TI 2007-060/3
Tinbergen Institute Discussion Paper

Welfare Effects of Distortionary Company Car Taxation

Eva Gutiérrez Puigarnau[1]
Jos van Ommeren[1,2]

[1] *VU University, Amsterdam;*
[2] *Frisch Center, Oslo.*

Tinbergen Institute
The Tinbergen Institute is the institute for economic research of the Erasmus Universiteit Rotterdam, Universiteit van Amsterdam, and Vrije Universiteit Amsterdam.

Tinbergen Institute Amsterdam
Roetersstraat 31
1018 WB Amsterdam
The Netherlands
Tel.: +31(0)20 551 3500
Fax: +31(0)20 551 3555

Tinbergen Institute Rotterdam
Burg. Oudlaan 50
3062 PA Rotterdam
The Netherlands
Tel.: +31(0)10 408 8900
Fax: +31(0)10 408 9031

Most TI discussion papers can be downloaded at http://www.tinbergen.nl.

WELFARE EFFECTS OF DISTORTIONARY FRINGE BENEFITS TAXATION: THE CASE OF EMPLOYER-PROVIDED CARS

Eva Gutiérrez-i-Puigarnau

VU University, Amsterdam, The Netherlands
egutierrez@feweb.vu.nl

Jos van Ommeren

VU University, Amsterdam, The Netherlands
jommeren@feweb.vu.nl

20-03-2009

Abstract

In Europe, for many employees, the employer-provided car is the single most important fringe benefit. Company cars are provided by employers as fringe benefits to their employees at a much lower (implicit) price than employees pay in the car market, mainly because of favourable taxation of company cars. We analyse the welfare effects of favourable taxation of company cars for the Netherlands by estimating to what extent the household's demand for cars changes when employees receive a company car. We find that favourable taxation of company cars generates a substantial welfare loss of about €900 per year per company car. This loss is largely due to a shift towards more expensive cars (about €700 per year), whereas the welfare loss due to increased car travel turns out to be smaller (about €200 per year). For the whole of Europe, the deadweight loss is estimated to be about 18 billion per year.

Keywords: Fringe benefits; taxation; company car; welfare

JEL codes: D12; D61; J33; R41; R48

The authors are grateful to Stef Proost, Piet Rietveld, Knut Roed, Jan Rouwendal, Erik Verhoef and Aico van Vuuren for comments on an earlier version of this article. Jos van Ommeren is affiliated to the Tinbergen Institute, Amsterdam, The Netherlands.

1. Introduction

One of the core activities of many economists is to focus on the optimal setting of taxes in the economy. Not surprisingly, labour market economists spend a lot of time analysing the effect of income taxation on the welfare in the economy. The majority of the latter research focuses on the distortionary effect of taxation of wages. Although the supply and demand for fringe benefits receive a lot of attention in economics textbooks (e.g. Ehrenberg and Smith, 2003), the effect of distortionary fringe benefits taxation receives little attention in the recent empirical literature.[1] This scarce attention may be justified as previous studies have found that the distortionary effect of fringe benefits taxation is small (Turner, 1987). However, these studies have ignored the provision of cars by employers, so-called *company cars*, which in Europe have become by far the most important category of fringe benefits. Employer-provided cars are cars that are either owned or, more frequently, leased by employers and provided to their employees for *private* usage. The employer pays for the car (or the car lease) including insurance, repairs and taxes. Furthermore, it is common that the employer pays for fuel consumption of private trips.

Company car policies are usually determined by occupation within companies (Tillema et al., 2008). As a general rule, employees at the top of companies are more likely to receive company cars. The same holds for employees who frequently use a car for business purposes (e.g. sales functions). Typically, administrative functions do not receive company cars. Nowadays, the large majority of company cars are provided through lease companies. When firms offer lease cars for certain occupations, they generally do not restrict the type of car, but restrict the maximum car lease cost (e.g. €1,000 per month). Hence, most employees may freely choose from a large number of types of cars (restricted by the firm's maximum lease costs). There is little known about to what extent employees may bargain with their

[1] One exception is healthcare benefits in the US (e.g. Gruber, 2001; Gruber and Lettau, 2004).

employers about a lease car, for example by trading off gross wages or other fringe benefits. Most evidence indicates however that few employees (have the option to) refuse company cars as a part of their employment contract. So, whether an employee has a company car is mainly determined by the firm's company car policy. Employees are required to hold on to the company car for the length of the lease contract, which is typically three to five years in most countries. If employees leave the firm before the lease contract expires, then the firm is still liable for the lease car cost. The lease contract between the firm and the lease company may be terminated before the stipulated end of the contract, but this is costly to the firm. On the other hand, firms that lease a large number of cars typically receive a bulk discount up to 10%.[2]

Company cars are extremely common. For example, in the Netherlands, which will be the focus of our empirical analysis, about one in seven male employees and one in 38 female employees has a company car (Statistics Netherlands, 2003).[3] In two-adult households with at least one car, which is the typical household formation in the Netherlands, the proportion of households with a company car is about 15%. Compared to other European countries, the Netherlands seems to take an average position in this respect, whereas in Belgium and the UK company cars seem to be more commonly used than anywhere else in the world.[4] Company cars are not only frequently received by employees as a fringe benefit, they are, apart from the wage, the single most important compensation for the employees' labour activity. For example, the firms' average annual cost of providing a car that is not used for business

[2] We will see that this bulk discount is much smaller than the reduction in price due to tax distortions and will be discussed in the sensitivity analysis of the welfare analysis.

[3] This gender difference is consistent with our data that show that part-time workers generally do not receive company cars. In the Netherlands, about 70% of the women work part-time. For employees in the private sector, the share of employees with a company car is even higher, as public-sector employees seldomly have a company car.

[4] For example, as reported in Wuyts (2009), in Belgium, 20% of employees have a company car. In Europe, 42% of all *new* personal cars sold are bought by firms (including rental companies). In the Netherlands, this percentage is 43%, just above the European average (Economist Intelligence Unit, 1996). It has been estimated for the Netherlands that about 12% of the *stock* of personal cars are company cars.

purposes is around €8,700, substantially more than other fringe benefits (including pensions).[5] It is therefore not surprising that company cars, and their taxation, are an important discussion topic in the political arena of many countries, mostly in Europe (e.g. Belgium, UK) but also, for example, in Israel.[6] Nevertheless, we know of no attempt to estimate the welfare effects of the tax system in Europe regarding the company car.[7] We are particularly interested to know whether the current tax system that is prevalent in Europe is distortionary. In the welfare analysis of company car taxation, we will explain that it is less important whether or not the availability of company cars are productive to the economy, but it is fundamental whether or not the type of company car (measured in the current paper by the number of cars units) is productive.

It is a common misunderstanding that most company cars are used for business purposes, and are therefore productive fringe benefits.[8] In contrast, a substantial proportion of company cars are *not*, or hardly, used for firms' business purposes, and are only used for private usage. In the Netherlands, 78% of employees with a company car have *not* used this car for any business purpose during a period of three months, and another 12% have travelled less than 100 km per week for business purposes.[9]

A second misunderstanding is the idea that in competitive markets, when company cars are used for business purposes, the firm will pay a large share of the overall car costs. However, given marginal cost pricing, employers will only pay for the marginal costs of the

---

[5] Company cars that are used for business purposes are even more costly, mainly because of additional costs of driving, and to a lesser extent because the purchase price of these cars is higher.

[6] As far as we are aware, company car taxation is *not* an issue in the US. The main reason is probably, as explained later on, that in this country the deadweight loss is negligible as the taxation follows standard recommendations of optimal tax policy.

[7] We are aware of one attempt to estimate the effects of changes in UK taxation on company cars in terms of environmental implications (e.g. Inland Revenue, 2004), but our study indicates that the welfare implications are not so much driven by the use of the car but by the increase in household car demand.

[8] With productive, we mean that company cars must provide additional revenue to the *employer* that provides the company car. With productive to the *economy*, we mean that company cars enhance revenue to the economy.

[9] These percentages have been calculated using the Dutch 1990–93 PAP survey. In this transport survey, which is unusual for this typed survey, one can distinguish between employees and self-employed. The PAP survey is not representative regarding lease cars, but it is not clear whether this generates any upward or downward bias in the percentages presented.

car's business trip and employees will pay for the fixed costs of holding the car. The main reason is that most employees who use a car for business travel anyway commute by (private) car to the workplace (about 90%), so the employees' private car is generally available to the employer for business purposes. [10] Arguably, for almost all professions, the number of jobs with an employers' demand for using a car for business purposes is much less than the number of employees with a demand for driving to work with a car (on average, on a workday, about 18% of car commuters uses a company car). Therefore, given efficient matching, any employer with a demand for a car for business purposes may find an employee who commutes by private car. In this case, the firm will only pay for the marginal costs of use for business purposes.

A third misunderstanding is that the use of a higher quality car makes employees more productive to the *economy*, which is one reason why firms may offer expensive cars. There are strong reasons to believe that this is not the case. In essence, (*i*) high-quality cars may increase status and are therefore productive to the firm,[11] but not to the economy, as status is a positional good (e.g. Hirsch, 1976; Frank, 1999); (*ii*) it is unlikely that high-quality cars strongly reduce fatigue in employees, which increases the employees' productivity; (*iii*) employees enjoy the quality of their cars during work, which is an important reason why employers offer high-quality cars to employees, but this enjoyment is on-the-job consumption, and not an increase in productivity.

In conclusion, there is little or no reason to believe that the quality of a company car makes an employee more productive to the economy, and must therefore be treated as a productive fringe benefit. Consequently, we will first proceed empirically on the assumption that the company car's quality, measured by the number of car units in the current paper, does

[10] The business use of an employee's private car is indeed a common market solution, and in countries such as the US where the tax system is much less (or even not) distortionary regarding company cars, this is effectively the dominant market form.

[11] In particular, it is plausible that a sales person with an expensive car may obtain a higher *status*, and may therefore be productive to the firm.

not increase the productivity of the employee. This allows us to use household panel datasets that do not provide information on business use of company cars, but which allow us to address unobserved household preferences. The welfare losses of current distortionary company car taxation based on this assumption may be a (slight) overestimate. This will be followed by an estimate of the welfare losses based on a car survey that allows us to control for business use of the car, but which is essentially a cross-section survey.

As we will explain later on, public economics theory is quite clear about the optimal level of taxation of fringe benefits (this theory takes into account that fringe benefits may be productive for the firm).[12] Using this theory, it is not so hard to see that in the Netherlands, and similarly in almost all other European countries, the tax system is likely far from optimal in this respect: in the Netherlands, company cars are provided to employees for private use at an implicit unit price that is 32.6 to 38.3% less than when bought by employees in the car market (the exact percentage depends on the employees' marginal income tax rate but *not* on the car's use for business purposes). The reduction in price can be decomposed into an income tax advantage (which varies between 24.6 and 30.3%) and a Value Added Tax (VAT) advantage of about 8%.[13] According to theory, only under specific circumstances, in particular only when the number of car units of the company car is extremely productive to the firm, such a high tax advantage can be justified. As only 22% of the company cars are used for business purposes, and the number of car units has little effect on the productivity of the employee as argued above, it may seem that for almost all company cars any tax disadvantage will imply a deadweight loss. However, it is theoretically possible that favourable taxation of company cars (relative to wages) generates *positive* welfare effects

[12] Reasons why profit-maximizing firms offer fringe benefits to employees can be found in the employees' compensation literature (e.g. Ehrenberg and Smith, 2003). In essence, it is assumed that fringe benefits do not generate as much value to employees as net wages of equal monetary value, because employees prefer wages to non-monetary benefits. Fringe benefits are attractive only when firms supply them at lower prices than employees would pay in the goods market. It is then economical to offer fringe benefits to employees for private usage and simultaneously reduce their wages. Firms and employees are then both better off (see Zax, 1988).

[13] As explained later on, users of company cars avoid paying VAT on the purchase of the car, as well as maintenance, but other expenses (e.g. fuel, insurance) are not VAT liable.

given the presence of other distortionary car taxes (in most European countries, there are purchase taxes on personal cars that are likely distortionary as they are not strongly related to externalities of car use). We examine the effect of other distortionary car taxes as well. It turns out that, in the Netherlands, the levels of the other distortionary car taxes are much lower than the tax advantage given to company cars.[14]

As stated above, in the current paper, we are mainly interested in estimating the deadweight loss of distortionary taxation of company cars. In essence, we identify this loss by estimating the effect of company car possession on household car unit demand.[15] We demonstrate that this loss is identified by estimating this effect on the market value of the most expensive car in the household, where the car's market value is assumed to measure the number of 'car units' available to the household.[16]

The calculation of the welfare effects of distortionary company car taxation depends on assumptions that one is willing to make with respect to the car and labour market (Zax, 1988; Wuyts, 2009). Throughout the paper, we will assume that we deal with a perfectly competitive labour market.[17] Furthermore, it is assumed that the car market is perfectly competitive with a horizontal supply curve (so that costs and therefore pre-tax prices of cars are constant). Hence, the theoretical model for the car market is the standard *partial*-equilibrium perfectly competitive model, where the model is partial, because it is assumed

[14] This argument seems to hold also for other European countries, except Norway and Denmark where purchase taxes are high.

