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Recruitment in a monopsonistic labour market: will travel costs be reimbursed?

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Abstract

Reimbursement of commuting costs by employers has attracted little attention from economists. We develop a theoretical model of a monopsonistic employer who determines an optimal recruitment policy – in a spatial labour market with search frictions, and show that, in general, partial reimbursement of commuting cost will be an element of the recruitment policy. The empirical evidence we offer is consistent with the interpretation of reimbursement as the result of monopsonistic behaviour. The alternative explanation, which stresses the role of tax incentives, is unlikely to provide a full explanation of commuting costs reimbursement.

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1. Introduction

Many employers in Europe (e.g., in Belgium, France, Germany, the Netherlands, Switzerland, Scandinavian countries) and Japan explicitly reimburse part of the home-to-work travel costs of their employees (for a recent review, see Potter et al. (2006)). In these countries, collective bargaining agreements usually stipulate the reimbursement rule, at the level of the firm (Tillema et al., 2008). Information about the reimbursement level is therefore available to job-seekers (for instance, through the firm's website). The presence of such a rule implies that reimbursement will be adjusted if the worker moves his/her residence closer to, or further from, the workplace location. Since the rule is applied to all workers, such reimbursement implies unequal treatment of identical workers within the same firm, but who have different residence locations.

Commuting costs, being the sum of monetary and time costs, can be quite substantial. For a worker with an 8-hour work-day and a one-way commute of half an hour, the commuting costs are estimated to be about 10% of the daily wage. About 70% of these costs are due to time costs, and about 30% are due to monetary costs (Small, 1992). For workers with longer commutes, the commuting cost can be substantially higher. Commuting costs for low-wage workers can be much more important, also. For example, in the U.S., the average *monetary* costs of travel are about 6% to 9% of a minimum-wage worker's full-time *gross* income (Bhaskar and To, 1999).[1] Clearly, reimbursement of commuting cost can make a substantial difference in a firm's payment to its workers – even if the reimbursement is only partial. Later in this paper, we will document that approximately one-third of Dutch workers receive an explicit reimbursement, and that – for those who receive it – the reimbursement, on average, amounts to almost 5% of total earnings, which is clearly non-negligible.[2]

Since reimbursement of commuting cost implies paying a different price to workers who are equally productive, but who live at different locations, it seems natural to regard such reimbursement as an example of *intra-firm* wage discrimination.[3] This is consistent with a monopsonistic labor market. Arguments suggesting monopsonistic competition in the labour

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[1] Similarly, for part-time workers, these costs (relative to wages) may be even more significant (Manning, 2003a).

[2] We do not find any evidence of implicit reimbursement for the Netherlands, but we will argue later that implicit reimbursement is much more difficult to identify.

[3] Intra-firm wage discrimination has been extensively studied, within the context of academic markets (for example, Ransom, 1993; Bratsberg et al., 2003). In this literature, the extent to which seniority decreases wages is examined, since incumbent academics with positive migration costs may accept lower wages than job applicants from other locations, who may consider other job openings at lower costs.

market have been around at least since Mortensen (1970) observed that, in a labour market with search, employers face an upward-sloping supply curve for labour. Boal and Ransom (1997) and Rogerson, Shimer and Wright (2005) provide reviews of the literature on monopsonistic labour market models that have emerged since then. Bhaskar, Manning and To (2002) provide a more recent discussion of the relevance of this market type, for labour market analysis, e.g., for the effect of minimum wages on employment. However, as far as we know, there exist no empirical studies of monopsonistic labour market behaviour that focus on commuting costs. Since reimbursement of commuting costs is widespread in many countries, a monopsonistic view appears to be a natural perspective from which to analyze this phenomenon.

We are aware of a limited number of theoretical studies that analyze wage discrimination based on commuting cost from a different perspective. For example, Van Ommeren and Rietveld (2005) analyze a standard wage bargaining model that allows for commuting costs, in the spirit of Pissarides (2000). Additionally, we are aware of brief discussions of a spatial labour market, in Bhaskar and To (1999) and Bhaskar, Manning and To (2002). In the latter study, it is shown that *inter-firm* wage discrimination on the basis of location would be profitable to the firm. However, the authors do not pursue the issue of *intra-firm* discrimination. Furthermore, in their model, location is a metaphor for unobservable preferences for job characteristics.

There is no reason to regard location only as a metaphor, though, when studying monopsonistic behaviour. We agree with Manning (2003a, b), who argues that the 'thinness' of the labour market, which is required for monopsonistic behaviour, is closely related to the geographical aspect of that market. In Manning's model, firms do not discriminate between employees, and therefore do not explicitly reimburse the commuting costs of their employees. Nevertheless, in equilibrium, workers are partially compensated for commuting costs by higher wages, as a result of the matching process on the labour market. In this paper, we take a different look at the spatial aspect of the labour market, and examine whether it provides a monopsonistic employer a reason to discriminate workers based on the length of the commute, and provides an explanation for reimbursement of commuting costs.

Our focus is on *explicit* reimbursement – a reimbursement earmarked for commuting costs – because this allows us to distinguish the reimbursement from other wage components, making it convenient for our empirical analysis. Explicit reimbursement is not fundamentally different from *implicit* reimbursement, that is, a positive relationship between wages and commuting costs, for otherwise identical workers. Empirical evidence for countries where explicit reimbursement is uncommon, such as the U.S. and the U.K.[4], indicates a positive relationship between wages and the length of the commute, consistent with implicit reimbursement. Manning's (2003a) explanation of this phenomenon stresses the role of spatial wage gradients or heterogeneity in wage offers, and considers the latter as the most likely explanation. Explicit and implicit reimbursement may both be present in each economy, and, in any empirical analysis, it is important to control for alternative explanations of commuting reimbursement, to identify monopsonistic behaviour separately, as we are able to do in our empirical analysis.

Since our analysis can be regarded as an investigation of the presence of monopolistic competition in the labour market, it is useful to point out that the focus on commuting has a number of theoretical and empirical advantages for this purpose. One important advantage is that the commute is, in principle, not directly related to the productivity level of the worker.[5] A second advantage is that employers can easily observe the commute, at no cost. This is consistent with empirical evidence for the U.K. (RCI, 2001), where almost all employers were able to report the commuting time of recently-recruited employees (suggesting that the commute plays a role in the recruitment process).

A third advantage is that the length of the commute may change, through a residence move. This implies that, given panel data observations, and by selecting *workers that remain with the same firm*, one is not only able to control for (unobserved) worker characteristics, but also for (unobserved) job and firm characteristics, when analyzing reimbursement behaviour. In the current paper, controlling for job and firm characteristics is relevant to distinguish between explanations based on monopsonistic behaviour, and alternative explanations, such as favourable tax treatment of fringe benefits. This is also relevant since firm location is likely endogenous with respect to population density and local labour markets. By keeping firm characteristics constant, we may assume that the firm location is given, throughout the theoretical analysis. The focus on explicit commuting reimbursement has other advantages as well. In the Netherlands, to which our empirical work refers, reimbursement of commuting expenses is explicit, since for institutional

[4] In the U.S., explicit commuting reimbursement is rare (but see the examples given in Potter et al. (2006)). In the U.K., explicit commuting reimbursement is also rare, although interest-free loans for season tickets appear to be common, which can be interpreted as a form of explicit reimbursement.

[5] Arguably, the commute may be related to productivity levels, due to fatigue, etc., implying that workers with a long commute are *less* productive. The main implication is that it is less attractive for an employer to offer reimbursement of commuting costs, implying that our estimates (which show a positive relationship between reimbursement levels and commuting) are conservative.

reasons and tax purposes, it is specifically earmarked by employers. This makes interpretation of the econometric analysis more straightforward, because employers and workers distinguish between payments for productive labour, which we will label the "normal wage", and compensation for commuting expenses: the commuting reimbursement. The majority of employees in the Netherlands are subject to collective bargaining agreements, which usually include rules about reimbursement of commuting costs, *at the level of the firm or industry*. So, observed reimbursement of commuting expenses is unlikely to be related to individual productivity levels. In a recent Dutch *employer* survey (Tillema et al., 2008), about 50% of the employers state that they *always* reimburse some of the commuting expenses, whereas 15% to 35% *never* reimburse commuting expenses, for certain well-defined groups of workers. This indicates that the large majority of employers decide on the level of reimbursement (as a function of the length of the commute), unconditionally from the productivity level of a certain worker.

The focus on reimbursement of commuting costs as a way of measuring monopsonistic behaviour has one potential weakness: it may be argued that reimbursement is *entirely* tax-induced, because in the Netherlands, as in many other countries, reimbursement of commuting expenses is taxed at lower marginal tax rates than wages.[6] Tax facilities may explain the presence of reimbursement practices in a competitive labour market, when reimbursement of commuting expenses is entirely offset by lower (gross) wages, so the total compensation paid by the employer is identical for workers with the same productivity. We will present the results of a panel data analysis, which indicates that the tax-induced explanation is unlikely to hold.

The outline of the paper is as follows. In section 2, we introduce the theoretical model. In section 3, we further discuss the role of taxes and the institutional setting of the Netherlands. In section 4, we investigate empirically the reimbursement of commuting costs, testing for monopsonistic behaviour. Section 5 concludes.

