			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Constant	**0.95**	**0.96**	**0.96**	**0.88**	**0.95**	**0.90**	**0.89**	**0.82**
Owner-occupier	**0.034**	**0.026**	-0.015		**0.035**	**0.024**	**-0.053**	
Mortgage payment*				**0.22**				**0.096**
Social rented housing				**0.06**				**0.093**
Educ. Level 1		**0.035**	**0.043**	**0.038**		**0.044**	**0.057**	**0.054**
Educ. Level 2		**0.033**	**0.042**	**0.037**		**0.057**	**0.077**	**0.069**
Educ. Level 3		**0.041**	**0.055**	**0.026**		**0.067**	**0.093**	**0.082**
Educ. Level 4		**0.045**	**0.061**	0.011		**0.074**	**0.10**	**0.087**
Age x 100		**-0.086**	**-0.059**	**-0.040**		**-0.056**	-0.002	-0.0078
Single		**-0.030**	**-0.041**	-0.0015		-0.016	**-0.037**	-0.019
Single-parent		**-0.028**	**-0.035**	-0.0011		-0.0069	**-0.030**	-0.020
Two earners		0.0017	**0.051**	**-0.014**		0.0072	**0.022**	0.0087

R^2	0.010	0.021	0.007	-	0.009	0.020	-
n	37,031				27,477		

* In thousand euros per month.

Bold figures refer to significant coefficients. Significance (at 5% or better) has been determined on the basis of robust standard errors.

Instrumenting the homeownership dummy leads to a reversal of sign in both regressions. The coefficient for homeownership in the regression for males is now insignificant, but in the regression for females it is significant, as would be expected on the basis of Oswald's hypothesis. To investigate the effect of a mortgage and of social rented housing we introduced dummies indicating these two variables, but instrumental variable regression did not produce meaningful results. The probable reason is that in the Netherlands the majority of rental housing is social housing and most of the owner-occupied houses have a mortgage. These variables are thus highly correlated. In order to circumvent these problems we introduced (monthly) mortgage payment and a dummy for renting in the social sector into the regression equation, while removing the dummy for owner-occupation from it. Results of instrumental variables regression are given in columns (4). They show that owner-occupiers with a mortgage have a higher probability of being employed than the group owners without a mortgage and renters outside the social rented sector. Workers in social rented housing also have a higher probability of bring employed. These results can be interpreted as confirming Oswald's hypothesis for outright owners, but not for owners with a mortgage.

Conclusion

Even though the results discussed above are clearly preliminary, they are in line with the findings in the literature reviewed in section 2. They leave open the possibility that Oswald's thesis is valid for outright owners, as has been done in other empirical work, notably that of Flatau et al. (2003). We plan to investigate this issue more closely in additional empirical work using discrete choice models.

5. Conclusion

In the previous sections we have interpreted the literature generated by Oswald's thesis. The challenging hypothesis that an increase in homeownership has the potential to increase unemployment by a substantial amount receives its plausibility from the negative effect of moving cost on labour market mobility. This aspect of the thesis is generally confirmed in the empirical work. The surprising issue is that, despite the fact that homeownership does hamper geographical mobility substantially, it does not seem to have negative effect on the length of unemployment spells. To the contrary, the studies of Flateau et al. (2003) and Munch et al. (2005) suggest that the net effect of homeownership on unemployment duration may be positive, at least for the important group of homeowners with a mortgage.

To interpret these results, we developed a model for labour market search that incorporates the effects of homeownership by taking into account out-of-pocket housing expenses and moving costs. The model implies that homeowners are more reluctant to search for job offers outside their local labour market, which is the basic argument underlying Oswald's thesis. However, it does not predict that homeowners have longer unemployment spells than renters, even though it does not exclude this possibility. The empirical violation of this basic ingredient of Oswald's thesis can therefore be explained by a relatively simple search model that deals explicitly with two elementary housing issues, viz. moving cost and out-of-pocket housing costs. The model we developed is also consistent with empirical evidence that shows that highly leveraged homeowners have lower unemployment durations than renters and outsight owners and that homeowners are more likely to find a job on the local labour market than renters.

The key to our results is that we have endogenized the arrival rates of local and national job offers by linking them to search costs that depend on cash-on-hand. The latter variable is defined as the difference between the unemployment benefit and out-of-pocket housing cost, that is, rent or mortgage payments. High mortgage payments therefore imply an incentive to search that is comparable to that of a low unemployment benefit.

Like Munch et al. (2005) we distinguish between search on the local labour market and elsewhere. Unlike them, we do not assume a wage offer distribution and a reservation wage strategy, but concentrate on search intensity for jobs that offer a given wage. However, the results of their model with respect to exit rates from unemployment are similar to those derived here.

Perhaps the most interesting aspect of the literature generated by Oswald's hypothesis is that it strongly suggests, that the duration of unemployment is influenced substantially by

incentives that originate form the housing market. In particular, searchers seem to be able to react to decreased opportunities for geographical mobility by increasing their chances to find a job on the local labour market substantially, even to such an extent that the net effect on unemployment duration becomes positive.

The previous observations and modelling experiments prompt the need for further theoretical and applied research. There is apparently a lack of a solid comprehensive framework that would have explanatory and predictive power for the unemployment-housing tenure interaction (including commuting). Next, there is also a need for micro-based individual panel data (preferably of a longitudinal nature) that would allow us to do a more rigorous testing also against other explanatory factors for unemployment (such as openness of the economy, immigration, trade union power, unemployment benefits and marginal tax rate systems). A careful specification analysis may also be able to cope with problems of reverse causality. In particular, it is important to trace the causes of law labour mobility over space (such as rental subsidies, high moving costs for tenants, institutional protection systems and the like. Especially the impacts of policy (housing, education, labour, transportation) deserve further attention and may lead to the need to specify a model with endogenous policy effects in terms of urbanisation, land use, commuting, labour market or fiscal effects.