[15] An alternative identification strategy is to use changes over time in company car taxation. Such a strategy is difficult to apply as changes in tax rates have been minor, and as a minimum requires information about the elapsed length of holding a particular car (as most company cars are leased over periods of at least three years), which is missing in surveys known to us. Our research fits within the taxation literature that examines the welfare effects of car taxes. See, for example, Craft and Schmidt (2005), who examine welfare effects associated with car property taxes through changes in car demand.

[16] To estimate the deadweight loss, we take into account that firms provide cars to employees as fringe benefits at lower unit prices than the market not only because of lower income taxes on company cars than on wages, but also because firms pay no VAT. Note that some firms lease a large number of cars and receive cost reductions, which are likely due to a reduction in retail costs (some firms even avoid retail costs, as they lease cars directly from car manufacturers).

[17] The consequences of the assumption of a competitive labour market, although commonly made in the context of fringe benefits, are not well understood. Yet, results by Zax (1988) indicate that allowing for monopolistic market power generates welfare effects of the same magnitude.

that pre-tax prices of cars (and prices of other goods) are not affected by the tax distortion identified in the current paper.[18]

Taxation of company cars has already been described as distortionary in the 1980s (see Ashworth and Dilnot, 1987). Distortionary taxation may have large negative welfare implications through overconsumption of car units (which we will measure using the value of the car in the market).[19] Favourable taxation reduces the implicit unit price of the company car provided by the firm. Importantly, tax authorities offer only tax advantages to maximally *one* company car per employee, so that favourable taxation of company cars does not affect the unit price of other (usually non-company) cars that may be present in a household. Given this tax restriction, it will be beneficial to the employee (and therefore to the firm) to apply the company car tax advantage to the most expensive car within the household (thus, the car with the most car units). Hence, if there is one company car in the household, this car must be the most valuable car in the household.

It is therefore natural to simplify the theoretical analysis by assuming that (*i*) the market value of a car measures the number of car units multiplied with the unit price per car, (*ii*) in each household there is maximally one company car, and (*iii*) the company car is more valuable and therefore has more car units than any other car in the household (if present). The latter two assumptions are empirically justified.[20] Hence, our emphasis is on the deadweight

[18] One may argue that the use of a partial model may not be a reasonable in the light of evidence that the *car type* market is oligopolistic (e.g. Verboven, 1996), because of company cars represent about 43% of all new personal cars and the car's ownership costs are about 40% of the overall annual car costs. Note that this oligopolistic behaviour regarding car types does *not* imply that the car industry as a whole is oligopolistic. We come back to this issue in the sensitivity analysis.

[19] Note that these car units may measure the size of the car, horse power, etc., and the price of a unit can be interpreted as the hedonic unit price.

[20] In the samples analysed, only 0.5% of households have two company cars, and only 0.8% have a company car that is not the most valuable car in the household. For only a few observations, the reported market value of a privately owned car exceeds the value of the company car in the household.

loss of taxation of company cars through a change in the *household demand for the most valuable car in the household*.[21]

Company car taxation may also encourage *private* travel behaviour of employees as the company car's marginal costs of car use are reduced to zero, which may also induce a welfare loss. Furthermore, a range of externalities may be induced by the additional private travel (Parry et al., 2007). In the empirical analysis, we will demonstrate that private travel increases due to the possession of a company car. The welfare losses of favourable company car taxation through increased travel behaviour are shown to be substantial (as the commute increases), but much smaller than the welfare loss due to increases in car consumption. This finding is consistent with the literature that points out that the demand for travel is rather price inelastic, whereas the demand for size of car is rather elastic. This justifies our simplifying assumption, which is used for expositional reasons in the next section, that company car taxation may change *household car demand* but does not affect private car use.

Tax treatment of most fringe benefits is quite different among European countries, but a common characteristic is that the income tax on company cars is related to the purchase price of the car (the car may be new or second hand).[22] For simplicity, we assume that the marginal income tax rate does not vary by income. For now, we will ignore treatment of the VAT, and assume that employees and firms buy cars at the same price. Employees' net income is then defined as $m - \tau(m + \pi f)$, where m is the (gross) wage, τ is the marginal income tax rate, f is the company car's purchase price, and π is the imputed *tax rate* of the purchase price. Hence, πf is the imputed value of a company car according to tax authorities (which is added to the employee's taxable income). In the Netherlands for the period investigated, when the

[21] Given the assumption that car supply is fully elastic and information on any other distortionary tax, as well as the reduction in the car unit price paid for a company car, the deadweight loss can be easily derived. For example, given a linear demand function the 'rule of a half' can be used (see textbooks such as Varian, 1992, p. 229).

[22] Interestingly, this may induce a strong increase car turnover, because the households' value derived from a company car will reduce over time (as the car depreciates), but the additional tax paid does not. However, in some countries, there are also rules regarding the age of the company car. Few countries (e.g. Norway) reduce the implied tax of older cars.

company car is privately used, 22% of the purchase price must be added to taxable income, so $\pi = 0.22$.[23]

According to standard theory regarding fringe benefits, a company car that is provided to employees should be accounted for as employee's income and be taxed according to the firm's *net* costs of providing the company car to the employee, defined as the firm's gross costs minus the costs for business travel, because costs of business usage of a company car should not be taxed (see Clotfelter, 1983; Katz and Mankiw, 1985). Hence, we will control for the business usage of cars in our estimates when using the car survey.

We aim to answer the question whether the imputed income tax rate is distortionary. We will argue here that the imputed 22% income tax rate on the value of a company car is *much* less than the optimal non-distortionary rate.[24] The firm's *net* costs of company car provision to the employee can easily be derived from its purchase price for company cars that are not used for business purposes.[25] In the Netherlands in 2007, we will estimate that the average purchase price of such a company car is (about) €17,000, so each year about €3,700 is added to the employees' taxable income when a company car is provided. As explained in detail in Appendix A, the firm's annual costs of providing a company car to the employee exceed this imputed company car's value by a large amount. The €3,700 imputed by the tax authorities is 58.5% less than the firm's average annual costs, which are, as mentioned above, around €8,700. This indicates that (given the absence of other distortions) the non-distortionary tax rate π is 0.51 (instead of 0.22). Hence, employees that receive a company car face a *much* lower implicit price than they would pay in the car market and are therefore expected to increase their demand for cars in various ways. Most company car owners are taxed at a

[23] In most countries in Europe, the imputed tax rate π does not depend strongly on the purchase price. There are some exceptions though, such as in Norway, where the tax rate is regressive.

[24] We focus on the Netherlands, but for most other European countries similar arguments can be made. Note that for Denmark and Norway, the argument may not apply because the high levels of a distortionary purchase tax. It is likely that in these two countries the tax treatment of company cars corrects for the high level of the distortionary purchase tax.

[25] Our calculations (see Appendix A) suggest that the firms' *net* costs for company cars used for business are slightly higher, because these cars tend to be more expensive.

marginal income tax rate of 42 or 52%. Given a marginal income tax of, let's say, 52% (42%), the implicit price subsidy is about €2,700 (€2,200), so 30.3% (24.6%) of the *annual* unit cost price of a car.[26] In short, the *income tax advantage* of a company car is between 24.6 to 30.3% of the car unit price. This ignores though that users of company cars are able to avoid paying for the VAT, which amounts to 19% in the Netherlands. The VAT is paid on the purchase as well as repairs, so about 40% of the total costs, but not on fuel expenditure and insurance. The VAT tax advantage is estimated to be approximately 8%. Consequently, the total income tax advantage is between 32.6 and 38.3%.[27]

Another relevant characteristic of the company car as a fringe benefit is that most employees use the same company car for a period of about three (e.g. Netherlands) to five years (e.g. Belgium). This period is defined by the minimum length of the lease contract between firms and lease companies. This implies that for smaller companies the provision of a company car may be risky, as determination of a lease contract before it expires is costly.

It should be noted that in the US, cars provided by employers are taxed broadly in line with economic theory. In the US, it is common that employers provide a monetary contribution to employees that can be used to lease a car (the employee is the lessee and pays for all taxes). The employee is then taxed on this monetary contribution as wage. When the company car is used for business purposes, the employee receives from the employer a

---

[26] In most European countries, a company car is exempted from any imputed tax when the number of private kilometres is less than a certain threshold value. In the Netherlands, the threshold value is 500 km per year *excluding commuting* by the worker. This exemption rule is likely extremely distortionary, as it gives an incentive for employees to use the company car for the commute, and to use another (privately-owned) car for other private trips. When this tax exemption rule applies, the implicit price subsidy will equal the marginal income tax rate, so it will be 42 or 52%.

[27] Note that only a subset of firms offers company cars to their employees, which seems surprising given the tax price advantage. This rises the question why not all firms are willing to offer company cars to their employees. One reason may be that lease contracts of company cars are for at least three years, implying substantial costs on firms if the employee leaves (voluntarily or involuntarily) within three years. In particular, for firms with few company cars, offering company cars may imply a substantial risk. This particularly holds for jobs where the expected job duration is relatively short.

reimbursement for the car's marginal costs. This reimbursement is not taxed, in line with recommendations of optimal taxes by economic theory (Katz and Mankiw, 1985).[28]

To determine the welfare effects of a specific tax on (consumer) goods in a competitive market with a horizontal supply curve (and given information on other distortionary taxes on these goods), it is sufficient to know (*i*) the change in the price of the good due to the tax analysed, and (*ii*) the demand price elasticity to determine the change in consumption due to the change in the price of the good.

The welfare effect of company car taxation *cannot* be derived from standard car demand elasticities, because the effect of favourable taxation of company cars on household car demand may be quite different from general car price reductions. General price reductions affect the prices of *all* cars in the household, whereas favourable taxation of company cars affects only the price of the company car, but not the price of other (private) cars in the household. Furthermore, as the car is provided by the employer, employees who face credit constraints may be able to have access to more expensive cars. This implies that results of empirical studies that focus on general car price elasticities are only indicative. Nevertheless, this literature suggests that the deadweight loss may be substantial, because the price elasticity for (new) cars is about unity (Hess, 1977; McCarthy, 1996).[29]

In our empirical analysis, we aim to estimate to what extent the household car demand changes when an employee belonging to a household receives a company car at an effective price below the car price paid by this employee in the consumer car market if the employee would not receive a company car (the counter factual), but, for example, a higher wage.[30] Our estimation method essentially implies a household fixed-effects procedure using information

[28] It is therefore unsurprising that in the US company cars have not received any attention by economists.
[29] Note that this elasticity is far below own-price elasticities of car *type* demand (Berry et al., 1995; Verboven, 1996).
[30] One may also imagine other ways of compensation. For example, public organisations may compensate employees not by providing a company car, but by providing more holidays, more job security, less demanding work, etc.

from a *household panel survey* from 1995 to 2006.[31] Based on these estimates, we are able to derive the welfare effects of company car taxation.[32]

In the household panel survey, information on car use is not available. We therefore cannot for the possibility that company car is productive. For this reason, we also employ a *car panel survey*, which gives us the required detailed information about the use of the (company or private) car during a period of three months, but which is essentially a cross-section survey for our purpose. This survey provides the information needed only for the period 1990 to 1993, so the time period of sampling of the household panel survey and car survey differs. This is essentially because the proportion of company cars in the Dutch economy has been rather stable over the last 20 years (a small increase from about 10% in 1985 to about 12% of all cars nowadays), but the proportion of company cars that are leased has strongly increased (Wilmink et al., 2002). Car leasing has been introduced in the Netherlands in 1986, but was still relatively unimportant during the period 1990−93 (about 29% of all company cars), whereas between 1996−2005 most company cars were leased (about 70% of all company cars).[33] Presumably, the development of a large competitive leasing market has made the supply of company cars more efficient. The increased efficiency implies that employees are more likely able to make use of the tax advantage associated with company cars, implying larger welfare losses.[34] This strongly suggests that the welfare losses

---

[31] Although one may imagine that the use of household fixed-effects is sufficient to deal with time-invariant unobserved heterogeneity (which is important, as 'car-loving' households are more likely to sort themselves into jobs with access to company cars), we go one step further and use instrumental variables techniques as well.

[32] Note that we will *not* estimate the effect of company car taxation on the provision of company cars through employers. Although interesting, this does not provide an answer to the welfare effects of company car taxation. For example, if due to company car taxation the number of cars increases, whereas the number of private cars falls to the same extent, then the welfare effects through a change in consumer surplus will be absent if the sizes of company cars and private cars are identical.

