CEPIE Working Paper No. 01/22

Center of Public and International Economics

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March 2022

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Editors: Faculty of Business and Economics, Technische Universität Dresden.

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ISSN 2510-1196

Working from Self-driving Cars

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March 03, 2022

Abstract

Once automatic vehicles are available, working from self-driving car (WFC) in the AV's mobile office will be a real option. It allows firms to socialize land costs for office space from the office lot to road infrastructure used by AV. Employees, in turn, can switch wasted commuting time into working hours and reduce daily time tied to working. We develop a microeconomic model of employer's offer and employees choice of WFC contracts and hours. Using data for Germany and the U.S., we perform Monte Carlo studies to assess whether WFC may become reality. Eventually, we study the impact of transport pricing on these choices. Our findings is, that WFC contracts are likely to be a standard feature of large cities given current wages, office, and current and expected travel costs. There is a clear decline of hours spent working in office. On average, WFC hours and distance traveled slightly exceed commuting figures.

Keywords: Autonomous driving, telecommuting, working from car, working from home, transport economics
JEL codes: R40, R41, R48

Acknowledgements

Financial support from the German Research Foundation (DFG), grant 434191927, is gratefully acknowledged.

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1 Introduction

Commuting is one of the most disliked ways of time use in our world (see (e.g. Kahnemann et al., 2004; Stutzer and Frey, 2008). Therefore, if asked, employees may opt for telecommuting, which usually refers to working from home (WFH). WFH reduces the number of commuting trips and frees time for other purposes. Employers, in turn, can reduce office costs by allowing telecommuting, recently pushed by ICT developments such as cloud computing. Another way of telecommuting is to transfer wasted commuting into working time while traveling. Currently, this is partially possible by riding with taxis, ride-hailing, or transit. However, the spread of autonomous driving may change the game (Correia et al., 2019). Once automatic vehicles (AV) are available, working from self-driving cars (WFC) will be a real option since the interior of an AV can be decorated as an office with good ergonomic characteristics offering full access to the firm's IT network (e.g. Li et al., 2019; Janssen et al., 2019).

In principle, WFC offers the same benefits as WFH. Research provides evidence that the latter reduces commuting costs, increases time available for non-work activities due to reduced commuting (Wulff and Vernon, 2021) and improves the flexibility concerning time use (e.g., He et al., 2021)), and may improve the work-life balance since it (discussion see Zhang et al., 2020; Wulff and Vernon, 2021). In addition, productivity concerning creative tasks may be higher compared to WFH because there is less stressful commuting and more time is available to sleep or regenerate (Bloom et al., 2015; Dutcher, 2012; Harker Martin and MacDonnell, 2012). Firms can save office space and costs since fewer employees are at the office on average.

However, there are also adverse effects of WFH. It may lower productivity since it increases isolation and reduces face-to-face contacts and employee density at the office needed for knowledge spillovers (Frakes and Wasserman, 2021; Rosenthal and Strange, 2020; Golden et al., 2008). Further, employees have less access to information and job networks (Golden and Veiga, 2015), may experience reduced career chances (Golden and Eddleston, 2020), and more family-to-work conflicts due to the loss of boundaries between work and private life (Sarbu, 2018).

WFC may help to reduce some of these issues. It makes it easier to disentangle work from private life and meet colleagues more often and with less effort than WFH. One can meet coworkers at the next cafe, temporarily book a co-working space, or drive to the office. Further, employees may be closer to the office than with WFH and can work on their way to a customer. Further, using a self-driving car makes even commuting less wasteful because more activities are available on the trip (Pudãne and Correia, 2020).

Additional costs from organizing WFH or WFC may differ. With WFH, firms outsource office costs to employees. In contrast, with WFC, land costs are outsourced to the society that finances road infrastructure. WFC may increase the range of telecommuting since employees that do not have enough room at home or cannot work from home on account of family interruptions can use WFC. Further, the costs for employers such as monitoring or IT security costs may be even lower with WFC than WFH since the employee is working in the firm's mobile office.[1]

Empirical evidence shows that many employees in the U.S. have a positive willingness-to-accept lower wages in exchange for the option to WFH, indicating that there is a private net-benefit of WFH(8% and 4.1% wage discount, see Mas and Pallais, 2017; Maestas et al., 2020). Since WFC provides similar advantages, we expect that many employees have a positive willingness-to-accept WFC.