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Appendix Comparative statics of the search model

In this appendix we consider the effect of small changes in the variables $\theta = [w, b, r, mc, \sigma, \rho]'$ on the optimal values of the arrival rates of job offers from the local labour market, q_l^o, and from elsewhere, q_n^0. These optimal values are the solutions to the first order conditions (24) and (25). However, it turns out to be more convenient to use instead the pair of equations (25) and (26), which are mathematically equivalent to (24) and (25). We write:

$$f_1(q_l, q_n; \theta) = \frac{\partial a(q_l, q_n; b-r)}{\partial q_l} - \frac{w - b + r + a(q_l, q_n; b-r) + q_n mc}{q_l + q_n + \sigma + \rho} \tag{A1}$$

$$f_2(q_l, q_n; \theta) = \frac{\partial a(q_l, q_n; b-r)}{\partial q_l} - \frac{\partial a(q_l, q_n; b-r)}{\partial q_n} - mc \tag{A2}$$

Maximization of the value of unemployment *V* implies: $f_1(q_l^o, q_n^o; \theta) = f_2(q_l^o, q_n^o; \theta) = 0$.

Taking the full derivative of (A1) in the optimum gives:

$$\frac{\partial^2 a}{\partial {q_l}^2} dq_l^o + \frac{\partial^2 a}{\partial q_l \partial q_n} dq_n^o = -\sum_i \frac{\partial f_1}{\partial \theta_i} d\theta_i . \tag{A3}$$

Similarly, taking the full derivative of (A2) in the optimum gives:

$$\left(\frac{\partial^2 a}{\partial {q_n}^2} - \frac{\partial^2 a}{\partial q_l \partial q_n} \right) dq_n^0 = \left(\frac{\partial^2 a}{\partial {q_l}^2} - \frac{\partial^2 a}{\partial q_l \partial q_n} \right) dq_l^0 + \sum_i \frac{\partial f_2}{\partial \theta_i} d\theta_i . \tag{A4}$$

Solving equations (A3) and (A4) gives:

$$dq_l^o = -\frac{1}{A} \left(\left(\frac{\partial^2 a}{\partial {q_n}^2} - \frac{\partial^2 a}{\partial q_l \partial q_n} \right) \sum_i \frac{\partial f_1}{\partial \theta_i} d\theta_i + \frac{\partial^2 a}{\partial q_l \partial q_n} \sum_i \frac{\partial f_2}{\partial \theta_i} d\theta_i \right) \tag{A5}$$

$$dq_n^o = -\frac{1}{A} \left(\left(\frac{\partial^2 a}{\partial {q_l}^2} - \frac{\partial^2 a}{\partial q_l \partial q_n} \right) \sum_i \frac{\partial f_1}{\partial \theta_i} d\theta_i - \frac{\partial^2 a}{\partial {q_l}^2} \sum_i \frac{\partial f_2}{\partial \theta_i} d\theta_i \right) \tag{A6}$$

with:

$$A = \frac{\partial^2 a}{\partial {q_l}^2} \frac{\partial^2 a}{\partial {q_n}^2} - \frac{\partial^2 a}{\partial q_l \partial q_n} . \tag{A7}$$

We can now derive the following results:

- for $\theta_1 = w$, $\frac{\partial f_1}{\partial w} < 0$, $\frac{\partial f_2}{\partial w} = 0$, hence $\frac{dq_l}{\partial w} > 0$, $\frac{dq_n^o}{dw} > 0$

- for $\theta_2 = b$, $\frac{\partial f_1}{\partial b} = \frac{\partial^2 a}{\partial q_l \partial x} + \frac{1-(\partial a/\partial x)}{q_l + q_n + \sigma + \rho} > 0$, $\frac{\partial f_2}{\partial b} = \frac{\partial^2 a}{\partial q_l \partial x} - \frac{\partial^2 a}{\partial q_n \partial x} > 0$; hence $\frac{dq_l}{db} < 0$, but the sign of and $\frac{dq_n}{db}$ is undetermined.

- for $\theta_3 = r$, $\frac{\partial f_1}{\partial r} = -\frac{\partial^2 a}{\partial q_l \partial x} + \frac{\partial a/\partial x}{q_l + q_n + \sigma + \rho} < 0$, $\frac{\partial f_2}{\partial r} = \frac{\partial^2 a}{\partial q_l \partial x} - \frac{\partial^2 a}{\partial q_r \partial x} < 0$; hence $\frac{dq_l}{dr} > 0$, but the sign of $\frac{dq_n}{dr}$ is undetermined.

- for $\theta_4 = mc$, $\frac{\partial f_1}{\partial mc} < 0$, $\frac{\partial f_2}{\partial mc} < 0$, hence $\frac{\partial q_l}{\partial mc} > 0$, $\frac{\partial q_n}{\partial mc} < 0$

- for $\theta_5 = \sigma$, $\frac{\partial f_1}{\partial \sigma} > 0$, $\frac{\partial f_2}{\partial \sigma} = 0$, hence $\frac{dq_l^o}{d\sigma} < 0$, $\frac{dq_n^o}{d\sigma} < 0$

- for $\theta_5 = \rho$, $\frac{\partial f_1}{\partial w} > 0$, $\frac{\partial f_2}{\partial w} = 0$, hence $\frac{dq_l^o}{d\rho} < 0$, $\frac{dq_l^o}{d\rho} < 0$.