[33] Furthermore, as it will later on be explained in detail, lease cars are essentially absent in the responses for the PAP survey, so company cars in the PAP survey are all owned by the employer.

[34] In addition, leasing allows employees to choose a car from a large range of cars, which also increases the likelihood that the employee chooses the car in line with her preferences, so making better use of the tax advantage.

with company cars are substantially higher over the last decade than in the beginning of the nineties.

The welfare analysis in the current paper is developed using empirical results of the effect of company car provision on household car demand. In the next section, we discuss the theoretical setting. The remainder of the paper is structured as follows: section 3 provides information on the data used, introduces the different statistical models and presents the empirical results. Section 4, 5 and 6 discuss the welfare analyses using different measures. Section 7 discusses the effect of company car on other transport demand. Section 8 concludes.

2. The Model

2.1. *Theory*

To determine the welfare effects of the tax treatment of company cars, we will make use of a household model that includes wages and car consumption. Car consumption, and its costs, refers here, for convenience, only to ownership. So, we will ignore car *use*, and therefore essentially assume that the reduction in the price of car use is not the main issue regarding company car taxation.[35] We do not consider this assumption as essential to our analysis, but as it turns out to be a good approximation, it simplifies the theoretical framework here. Furthermore, as stated above, we assume that the car market is perfectly competitive.

We will assume that the household has a demand for 'units' of each car, where the price of a car *unit* is exogenous and equal to p. So, p refers to the given unit price of holding one car unit (e.g. one euro per unit per year). There is only another good z. It is assumed that the households concave utility function U can be written as $U(x, y, z)$ where x denotes the number of units of the first car, y denotes the number of (sum of) units of other cars and z refers to the

[35] Hence, we avoid the complication that car demand is determined by the price of *owning* a car as well as by the price of *using* a car (De Jong, 1990). Company car taxation affects both these prices. Because we find that travel behaviour is not so much affected by company car possession, it is arbitrary whether company car taxation influences car demand through a reduction in the price of ownership or the price of car use. Hence, we may assume that the household's car demand depends on the cost of owning cars.

other good. The number of car units of the first car exceeds the number of units of the second car. The price of cars and other goods are given, and total after-tax income of the household is $m\ (1-\tau)$, where m is gross income and τ is the tax rate ($\tau > 0$).

As alluded to above, in the introduction, one important characteristic of the tax system in the Netherlands (as well as in other European countries) is that it allows employers to supply only *one* company car per employee as a fringe benefit. So, the unit price of one, in our case the first, car may be affected by company car tax facilities,[36] but the unit price of the other cars will not be affected by the tax treatment of the company car, as the market is assumed to be competitive. Hence, we may rewrite $U(x, y, z)$ as $U(x, m\ (1-\tau) - px)$, where $m\ (1-\tau) - px$ equals the expenditure on all other goods than the first car (a combination of y and z) and where the price of the other goods is standardized to one. Hence, one may assume that the household maximizes $U(x, y)$ given $px + y = m\ (1-\tau)$. As it is well known, the solution to this standard (two-good) problem is that $U_x/U_y = p$ and $x(p, m\ (1-\tau))$, where $x(p, m\ (1-\tau))$ denotes the Marshallian car unit demand function.[37] We will assume that this problem has a solution, so the household has at least one car.

Now suppose that the employee considers alternative employment with a firm that offers car units, x^c, as a fringe benefit and gross income, m^c. The tax system values each car unit at a price H, where $H \leq p$.[38] In a competitive labour market, a profit-maximizing firm chooses to offer m^c and x^c such that $U\left(x^c, m^c - \tau\ \left(m + Hx^c\right)\right) = U\left(x, m\ \left(1-\tau\right) - px\right)$. In this case, the following condition holds:

[36] It will generally be beneficial to the employee (and therefore the firm) that the car with most units in the household is provided as a company car.
[37] Our methodology to identify the effect of company car taxation is to estimate this demand function where the value of p is the same for all households, except for households with a company car.
[38] Note that tax authorities use the purchase price of the car, and not the annual costs p (e.g. the lease costs). As these two prices are roughly proportional, we ignore this distinction here. In the welfare analysis, we, of course, make the distinction.

$$U_{x^c}/U_Y + \frac{\tau}{1-\tau}\left(U_{x^c}/U_Y - H\right) = p. \tag{1}$$

This (well-known) condition says that the sum of the employee's marginal utility and the marginal tax advantage is equal to the marginal costs.[39] Rewriting (1), we obtain:

$$U_{x^c}/U_Y = p - \tau(p - H). \tag{2}$$

Hence, the marginal rate of substitution between company car units and other goods, U_{x^c}/U_y, is less than p because $p > H$. Note that $p - \tau (p - H)$ is the *economic* rate of substitution between company car units and other goods, so that $p - \tau (p - H)$ can be interpreted as the effective price of a car unit and $- \tau (p - H)$ as the tax advantage given to company cars.

We have ignored above that the presence of a company car may make an employee more productive to the firm (as explained in the introduction, about a quarter of employees with a company car use it for business purposes). This has little consequence for equation (1) as long as the firm's revenue only depends on the use of a company car for business purposes, but, let's assume initially that not on the number of car units x^c.[40] Hence, the choice of the number of car units x^c will not be affected by this extension.

---

[39] Given a concave utility function, $x^c > x$ and $m^c < m$. A (textbook) non-distortionary tax treatment of company cars requires $U_{x^c}/U_y = p$. So, $U_{x^c}/U_y = H$, therefore $H = p = U_{x^c}/U_y$ and $m^c = m - px^c$. Note that the result that $m^c = m - px^c$ holds given the assumption that employees' compensation only consists of company cars and wages. In general, the latter result will not hold if employees also receive other fringe benefits.

[40] In this case, equation (1) still holds as long as the employee's utility of having a car does not depend on the use of the car for business purposes. This seems a reasonable condition. We have examined this condition using data on the use of car for commuting as well as for business purposes, and it appears that at least 90% of the cars used for business purposes are also used for commuting. Hence, it appears that this condition is fulfilled.
As an aside, note that one of the consequences of this condition is that the fixed cost of having a car (the costs not related to the number of car units, mileage, etc.) will be borne by the employee and the firm. The employee and the firm will then both pay a share of the fixed costs. As it is well known from the literature on fixed costs, these shares are endogenously determined by the total market demand for cars by employees and firms. Given the reasonable assumption that the employee's demand for cars exceeds the firm's demand for cars, the employee will pay the *full share* of the fixed costs. This assumption is reasonable, as even among users of company cars, only a quarter of cars are used for business purposes.

For the purpose of the current paper, it is more interesting to assume that the revenue, *R*, is a positive function of the number of car units x^c. In this case, it can easily be shown that:

$$U_{x^c}/U_Y + \frac{\tau}{1-\tau}\left(U_{x^c}/U_Y - H\right) + R_{x^c} = p. \qquad (3)$$

Hence, in a competitive market, the expenditure on company cars by firms is such that the sum of the employee's marginal utility, marginal tax advantage and firm's marginal revenue is equal to the company car's marginal costs (see e.g. Katz and Mankiw, 1985). So, $U_{x^c}/U_y = p - R_{x^c} - \tau\,\left(p - H - R_{x^c}\right),$ so that the tax advantage equals $-\tau\,\left(p - H - R_{x^c}\right).$ The tax system is then not distortionary when $H = p - R_{x^c}$ (so, $U_{x^c}/U_y = H = p - R_{x^c},$ where $p - R_{x^c}$ are the *net* costs).[41] The main implication for the current paper is that the car unit price depends not only on the size of the tax advantage $-\tau\,(p - H)$, but also on the marginal revenue effect when $R_{x^c} \neq 0.$ This marginal revenue effect is likely small and, if it applies, it will apply only to company cars that are used for business purposes (a quarter of all company cars, as explained in the introduction). Nevertheless, this issue will receive attention in the empirical analysis by controlling for the cars' business use.

2.2. *Estimation of Marshallian car demand functions*

We aim to estimate the demand for car units, *x*, of one car which we treat as a single good.[42] We assume that all cars are not productive. So, in general:

[41] To be more precise, the tax system is not distortionary given the income tax rate τ. When τ is also optimally chosen, and the government is not able to use lump-sum transfers, the optimal rate *H* may be higher to generate government revenues using Ramsey pricing (see e.g. Wuyts, 2009).

[42] We have modeled car demand as a choice between car units for one car and 'all other goods'. As it is well known, almost any functional form for the demand function is consistent with utility maximization (so, there is an indirect utility function that will generate a single demand equation by Roy's law). This means that one has great freedom in choosing functional forms that are consistent with optimization.

$$x_i = T\left(p_i, m_i, s_i\right), \qquad (4)$$

where subscript i denotes household i. So, x_i denotes the household demand for car units, p_i denotes the car units price faced by household i, m_i is the (after-tax) income and s_i denotes (observed and unobserved) variables that affect car unit demand (e.g. number of children). To identify the effect of p_i, we impose certain restrictions on the functional form T. We assume that T is *additive* in p_i, m_i and s_i in the sense that:

$$x_i = h\left(p_i\right) + k\left(m_i\right) + j\left(s_i\right), \qquad (5)$$

where h, k and j denote functions. If household i has a company car, then $p_i = p^c$, where $p^c = p - \tau\,(p - H)$, otherwise the household faces a car unit price of p. This implies that the difference in demand for car units (of the first car) for households with or without a company car, Δx_i, is then defined as follows:

$$\Delta x_i = x_i - x_i^c = h\left(p\right) - h\left(p^c\right) + k\left(m_i\right) - k\left(m_i^c\right). \qquad (6)$$

Note that $h(p) - h(p^c)$ is household specific, and refers to the tax-induced change in car units controlling for (tax-induced) changes in labour income. Its value can be estimated by assuming that h (.) is identical to all households, such that $h(p) - h(p^c)$ is a constant which we will label by Δx. The variable Δx refers to the tax-induced average change in the demand for car units, *when controlling for changes in income*. In the current paper, we will estimate Δx.

Note that given the assumption of a competitive labour market, the income effect of the tax advantage is absent (as firms will reduce the wage when a company car is offered such that the employees' utility of holding a company car is the same as not holding one). Although this result may strictly speaking not hold in general (e.g. it may not hold when labour markets are not perfectly competitive), it makes it plausible that the income effect of the company tax advantage on the demand for car units is small. This implies that Δx

predominantly identifies the substitution effect of the tax advantage.

2.3. *Welfare analysis*

To determine the welfare effect of the tax treatment of the company car based on estimates of Δx is now possible. Note that when we estimate (6), we control for changes in income. When income is given, it is well known that consumer's surplus is a reasonable approximation of welfare (e.g. Varian, 1992, p. 167).[43] Given a linear demand function, the change in consumer's surplus and therefore welfare, ΔW, can be measured by ½ $\Delta x\ \Delta p$, where $\Delta p = p - p^c$. In the empirical application, we will identify Δx by relating changes in car demand Δx, which we do not observe, to changes in the car's market value ΔV, which we observe. We will assume that px, which measures the annual car expenditure, is proportional to V, so $px = \alpha V$, where $\alpha > 0$ is given.[44] It follows that $\Delta V = \alpha\, p\, \Delta x$. So,

$$\Delta W = \tfrac{1}{2} \Delta p\ \Delta x = \tfrac{1}{2}\ \frac{\Delta p}{p}\ \alpha\ \Delta V. \qquad (7)$$

In our empirical application, we will estimate ΔV, which measures the (average) tax induced-change in the market value of the most expensive car in the household, whereas for $\Delta p/p$ and α we will use market averages. Information on the tax-advantage of having a company car, as provided in the introduction, indicates that $\Delta p/p$ is between 0.32 and 0.39. The proportionality factor α is straightforward to determine using information on annual lease costs, px, and the market value of the car, V, and is about 0.40 (see Appendix A). Given a log-linear specification, a similar calculation as (7) applies.

[43] Given a quasi-linear utility function the measure is exact.

[44] The assumption of proportionality appears to be reasonable: the relationship between annual lease costs and the market value of cars is roughly proportional.

3. Car Demand Analysis

3.1. *The data*

We aim to estimate the effect of company car possession on the demand of the most expensive car in the household. Our empirical analysis is mainly based on information from the annual DNB (Dutch Central Bank) *household survey* for the years 1995–2006, the 1990–93 PAP *survey* (Dutch Car Panel Survey), which is a *car survey*, based on samples from a car registration database. Further, we use the NTS *survey* (National Travel Survey) for 1996 to examine the effect on private travel behaviour, which is a *travel survey*.

All surveys allow us to distinguish between private and company cars, although definitions of company car differ between surveys. The NTS survey contains information on travel behaviour of all members of a household during one day. The DNB survey is a standard household panel survey and provides information about market values of cars in the household and the interview date.[45] Usually, the respondent is the head of the household. The PAP survey has the car as a unit of measurement, and contains information about the car use distinguishing between private and business use for a period of three months up to a year.