Therefore, the question is not if there will be a supply of mobile offices, but whether this will become a widespread feature of tomorrow's world. If this is the case, we may observe a re-organizing of work with stark consequences on traffic comparable to the switch to just-in-time production changed the inventory handling (McKinnon and Woodburn, 1996). We examine how likely working from a self-driving car (WFC) is given current and expected prices and magnitudes of relevant parameters.

The first condition for widespread use of WFC is that enough jobs or tasks are suited for WFC. This condition is unambiguously fulfilled, given that a considerable share of work is suited for telecommuting (40% in the U.S. Dingel and Neiman, 2020). The second condition is that WFC offers strong enough advantages to employees and employers to offset adverse effects. This second condition is our focus. We ask whether WFC is likely to become a significant feature of our world. We look into this issue by studying the economics of WFC with a focus on employees' and employers' decisions.

We proceed in the following way. First, we derive a model of the economic decisions of employees and employers on WFC. We assume that an employee decides on the extensive and the intensive margin of WFC. The extensive margin is the choice of whether to accept a contract that offers the opportunity of WFC. Given that decision, the intensive margin is the decision on time spent working in AV. i. e. WFC hours. We perform comparative statics on this model to identify the impacts of different parameters, including taxes, subsidies, and fees, on these decisions.

Second, we develop a decision model of the firm. The firm offers mobile-work contracts with a wage discount and an employee's payment for the private use of the firm's AV. The profit-maximizing firm chooses the mobile-work wage and the travel-cost payment considering differences in productivity and costs between WFC and working in the office (WFO). We perform comparative statics to discuss these wage components using this approach.

[1] But due to IT developments, monitoring costs decline over time and are getting smaller with WFH, too (Oettinger, 2011).

Our model is closely related to De Borger and Wuyts (2011a) but bears also from Fetene et al. (2016) and Pudãne and Correia (2020). We extend the model of De Borger and Wuyts (2011a) that considers only the wage offer by the firm by adding the firm's decision on the payment for private use of the firm's AV.

Eventually, we run Monte Carlo simulations to understand under which parameter constellations WFC becomes a likely feature of the model's labor market. We study parameters like office costs, wage distribution, travel costs of electric cars and AVs, expected leasing and travel costs, the variation in utility function parameters, and heterogeneous preferences for WFC.

Our contribution is threefold: 1) There is hardly any literature on WFC. None is studying the economic decisions of both employees and employers on this type of mobile work. Our study is the first to examine these decisions in a single framework to the best of our knowledge. 2) We adopt the single-price model of De Borger and Wuyts (2011a) and extend it to a case with two relevant prices: wages and price for using the firm's car. 3). We first apply Monte-Carlo Simulations to this type of approach.

In the next section, we develop the model that is subsequently used for some comparative statics to understand the main mechanisms of the model. Afterward, we present our data and perform Monte-Carl simulations. Eventually, we discuss the results and provide some conclusions.

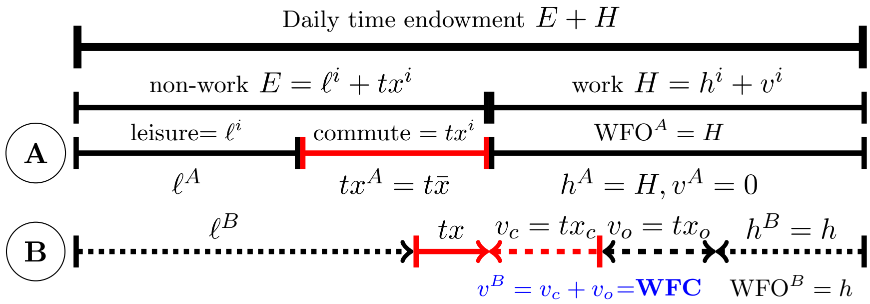
2 Model of Decisions on Working from Self-driving Car

We develop a model of employees' and employers' decisions on WFC in the following. We distinguish two work contracts: Contract A enables only working in the office (WFO) while contract B allows WFC.

Employees maximize their expected utility in two stages. In the first stage, they decide on the intensive consumption margins for both contracts. In contract B, they also decide on non-WFC travel time and the allocation of working time to WFC and WFO. In the second stage, heterogeneous employees decide in a random utility approach whether to sign contract B.

Employers decide on the maximum wage they accept to hire mobile workers, i. e. workers with contract B, and the employee's payment for the private use of the firm's AV.

Contract A is the standard contract of an office worker where WFO is the only option. The employee has to work at the office at the current market wage w. We denote this contract as $A \equiv \{w; \text{WFO}\}$. It defines the benchmark without WFC. Contract $B \equiv \{\omega; b; \text{WFC}\}$ is the contract enabling WFC. ω is the wage that may include a discount or supplement to the market wage, and b is the share of private travel costs in the firm's AV paid by the employee.