[6] In the empirical analysis, we focus on the Netherlands. We will explain later, in more detail, but in essence the lower tax rate applies only when the reimbursement exceeds a certain minimum and is less than a certain maximum. One of the consequences is that only a *part* of the reimbursement does not attract tax. For longer commutes, about 75% of the reimbursement is taxed as labour income. In the U.S., reimbursement of up to $105 per month for public transport, and $205 per month for parking, does not attract personal income tax. Furthermore, there are special tax rules related to company cars, including the value of the fuel provided to employees (IRS, 2008). In the U.K., reimbursement for parking is not taxed. The use of a company car, including free fuel, is also taxed at lower rates than income.

2. Theoretical analysis: optimal recruitment strategy in a spatial labour market with search

2.1 The spatial labour market

The model we will develop concerns a single firm operating in a spatial labour market. In this subsection, we begin by sketching the environment in which this firm operates. We consider a firm that is small in comparison to the relevant labour market, and therefore takes labour market conditions as given (e.g., Seater, 1979).[7] This labour market is spatial: employment and workers are dispersed over space, although in section 2.3 some attention will be devoted to the monocentric situation, in which all firms are located at a single site. All firms post a net wage that may depend on the residential location of the worker who fills a vacancy. The reimbursement for a worker living at distance x from the firm where he is employed is equal to the difference between the wage he earns, and the wage earned by a worker with commuting distance 0, who is employed by the same firm.

The utility of a job equals the difference between the offered wage (including the compensation for commuting cost) and the actual commuting cost incurred by the worker. The distribution of the utilities implied by the wage offers is therefore determined by the wage-posting behaviour of the firms with a vacancy, *and* by the worker's residence location, relative to these firms. An important implication of this setting is that even if all firms offer the same wage and partial commuting cost reimbursement, the implied worker utilities differ, depending on the residence location of the worker. In other words: in this case, the distribution of the worker utilities implied by the wage offers is not degenerate, because of the spatial element.

Given a non-degenerate distribution of utilities implied by the wage offers, workers determine their optimal search strategy in the usual way, that is, by accepting the first offer that implies a utility exceeding their critical (reservation) level. We allow for on-the-job search, and for the implied possibility that searchers at the same residential location can have different reservation utilities. The employer whose behaviour we study is assumed to know the distribution of the reservation wages at every residential location, but not the reservation utility of individuals. Since we allow for on-the-job search, we also take into account that workers can voluntarily quit their jobs, and that their propensity to do so depends on the wage offered by the employer.

[7] Note that we do not explicitly model the land / housing market. In section 2.2, we come back to this issue.

We assume the regional labour market to be in equilibrium, in the sense that none of the firms can increase profits by moving the workplace to a different location. Workers are assumed to be immobile, in the sense that they are unable to adjust their residential location at no cost. We assume that every worker has the opportunity to find employment in a number of different firms that are located at acceptable commuting distances, and that each firm has a number of different job-seekers in its vicinity. Indeed, except in one special case, the monocentric city, we treat firms and workers as being spread continuously over space, and assume a continuous distribution of reservation wages to job seekers at every distance from the firm.

To study reimbursement of commuting costs, we take as a benchmark a spatially homogeneous labour market, that is, a market in which the distribution is independent of the location of the job-seekers. A spatially homogeneous labour market is essentially a market where identical workers and firms are distributed continuously over space at a uniform density. The homogeneous labour market is a convenient starting point, because, in such a situation, incentives to reimburse commuting costs – in order to benefit from spatial heterogeneity (e.g., by attracting workers from areas with many other opportunities to find employment) – are lacking. In section 2.3, we discuss the implications of relaxing the assumption of spatially homogeneous labour markets.

2.2 The wage posting model with a homogeneous labour market

Let us concentrate on a single firm, within the spatial setting discussed above, and assume it has one vacancy. As long as the vacancy is not filled, the firm has a cost rate k (k>0). The vacancy is offered to job-seekers, at an intensity μ, which is beyond its control. The density of job-seekers at distance x from the firm is exogenously given, and denoted as $f(x)$. The firm will be allowed to make the offered wage a function of the commuting distance of the job-seeker. We will not impose any particular (for instance, linear) reimbursement schedule, but allow for complete generality in this respect.[8] The wage offered to a job-seeker at distance x is denoted as w_x. The implied reimbursement of commuting costs equals w_x minus w_0.[9]

[8] One reason for not imposing linearity of the reimbursement schedule, a priori, is that our data do not show this property. For example, hardly any reimbursement is given for short commutes.

[9] This is not a restrictive assumption. It is equivalent to the assumption that the worker's relocation decision is exogenous with respect to be reimbursement schedule, and that, after a residence relocation, the firm will just adjust the wage based on the new commuting distance, using the pre-announced reimbursement schedule. In the empirical model, variation in the commuting distance, due to residential relocations, will be used to identify the reimbursement schedule.

When the job-seeker accepts the wage, he will incur commuting costs that are proportional to the commuting distance *x*. To emphasize that the utility *v* depends on *x*, we rewrite the utility as $v_x = w_x - tx$, where *t* denotes transportation cost per unit of distance. Hence, the utility v_x refers here to the wage *w*, paid by the firm, *minus the commuting cost* (see Manning, 2003a). Job-seekers will accept all job offers that imply a utility that exceeds the reservation utility. Job-seekers are assumed to be identical in all aspects except for distance *x* and the reservation utility. As noted above, we assume that *the firm observes the commuting distance*, but *the firm does not know the job-seeker's reservation utility*. The reservation utility of job-seekers is a random draw from a distribution known to the firm, and denoted as $H(v_x)$. The corresponding probability density is denoted as *h*. We assume that the distribution *H* is log-concave, so, the second partial derivative of *H* is negative. Log-concavity is a weaker assumption than concavity. It is not restrictive, as many popular distributions possess this property, for instance, the uniform, the (truncated) normal, the lognormal and the gamma distributions (see, e.g., Bagnoli and Bergstrom, 2005).

Further, the support of *H* has a lower bound *b*, so no worker will accept a job if the offered net wage is less than *b*. One may interpret this lower bound as the reservation utility of unemployed searchers. It is 'sharp' in the sense that $H > 0$ if $v_x > b$. We allow the quit rate λ to be dependent on the worker's utility, so $\lambda = \lambda(v_x)$. We assume that the quit rate is decreasing and log-convex in its argument.

Denoting the value of a vacancy as V_0 and that of a filled position as V_1, we write the Bellman equation associated with V_0 as:

$$\rho V_0 = -k + \mu \int f(x)\, H(v_x)\, [V_{1x} - V_0]\, dx. \tag{1}$$

When the vacancy is filled, it adds *r*-*w* to the profits of the firm, where *r* denotes the contribution of this position to the firm's total value-added, and *w* the wage. Filled positions become vacant again at a (given) rate λ. The value of a filled position, V_{1x}, is defined by the following Bellman equation:

$$\rho V_{1x} = r - w_x + \lambda(v_x)\, [V_0 - V_{1x}]. \tag{2}$$

Interpretation of the above two equations is straightforward. Equation (1) states that the discounted present value of a vacant job is equal to the sum of the recruitment cost *k* and the expected additional value of filling the vacancy. Equation (2) states that the discounted present value of a filled position is equal to the difference between the profit rate (r-w_x) and the expected loss of the position becoming vacant. The firm chooses its optimal recruitment strategy by determining the optimal *wage offer function* w_x, so as to maximise the value of V_0, so the firm posts wage offers that depend on the length of the commute.

Given the above assumptions, it is shown in Appendix A.1 that this leads to the following equation for the wage offers:

$$w_x = r - \rho V_0 - \frac{1}{\frac{\partial \ln H(v_x)}{\partial w_x} - \frac{\partial \ln(\rho + \lambda(v_x))}{\partial w_x}}. \tag{3}$$

Note that we have modelled the wage behaviour of a *single* firm. In equilibrium, the number of firms may be argued to be endogenous, and firms may be assumed to enter the market such that $V_0 = 0$, but our conclusion does not require that assumption, so we assume only that V_0 is non-negative. Log-concavity of H and log-convexity of λ imply that the last term on the right-hand-side of (3) is positive. Hence, it can easily be seen that $w_x < r$. This immediately implies that the employment area is spatially-bounded. The reason is that, w_x-tx must be higher than b, for any worker at x to be willing to accept the wage offer.

It is shown in Appendix A.2 that the *overall* effect of distance x on the wage w_x is:[10]

$$\frac{dw_x}{dx} = \left(\frac{M}{N^2 + M}\right) t, \tag{4}$$

where:

$$M = -\frac{\partial^2 \ln H}{\partial w_x^2} + \frac{\partial^2 \ln(\rho + \lambda)}{\partial w_x^2}, \tag{5}$$

$$N = \frac{\partial \ln H}{\partial w_x} - \frac{\partial \ln(\rho + \lambda)}{\partial w_x}. \tag{6}$$

Under the log-concavity and log-convexity assumptions made previously, M is positive. Hence, the ratio on the right-hand-side of (4) is positive, and at most equal to 1. The implication is that the wages w_x will be set in such a way that commuting costs are *partially* reimbursed.[11] This is

[10] Note that we are interested in the overall, and not the partial, effect of x on the wage, because we estimate the overall effect of x later on.
[11] This result can also be derived within a search equilibrium model, in the spirit of the job-matching model of Pissarides (2000), when commuting costs are introduced (see the study by Van Ommeren and Rietveld (2005)). In

the main theoretical result of this paper. It shows that, in a homogeneous spatial labour market with search, monopsonistic firms have an incentive to reimburse the commuting costs of their workers. Note that this implies the unequal treatment of workers who are identical in all respects, except for their residential location. In particular, they are all equally productive.