In all the analyses, we will employ samples of households that posses *at least* one car and which contain at least one full-time working adult.[46] To facilitate interpretation, we only select households that have maximally one company car as two cars occur rarely.[47]

---

[45] In the DNB survey, 14% of the households own a company car, consistent with other sources.

[46] Given an unconstrained choice of the dataset the statistical analysis becomes cumbersome, as the presence of a company car is then endogenous (as it indicates the presence of at least one car). There are two reasons why we believe it is unproblematic in the current application to use the selective sample. First, in the sample of the population of households with an employed person, merely 6% of households do not own a car. Therefore, the non-selected sample is rather small. Second, households without a car seldomly belong to the group of households of which employees receive a company car, because household characteristics differ strongly between households without a car and households with a company car. In particular, in the datasets we analyse, households with a company car have a much higher income. This has also been reported in Statistics Netherlands (2000).

[47] In our datasets, only 0.5% of households with at least one car have two company cars. This number is consistent with the observation that (most) two-earner households consist of a male and a female, and the males' respectively females' probability of having a company car is 0.14 and 0.025 respectively ($0.14 \times 0.025 = 0.35\%$). Bivariate probit models demonstrate that the employees' probability of having a company car is independent of the probability that the employees' partner has a company car.

3.2. *DNB survey*

3.2.1. *Panel estimation results*

In our empirical application, the value of the most expensive car in the household is the dependent variable, and we assume a linear as well as a log-linear specification. We also estimate specifications allowing for fixed as well as random household effects. By controlling for household effects, we essentially avoid arguments that the effect of company car is due to unobserved preferences of households for cars. The value of a car is the value in the second-hand market, as reported by the respondent. For cars that were owned for less than three years, the purchase price was reported by respondents. We have used the latter price as the estimate of the current market value.

We use a large number of time-varying control variables, including number of children, household income, address density indicator (number of addresses per square kilometre) in the municipality of residence, head employment status, ownership of the current residence, head working hours per week, job duration (in years) and employment duration in the labour market (in years) by the head of the household. Further, we control for time and the residence region. When we do not control for household fixed effects, we also control for age and education.

Our main finding is that the possession of a company car *strongly* increases the value of the (most expensive) car in the household. The linear specification generates an increase in the value of a car, ΔV, of about 9,000 to €12,000 (see Table 1), the log-linear specification implies an increase of about 80 to 120 logarithmic points (see Table 2). As a company car implies a price reduction of about 32 to 38%, the implied price elasticity of the most expensive car in the household is therefore about –2. Allowing for fixed or random effects generates essentially the same estimate (using Hausman t-tests both have a t-value of around 0.70, see Wooldridge, 2001).

By controlling for household effects, we effectively control for unobserved demand factors. One counter argument, which invalidates our estimates, is that we do not control for *time-varying* unobserved demand variables, and that a sudden increase in the demand for a larger car induces employees without a company car to sort themselves into other jobs that offer company cars, which creates an estimation bias. However, we believe that this type of bias is extremely unlikely as we control for many time-varying demand variables including income and the number of children. Furthermore, if unobserved preferences of households play an important role then one expects a (large) difference in the point estimate of company car when using or not using household fixed effects. To be more precise, including household fixed effects must result in a lower estimate when time-invariant household preferences are relevant. However, the point estimate of company car is not lesser when including fixed effects. In fact, it is slightly greater given the linear specification, and is almost exactly the same given the log-linear specification (see Tables 1 and 2). If sorting based on time-invariant unobserved preferences does not play a role, then it is extremely unlikely that sorting based on time-varying unobserved preferences creates any bias.

Nevertheless, we have also estimated models where we instrument company car ownership. We have used two estimation procedures which are both based on the idea that the type of sector is a valid instrument as it strongly determines the supply of company cars for reasons unrelated to the demand for car units by employees. In particular, in industries where cars are used during business hours, it is more economical to provide company cars. In the first procedure, we use only public sector as an instrument. Our assumption which validates this procedure is that the public sector strongly differs in its supply of company cars for reasons that are unrelated to the demand for car units by employees. For example, according to theory, public sector organizations are not willing to offer company cars, because the external effect of the tax treatment of company cars (the reduction in taxes paid to the tax authorities) is internalized by these organisations. Another reason may be that company cars are usually seen as environmentally unfriendly. In our data, the number of employees who move between sectors and for whom changes in the presence of company cars is observed is almost negligible, which precludes the use of fixed effects when instrumenting the company car, so we estimate random-effects models.[48] We find that the instrumental variable (IV) estimate for the effect of company car is somewhat below the results presented above, but essentially the same results are obtained (see column 4 of Table 1). In the second procedure, we have estimated the same model using the type of sector of employment as an instrument (and not only the public sector) and obtain almost identical results (see column 5 of Table 1).[49] Summarising, using fixed, random effects or IV estimators generates almost the same results as standard regression analysis indicating that unobserved household preferences play only a minor role.

3.2.1. *Sensitivity analysis with respect to controls for travel*

Several analyses have been conducted to evaluate the sensitivity of the reported effect of company car possession on car demand. In particular, it may be the case that the increased demand for car units is mainly through increases in travel and, as a consequence, the above-reported effect of company car may partially capture the effect of (increases in) travel on car demand. We have therefore re-estimated the fixed-effects model for the DNB dataset, controlling for the head's commuting distance. We find that the effect of company car remains the same. Note that we are not able to control for private kilometres travelled (as it is unobserved in this dataset), but this is less relevant as households with a company car travel hardly more privately by car (except for commuting purposes), as shown later on.

[48] The first step results of the IV procedures can be found in Table B1.

[49] The instrument is strong with an *F*-value that exceeds 150.

3.3. *PAP survey*

3.3.1. *Employees: controlling for car business use*

The PAP survey is based on a dataset of *random* draws from number plate car registrations. All cars are required by law to be registered. In this dataset, the name of the owner is identified, and the driver of the car is interviewed by telephone. One disadvantage of the PAP survey is that, although the sampling is random, the response is non-random, particularly when the car is not driven by the owner of the car. In the case of lease cars, the car is usually registered with the lease company (Korver and Vanderschuren, 1995), who for privacy reasons do not wish to provide the names of the drivers.[50] So, it turns out that in the PAP survey, lease cars are effectively not represented.

In the PAP survey, there are two questions that allow us to identify whether respondents receive a company car: questions related to the type of agent (firm or private person) who has registered the car as well as questions on whether the respondents receive *full* reimbursement for use of the car. In case of *employees*, the answers to these questions are strongly related. We present here results where company car is defined to be a car registered by a firm.

In the PAP survey, there is information on the business use of the car during one year, which allows us to control for differences in firms' revenue of providing a company car (see the end of section 2.1).[51] The survey also contains information about the number of cars in the household. This is useful, as in a car survey analysis, households with more cars are overrepresented. Hence, we will use weights to make the sample more representative for a

---

[50] In the period analysed, the proportion of lease cars was still relatively low. From 1990 to 1993, the proportion of lease cars out of company cars was about 27% (Korver and Vanderschuren, 1995). Note that during this period, company cars were primarily leased by large firms (more than 100 employees), whereas small firms (less than 10 employees) primarily owned their company cars (Wilmink et al., 2002). As small firms' employees tend to earn less than large firms' employees (and are taxed at a lower marginal rate), it seems plausible that the average effect of company car possession on the value of the (most expensive) car in the household is smaller using the PAP survey than using the DNB survey.

[51] To be more precise, business-use information is based on a question about car use for the previous month. This question is asked for three months in a row (a panel). We only employ observations which provide answers for all three interviews. Based on information about a three months period, business use for a year can be calculated.

sample of households.[52]

In the econometric analysis, we control for business use using a dummy variable whether or not the car is used for business, and also control for the number of kilometres using a quadratic specification. Information on the market value of the registered car in the PAP survey is provided in eight categories. Recall that we do *not* employ the value of an arbitrary car in the household as the dependent variable, but the value of the most expensive car in the household. The latter is unknown in the survey when there is more than one car in the household. In case of multiple cars in the household, we only know that the value of the most expensive car is equal or exceeds the value of the car reported. So, essentially we estimate a (grouped) regression model, where we (left) censor the value of the car in case of multiple car ownership.[53] Another issue is that the value of the car provided by the respondent is not the current market value, but the original purchase price at the moment of the purchase (on average about three years before the interview date). Therefore, we control for the (logarithm of the) time spell of owning the car.[54]

In Tables 3 and 4, one can find the effect of company car possession on the value of the (most expensive) car in the household, given a linear as well as a log-linear specification.[55] When we do *not* control for business use, we find that increased car value for company cars, ΔV, is €7,112 respectively 65 logarithmic points. This estimate is somewhat lower than the estimate based on the DNB survey, which has been estimated for another period, when leasing is much more common. One explanation for the difference in the estimates is therefore that leasing increases the efficiency of the market and gives employees a choice among a large number of types of new cars (conditional on the lease costs), whereas non-leasing

[52] Estimates without weighting provide almost identical results.
[53] Hence, if the reported value of a car is x, then we know that the value of the most expensive car in the household is at least x.
[54] The mean difference in the time spell of owning the car between company car owners and private car owners is less than five months, so this control variable turns out to be not essential.
[55] Note that for reasons of comparability, the results are given in euros for 2001, using a car price deflator.

company cars are bought by the company, which does not necessarily take into account the preferences of the employee (Wilmink et al., 2002). When we control for business use, the increase in car value for company cars is 'only' €3,933, respectively 25 logarithmic points. We emphasize that the latter estimates, although still substantial, are likely underestimates, as it is plausible that employees who drive more for business purposes prefer more valuable cars during working hours for consumption and status purposes.[56] Furthermore, these estimates are based on observations of company cars that were not leased. For this reason, we will use the DNB estimates for welfare analysis.

3.3.2. *Self-employed*

In the PAP survey, we are *not* able to control for unobserved household preferences (so, one may argue that households with a love for valuable cars are more likely to sort themselves into company car jobs). Not controlling for unobserved household preferences may imply that the identified effect of company car partially, or even fully, is due to sorting. It is therefore informative to focus on the *self-employed*. In case of self-employed, the effective price of the most expensive car in the household is essentially affected by the same company-car tax advantages as the employee, *conditional on the business distance*.[57] One main difference with employees is that *all self-employed* have the option to make use of the tax advantages. Therefore, *ceteris paribus*, the optimally chosen value of the (most expensive) car by all self-employed persons must be the same as the optimally chosen value of the (most expensive) car by employees with a company car.

The ceteris paribus condition is likely fulfilled when the self-employed and employees do not differ in their preferences for cars. This is plausible as we control for income. If the

[56] Note that we only present results for years from 1990 to 1993. Before 1990, the PAP survey lacks information about some controls. Nevertheless, we have also estimated models from 1986 to 1993 using fewer controls. The effect of company car turns out to be slightly higher.
[57] Not conditional on the business distance, the tax advantages differ substantially.

ceteris paribus condition is fulfilled, we can test for sorting, because the effect of company car and the effect of 'being self-employed' on the value of the (most expensive) car must be the same. Therefore, we estimate the same model as before, but now on a sample of employees and self-employed. For results, see the last column of Tables 3 and 4. It turns out that for the linear as well as the log-linear specification, both effects are about the same and the implied restriction on these effects is *not* rejected ($X^2(1) = 0.47$ and $X^2(1) = 0.55$). This indicates that the effects of company car as reported in the previous section can be interpreted as causal, and are not due to sorting.

4. Welfare Effects

The deadweight loss of company car tax treatment depends on the presence of *other* distortionary taxes: taxes on income and taxes on personal cars. Taxes on personal cars entail taxes on: ownership, purchase (Vehicle Excise Duty), and use of these cars (through fuel taxes and parking charges). Note that the aggregate revenues from these taxes are considerably in Europe, so, in principle, they cannot be ignored. Let us *initially* assume that other car taxes are at the optimal level.[58]

Another issue is that in a paper by Parry and Bento (2001), it has been argued that employees choose labour supply (number of working hours) at a non-optimally l*ow* level, because of a distortionary income tax τ. One of the consequences is that favourable taxation of company cars may have *positive* consequences for welfare when this increases labour supply. More likely however, the effect of favourable taxation of company cars on labour supply is negligible. This is based on two arguments. First, the number of hours worked for full-time positions depends mainly on the employees' *hourly* compensation, and less on fringe benefits,

[58] One (partial) justification for this assumption is that other car taxes are a way of addressing environmental and congestion externalities and use of car-related public goods such as road construction and maintenance (see Small and Bento, 2005). Although these taxes are unlikely optimal as first-best instruments, they may be useful as second-best instruments, because governments are not able to use first-best instruments such as road pricing. Later on, this assumption will be relaxed.

such as company cars, that are usually given independent of the number of hours worked (Ehrenberg and Smith, 2003). Second, and probably more importantly, labour supply effects in the economy are mainly through variation in *female* labour participation (the extensive margin) and not so much in change of number of hours worked given labour market participation (the intensive margin). As indicated in the introduction, females are much less likely to receive a company car than males, and this is even more extreme for females with part-time jobs (who are more likely to stop working because of changes in taxation). So, it is safe to assume that the labour supply effect of favourable company car taxation is close to zero.