To provide some intuition as to why it is attractive for a firm to engage in wage discrimination, consider what would happen if no reimbursement of commuting cost were offered. Without reimbursement of commuting costs, we would have a uniform wage w^*: $w_x=w^*$ for all $x>0$. Assume that the value of the uniform w^* equals that of $w_{x'}$, for a particular commuting distance x', under the optimal wage-posting strategy. With a uniform wage, the firm would attract more workers with shorter commutes, but less with longer commutes, than it would with the optimal reimbursement policy. All workers with a commute shorter than x' will have to be paid more, and the probability that such workers accept a job increases. Workers with a commute larger than x' will have to be paid less, with the uniform wage, but the probability that such workers accept the job offer decreases. This result implies that, in our model, the negative effect of the higher wages to be paid for short commutes, and the lower acceptance probabilities of the long-distance commuters, always exceeds the positive effect of the higher acceptance probabilities of the short-distance commuters (who already had a relatively high acceptance probability) and the lower wage for the long-distance commuters (whose number is relatively small).

Note that it will not be optimal for the firm to offer full compensation of commuting costs at all commuting distances, since this would attract many workers with long commutes to the firm, with (very) large total reimbursement costs as a consequence. A partial reimbursement will attract more workers to the firm, while keeping total reimbursement costs limited.

A simple illustration of the above result is obtained when the quit rate is independent of utility, and therefore exogenously given, and a homogeneous distribution of reservation utility is assumed:

$$H(v) = (v-b)/(a-b) \,, \tag{7}$$

such a set-up, the marginal reimbursement depends on the worker's bargaining power only, which is exogenously given. Note that in the latter study, firms have full information about job-seekers. We do not make such an assumption. In particular, the reservation utility is unknown. In our model, if the firm would observe the worker's reservation utility v^r, then the firm will pay a wage w_x such that w_x-tx = v^r, so w_x = v^r+tx. Hence, the firm will reimburse *fully* the worker's commuting costs.

defined for $b \le v \le a$. Substituting (7) into (3), and noting that $v = w_x - tx$, it follows that:

$$w_x = \frac{1}{2}(r - \rho V_0 + b + tx), \tag{8}$$

which shows that the marginal effect of distance on the wage is *t/2*, implying that half of the commuting costs will be reimbursed. In this illustration, the marginal reimbursement is a constant, and does not depend on any exogenous variable (e.g., the quit rate λ or recruitment cost *k*).

It is useful to compare the implications of equation (4) with those for a firm in a competitive labour market. In such a market, the firm will pay a wage that equals marginal productivity, so $w_x = r$, and subsequently $dw_x / dx = 0$. Clearly, there will not be any wage differentiation, within the firm, that is related to the length of the worker's commute.

2.3 Spatially heterogeneous labour supply and the housing market

In the previous subsection, we assumed that the labour market is spatially homogeneous: the distribution of the reservation utility does *not* depend on the job-seeker’s location. In reality, labour supply may not be spatially homogeneous. In that case, the distribution of reservation wages, and the quit rate, depends on *x*, and therefore will be denoted as $H_x(v)$ and $\lambda_x(v)$. Equation (3) still holds, with the suffix *x* added to *H* and *λ*, but no longer implies (4).

To see what can happen, we first consider the extreme case of a monocentric labour market: all firms are located on the same site. Moreover, we assume that all firms post a uniform wage, so that workers receive no reimbursement of commuting costs. We will consider the optimality of this strategy below. If all firms post a uniform wage, the distribution of the offered wages is identical for all workers. We assume that the unemployment benefit is related to worker utilities, and equals $b - tx$ for a worker located at distance *x* from the city centre. In these circumstances, job-acceptance behaviour is independent of the job-seeker’s location. This implies that the distribution of the reservation utilities satisfies:

$$H_x(w - tx) = H_0(w), \text{ for all } x>0 \tag{9}$$

where the subscript 0 refers to a residential location next to the employment centre, with zero commute. This equation states that if a firm offers a uniform wage *w*, the probability that the offer will be accepted is independent of the residential location of the job-seeker who receives the offer.[12]

Note that this also implies that the probability that a worker quits his job after having received a better wage offer is also independent of his residential location, implying that λ_x is independent of *x*, that is $\lambda_x = \lambda_0$, for all *x*>0. Now, substitute this result and (9) into (3) and observe that for any uniform wage (w_x=w*, for all *x*>0), the right-hand-side is independent of *x*. Thus, the left-hand-side, w_x, is also independent of *x*. Setting a uniform wage is therefore the optimal strategy for the firm. The optimal uniform wage is the one for which both sides of (3) are equal to each other. We have therefore identified a situation in which it is optimal not to reimburse commuting costs.

It may be noted that, in the monocentric setting just studied, the Diamond paradox may arise: if all firms post the same wage, then the wage-offer distribution degenerates. However, this is not necessarily the case: with a Burdett-Mortensen approach, the paradox could be avoided.

In reality, we do not expect a spatial labour market to be completely monocentric. Even in metropolitan areas with large concentrations of employment in the central business district (CBD), employment is usually very dispersed, spread over the whole urban area, and, often, substantial sub-centres exist as well. In such environments, equation (9) will, in general, not be satisfied, because it is unlikely that accessibility to jobs is perfectly correlated with distance to the firm, whose wage-setting behaviour we study. Therefore, we expect that there will usually still be an incentive for the firm to provide compensation for commuting cost.[13] To consider what may happen in such intermediate cases, we consider a labour market that is between the two extremes of complete homogeneity (with $H_x(v) = H_0(v)$), and monocentricity (characterized by (9)). More precisely, we assume that

$$H_x(v - \alpha(x)\, tx) = H_0(v)\,, \tag{10}$$

with $\alpha(x)$ a function of the commuting distance *x*, which takes on values between 0 and 1. If $\alpha(x)$ is always equal to zero, we have a homogeneous labour market; if it equals 1 everywhere, we are in the monocentric situation. When the firm whose behaviour we study is located in an

[12] It should be noted that the lower utilities experienced by workers with a larger *x* does not necessarily imply that their overall utilities are lower: in conventional monocentric models, the housing market provides compensation for longer commutes.

[13] It may also be noted that the unemployment benefit is usually independent of a worker's location, and this invalidates (9) – even if all employment is located on a single site.

employment centre (e.g., a CBD) we expect $\alpha(x)$ to be close to 1 for small commutes, and closer to 0 for larger ones. The reason is that the employment centre may be expected to have a large effect on workers living in its proximity, while, for workers living further away, other employment centres located elsewhere in the same regional labour market will be more important. We therefore allow $\alpha(x)$ to be a differentiable non-increasing function, taking on values between 0 and 1.

For similar reasons, we generalize the quit rate function to:

$$\lambda_x(v - \beta(x)\,tx) = \lambda_0(v)\,, \tag{11}$$

with $\lambda_x(v)$ the quit rate, as a function of the net wage for workers living at commuting distance x from the firm whose behaviour we study, and $\beta(x)$ a continuous non-increasing function, taking on values between 0 and 1.

It is shown in the Appendix A.3 that, in this more general model, we still find a positive value for dw_x/dx, whenever α or β is larger than 0. Perhaps somewhat surprisingly, we find that the marginal commuting reimbursement is not necessarily *partial* in this case: the value of dw_x/dx can be larger than 1, if the slope of the functions α or β is large in absolute value. We conclude therefore that employers, in general, have an incentive to reimburse commuting costs also, in non-homogeneous markets, as long as the regional labour market is not completely monocentric. Empirically this is not a restrictive condition.[14]

We expect that, with dispersed employment, there is only a weak correlation between accessibility to jobs in the regional labour market at large, and a job-seeker's distance to a particular firm. In such a situation, there will not be a systematic relationship between the job-seeker's distributions of utilities of offered jobs H_x and the commuting distance x. We note that, in the Netherlands, to which our empirical work refers, there are many employment centres within a relatively small distance of each other, especially in the densely-populated western part of the country. For this reason, we expect that, in this country, the spatial labour market is closer to the homogeneous extreme than to the monocentric one. In other countries, there are

[14] The assumption that all employment is located in a single centre is an extreme one, and universally contradicted by reality. If employment is decentralized, the housing market will not provide full compensation for commuting costs when the labour market is imperfect and workers accept job offers from different workplace locations. Empirical evidence confirms that the house price gradient in urban areas is far from steep enough to provide full compensation for commuting (see, e.g., Söderberg and Janssen (2001)).

metropolitan areas with large concentrations of employment in a limited number of centres, and in those cases the spatial labour market may be closer to the monocentric extreme, and we should expect less reimbursement of commuting costs.