Given the assumptions made above, we are able to examine now the welfare effects of company car taxation using standard welfare analysis techniques (Varian, 1992). We assume a linear demand function for cars. As explained above, the welfare losses per company car can then be calculated as half times the ratio between the *annual* price of using a car and the purchase price of a car, α, times the change in the demand for the (most expensive) car in the household times the tax advantage, known as the 'rule of a half'. The tax advantage, as explained in the introduction, is about 32 to 38%, so we will use 35%, whereas α is equal to 0.40 (see Appendix A). So, ΔW = –7% ΔV. Using the DNB, our estimates for ΔV vary between 9,000 and €12,000. For our welfare analysis, we will suppose that ΔV equals €10,000.[59] It follows that the annual welfare losses per company car due to a shift towards more expensive cars are about €700, about 8% of the company cars' annual costs.

In the Netherlands, there are 795,000 company cars (RDC, 2002). The *annual* welfare loss in the Netherlands of favourable taxation of company cars through increased household car unit demand is therefore about €560 million. Using the logarithmic demand functions, we obtain roughly the same estimates. In conclusion, the welfare losses of distortionary company

[59] Using the PAP survey, which is more valid in economies where company cars are not leased but owned by employers, the estimates are between 4,000 and €7,000, but the higher value has been argued to be likely more accurate.

car taxation are substantial, and welfare losses can be reduced by increasing the tax on company cars. We will later on focus on other welfare effects of company car taxation, in particular car travel demand.

Given the assumption that the welfare loss is proportional to the difference between the applied tax level (22%) and the non-distortionary tax level (51%), every percentage-point-increase of imputed tax rate of the company car's value generates welfare benefits of about €25 per company car. These results allow us to calculate the effects of policy changes. For example, in the Netherlands, the imputed tax rate of the company car's value has recently increased in 2008. For a large share of the company car commuters, the imputed rate has increased from 22 to 25%.[60] Likely, this change had no effect on the number of cars in the economy, but may have decreased the number of company cars, as well as decreased the expenditure per company car. We can only speculate by how much the number of company cars decreases, but it is clear that by focusing only on the change in car expenditure per company car we underestimate the change in welfare. Hence, using the estimates of the current paper, the annual welfare gains due to this change in policy are therefore at least €60 million. However, for energy-efficient cars the imputed tax rate has been *reduced* to 14%. If this policy implies that employees choose more expensive cars, then an additional loss of about €200 is incurred for company cars that use energy more efficiently (such as Toyota Prius, Honda Civic). For these cars, the welfare increases associated with a reduction in energy externalities is less than the increase in welfare losses due to increased consumption.[61] On the other hand, if it is the case that this policy stimulates employees to accept cheaper cars (such as Smart), then this energy-friendly tax policy may be welfare improving.

[60] The imputed tax rate of a company car was 24% before 2001 and 22% since 2004 until 2007 (between 2001 and 2004, other changes in the tax rules were introduced making a comparison impossible).
[61] For example, Parry et al. (2007) review the literature and conclude that the external CO_2 costs per company car are about 30 to €360 per car, whereas meta-analyses suggest a value of €60 per car. Only if an energy-efficient car is at least 50% more efficient compared to a standard car, this tax policy may then not generate a welfare loss.

5. Welfare Effects: Sensitivity Analysis

5.1. *Other distortionary car taxes/subsidies*

In our calculation of the welfare effects of distortionary taxation of company cars, we have assumed a world in which overconsumption of cars is the sole distortion in the economy. In reality, we are aware of a number of taxes, as well as subsidies, on (the use of) cars. In the Netherlands, the most relevant taxes are a fuel tax, car use taxes and a purchase tax on (new) cars. Plausibly, fuel taxes and taxes on car use (about €400 per year in the Netherlands) may be justified as second-best instruments to finance road maintenance costs and to address congestion and other externalities associated with travel (Vickrey, 1963; Small and Bento, 2005; de Palma et al., 2006; Small and Verhoef, 2007). Yet, this is less plausible for purchase taxes. In the Netherlands, the car purchase tax is 45.2%, which implies an average *annually* amortized tax-advantage of about 19%. Note that this tax disadvantage is substantially smaller than the tax advantage obtained from the provision of a company car. Therefore, our results are qualitatively robust with respect to the presence of other distortionary car taxes. In the extreme case that the purchase tax is *fully* distortionary, the deadweight loss is about 50% less than the number given above, so the annual deadweight loss is about €350. However, purchase taxes likely address a few car externalities, because the purchase price is strongly related to size, including accident externalities (larger cars may cause more damage to others), parking externalities, and congestion externalities in cities (Parry et al., 2007), so purchase taxes are unlikely fully distortionary and the welfare loss per company car will be closer to €700 per year.[62] Finally, the Dutch purchase tax may be removed in 2012, so from that date, €700 is the most accurate estimate.

[62] When employees have a company car, they do not have access to two *subsidies* on the use of private cars by employees. The first subsidy is that firms may reimburse commuting costs to employees. Reimbursement of commuting costs is attractive as a part is tax free. The second subsidy is that firms may reimburse employees for their business trips up to a certain maximum per kilometre. This reimbursement is tax free. Until 2007, the maximum reimbursement exceeded the marginal costs of driving, so essentially, the employer was able to pay

5.2. *Horizontal car supply curve, monopolistic markets, bulk discounts*

Throughout the analysis, we have assumed that the car market is perfectly competitive with a horizontal supply curve, so car costs are constant. There may be three objections to this assumption. The first objection is that the curve is upward sloping. Since the Dutch car market is small in the world (e.g. it is smaller than the car market of Los Angeles) and Dutch cars are imported, the horizontal supply curve assumption seems reasonable. The second objection is that one may argue that the supply of *type* of cars is oligopolistic (see e.g. Berry et al., 1995; Verboven, 1996). This suggests that car supply at the aggregate may also be somewhat oligopolistic. If this is the case, then the reported welfare loss for the Dutch economy is an underestimate, because foreign car suppliers benefit from the tax advantage. To understand this result, let us suppose that, due to the tax treatment of company cars, car suppliers *fully* increase the pre-tax price of company cars such that the overall price of cars does not change.[63] In the rather extreme case of full adaptation of pre-tax prices, the profits of foreign car suppliers will increase due to company car tax facilities, but this does *not* affect welfare of the Dutch economy (as car prices remain the same) except through a change in tax revenues. The deadweight loss per company car *for the Dutch economy* will then be equal to the reduction in tax revenue per company car. The reduction in tax revenue depends on how much employers reduce wages when providing company cars, but in a competitive labour market the reduction in wages will be in the order of the tax advantage given to employees (see section 2) which is about 2,200 to €2,700. Hence, if the car market is oligopolistic, our reported welfare losses for the Dutch economy are then conservative.

---

employees tax free through a travel reimbursement. It is unknown to what extent these subsidies induce an increase in private car demand, but this makes it actually likely that our welfare effects are *underestimates*.

[63] Car suppliers may be able to do so as most company cars have certain specific characteristics (e.g. a diesel motor).

The third objection is that firms that lease a large number of cars may receive bulk discounts due to a reduction in transaction costs.[64] Bulk discounts are typically less than 10%, but precise figures are unknown to us. If we assume that, on average, firms are able to provide company cars to their employees at a reduction of 5%, then the annual welfare loss due to the tax distortion is €600 (instead of €700), so essentially the same result is obtained.[65]

6. Welfare Effects through Changes in Travel Behaviour

Note that the distortionary effect of company car taxation through increases in private travel is likely not captured by the tax-induced increase in the value of the car as derived above. Recall that the purchase price of the company car is taxed, but *not* the use so that this provides an incentive for the employer to subsidise private travel. This is generally observed, as the *monetary costs* of private travel are usually fully paid by the employer. Travel costs consist of monetary and time costs. The time costs are *not directly* affected by tax facilities, so welfare analysis must be based on travel distance (which reflects monetary costs) and not on travel time.

In separate analyses for which the results are provided in Appendix B, we have analysed the effect of company car on the workers' travel behaviour, distinguishing between (*i*) commuting distance, (*ii*) private travel-distance for car trips on workdays (excluding commuting) and (*iii*) private travel distance for car trips on non-working days. A Tobit analysis for private travel distance (excluding commuting), based on the 1996 NTS, implies that there is no positive effect on private travel during workdays.[66] The effect on private travel during weekend (and other non-working days) is identified using a sample of males who did

[64] If firms get reductions because of market power, then these reductions should be ignored in our welfare calculation. When these reductions entail a decrease in retail distribution costs or other real costs, then the decrease in costs should be included.
[65] Allowing for a 10% retail discount does not change our conclusions.
[66] We use Tobit analyses, as a positive proportion of individuals do not make any private trip (except for commuting).

not work during this day.[67] We find a positive, but small effect: 3 km per weekend day, so 300 km per year, about 8.5% of weekend travel (see Table B2). A small effect makes sense as elasticities of car use with respect to variable costs are usually thought to be small, in particular for high income groups (Jørgensen and Dargay, 2007). Welfare losses through increased private travel are therefore small and around €20 per company car.[68]

Using the DNB panel data and an employee fixed-effects approach, the effect of company car on the logarithm of commuting distance is statistically significant and is about 0.14 (see Table B3), implying an increase of about 1,200 km per year.[69] The *annual* deadweight loss through increased commuting is then estimated to be about €90.[70] Therefore, the negative welfare effects of company car taxation because of additional travel are substantially smaller than the welfare effects associated with change in car demand. The welfare losses through increased private travel including commuting are therefore about €100 per year. One may argue that some of these additional welfare effects are already captured by the car demand analysis in the previous section, because workers who receive a company car will realise that they will travel more, and *therefore* will demand a more expensive car. However, as reported in section 3.2.1, the effect of company car on the value of the most expensive car in the household does not change when we control for commuting distance, so likely the demand for the more expensive car is not so strongly affected by the increase in

[67] We selected males only, as they are most likely to use the company car.

[68] The welfare losses through private travel (excluding commuting) can be approximated by the rule of a half, so as half times the change in the number of kilometres travelled privately times the tax-induced reduction in cost per kilometre. The sum of the fuel and depreciation costs per kilometre of a representative company car is estimated to be about €0.15. In absence of travel externalities, the annual welfare losses are then merely €22.5 (that is, 0.5 × 0.15 €/km × 300 km). As the analysis is based on a cross-section survey, this estimate is likely even a (potentially large) overestimate. In the survey, all travels must have occurred within the Netherlands. However, the additional annual amount of additional private travel outside the Netherlands is likely limited.

[69] The use of employee fixed-effects is important here. The cross-section estimate is several times larger than the employee fixed-effects estimate. This suggests that commuters confronted with a longer commute (e.g. those who live far from employment centres) are more likely to sort themselves into jobs that offer company cars.

[70] In the DNB dataset, the mean daily commute is about 40 km. The employee fixed-effects analysis implies that a company car driver has, on average, a commuting distance that is 6 km longer *per day*. As the number of working days per year is about 200 days, the annual increment in travel distance is 1,200 km (that is, 6 km × 200 days). Assuming absence of travel externalities, the annual welfare losses through commuting can then be calculated as half times the change in the commuting distance times the tax-induced reduction in cost per kilometre €90 (= 0.5 × 1,200 km × 0.15 €/km).

travel, and the welfare loss of additional driving can be added to the welfare loss due to possessing a too expensive car.

The above estimate ignores the increase in externalities due to additional driving, which are mainly due to additional congestion and externalities of accidents. Note that this additional driving is mainly during rush hours, when the external costs due to congestion are higher (but the external costs of accidents may be lower). Using estimates as provided in Small and Verhoef (2007), the external costs per km are about €0.08, hence the externalities increase by about €100. Consequently, the welfare costs (the sum of the deadweight loss and the external costs) due to additional driving are about €200 per year.

7. Effects of Company Car on Other Demand Indicators

In the current paper, welfare loss of company car taxation is based on the change in market value of the most expensive car in the household. We have also examined the effect on other car demand variables to test the hypotheses that company car taxation also affects car ownership, measured by the value of *all* cars in the household or by the number of cars in the household. Information of the effect on both demand variables is informative, because it highlights the behavioural decisions of the household.

The effect of company car possession on car ownership, defined by the number of cars, is straightforward to determine using the DNB. In the Netherlands, the number of households with three or more cars is limited (merely 5 percent of the households with at least one car own three or more cars). We therefore distinguish only between households that have one car or at least two cars, so that we have a standard discrete choice. We have estimated a household fixed-effects discrete logit model, which can be estimated using a conditional maximum likelihood estimation method, as introduced by Chamberlain (1980). Using the same explanatory variables as in Table 1, we find a marginal effect of company car of 0.48

(s.e. 0.02), see Table B5.[71] This suggests that company car taxation strongly increases the number of cars in the household.[72]

We have also examined the effect of favourable company car taxation on household *value* of *all* cars by estimating the effect of company car possession on the value of all cars for the 1995–2006 DNB survey. We use a similar methodology and data as applied in the previous section. Using a household fixed-effects model, we find that the effect of the presence of a company car on household value of cars is about €14,066, see Table B4, which exceeds the effect of company car on the most expensive car in the household reported above. This strongly suggests that due to company car taxation, households increase total expenditure on cars, partially by increasing car ownership, partially by increasing the value of cars.

8. Conclusions

Economic theory is quite clear on how fringe benefits should optimally be taxed. In Europe, company cars are for many employees the most important (tax-induced) fringe benefit, but the welfare effects of the current tax system in Europe are unknown. This paper offers a study of the welfare effects of company car taxation. One novelty is that we identify this effect by examining the effect of having a company car on the market value of the most expensive car in the household. In the estimation procedures, we use household fixed effects as well as IV estimators to deal with unobserved household preferences for quality of cars, which indicate

[71] We are aware of two cross-section studies that examine the company car possession effect on the number of cars in the household (Whelan et al., 2001; Han, 2001). These studies also find that the presence of a company car increases the number of cars. However, they ignore a range of statistical issues. In particular, they control only for a few explanatory variables. We use panel data allowing for fixed effects and control for relevant variables. Note that the approach of Small and Rosen (1981) to determine the effect on welfare is not applicable, as the price of privately owned cars is not affected by company car taxation.

[72] One reason that this effect is so large is that there are other tax incentives to increase the number of cars in the household when a company car is provided, if the employee uses the company car only for commuting but not for other private travel. As we do not know to how many households this loss applies (we do not observe travel in this survey), we do *not* include this loss in our welfare calculation, but it suggests that the reported welfare loss is an underestimate.

that household sorting does not play a role in our estimates. Our results imply that, despite the high levels of other distortionary car taxes, the current tax treatment of company cars is strongly distortionary. Our analyses for the Netherlands indicate that the annual welfare losses of distortionary taxation are mainly due to a shift towards more expensive cars and are about €700 per company car.[73]

Company cars are predominantly taxed in Europe based on the company car's purchase price. In the Netherlands, the imputed tax rate of 22% of the company car's purchase price does *not* cover the firm's costs of company car provision to the employee, which creates a distortion in the optimal car decision-making of households. Given the assumption that tax authorities seek to tax the car's purchase price, they should set a tax at a much higher rate than the current one.[74] Nevertheless, we must emphasize that economic theory indicates that optimal taxation must not be based on the company car's purchase price, but must be derived from the firm's *net* costs of providing a company car, which is the current taxation practice in the US (IRS, 2008).[75]

We have focused in the current paper on the welfare losses of distortionary taxation of company cars through a shift towards more expensive cars. The welfare costs (the sum of the deadweight loss and the external costs) because of increases in travel (about 1,500 km per year) are shown to be smaller (about €200 per year). The total annual welfare loss due to distortionary taxation of company cars for the Dutch economy is estimated to be about €900 million. In the current paper, we have also ignored that car value is positively correlated with size of the car, so it is likely that a tax-induced increase in the size of the car creates a range of

[73] If it is the case that the current level of purchase taxes on personal cars (42% in the Netherlands) is *fully* distortionary, which is unlikely, the estimate is reduced to €350.

[74] The non-distortionary imputed tax is at least 36% (when purchase taxes are fully distortionary) and must be even 50% (when purchase taxes are non-distortionary). In countries where the purchase tax is absent (such as the UK), the 50% seems to apply.

[75] However, this tax policy requires differentiation between business and private kilometres for tax purposes, which might entail other costs in terms of monitoring by tax authorities.

other negative environmental, parking, accident and congestion externalities (see e.g. Parry et al., 2007).[76]

We have seen that one may argue that the tax advantage given to company cars may *partially* compensate for the presence of distortionary purchase taxes on personal cars, which is prevalent in the Netherlands. So, one may wonder whether our conclusion can be extended to other countries with different levels of purchase taxes. In most other European countries, the level of purchase car taxes tends to be less or equal to the Netherlands (see European Commission, 2002). Hence, arguments made for the Netherlands can be generalized to these European countries. For Denmark and Norway though, it is possible that favourable company car taxation generates welfare *benefits* as purchase taxes on personal cars can be argued to be too high in these countries, so company car taxation can be argued to correct for another tax distortion.

We estimate that the number of company cars in the EU–15 is about 20 million.[77] The average European taxation on the value of company cars is around the Dutch level.[78] Applying the assumptions as used for the Dutch economy, the European welfare losses due to distortionary company car taxation are estimated to be about €18 billion per year. The size of the welfare loss of distortionary company car taxation is intuitive as it is understood that the tax advantage given to company cars is large, and demand elasticities for cars tend to be substantial.

---

[76] Note however that company cars are more fuel efficient, *conditional on the size of the car* (Korver and Vanderschuren, 1995), which suggests that there may be positive externalities. It is not clear however whether company cars are more fuel efficient than privately bought cars, unconditional on size.

[77] It is not so straightforward to obtain accurate estimates of the number of company cars in Europe (as only the number of *lease* cars is well recorded). We have estimated the number of cars in the EU–15 on the assumption that the ratio of company cars to employees for the whole of the EU is equal to the ratio for the Netherlands, which is 12% (see European Commission, 2004). Given this assumption, there are roughly 20 million company cars in Europe (172 million employees × 0.12).

[78] Note that some countries have a higher taxation on the company cars' value (e.g. the UK has a 35% tax, but applies a discount depending on the business kilometres), while others have lower rates (e.g. Spain and Finland have a 15% tax).

References

Ashworth, M. and Dilnot, A. (1987). 'Company cars taxation', *Fiscal Studies*, vol. 8(4) (November), pp. 24–38.

Berry, S., Levinsohn, J. and Pakes, A. (1995). 'Automobile prices in market equilibrium', *Econometrica*, vol. 63(4) (July), pp. 841–90.

Chamberlain, G. (1980). 'Analysis of covariance with qualitative data', *Review of Economic Studies*, vol. 47(1) (January), pp. 225–38.

Clotfelter, C. (1983). 'Tax-induced distortions and the business-pleasure borderline: the case of travel and entertainment', *The American Economic Review*, vol. 73(5) (September), pp. 1053–65.

Craft, E. D. and Schmidt, R. M. (2005). 'An analysis of the effects of vehicle property taxes on vehicle demand', *National Tax Journal*, vol. 55(4) (December), pp. 697–720.

De Jong, G. C. (1990). 'An indirect utility model of car ownership and private car use', *European Economic Reviews*, vol. 34(5) (July), pp. 971–85.

de Palma, A., Lindsey, R. and Proost, S. (2006). 'Research challenges in modelling urban road pricing: an overview', *Transport Policy*, vol. 13(2) (March), pp. 97–105.

Economist Intelligence Unit (1996). *Motor Business Europe*, London.

Ehrenberg, R. G. and Smith, R. S. (2003). *Modern Labor Economics: Theory and Public Policy*, New York: Addison-Wesley.

European Commission (2002). *Fiscal Measures to Reduce CO2 Emissions from New Passenger Cars*, COWI A/S, Brussels.

_______ . (2004). *Employment in Europe 2004, Recent Trends and Prospects*, Luxembourg.

Frank, R. H. (1999). *Luxury Fever*, New York: Free Press.

Gruber, J. (2001). 'The impact of the tax system on health insurance coverage', *International Journal of Health Care Finance and Economics*, vol. 1(3–4) (September), pp. 293–304.

Gruber, J., and Lettau, M. (2004). 'How elastic is the firm's demand for health insurance?', *Journal of Public Economics*, vol. 88(7–8) (July), pp. 1273–93.

Han, B. (2001). 'Analyzing car ownership and route choices using discrete choice models, Royal Institute of Technology', Stockholm (dissertation).

Hess, A. C. (1977). 'A comparison of automobile demand equations', *Econometrica*, vol. 45(3) (April), pp. 683–701.

Hirsch, F. (1976). *Social Limits to Growth*, Cambridge: Harvard University Press.

Inland Revenue Service (2008). www.irs.gov.

Inland Revenue (2004). *Report of the Evaluation of Company Car Tax Reform*, UK.

Jørgensen, F. and Dargay, J. M. (2007). 'Inferring price elasticities of car use and moral costs of driving without a licence', *Transportation Research Part A: Policy and Practice*, vol. 41(1) (January), pp. 49–55.

Katz, A. and Mankiw, G. (1985). 'How should fringe benefits be taxed', *National Tax Journal*, vol. 38(1) (March), pp. 37–47.

Korver, W. and Vanderschuren, M. J. W. A. (1995). *De zakenautorijder is perspectief*, TNO Inro, Delft.

McCarthy, P. S. (1996). 'Market price and income elasticities of new vehicle demands', *Review of Economics and Statistics*, vol. 78(3) (May), pp. 543–47.

Parry, I. W. H. and Bento, A. (2001). 'Revenue recycling and the welfare effects of road pricing', *Scandinavian Journal of Economics*, vol. 103(4) (December), pp. 645–71.

Parry, I. W. H., Walls, M. and Harrington, W. (2007). 'Automobile externalities and policies', *Journal of Economic Literature*, vol. 45(2) (June), pp. 373–99.

RAI Documentatie Centrum (2002). *Bestandsanalyse 2002,* Amsterdam.

Small, K. A. and Bento, A. (2005). 'Does Britain or the United States have the right gasoline tax?', *The American Economic Review*, vol. 95(4) (September), pp. 1276–89.

Small, K. A. and Rosen, H. S. (1981). 'Applied welfare economics with discrete choice models', *Econometrica*, vol. 49(1) (January), pp. 105–30.

Small, K. A. and Verhoef, E. T. (2007). *The Economics of Urban Transportation,* London & New York: Routledge.

Statistics Netherlands. (2000, 2003). *Social Statistical Database SSB 2000/03,* The Hague, The Netherlands.

Tillema, T., van Wee, B., Rouwendal, J. and van Ommeren, J. (2008). Firms: Changes in trip patterns, product prices, locations and in the human resource policy due to road pricing. In: *Pricing in Road Transport*, edited by E. Verhoef, M. Bliemer, L. Steg and B. Van Wee, Edward Elgar, Cheltenham.

Turner, R. W. (1987). 'Taxes and the number of fringe benefits received', *Journal of Public Economics*, vol. 33(1) (June), pp. 41–57.

Varian, H. R. (1992). *Microeconomic Analysis*, New York: WW Norton and Company.

Verboven, F. (1996). 'International price discrimination in the European car market', *The RAND Journal of Economics*, vol. 27(2) (Summer), pp. 240–68.

Vickrey, W. S. (1963). 'Pricing in urban and suburban transport', *American Economic Review, Papers and Proceedings*, vol. 53(2) (March), pp. 452–65.

Whelan, G., Fox, K. and Daly, A. (2001). *Updating Car Ownership Forecasts*, Institute for Transport Studies, UK.

Wilmink, I. R., Eijkelenbergh, P. L. C., Korver, W. and Droppert-Zilver, M. N. (2002). *De Zakenautorijder aan het Begin van de 21e Eeuw*, TNO Inro, Delft.

Wooldridge, J. M. (2001). *Econometric Analysis of Cross Section and Panel Data*, Cambridge: MIT Press.

Wuyts, B. (2009). 'Essays on congestion, transport taxes, and the labour market', Universiteit Antwerpen (dissertation).

Zax, J. S. (1988). 'Fringe benefits, income tax exemptions and implicit subsidies', *Journal of Public Economics*, vol. 37(2) (November), pp. 171–83.