The discussion thus far has referred to homogeneous groups of workers, as seems natural when we consider the behaviour of a single firm. If the firm uses different types of labour, it may differentiate the fringe benefits, possibly including the reimbursement of commuting costs, offered to various groups of workers.

3. Taxes and the reimbursement of commuting cost

In the Netherlands, as in many other countries, there are tax facilities for commuting reimbursement (e.g., Potter, et al., 2006). This is advantageous, for the purpose of the present paper, because reimbursement of commuting cost is specified separately from other earnings components. However, a potentially troublesome implication is that the presence of tax facilities for commuting reimbursement may provide incentives that interact with those provided by a monopsonistic market. To study this issue, we incorporate taxes and facilities into our model. We will first consider two simple cases, and then turn to the institutional setting of the Netherlands.

3.1 Two simple cases

When taxes are introduced into the model, it is useful to distinguish between workers' *net wage*s (wages after subtraction of income tax and social insurance premiums) and firms' labour cost. We assume that job-seekers react only to the net wage, and the symbol w_x will refer to this variable from now on. Labour cost is the sum of the net wage and taxes *T*, which may depend on income and the commuting distance of the worker:

$$T = T(w_x.x). \tag{12}$$

The employer should be aware of the fact that, in general, changing the wage will now imply a change in taxes. The second Bellman equation, (2), becomes:

$$\rho V_{1x} = r - w_x - T(w_x, x) + \lambda(v_x)\,[V_0 - V_{1x}], \tag{13}$$

while the first one remains unchanged. If taxes are linear in the net wage w_x and in the commuting distance *x*, it is shown in the Appendix that:

$$\frac{dw_x}{dx} = \frac{tM\left(1+\frac{\partial T}{\partial w_x}\right) - N^2 \frac{\partial T}{\partial x}}{\left(N^2+M\right)\left(1+\frac{\partial T}{\partial w_x}\right)}$$

$$= \frac{tM}{\left(N^2+M\right)} - \frac{N^2 \frac{\partial T}{\partial x}}{\left(N^2+M\right)\left(1+\frac{\partial T}{\partial w_x}\right)}, \tag{14}$$

where the symbols *M* and *N* have the same meaning as in the previous subsection. For instance, if the income tax is a piecewise linear function of the gross wage, as is the case in the Netherlands, the tax can also be expressed as a linear function of the net wage, as we do here. It is easily verified that if the marginal tax rate equals τ, we have $\partial T/\partial w = \tau/(1-\tau)$. We now consider two special cases:

Reimbursement is taxed as income. Suppose that the tax authorities do not distinguish between commuting reimbursement and other labour income, such as occurs in the U.K., for example. In that case, the tax does not react to the commuting distance itself $\left(\partial T/\partial x = 0\right)$, and (14) simplifies to (4). Hence the taxation has no affect on the reimbursement.

Reimbursement is taxed favourably. Suppose that tax authorities distinguish between payments for productive labour (which we call the 'normal wage', in the empirical part of our study), and reimbursement for commuting. The net wage w_x received by a worker is the sum of what remains of gross labour income y_x after taxation, plus the net reimbursement for commuting. We assume that the income tax is piecewise linear, and denote the relevant marginal tax rate as τ_w. We denote the gross reimbursement for commuting cost (given by the employer) as f_x, and assume that it is taxed proportionally at a rate $\tau_f < \tau_w$, as long as it does not exceed a prescribed maximum $f_x^{\max}$.[15] Reimbursements that exceed this maximum will be treated as normal wages. As long as the reimbursement does not exceed this maximum, we can write the net wage, therefore, as:

$$w_x = a + \left(1-\tau_w\right)y_x + \left(1-\tau_f\right)f_x \tag{15}$$

[15] The value of f_x^{max} may, for instance, be proportional to the length of the commute.

with *a* being a constant, related to the piecewise linearity. The total amount of taxes paid by the employer follows as:

$$T = -a + \tau_w y_x + \tau_f f_x . \tag{16}$$

An important implication of (15) and (16) is that a shift of one unit of money from the gross wage y_x to the reimbursement f_x implies that the net wage goes up by $\Delta w_x = \tau_w - \tau_f$, while tax payments go down by the same amount, $\Delta T = \tau_f - \tau_w$. Therefore, an employer who wants to minimize tax payments for a given net wage will choose the maximum allowable amount of commuting cost reimbursement, $f_x^{\max}$. Assuming that this strategy is followed, we substitute $f_x = f_x^{\max}$ into (15) and (16), solve (15) for y_x, and substitute the result into (16). The resulting expression implies a partial derivative of *T* (with respect to *x)* that is negative and equal to:

$$\frac{\partial T}{\partial x} = \left(\tau_f - \tau_w \frac{1-\tau_f}{1-\tau_w} \right) \frac{df_x^{\max}}{dx} . \tag{17}$$

It follows now from (14) that, in this situation, the partial derivative of the net wage, with respect to the commuting distance, will be larger than in the case where tax facilities for cost reimbursement are absent.

The above discussion suggests that exempting commuting cost reimbursement from income taxation creates an incentive to maximize the payments to the worker that are earmarked as such a reimbursement. As a consequence, the net marginal reimbursement of commuting costs $\partial w_x / \partial x$ is higher than it would be without the tax exemption. Note that, in general, this does not mean that the marginal reimbursement is equal to the marginal maximum reimbursement (that is, it does not imply $dw_x / dx = df_x^{\max} / dx$). The reason for this is that the gross wage y_x will be adjusted in such a way that the marginal reimbursement dw_x / dx has the optimal value for the employer's recruitment policy implied by (14). In other words, in addition to the explicit reimbursement $f_x^{\max}$, there will, in general, be an implicit reimbursement that is only apparent from the partial derivative dy_x / dx being unequal to zero.

Anticipating the discussion of the Dutch setting to which the empirical research of the paper refers, we would like to stress that our conclusions – with respect to the case with favourable taxation of commuting cost reimbursement – depend crucially on the ability of the employer to adjust the normal wage to the explicit cost reimbursement, so as to minimize tax payments. If this adjustment were not possible, it would also, in general, not be optimal to maximize the reimbursement.

3.2 The institutional setting in the Netherlands

The institutional setting in the Netherlands, to which our empirical work refers, is more complicated than the two examples above. First, it is important to note that wage bargaining results in a gross wage *y*, which is independent of a worker's commute, and possibly supplemented by a commuting cost reimbursement f_x. The tax rules concerning the commuting costs are as follows.

In the Netherlands, a *tax deductible* is based on the principle that any employee costs incurred in order to realize earnings (e.g., clothing) are deductible from taxable income. The cost of travelling from home to work is considered to be such a cost, and any employee with a commute of at least 10 km is therefore allowed to deduct a prescribed amount of money from his/her taxable income, when the employer does not reimburse (part of) the employee's commuting expenses.[16] This means that the amount of tax *T* to be paid depends negatively on the commute *x* ($\partial T/\partial x < 0$). According to (14), the optimal employer response to this situation would be to increase the marginal reimbursement $\partial w_x/\partial x$. The reason is that workers with long commutes are more attractive to the employer, since, for such workers, tax payments are lower.

In practice, this strategy is complicated by the fact that the employer sets the gross wage *y*. The tax savings associated with the deductible will therefore flow to the employee, unless the employer introduces a (negative) implicit reimbursement in the gross wage *y*, which is at variance with the bargaining agreements.

It should be noted that the incentive on commuting cost reimbursement provided by the tax deductible must be added to the incentive that originates from the spatial labour market situation. If the employer would be inclined to reimburse (part of the) worker's commuting cost in the absence of the tax deductible, the optimal reimbursement may still be positive after the effect of the tax deductible is taken into account. As previously noted, such a reimbursement is often part of the bargaining agreement. The worker must subtract this compensation from the amount of money he deducts from his taxable income. So, even though the reimbursement of

[16] The exact amount depends on some broad intervals of commutes, and differentiates between public and private transport – in an attempt to stimulate the former.

commuting cost itself is not taxed, the fact that the reimbursement received must effectively be added to taxable income implies that its effect on tax payment is the same as when it was taxed in the same way as the normal wage.

When the reimbursement provided by the employer exceeds the amount of money that can be subtracted from taxable income, the additional reimbursement has no consequences for the worker's taxable income. Effectively, this part of the reimbursement is exempt from income taxation, as long as the total reimbursement does not exceed a prescribed ceiling that depends on the length of the commute.[17]

3.3 Implication for empirical work

The implications of the tax treatment of commuting cost reimbursement for Dutch workers can be determined by the methods discussed in section 3.1. The presence of the tax deductible implies that, for a given net wage, the amount of tax to be paid decreases with in the commute: $\left(\partial T/\partial x < 0\right)$. As we have seen, this provides an incentive to the employer to increase the net wage with the commuting distance of the worker, while at the same time lowering the gross wage, which is excluded by the Dutch bargaining practices. Since many Dutch employers give a cost reimbursement (on top of a normal wage) that is independent of commute, the effect of the tax deductible appears to be limited.

If the reimbursement is so high that the tax deductible is exceeded, the analysis of section 3.1 suggests that the tax reimbursement should be maximized and the gross wage adjusted in such a way that the optimal value of the net wage will be reached. Again, this requires that the gross wage is made dependent on the worker's commute, which is at variance with the bargaining agreements.