Table 1. *Marginal Effects on Value of the Most Expensive Car in the Household (1995–2006 DNB)*

	[1]	[2]	[3]	[4]	[5]
Variables	Linear regression	Fixed-effects model	Random-effects model	Random effects-IV probit model	
Company car	11,878	12,718	12,372	10,581	9,565
	(260.9)**	(754.6)**	(384.5)**	(913.0)**	(858.6)**
Children 1	–168.4	763.4	558.7	656.9	766.4
	(318.2)	(528.2)	(377.7)	(304.6)**	(309.0)**
Children 2	–518.9	572.6	381.8	714.2	798.4
	(300.6)	(678.7)	(417.2)	(365.0)**	(370.4)**
Children ≥ 3	–2,546	–2,452	–1,719	–2,293	–2,254
	(356.6)*	(991.6)*	(519.6)**	(487.0)**	(492.7)**
Net household income in log	3,397	589.0	1,120	159.1	230.1
	(224.6)**	(208.8)**	(190.2)**	(144.7)	(146.1)
Head permanently employed	415.1	1,571	982.9	–388.8	–399.9
	(732.5)	(783.1)**	(663.4)	(540.1)	(514.4)
Head working hours	–103.1	149.6	–6.463	421.3	381.9
	(114.6)	(128.1)	(106.7)	(89.89)**	(90.56)**
(Head working hours)^2	2.036	–2.148	0.744	–8.139	–7.242
	(1.979)	(2.321)	(1.910)	(1.724)**	(1.728)**
Head working hours unknown	5,044	–324.0	1,780	–1,874	–1,861
	(2,014)**	(1,969)	(1,712)	(1,239)	(1,262)
(Head job duration)/100	107.3	26.574	16.482	89.81	75.49
	(39.63)**	(57.23)	(44.90)	(37.20)**	(37.53)**
(Head job duration)^2/10,000	–1.737	3.235	1.456	1.425	1.578
	(1.064)	(1.554)**	(1.221)	(0.966)	(0.981)
Head job duration unknown	–4,666	4,990	749.8	6,991	6,393
	(1,662)**	(1,800)**	(1,494)	(1,228)**	(1,238)**
(Head employment duration)/100	42.38	–49.28	22.60	–30.97	–30.40
	(38.30)	(49.38)	(40.70)	(30.48)	(31.04)
(Head employment duration)^2/10,000	0.309	2.000	0.362	1.339	1.284
	(0.785)	(1.088)*	(0.889)	(0.671)**	(0.684)*
Ownership of residence	2,495	894.9	2,409	1,759	1,823
	(313.7)*	(840.3)	(463.8)**	(422.8)**	(428.1)**
Residence density – very low	–521.7	–1,681	–105.6	–94.95	–44.81
	(384.3)	(2,309)	(675.0)	(746.8)	(750.3)
Residence density – low	–59.42	1,364	266.8	122.5	212.6
	(402.0)	(2,347)	(695.5)	(764.5)	(768.2)
Residence density – moderate	1,016	1,021	1,373	1,310	1,352
	(419.6)**	(2,276)	(712.9)	(766.7)*	(771.3)*
Residence density – high	38.03	2,758	766.9	305.9	362.1
	(433.0)	(2,457)	(743.7)	(805.5)	(810.1)
Two-earner household	–129.7	–954.0	–74.50	215.9	215.7
	(227.7)	(419.9)**	(290.8)	(238.8)	(242.6)
Head female	–322.7		–728.6	–3,301	–3,484
	(1,119)		(1,724)	(1,816)*	(1,831)*
Head female works full-time	483.4	1,416	1,251	5,402	4,290
	(1,381)	(2,671)	(1,919)	(1,843)**	(1,855)**
Head age	–8.025		–3.862	–73.71	–74.56
	(17.35)		(22.32)	(22.08)**	(22.21)**
Head education – primary	–180.9		–1,047	–1,028	–1,013
	(305.8)		(415.6)**	(354.7)**	(360.1)**
Head education – low secondary	179.8		–2,434	–2,437	–2,443
	(293.2)		(365.6)**	(300.5)**	(305.3)**
Head education – advanced secondary	894.9		–228.2	–337.2	–327.0
	(243.0)**		(344.3)	(302.5)	(306.8)
Head education – unknown	2,335		2,563	4,136	3,962
	(776.0)**		(948.9)**	(778.7)**	(790.7)**

	[1]	[2]	[3]	[4]	[5]
Constant	–33,659 (3,082)**		–11,030 (2,973)**	–960.7 (2,380)**	–11,030 (2,973)**
Year controls (12)	Included	Included	Included	Included	Included
Residence region controls (5)	Included	Included	Included	Included	Included
Adjusted R-squared	0.38	0.80			
No. observations	5,399	5,399	5,399	5,399	5,399
No. households	1,205	1,205	1,205	1,205	1,205

Notes: Value of the most expensive car in euros; number of working hours per week according to the contract; current job duration (in years); employment duration in the labour market (in years). The reference category for residence density and head education are 'very high' and 'high'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

Table 2. *Marginal Effects on Logarithm of Value of the Most Expensive Car in the Household (1995–2006 DNB)*

Variables	[1] Linear regression	[2] Fixed-effects model	[3] Random-effects model	[4] Random effects-IV probit model	[5]
Company car	1.220 (0.036)**	1.223 (0.094)**	1.251 (0.052)**	0.863 (0.109)**	0.813 (0.102)**
Children 1	–0.093 (0.044)	0.050 (0.066)	0.015 (0.049)	0.041 (0.036)	0.049 (0.037)
Children 2	–0.074 (0.041)*	0.072 (0.084)	0.038 (0.056)	0.072 (0.044)	0.079 (0.045)**
Children ≥ 3	–0.415 (0.049)**	–0.155 (0.123)	–0.254 (0.070)**	–0.250 (0.060)**	–0.249 (0.060)**
Net household income in log	0.387 (0.031)**	0.044 (0.026)*	0.086 (0.024)**	0.004 (0.017)	0.007 (0.017)
Head permanently employed	0.130 (0.101)	0.204 (0.097)**	0.161 (0.085)*	0.038 (0.060)	0.032 (0.061)
Head working hours	–0.025 (0.016)	0.018 (0.016)	–0.002 (0.014)	0.036 (0.011)**	0.034 (0.011)**
(Head working hours)^2/100	0.040 (0.027)	–0.033 (0.029)	0.003 (0.025)	–0.073 (0.020)**	–0.069 (0.020)**
Head working hours unknown	0.286 (0.278)	–0.530 (0.245)**	–0.314 (0.218)	–0.341 (0.146)**	–0.339 (0.148)**
(Head job duration)/100	1.201 (0.547)**	0.006 (0.712)	0.302 (0.582)	0.859 (0.441)*	0.792 (0.443)*
(Head job duration)^2/1,000	–0.119 (0.147)	0.273 (0.193)	0.152 (0.158)	0.159 (0.114)	0.164 (0.116)
Head job duration unknown	–0.420 (0.299)*	1.002 (0.224)**	0.536 (0.192)**	1.109 (0.145)**	1.080 (0.146)**
(Head employment duration)	0.001 (0.005)	–0.003 (0.006)	0.003 (0.005)	–0.002 (0.004)	–0.002 (0.004)
(Head employment duration)^2/100	0.011 (0.011)	0.021 (0.014)	0.005 (0.011)	0.014 (0.008)*	0.013 (0.008)
Ownership of residence	0.335 (0.043)*	0.263 (0.104)**	0.361 (0.062)**	0.316 (0.051)**	0.321 (0.052)**
Residence density – very low	–0.064 (0.053)	0.373 (0.287)	–0.046 (0.094)	–0.013 (0.095)	–0.012 (0.096)
Residence density – low	–0.062 (0.055)	0.266 (0.292)	–0.063 (0.097)	–0.053 (0.097)	–0.047 (0.098)
Residence density – moderate	0.121 (0.055)**	0.254 (0.283)	0.109 (0.099)	0.118 (0.097)	0.119 (0.098)
Residence density – high	–0.049 (0.060)	0.394 (0.306)	0.050 (0.103)	0.010 (0.102)	0.015 (0.103)
Two-earner household	0.026 (0.031)	–0.135 (0.052)**	–0.010 (0.038)	0.008 (0.28)	0.005 (0.29)
Head female	0.027 (0.154)		–0.019 (0.237)	–0.356 (0.229)	–0.386 (0.231)
Head female works full-time	0.030 (0.190)	0.319 (0.332)	0.132 (0.260)	0.585 (0.226)**	0.529 (0.227)**
Head age	–0.003 (0.002)		–0.002 (0.003)	–0.009 (0.003)**	–0.009 (0.003)**
Head education – primary	0.039 (0.042)		–0.091 (0.055)	–0.094 (0.043)**	–0.091 (0.043)**
Head education – low secondary	0.044 (0.040)		–0.301 (0.048)**	–0.322 (0.036)**	–0.321 (0.036)**
Head education – advanced secondary	0.159 (0.033)**		0.042 (0.046)	0.088 (0.036)**	0.089 (0.037)**
Head education – unknown	0.386 (0.107)**		0.309 (0.125)**	0.420 (0.093)**	0.408 (0.094)**

	[1]	[2]	[3]	[4]	[5]
Constant	3.947 (0.425)**		6.941 (0.385)**	7.845 (0.288)**	7.845 (0.291)**
Year controls (12)	Included	Included	Included	Included	Included
Residence region controls (5)	Included	Included	Included	Included	Included
Adjusted R-squared	0.26	0.81			
No. observations	5,399	5,399	5,399	5,399	5,399
No. households	1,205	1,205	1,205	1,205	1,205

Notes: Value of the most expensive car in euros; number of working hours per week according to the contract; current job duration (in years); employment duration in the labour market (in years). The reference category for residence density and head education are 'very high' and 'high'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

Table 3. *Effects on the Value of the Most Expensive Car in the Household (1990–1993 PAP)*

Variables	[1] *Employees*	[2] *Employees*	[3] *Employees + self-employed*
Company car	7,112 (590.6)**	3,933 (616.3)**	
Company car × employee			3,589 (635.4)**
Self-employed			3,502 (253.0)**
Car used for business purposes		366.3 (250.6)	–46.83 (232.5)
(Business km)/1,000		228.8 (35.80)**	304.6 (27.97)**
(Business km)^2/100,000,000		–69.13 (69.68)	–181.1 (49.64)**
Car ownership time spell in log/10	–49.24 (20.26)**	–50.19 (19.81)**	–54.80 (18.60)**
Income in log	2,335 (198.0)**	1,918 (197.1)**	2,510 (183.0)**
Income – unknown	1,889 (256.2)**	1,796 (251.1)**	1,962 (235.7)**
Work > 38 hours/week	113.0 (223.4)	42.53 (218.7)	
Female	781.3 (218.5)**	825.1 (213.9)*	895.7 (196.0)**
Age 25–30	–377.3 (350.5)	–325.2 (343.4)	–640.3 (350.5)*
Age 30–40	–294.6 (327.3)	–297.7 (320.9)	–594.6 (324.6)*
Age 40–50	1,061 (335.8)**	971.6 (329.2)**	751.1 (331.2)**
Age 50–60	2,268 (368.6)**	2,200 (361.3)**	1,895 (359.2)**
Age 60– 65	3,453 (857.2)**	3,518 (839.7)**	2,577 (653.6)**
Age >65	3,218 (2,331)	3,475 (2,281)	1,850 (954.5)**
Constant	–13,344 (1,987)**	–9,495 (1,974)**	–15,252 (1,880)**
Year controls (4)	Included	Included	Included
Residence province controls (12)	Included	Included	Included
Work province controls (12)	Included	Included	Included
Wald-statistic (β_ company car × employee – β_ self-employed)			0.366
Chi-squared(1)			0.545
Log likelihood	–12,739	–12,597	–14,481
No. observations	8,203	8,203	9,593

Notes: Value of the most expensive car in euros; number of business kilometres per year; time spell of car ownership in years. The reference category for age is '18–25'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

Table 4. *Effects on the Logarithm of the Value of the Most Expensive Car in the Household (1990–1993 PAP)*

Variables	[1] *Employees*	[2] *Employees*	[3] *Employees + self-employed*
Company car	0.654 (0.064)**	0.255 (0.067)**	
Company car × employee			0.333 (0.067)**
Self-employed			0.283 (0.027)**
Car used for business purposes		0.046 (0.028)	0.012 (0.025)
(Business km)/1,000		0. 022 (0.004)**	0.027 (0.003)**
(Business km)^2/100,000,000		–0.008 (0.007)	–0.016 (0.005)**
Car ownership time spell in log/10	–0.004 (0.002)*	–0.004 (0.002)**	–0.004 (0.002)**
Income in log	0.266 (0.022)**	0.224 (0.022)**	0.275 (0.020)**
Income – unknown	0.183 (0.028)**	0.174 (0.028)**	0.193 (0.025)**
Work > 38 hours/week	0.021 (0.025)	0.014 (0.024)	
Female	0.103 (0.024)**	0.107 (0.024)**	0.110 (0.021)**
Age 25–30	0.031 (0.039)	0.034 (0.039)	0.012 (0.038)
Age 30–40	0.045 (0.037)	0.041 (0.036)	0.024 (0.036)
Age 40–50	0.198 (0.038)**	0.187 (0.037)**	0.172 (0.036)**
Age 50–60	0.329 (0.041)**	0.321 (0.041)**	0.296 (0.039)**
Age 60– 65	0.429 (0.093)**	0.433 (0.092)**	0.338 (0.070)**
Age >65	0.333 (0.253)	0.356 (0.249)	0.257 (0.102)**
Constant	6.867 (0.221)**	7.252 (0.221)**	6.762 (0.204)**
Year controls (4)	Included	Included	Included
Residence province controls (12)	Included	Included	Included
Work province controls (12)	Included	Included	Included
Wald-statistic (β_ company car × employee – β_ self-employed)			0.527
Chi-squared(1)			0.468
Log likelihood	–12,844	–12,738	–14,524
No. observations	8,203	8,203	9,593

Notes: Value of the most expensive car in euros; number of business kilometres per year; time spell of car ownership in years. The reference category for age is '18–25'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

Appendix A: Calculation of the Firm's Annual Net Costs of Providing a Company Car to the Employee

At firm level, the decision concerning the provision of a company car to the employee is determined by the costs involved. We categorize these costs as either fixed costs, which are independent of the distance driven by the company car, or as variable costs, which are determined by the car usage. The fixed costs include the purchase cost or lease of the company car, vehicle licensing fees, insurance, and free road assistance. The variable costs include fuel costs, depreciation costs per kilometre (wear and tear), maintenance, and repairs. In our calculations, we distinguish between company cars that are productive (used for business purposes) and company cars that are not productive. Using the 1990–93 PAP, productive company cars are, on average, 30% more expensive and the annual business kilometres are 28,000. We will assume that these figures also hold in 2007.