In principle, it is possible that the labour market reacts to the incentives provided by the tax treatment of commuting cost reimbursement by a discrepancy between the formal results of bargaining and the actual process of wage determination, and that the latter confirms the results derived in section 3.1. If this were the case, we should observe employers maximizing commuting cost reimbursements to their employees, and introducing a relationship between the

[17] The amount that could be subtracted from taxable income depends on the length of the commuting distance in kilometres, and on the transport mode used. For example, in 1998, it was a maximum of 170 Dutch guilders per month for car drivers with a commute of at least 20 km, and a maximum of 390 Dutch guilders for public transport users with a commute of at least 80 km.

observable (gross and net) wages and the commuting distances, through implicit reimbursement. However, this does not seem to be the case. In our data, we find that earmarked commuting costs reimbursements reported by workers are usually well below the maximum that could be offered exempt from income taxation. Moreover, our analysis of normal wages does not provide evidence for the presence of implicit commuting cost reimbursement.

For this reason, we conclude that the institutional setting of the Netherlands differs from the model analyzed in section 3.1 because of the presence of an institutional constraint that prohibits implicit compensation of commuting cost via the normal wage. The appropriate model would then be one in which the normal wage is subject to income taxation but does not depend on the commuting distance, whereas the commuting cost reimbursement is taxed in-so-far as it does not exceed the tax deductible, and remains untaxed in-so-far as it exceeds this deductible. Since actual commuting cost reimbursements usually exceed the tax deductible, for the majority of workers the marginal tax rate on reimbursement received is equal to 0. As a consequence, the conclusions of the model without taxation appear to be relevant for the Dutch situation, despite the presence of various tax rules referring to commuting cost reimbursement.

In the next section, our empirical analysis proceeds on the basis of this conclusion, although we check for its appropriateness by investigating the presence of implicit commuting cost reimbursement. To anticipate the conclusion of this exercise: we do not find evidence for implicit reimbursement.

4. Empirical analysis: reimbursement of commuting costs in the Netherlands

4.1 Descriptives

Here, we study actual reimbursement of commuting costs in the Netherlands. It is important to start with the observation that simply finding a positive correlation between commuting distance and wage would not establish the relationship for which we are looking. Such a relationship may be the consequence of low-income workers living in small houses close to their jobs, and high-income earners living in spacious houses in the suburbs. It is therefore important to note that our analysis focuses explicitly on the size of the reimbursement, which is observed as a separate component of respondents' income, in our data set.

The data we use are based on a survey that was carried out bi-annually by the OSA (Organisation for Strategic Labour Market Research). We focus on employees. The survey contains the following question:

> "Over the last 12 months, did you receive a reimbursement of commuting expenses on top of your normal wage?"

In the case of a positive answer, respondents were asked for the monthly net reimbursement.[18] We focus on answers to this question, that is, on what one might call explicit reimbursement. Therefore, in the present section, we will distinguish between reimbursement and wages. This does not imply that we exclude the possibility of reimbursement of travel cost through the normal wage. We will also consider the possibility of such implicit reimbursement (e.g., reimbursement through wages), where this is appropriate. It may be recalled that the 'wage', in the theoretical model of the previous section, refers here to the sum of the normal wage and the explicit reimbursement.

Table 1 here

Until section 4.4, we concentrate on 1998, the most recent year for which the data are at our disposal.[19] From a sample with 2349 observations, we exclude observations referring to workers with a company car[20] and to respondents reporting to work less than 12, or more than 60, hours per week. Further, we exclude observations that are likely outliers.[21] This leaves us with 2078 observations.

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[18] We assume that respondents interpreted net reimbursement as referring to the amount of money paid by their employer as reimbursement of commuting expenses. In principle, the question could also be interpreted as referring to the amount of cost reimbursement that remains after its effect on the income tax has been subtracted. If respondents have chosen the other interpretation (that is, have computed the reimbursement that remains after taking into account the effect on income taxation), this affects the magnitude of estimated reimbursement, but not our conclusions.

[19] In section 4.4, we extend the analysis, with data from 1994 and 1996, in order to conduct a panel data analysis.

[20] In the large majority of cases, the company car is used for commuting. However, reimbursement of commuting cost is difficult to identify in these cases, as it cannot be distinguished from the compensation for travel for business purposes.

[21] Hence, we exclude workers who receive more than 1000 Dutch guilders per month as a reimbursement for commuting expenses, those who commute more than two hours (one way), and respondents who reported receiving a reimbursement, but stated that the reimbursement equals 0.

Table 1 shows the most relevant descriptive statistics.[22] We distinguish between workers with and without reimbursement. Workers who receive a reimbursement (36% of the sample) have an average commuting time that is twice as long, and earn, on average, 19% more, than other workers. The average reimbursement amounts to 133 Dutch guilders (approximately 60 euros) per month, in 1998 prices, approximately 5% of the net monthly wage.

In order to interpret the numbers shown in table 1, consider a representative full-time worker who travels half an hour from home to work, and vice versa, five days per week. His monthly commuting time is then 20 hours, approximately 12.5% of total monthly working hours. The reimbursement of commuting cost is therefore approximately one-third of the wage rate. The average reimbursement amounts to 6.5 Dutch guilders per hour of travel time. If we interpret this reimbursement as compensation for travel time, we must conclude that it is slightly lower than the value of travel time suggested by transportation studies, which often find values of time that equal about 50% of the wage rate (see, for instance, Small, 1992). However, this ignores the monetary costs of travel (fuel and maintenance for car drivers, or public transport expenses), which are about one-third of the total commuting costs, so reimbursement is about 50% of the workers' commuting costs. Hence, the descriptive statistics indicate that the reimbursement, on average, does not cover all commuting costs, in line with our theoretical model.

Table 2 here

Table 2 shows the relationship between commuting time and the explicit reimbursement for commuting costs. The share of workers receiving commuting reimbursement increases from less than 13% for those with a commute of at most ten minutes, to more than 60% for those who travel at least 30 minutes from home to work. It seems that the commute must exceed a threshold value before a worker receives a commuting reimbursement.[23] The amount of compensation received increases with commuting time, but does not appear to be proportional to commuting time.[24] The table also shows that compensation for commuting cost is a substantial share of net

[22] We use information about commuting time. We lack information about commuting distances. Both measures have their advantages, in the current context.

[23] The reason for this threshold may be found in administrative costs associated with reimbursement. Since the median commute is 17 minutes, a substantial fraction of workers is unable to claim reimbursement.

[24] The amount of compensation received per minute of commuting time is highest for those with short commutes, and decreases with the length of the commute. This makes sense when compensation for commuting expenses is

monthly wage for longer commutes, and comes close to 10% for those who travel more than one hour from home to work.[25]

4.2 Cross-section analysis

To gain additional insight into the determinants of receiving a commuting reimbursement, we estimate a standard probit model. To allow for nonlinear effects of commuting time, we also included its square and cube. Further, we interacted commuting time with permanent position.[26] Table 3 reports the results, including only a limited number of explanatory variables. There appears to be a significant effect of commuting time on the reimbursement probability. For commutes between 30 and 90 minutes, the probability of receiving reimbursement is an increasing convex function of commuting time. This pattern is consistent with the use of a threshold value for reimbursement claims, and with the information detailed in tables 1 and 2.

Further, we find that having a permanent position greatly increases the probability that compensation will be received, but it does not influence the effect of the commute on this probability. Note that the theoretical model presented above refers to jobs that are permanent. For temporary jobs, vacancy costs may be lower, and considerations with respect to the effect of reimbursement on the quit rate are probably absent, suggesting less compensation. Employment in the public sector implies a significantly lower probability of receiving compensation for commuting cost. This result is consistent with the idea that public organisations must internalize the external effects of commuting (e.g., congestion) and offer less reimbursement than private employers. Further, we find that employment at a large firm implies a significantly larger

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proportional to the length of the commute in kilometres, with a threshold value below which no compensation can be claimed. Such a reimbursement scheme implies that commuters who use a fast mode (car) will receive more compensation per minute of commuting time than those who use a slow mode (bike or public transport).

[25] There are substantial differences between the shares of workers receiving compensation for commuting cost, in various industries. Almost 50% of those employed in the financial sector receive such compensation, but only 28% of workers in the trade and retail industry; 33% of civil servants receive a reimbursement of their commuting cost. The differences between industries cannot be explained by tax incentives, since these are equal for all industries. Other explanations, related to the geographical location of firms in the various industries, have to be invoked. It may, for instance, be noted that companies in the trade and retail industry are more likely to be located close to residential areas, whereas companies in the financial sector and manufacturing are usually located in business districts. Approximately one quarter of the workers employed by a firm with less than 20 employees receive reimbursement for commuting cost, but more than 45% of those employed in a firm with more than 100 employees do so. Since large firms are more likely to have a monopsonistic position in local labour markets, this pattern is consistent with an explanation of reimbursement of commuting costs based on monopsonistic behaviour.

[26] We have included the monthly wage as a control variable, in alternative specifications. If reimbursement behaviour is (partly) driven by tax incentives, this variable will be endogenous. However, the coefficient for the wage was small, and statistically insignificant. Results for the model, excluding the wage, are almost identical to those reported here.

probability of receiving reimbursement.[27] The latter result suggests that larger firms have more monopsonistic power, but other explanations cannot be ruled out (see Burdett and Mortensen, 1998).

Tables 3 and 4 here

To examine the effect of commuting time on the reimbursement *level*, we estimated a linear equation, selecting only the observations of workers who receive a (positive) commuting reimbursement (710 observations). We employ a standard Heckman (1979) two-step procedure, to account for possible selection effects.[28] The column denoted as ‘Model I’ gives the results of a model with travel time as the only explanatory variable. It appears that workers receive a compensation of approximately 2.5 Dutch guilders per minute of commuting time.

Model II is a more elaborate version that also contains control variables. The marginal effect of commuting time on reimbursement is now about the same. In line with the theoretical model, these results imply that reimbursement is *partial*. The implied reimbursement for a one-hour commute is about one-fourth of the wage rate. The workers' costs of a one-hour commute are estimated to be considerably higher. Reimbursement is about one-third of the workers' commuting costs, and is therefore *partial*. In ‘Model III’, we add interactions between commuting time and a number of control variables: hours worked, industry and firm size. Interaction effects turn out to be less relevant.

4.3 Panel data analysis

Using the panel data, we report the results of an empirical investigation into the validity of the hypothesis that travel cost reimbursements are entirely tax-induced. If reimbursement of commuting cost is entirely tax-induced, changes in the commute of employees who changed residence but did not change their employer would result in a shift in the composition of total

[27] None of the other control variables included in the probit model has a significant coefficient. For instance, working on Saturday or Sunday does not appear to have a relationship to reimbursement of commuting cost, and, also, those with flexible working hours do not have a significantly smaller probability of receiving a reimbursement. Introduction of the hourly wage rate as a dependent variable does not result in a significant coefficient.

[28] The squared and cubed commutes have been used in the first step, but not in the second step. This approach can be justified, as these commutes are less likely to have an effect, given a positive reimbursement. We have also estimated tobit models. However, if employers use a (positive) threshold value for the compensation of commuting costs, then the tobit specification is misspecified.

payment: a larger commuting time would imply a higher compensation for commuting cost, but a lower normal wage. In a cross-section, differences in the composition of total payments could be the result of heterogeneity between employer and employees. Panel data allow us to control for such differences.[29]

The data for 1998, used in the previous subsection, are a single wave from a larger panel data set, and therefore they allow us to carry out this test. Every two years, a new wave is added to the OSA panel. We have combined the data from 1994 and 1996 with those of 1998. The total number of observations in these three waves is 7372. These data allow us to measure the effect of a change in the commute, while keeping the characteristics of the worker, and his employer, constant. In order to keep employer characteristics constant, we select workers who were observed at least twice and did not change employer. Hence, as argued in the introduction, we fully control for firm characteristics (such as size and location). Moreover, we selected observations in which the employee received a positive amount of reimbursement (similar to the previous subsection). The remaining 1112 annual observations refer to 488 individuals. We have estimated workers' fixed effects regression models, using these data. Since we control for worker-specific fixed effects, we also control for worker-specific *selection* effects, so correction approaches are not necessary, given fixed effects.

Table 5 here

In Table 5, we report the effect of the (time-varying) explanatory variables on three income components. The second column of table 5 shows a marginal effect of 2.13 Dutch guilders on the level of reimbursement, per minute of commuting time.[30] This effect is close to – but somewhat smaller than –the earlier cross-section estimate. It is still highly statistically significant. As noted above, the size of the effect implies that reimbursement is partial, in line

[29] It may be noted that the residential moving behaviour of workers, and the way it is potentially affected by commuting cost reimbursement, was not included in our theoretical model. However, the possible existence of such a relationship is immaterial for the purpose of the panel data analysis: to show that reimbursement of commuting cost is real and related to commuting distance, and not a device to avoid the income tax on part of the wage.

[30] The data do not allow us to identify, directly, those workers who moved residence, but changes in commuting time are registered, and this is the variable that is relevant for our purpose. It is plausible, however, that some workers report changes in commuting time that are caused by changes in infrastructure or congestion. In such cases, we expect the compensation for commuting cost (which is perhaps more related to commuting distance than to commuting time) to remain constant, in most cases. It is probable that this introduces a bias towards zero, in the estimated marginal effect of commuting time on the compensation. So, our results are conservative.

with the theoretical model. Recall that it is assumed that the workers' productivity/added value (in the theoretical model measured by *r*) is *not* related to the length of the commute. One may argue however that workers with longer commutes are *less* productive. Workers with long commutes may arrive late more often than others, may be absent more or exhibit less concentration during the working day. This effect can be incorporated into the theoretical model, by rewriting the value added, *r*, as a negative function of the commute.

The third column shows that there is no discernible negative effect of commuting time on the normal wage. The coefficient is small and highly insignificant. If there is any effect, it is more likely to be positive. This implies that there is no support for the view that a portion of regular earnings will be switched to a compensation for commuting cost, in order to realize a tax benefit – for the employer or the worker – when the commute increases.[31] These results suggest that if a reduced tax on reimbursement has any effect on the level of reimbursement, then the implicit subsidies accrue to workers and not to firms, in line with monopsony (see Zax, 1988).

The fourth column shows that the sum of normal wage and reimbursement increases when a worker's commuting time increases. The coefficient for travel time is larger than that estimated for the reimbursement equation (second column). Its standard error is of similar size to that estimated for the travel time coefficient in the normal wage equation (third column), reflecting the larger noise component in this variable. This result illustrates the relevance in distinguishing commuting costs reimbursement from other income components.

The results are consistent with the panel data study by Manning (2003a), for the U.K., which also shows a positive relationship between wages and commuting. In this study however, it is not possible to distinguish between 'normal wages' and explicit reimbursement, and the study does not control for workplace (by selecting workers who do not change employer). Manning (2003a) convincingly points out that the positive relationship between wages and the commute cannot be explained by the presence of wage differences within or between urban areas, viz. the presence of a wage gradient. The latter interpretation has been common in the urban economics literature, but is based on cross-section studies entirely. In the current panel data analysis, we control for workplace location (by selecting workers who do not change workplace), hence our result may also *not* be interpreted as the result of a wage gradient.

[31] Note that the normal (after-tax) wage may change if the worker moves residence, as income tax in the Netherlands depends on the tenure of the residence and the size of mortgage (interest payment are deductible). Apparently, this effect is not systematically related to the length of the commute.

Until now, we have assumed that the effect of the commute on the level of reimbursement, and on the normal wage, is causal, but we have ignored the possibility that this causal effect could be the other way around. At least theoretically, it is possible that high-income workers have a longer, or a shorter, commute. For example, in a standard monocentric city model, high-income workers prefer to live in a large residence, when residential space is a normal good (Fujita, 1989). As a result, low-income workers live in small residences close to their jobs, whereas high-income workers live in larger residences, in the suburbs. In the time-extended monocentric city model, where the time costs of commuting are positively-related to income, the result may be reversed: high-income workers live in small residences close to their jobs, whereas low-income workers live in larger residences, in the suburbs (see Fujita, 1989). We emphasise here that the reversed effect of the level of reimbursement on commuting time can be easily excluded. Recall that we include only workers who remain with the same firm. It is extremely implausible that firms (systematically) change the level of reimbursement, and therefore workers change residence. Given the current data, it is straightforward to show that the reversed effect of the (normal) wage on commuting time can be excluded by estimating a worker's fixed-effects model, with commuting time as the dependent variable and the normal wage as the independent variable. Similar to the results shown in table 5, there appears to be no statistical relationship between the normal wage and commuting time.

Summarizing, the results presented in table 5 confirm our hypothesis that employees receive *partial* compensation from their employers when they have a large commute. Since the reimbursement of commuting costs increases and the normal wage does *not* decrease, this implies that labour cost increases with the commute. As argued above, this is consistent with monopsonistic behaviour, but not with a competitive labour market.

5. Conclusion

This paper documents the widespread presence of commuting cost reimbursement, for workers in the Netherlands. Approximately one-third of workers in the Netherlands receive a compensation for commuting costs. A wage-posting model is used to show that reimbursement of commuting cost may be interpreted as an instrument of a monopsonistic employer's recruitment policy, and is an example of *intra-firm* wage differences for equally-productive workers. [32]

It is noted that the country-specific tax treatment of such reimbursement may have strong effects on the marginal reimbursement level offered by the firm, as well as on the reduction in other labour-income components offered by the firm. Interestingly, it is shown that it may be optimal for monopsonistic firms to offer a commuting reimbursement – taking full advantage of the lower income taxes on commuting reimbursement – but, at the same time, not adjust other labour payments to the worker.