We provide calculations under the assumption that the car is leased. We have obtained from a Dutch lease company the annual lease price of a representative car in 2007 and derived the lease price based on 0 km. This implies an average purchase price of €22,000 for a productive car and €17,000 for a non-productive car. The corresponding *annual* lease price of the car is €4,500 and €3,700, respectively. This lease price does *not* include the variable costs (fuel and depreciation) and some of the fixed costs (insurance, free road assistance) that are usually paid for by the firm.

Using the 1990–93 PAP, we find that, on average, company-car owners drive about 17,000 *private* kilometres per year. The sum of the fuel and depreciation costs per kilometre of a representative company car is estimated to be about €0.15, consequently the variable *private* costs are estimated to be €2,550 (that is, €0.15 × 17,000 km). The insurance premium is dependent on many factors such as car price, age of the car, province of residence and age of the driver. We calculate our annual premium, €1,700, for a one-year-old car in the province of North-Holland for a forty-year-old driver. Free road assistance is rather negligible, at €69.50. The vehicle user tax, which reflects the costs of road usage, is dependent on residence province and on weight, an on average amounts to €2,500 annually. For a *non-productive* car, the total costs are €8,700 (that is, €3,700 + €2,550 + €2,500). This suggests that α is slightly above 0.50 (€8,700/€17,000). Fuel costs are however less than proportional with other costs, so we use $\alpha = 0.40$.

The annual fixed costs of a *productive* company car are about €7,000, the variable costs for private travel equal €2,550 and the variable costs for business travel equal €4,200. So, the firm's average annual *gross* costs for a productive car are €13,700 (that is, €4,500 + €2,500 + €2,550 + €4,200). Firms pay for the cars' *marginal* costs of business travel, so the firm's average annual total *net* costs of providing a company car to the employee are €9,500 (that is, €13,700 – €4,200).

Appendix B: Tables

Table B1. *First Step Results of the Household company car IV-probit Procedure (1995–2006 DNB)*

Variables	[1]	[2]
Instruments		
Head works for public sector	–1.138 (0.072)**	–1.112 (0.074)**
Head works in metal sector		0.129 (0.088)
Head works in construction industry		0.577 (0.131)**
Head works in graphic industry		0.568 (0.190)**
Head works in retail		–0.290 (0.177)
Head works for electronic company X		–0.813 (0.220)**
Head works in bank sector		0.097 (0.100)
Control factors		
Children 1	0.059 (0.077)	0.090 (0.078)
Children 2	–0.010 (0.073)	0.018 (0.074)
Children ≥ 3	0.036 (0.084)	0.068 (0.084)
Net household income in log	0.525 (0.069)**	0.539 (0.070)**
Head permanently employed	0.566 (0.181)**	0.626 (0.183)**
Head working hours	–0.127 (0.031)**	–0.135 (0.032)**
$(\text{Head working hours})^2/100$	0.325 (0.051)**	0.340 (0.052)**
Head working hours unknown	0.914 (0.563)	0.880 (0.565)
(Head job duration)	–0.056 (0.009)**	–0.059 (0.009)**
$(\text{Head job duration})^2/10$	0.009 (0.002)**	0.011 (0.003)**
Head job duration unknown	–3.240 (0.387)**	–3.288 (0.387)**
(Head employment duration)/10	0.013 (0.012)	0.009 (0.012)
$(\text{Head employment duration})^2/100$	–0.008 (0.024)	0.002 (0.024)
Ownership of residence	0.136 (0.096)	0.110 (0.097)
Residence density – very low	0.224 (0.103)**	0.214 (0.103)**
Residence density – low	0.172 (0.107)	0.168 (0.108)
Residence density – moderate	0.246 (0.110)**	0.251 (0.111)**
Residence density – high	0.155 (0.114)	0.125 (0.115)
Two-earner household	–0.043 (0.056)	–0.041 (0.057)
Head female	1.240 (0.301)**	1.299 (0.301)**
Head female works full-time	–1.372 (0.348)**	–1.418 (0.349)**
Head age	–0.005 (0.006)	–0.004 (0.006)
Head education – primary	–0.019 (0.083)	–0.045 (0.085)
Head education – low secondary	–0.140 (0.076)*	–0.163 (0.078)**
Head education – advanced secondary	–0.057 (0.064)	–0.048 (0.065)
Head education – unknown	–0.743 (0.282)**	–0.742 (0.284)**
Constant	–5.659 (0.939)**	–5.772 (0.952)**
Year controls (12)	Included	Included
Residence region controls (5)	Included	Included
Log likelihood	–1,816	–1,790
No. observations	5,399	5,399
No. households	1,205	1,205

Notes: Number of working hours per week according to the contract; current job duration (in years); employment duration in the labour market (in years). The reference category for residence density and head education are 'very high' and 'high'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses. Columns [1] and [2] are respectively the first step results of the IV procedures of columns [4] and [5] in Tables 1 and 2.

Table B2. *Marginal Effects on Private Travel Distance during Weekends of Males (1996 NTS) Using Tobit Analysis*

Variables	Tobit model
Company car	3.075 (1.517)**
Child < 12	–2.306 (1.845)
Married	–0.453 (2.016)
Household members 2	0.938 (2.873)
Household members 3	0.212 (3.145)
Household members 4	–2.350 (3.208)
Household members ≥ 5	–2.118 (3.517)
Net income 25–32	4.218 (3.235)
Net income 32–40	7.431 (3.296)**
Net income 40–55	6.656 (3.404)**
Net income >55	10.80 (3.559)**
Net income unknown	–4.744 (4.383)
Net household income in log	3.936 (3.739)
Age 20–25	8.088 (3.883)**
Age 20–30	8.412 (2.496)**
Age 30–40	6.274 (2.009)**
Age 40–50	6.303 (1.815)**
Education – primary	–11.30 (3.306)**
Education – low secondary	–3.923 (1.668)**
Education – advanced secondary	–1.721 (1.509)
Education – unknown	–13.27 (7.260)*
Saturday	7.692 (1.180)**
Residence density	–0.341 (0.462)
Constant	1.038 (6.170)
Log likelihood	–25,647
No. observations	5,602

Notes: Private travel distance (excluding commuting) per day in km; income in euros. The reference category for income, age and education are '16–25', '25–30' and 'higher'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Heteroscedastic standard errors are in parentheses. The estimates refer to males who did not work during these days.

Table B3. *Marginal Effect of Company Car Possession on Logarithm of Commuting Distance (2001–2006 DNB)*

	[1]	[2]	[3]
Variables	Linear regression	Fixed-effects model	Random-effects model
Company car	0.648 (0.041)**	0.138 (0.040)**	0.148 (0.038)**
1 Child	0.020 (0.047)	–0.083 (0.045)*	–0.060 (0.042)
2 Children	0.114 (0.042)**	–0.157 (0.056)**	–0.101 (0.050)**
≥ 3 Children	0.094 (0.052)*	–0.238 (0.077)**	–0.146 (0.069)**
2 Adults	0.142 (0.046)**	0.552 (0.082)**	0.508 (0.067)**
≥ 3 Adults	0.379 (0.176)**	0.620 (0.123)**	0.592 (0.114)**
Net income in log	0.065 (0.034)*	–0.029 (0.015)*	–0.026 (0.015)*
Household net income unknown	–0.058 (0.028)**	–0.036 (0.016)**	–0.034 (0.016)**
Head permanently employed	0.057 (0.055)	–0.285 (0.039)**	–0.245 (0.038)**
Head working hours	0.003 (0.009)	–0.035 (0.007)**	–0.021 (0.007)**
(Head working hours)^2/100	0.016 (0.013)	0.054 (0.013)**	0.041 (0.013)**
Head working hours unknown	–0.797 (0.160)**	–0.727 (0.140)**	–0.451 (0.132)**
(Head job duration)/100	–1.156 (0.004)**	–0.010 (0.004)**	–1.190 (0.356)**
(Head job duration)^2/1,000	0.018 (0.121)	0.184 (0.100)*	0.221 (0.097)**
Head job duration unknown	0.422 (0.553)	–0.035 (0.243)	–0.033 (0.241)
(Head employment duration)	–0.008 (0.005)	–0.001 (0.004)	0.002 (0.004)
(Head employment duration)^2/100	0.269 (0.114)**	0.001 (0.011)	–0.004 (0.010)
Ownership of residence	0.023 (0.037)		0.006 (0.042)
Ownership of residence unknown	–2,347 (3,700)		–649.7 (4,160)
Residence density – very low	0.040 (0.056)	–0.489 (0.150)**	–366.5 (0.115)**
Residence density – low	0.205 (0.060)**	–0.469 (0.141)**	–0.330 (0.116)**
Residence density – moderate	0.213 (0.060)**	–0.793 (0.196)**	–0.581 (0.136)**
Residence density – high	0.245 (0.063)**	–0.584 (0.180)**	–0.332 (0.133)**
Two-earner household	–0.063 (0.035)*	–0.141 (0.035)**	–0.115 (0.034)**
Head female works full-time	–0.097 (0.044)**	–0.046 (0.068)	–0.162 (0.060)**
Head education – primary	–0.116 (0.051)**		–0.104 (0.053)*
Head education – low secondary	0.045 (0.046)		–0.040 (0.046)
Head education – advanced secondary	0.114 (0.046)**		0.011 (0.054)
Head education – unknown	–0.074 (0.039)*		–0.056 (0.030)*
Constant	1.404 (0.394)**		3.310 (0.230)**
Year controls (12)	Included	Included	Included
Residence region controls (5)	Included	Included	Included
Adjusted R-squared	0.10	0.89	
No. observations	6,226	6,226	6,226
No. households	1,221	1,221	1,221

Notes: Commuting distance of the head in km; company car of the head, number of working hours per week according to the contract; current job duration (in years); employment duration in the labour market (in years). The reference category for residence density and head education are 'very high' and 'high'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

Table B4. *Marginal Effects on Household Total Value of Cars (1995–2006 DNB)*

Variables	Fixed-effects model
Company car	14,066 (1,196)**
Children 1	2,729 (766.8)**
Children 2	–773.5 (1,024)
Children ≥ 3	–4,632 (1,426)**
Net household income in log	1,173 (300.5)**
Head permanently employed	–1,055 (1,117)
Head working hours	440.0 (185.4)**
(Head working hours)^2	–7.099 (3.321)**
Head working hours unknown	2,597 (2,831)
(Head job duration)	–61.07 (82.12)
(Head job duration)^2	6.026 (2.224)
Head job duration unknown	6,487 (2,550)**
(Head employment duration)	–100.83 (70.20)
(Head employment duration)^2	3.345 (1.547)**
Ownership of residence	3,994 (1,267)**
Residence density – very low	2,234 (3,269)
Residence density – low	4,419 (3,333)
Residence density – moderate	2,272 (3,220)
Residence density – high	535.4 (3,545)
Two-earner household	689.5 (613.9)
Head female works full-time	1,667 (3,766)
Year controls (12)	Included
Residence region controls (5)	Included
Adjusted R-squared	0.82
No. observations	5,293
No. households	1,187

Notes: Value of total value of cars in euros; number of working hours per week according to the contract; current job duration (in years); employment duration in the labour market (in years). The reference category for residence density is 'very high'. **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

Table B5. Marginal Effects on the Probability of Owning at least Two Cars (1995–2006 DNB)

Variables	Conditional Fixed-effects Logit model
Company car	0.480 (0.019)**
Children 1	0.048 (0.169)
Children 2	–0.615 (0.298)**
Children ≥ 3	–1.150 (0.426)**
Net household income in log	0.236 (0.132)*
(Head employment duration)	–0.037 (0.028)
(Head employment duration)^2/10	0.005 (0.007)
Year controls (12)	Included
Log likelihood	–151.92
No. observations	5,399
No. households	1,205

Notes: Employment duration in the labour market (in years). **, * – indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.