The empirical analysis of the current paper is consistent with the notion of intra-firm discrimination based on worker's commute. A panel data analysis demonstrated a positive effect of commuting time on reimbursement, but showed no evidence of an offsetting reduction in other labour-income components, which one would expect in a perfectly-competitive labour market with tax-induced reimbursement of commuting costs. [33]

In the Dutch labour market, the average reimbursement for commuting is about 5% of net monthly income, with one out of three workers receiving this reimbursement. Hence, up to 1.7% of average employer payments to workers may be explained by intra-firm wage variation, due to the spatially monopsonistic behaviour of employers.[34] The level of reimbursement depends on the length of the commute. For workers with a minimal commute (e.g., less than ten minutes one-way; about 30% of the workforce), average reimbursement is 0.3% of net income, and therefore almost negligible. For workers with a one-way commute that exceeds one hour (about 7% of the workforce), reimbursement is approximately 6.9% of net income, and therefore clearly

[32] There exists a large literature on wage dispersion and productivity, which essentially argues that greater *intra-firm* wage disparity may reduce team performance, as wage disparity is seen as not being fair (e.g., Akerlof and Yellen, 1988; Depken, 2000). In this literature, individual wage differences are based on individual differences in productivity. In contrast, we focus on the wage differences of workers who are equally productive, but differ (only) in their commuting costs. Note that reimbursement of commuting expenses is in line with (economic) notions of fairness (e.g., Feldman and Kirman, 1974), since those who are worse off receive a higher level of reimbursement.

[33] Our study has consequences not only for labour economists interested in the competitiveness of the labour market, but it also has implications for the setting of optimal taxes. In particular, a large number of studies have shown that the external costs of commuting are substantial, due to congestion and negative environmental impacts. Economists' natural response to external costs is the introduction of a Pigouvian road tax. The general welfare effects of such a tax must be evaluated, given the presence of distortionary labour taxes; it has been argued that road tax is only welfare-improving when tax revenues are reduced, in order to reduce taxes on labour income (see e.g., Parry and Bento, 2001). Our study points out that it is not implausible that a road tax is *partially* reimbursed by employers, an element which is missing in these models. Our study suggests that up to one-third of a worker's expenses is reimbursed via a road tax. As far as we know, the effect of road-pricing schemes on compensation by employers has received little explicit attention.

[34] The descriptive data and the panel data analyses indicate reimbursement effects of about the same order of magnitude, so we may interpret the above-mentioned 5% as a causal effect.

substantial. Such an estimate of monopsonistic effects is not unreasonable, in the light of previous studies, which show that gross wages are about 20% less than marginal productivity levels (e.g., Card and Krueger, 1995). Our results suggest therefore that workers with a long commute are able to reduce the gap between wages and productivity levels up to one quarter. In light of our monopsonistic model, applicants with a long commute are able to substantially reduce the monopsonistic power of the employer, because, for these applicants, employment *at this firm* is less valuable.

Appendix

A.1 Derivation of the optimal wage

To find a wage offer at an arbitrary location x, we rewrite (1) as:

$$\rho V_0 = -k + \mu \int f(x) H(w_x - tx)[V_{1x} - V_0] dx \,. \tag{A1}$$

The probability θ that a job-seeker will accept a job offer is equal to $\theta = \int f(x) H(v_x)\, dx$.

Rearranging terms and using the definition of θ, (A1) becomes:

$$V_0 = \frac{-k + \mu \int f(x) H(w_x - tx) V_{1x} dx}{\rho + \mu \theta} \,. \tag{A2}$$

The employer maximizes V_0 by choosing the offered wage, as a function of x. The first-order condition implies then that for every x: $\partial V_0 / \partial w_x = 0$. Elaboration of this condition gives:

$$\begin{aligned}(\rho + \mu\theta)\mu\, f(x)\left[h(w_x - tx) V_{1x} + H(w_x - tx) \frac{\partial V_{1x}}{\partial w_x} \right] - \\ \left[-k + \mu \int_0^\infty f(z) H(w_z - tz) V_{1z} dz \right] \mu \frac{\partial \theta}{\partial w_x} = 0.\end{aligned} \tag{A3}$$

To simplify this expression, we observe that the second expression in square brackets equals $(\rho + \mu\theta) V_0$ V_0 and that:

$$\frac{\partial \theta}{\partial w_x} = f(x)\, h_x (w_x - tx) \,. \tag{A4}$$

This allows us to rewrite (A3) as:

$$h(w_x - tx)\left(V_{1x} - V_0\right) + H(w_x - tx)\frac{\partial V_{1x}}{\partial w_x} = 0. \tag{A5}$$

The next step is to compute the partial derivative $\partial V_{1x} / \partial w_x$. We start by rewriting (2) as:

$$V_{1x} = \frac{r - w_x + \lambda\left(w_x - tx\right)V_0}{\rho + \lambda\left(w_x - tx\right)} \tag{A6}$$

and use this to derive:

$$\frac{\partial V_{1x}}{\partial w_x} = -\frac{1 + \left(\partial\lambda(w_x - tx)/\partial w_x\right)\left(V_{1x} - V_0\right)}{\rho + \lambda(w_x - tx)}, \tag{A7}$$

and substitute this result into (A5). After rearranging terms, we get:

$$V_{1x} = V_0 + \frac{H(w_x - tx)}{(\rho + \lambda(w_x - tx))\,h(w_x - tx) - (\partial\lambda(w_x - tx)/\partial w_x)H(w_x - tx)}. \tag{A8}$$

After substitution of V_{1x} from (A6) into (A8), we can derive the following expression for w_x:

$$\begin{aligned} w_x &= r - \rho V_0 - \frac{1}{\dfrac{h(w_x - tx)}{H(w_x - tx)} - \dfrac{\partial\lambda(w_x - tx)/\partial w_x}{\rho + \lambda(w_x - tx)}} \\ &= r - \rho V_0 - \frac{1}{\dfrac{\partial \ln H(w_x - tx)}{\partial w_x} - \dfrac{\partial \ln\left(\rho + \lambda(w_x - tx)\right)}{\partial w_x}}. \end{aligned} \tag{A9}$$

This is equation (3) in the main text (note that $v_x = w_x - tx$).

This derivation assumes that H is positive. As noted in the main text, this requires that the net wage is at least equal to b, the lower bound of the support of H:

$$w_x \geq b + tx\,. \tag{A10}$$

It follows then that the third term on the right-hand-side of (A9) is defined only for wages that satisfy condition (A10). If this condition is not satisfied, no wage can be set. This can be interpreted as saying that commuting distances for which (A10) is violated are outside the recruitment area of the firm.

The assumptions made about the distribution of the reservation utility and the quit rate imply that the third term on the right-hand-side of (A9), and therefore the whole right-hand-side of this equation, is decreasing in w_x. The left-hand-side is, of course, increasing, with a slope equal to 1. Therefore, we can conclude that there will be a value of w_x that satisfies (A10) if and only if the left-hand-side of (A9) is smaller than the right-hand-side for $w_x=b+tx$, that is, if and only if:

$$r-\rho V_0-\frac{1}{\frac{\partial \ln H(v_x)}{\partial w_x}-\frac{\partial \ln(\rho+\lambda(v_x))}{\partial w_x}}\geq w_x \text{ if } w_x=b+tx \ . \qquad \text{(A11)}$$

A.2 The relationship between the optimal wage and the commuting distance

To determine the sign of dw_x/dx, we rewrite (A9) as:

$$w_x=r-\rho V_0-\frac{1}{N}, \qquad \text{(A12)}$$

where

$$N=\frac{\partial \ln H(v_x)}{\partial w_x}-\frac{\partial \ln(\rho+\lambda(v_x))}{\partial w_x}. \qquad \text{(A13)}$$

From (A12) we derive:

$$dw_x=\frac{1}{N^2}dN \ . \qquad \text{(A14)}$$

Further,

$$dN=\frac{\partial^2 \ln H(v_x)}{\partial w_x^2}(dw_x-tdx)-\frac{\partial^2 \ln(\rho+\lambda(v_x))}{\partial w_x^2}(dw_x-tdx) \ . \qquad \text{(A15)}$$

If we substitute this result into (A14) and rearrange terms, we obtain:

$$\frac{dw_x}{dx}=\frac{tM}{N^2+M} \qquad \text{(A16)}$$

where:

$$M=-\frac{\partial^2 \ln H(v_x)}{\partial w_x^2}+\frac{\partial^2 \ln(\rho+\lambda(v_x))}{\partial w_x^2}. \qquad \text{(A17)}$$

A.3 A non-homogeneous labour market

We now generalize the model studied in section A.2, and apply it to the situation described by equations (10) and (11) in the main text. Taking into account that the distribution of the reservation wage H and the quit rate λ are now both dependent on the commuting distance x, instead of (A9), we derive:

$$w_x = r - \rho V_0 - \frac{1}{\frac{\partial \ln H_x(w_x - tx)}{\partial w_x} - \frac{\partial \ln(\rho + \lambda_x(w_x - tx))}{\partial w_x}}. \tag{A18}$$

Substitution of (10) and (11) gives:

$$w_x = r - \rho V_0 - \frac{1}{\frac{\partial \ln H_0(w_x - (1-\alpha(x))\,tx)}{\partial w_x} - \frac{\partial \ln(\rho + \lambda_x(w_x - (1-\beta(x))tx))}{\partial w_x}}. \tag{A19}$$

Defining N' as:

$$N' = \frac{\partial \ln H_0(w_x - (1-\alpha(x)tx))}{\partial w_x} - \frac{\partial \ln(\rho + \lambda_x(w_x - (1-\beta(x))))}{\partial w_x}, \tag{A20}$$

we now write:

$$dw_x = \frac{1}{N'^2} dN'. \tag{A21}$$

Proceeding in the same way as in section A.2, we elaborate dN' as:

$$\begin{aligned} dN' = {} & \frac{\partial^2 \ln H_0(v_x)}{\partial w_x^2}(dw_x - ((1-\alpha(x)) - \alpha'(x))tdx+) - \\ & \frac{\partial^2 \ln(\rho + \lambda(v_x))}{\partial w_x^2}(dw_x - ((1-\beta(x)) - \beta'(x))tdx), \end{aligned} \tag{A22}$$

where α' and β' denote the first-order partial derivatives of α and β, respectively. Since both functions are assumed to be non-increasing, these derivatives are non-positive. Rearranging terms, we now derive:

$$\frac{dw_x}{dx} = \frac{1}{N'^2 + M'} t\left[-\frac{\partial^2 \ln H_0}{\partial w_x^2}(1-\alpha(x) - \alpha'(x)) + \frac{\partial^2 \ln(\rho + \lambda_x)}{\partial w_x^2}(1-\beta(x) - \beta'(x)) \right] \tag{A23}$$

where M' is similar to M in (A17), but now for x-specific H and λ.

From (A23), it is easy to verify that $dw_x/dx=0$, when α and β are always equal to 0 (monocentric case), and that we obtain the same result as derived in section A.2, when α and β are always equal to 1 (homogeneous labour market). For intermediate cases, (A23) implies that, under the assumptions made with respect to H, λ, α and β, $dw_x/dx>0$ if α or β (or both) are less than zero. Note, however, that we can no longer be sure that there is partial compensation only: there may be full, or even more than complete, compensation of the cost of an additional commuting kilometre, when the derivatives α' and β' are large in absolute value.

A.4 The effect of taxes

The consequences of using (13) instead of (2) to derive an equation for the optimal wage, similar to (A9), are modest. Equations (A1)-(A5) remain unchanged, but (A6) becomes:

$$V_{1x} = \frac{r - w_x - T(w_x) + \lambda(w_x - tx)}{\rho + \lambda(w_x - tx)}. \tag{A24}$$

Taking the partial derivative with respect to w_x, instead of (A7), we find:

$$\frac{\partial V_{1x}}{\partial w_x} = -\frac{1 + \partial T/\partial w_x + (\partial\lambda(w_x - tx)/\partial w_x)[V_{1x} - V_0]}{\rho + \lambda(w - tx)}. \tag{A25}$$

Substitution of this result into (A5) then gives:

$$V_{1x} = V_0 + \frac{H(w - tx)\left(1 + \dfrac{\partial T(w_x, x)}{\partial w_x}\right)}{(\rho + \lambda(w - tx))h + (\partial\lambda(w - tx)/\partial w_x)H(w - tx)}, \tag{A26}$$

which should extend (A8). Further elaboration then yields an equation that is analogous to (A9):

$$w_x = r - \rho V_0 - T(w_x, x) - \frac{1 + \dfrac{\partial T(w_x, x)}{\partial w_x}}{\dfrac{\partial \ln H(w_x - tx)}{\partial w_x} - \dfrac{\partial \ln(\rho + \lambda(w_x - tx))}{\partial w_x}}. \tag{A27}$$

Using the same notation as in section A.3, we can write:

$$dw_x = -\frac{\partial T}{\partial w_x} dw_x - \frac{\partial T}{\partial x} dx - \frac{1}{N^2}\left[\left(\frac{\partial^2 T}{\partial w_x^2} dw_x + \frac{\partial^2 T}{\partial w_x \partial x} dx\right) N - \left(1 + \frac{\partial T}{\partial w_x}\right) dN\right]. \tag{A28}$$

Further elaboration gives an equation that is analogous to (A9):

$$\frac{dw_x}{dx} = \frac{tM\left(1 + \dfrac{\partial T}{\partial w_x}\right) - N^2 \dfrac{\partial T}{\partial x} - N \dfrac{\partial^2 T}{\partial w_x \partial x}}{(N^2 + M)\left(1 + \dfrac{\partial T}{\partial w_x}\right) + N \dfrac{\partial^2 T}{\partial w_x^2}}. \tag{A29}$$

This looks considerably more complicated than equation (4) in the main text. However, it is easy to verify that the equation simplifies to (4) if all partial derivatives of the tax *T* are equal to zero.

If we restrict attention to taxes that are linear in the two parameters w_x and x, the second-order partial derivatives are all equal to zero, and (A29) becomes:

$$\frac{dw_x}{dx} = \frac{tM\left(1+\frac{\partial T}{\partial w_x}\right) - N^2 \frac{\partial T}{\partial x}}{\left(N^2 + M\right)\left(1+\frac{\partial T}{\partial w_x}\right)} \quad . \tag{A30}$$

This is equation (14) in the main text.

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Table 1. Descriptive statistics.

	Workers with reimbursement	Workers without reimbursement
Number of observations	739	1339
Average commuting time[1]	31.37	15.85
Average net monthly wage[2]	2861.96	2402.23
Average monthly reimbursement[2]	132.93	-
Reimbursement/monthly wage	0.051	-

[1] Minutes, one-way trip
[2] Dutch guilders, at current (1998) prices

Table 2. Commuting reimbursement and commuting time.

Commuting time[1]	% receiving reimbursement	Average amount of reimbursement[2]	Reimbursement/ Net monthly wage
0	0	-	-
1-5	8	70.36	0.025
6-10	13	79.87	0.033
11-15	27	83.64	0.037
16-20	49	109.22	0.048
21-25	54	157.57	0.064
26-30	53	121.35	0.047
31-45	73	159.04	0.054
46-60	74	190.56	0.068
>60	65	275.59	0.095

[1] Minutes, one-way trip
[2] The average refers only to workers who receive compensation for commuting cost, expressed in Dutch guilders at current prices

Table 3. Probit estimates for receipt of reimbursement for commuting costs.

Variable	Coefficient (st. err.)
Commuting time	0.124 (0.011)
(Commuting time)^2/10^2	-0.182 (0.028)
(Commuting time)^3/10^4	0.0804 (0.019)
Permanent position	0.578 (0.14)
Hours worked per week	-0.002 (0.004)
Metal manufacturing	0.211 (0.16)
Other manufacturing	0.104 (0.16)
Trade and retail	-0.240 (0.13)
Transport	-0.0740 (0.16)
Financial sector	0.160 (0.14)
Public sector	-0.383 (0.11)
20-100 employees	0.113 (0.09)
More than 100 employees	0.350 (0.09)
Control variables	Yes
Number of observations	1987
Log likelihood	-974.24

In addition to the variables reported in the table, we include a constant and controls for gender, age, wage, education, type of work (dangerous, dirty, etc.), job level dummies, working on Saturday or Sunday, flexible working hours, and the presence of a partner. The reference for industry is a remainder category containing agriculture, mining, construction and public utilities; the reference for firm size is firms with less than 20 employees, and a small number of observation for which firm size was not reported. When only a constant is estimated the likelihood is –1352.49. The pseudo-R^2 equals .25. Standard errors are reported in parentheses.

Table 4. Determinants of reimbursement of commuting costs.

Variable	Model I	Model II	Model III
Constant	55.44 (16.69)	-18.20 (15.34)	- 57.80 (60.1)
Commuting time	2.55 (0.26)	2.68 (0.28)	4.52 (1.19)
Hours worked per week		2.62 (0.51)	3.42 (0.81)
Comm. time*Working hours			- 0.034 (0.025)
Comm. time*Metal			-0.78 (0.87)
Comm. time*Other Man.			-0.71 (1.06)
Comm. time*Trade and retail			-0.68 (0.74)
Comm. time*Transport			-0.42 (0.88)
Comm. time*Financial sect.			-0.28 (0.66)
Comm. time*Public sector			-1.16 (0.60)
20-100 empl.		-25.23 (10.14)	3.60 (19.1)
More than 100 empl.		-14.66 (10.06)	-27.7 (18.5)
Comm. time*20-100 empl.			-0.97 (0.52)
Comm. time* More than 100 empl.			0.33 (0.49)
Control variables	No	Yes	Yes
λ *(inverse Mill's ratio)*	- 4.36 (12.5)	-10.04 (15.07)	12.71 (15.28)
Number of observations		710	

Heckman's two-step procedure has been applied, in order to correct for possible selectivity effects. The probit model of the previous subsection has been used as the selection equation. In models II and III, all the variables used in this probit model, except the squared and cubed commutes, have been added as control variables. Without this correction, linear regression gives almost identical results for each of the three models. Standard errors are reported in parentheses.

Table 5. Fixed effects results for three income components.

Variable	Reimbursement	Wage	Reimbursement + wage
Commuting time	2.13 (0.27)	0.925 (1.2)	2.79 (1.2)
Hours worked	1.33 (0.87)	45.07 (4.0)	47.34 (4.2)
Dummy for 1996	8.33 (4.3)	224.81 (19.8)	232.42 (20.5)
Dummy for 1998	10.23 (5.5)	280.98 (25.2)	293.41 (26.1)
R^2 between	0.20	0.32	0.35

Standard errors are reported in parentheses.