WFO is working from office, WFC is working form self-driving car. Superscript A denotes contract A with WFO only, while superscript B denotes contract B with the WFC option. $t\bar{x}$ is the total travel time from home to office equivalent to commuting time under contract A. In contract B, it encompasses pure commuting time $tx^B = tx$ and former commuting time now used for basic WFC $v_c = tx_c$, i. e. WFC instead of commuting where tx_c is travel time while using WFC. In addition, additional WFC occurs outside the trip from home to office, denoted as v_o with tx_o as the corresponding travel time. Note: $t\bar{x} = tx_o+tx_c$, $v_c = tx_c$, $v = v_c+v_o$, $H = v_c+v_o+h$.

Figure 1: Time use

Figure 1 displays the complexity of time allocation in the model. A typical contract-A employee's commuting distance to work, $\bar{x}$, is constant. She commutes using an electric (EV) but not an autonomous car. Time traveled per unit of distance t depends on traffic flow. Daily working time H is fixed and entirely spent at the office, while WFC is zero. We assume constant daily working H and non-working time E. Leisure is the residual $\ell^A = E - t\bar{x}$. Because in contract A WFO is the only available choice time spent working in the office is H.

A typical employee with contract B uses the firm's autonomous car (AV) for working (WFC) or non-working-related time use. To simplify, we assume that this non-WFC travel time is pure wasted commuting time. We assume that the employee travels from home to the office once a day. The employee's time use on this trip comprises commuting time tx and basic WFC $v_c = tx_c$ with x_c as distance traveled while WFC. If travel time per VDT is the same, the home-to-office trip takes the same time under both contracts, hence, $t\bar{x} = tx + tx_c$. The employee can also substitute additional WFC, v_o, corresponding to the travel distance x_o. She spends left-over working time $h = H - v_o$ at the office (WFO).

2.1 Employee's decision with contract A

We assume that employees are identical except for their intrinsic preference for WFC. They derive (dis)utility from consumption z, leisure spent outside any car ℓ, and commuting time tx, where x denotes vehicle distance traveled

(VDT). The utility function

$$U^A(z, \ell, tx) = z + u_2(\ell) + u_3(tx) \tag{1}$$
$$u_2' > 0;\ u_3' \lesseqgtr 0;\ u_2'',\ u_3'' < 0.$$

is quasi-linear in consumption z, concave in leisure ($u_2(\ell)$) and inversely u-shaped in tx to consider additional costs of commuting. In contrast to the time-use literature there is no time for activities z and ℓ, and working generates no (dis)utility (DeSerpa, 1971; Jara-Diaz et al., 2008). A consequence of quasi-linearity is a constant marginal utility of income (MUI) that we set to unity in the following.

$u_3(tx)$ is the intrinsic value of time, i.e., the direct dis(utility) of the travel activity that depends on the quality of in-vehicle time and options to perform secondary activities (DeSerpa, 1971; Jara-Diaz et al., 2008). Employees may prefer a small amount of commuting travel usable for secondary activities, e.g., transport children, buffer between working and family live (Redmond and Mokhtarian, 2001). In contrast, they suffer from longer commuting due to the stress of driving, implying that the disutility of longer commutes may exceed the disutility from loss of leisure (reviewed by Chatterjee et al., 2020). Therefore, we define $u_3(tx)$ as an inverted u-shaped function.

g_m denotes gross monetary costs per VDT on the commuting trip. It depends on speed, subsidies, and all taxes levied on car usage, including fuel taxes, VAT on fuel and car's purchase price, insurance, and sales taxes. We calculate them as averages per VDT. We assume that the traffic flow is fixed outside the model, implying that t and g_m are constants in the choice problems. VDT traveled is measured as the two-way commuting distance x. We further implement a congestion toll τ_c on travel time and a wage tax τ_w on wage income. The daily market wage is w.

Employees spend income net of taxes and commuting costs for private consumption z. Hence, in terms of days, the budget constraint is

$$z = (1 - \tau_w)w - \tau_q H - (g_m + \tau_c t)\bar{x} \tag{2}$$

where z is private consumption per day and $(1 - \tau_w)w$ is daily net wage. $\tau_q H$ is the daily parking cost at the workplace, with τ_q as the hourly parking fee.

Substituting (2) into (1) yields indirect utility on a workday

$$V^A(w, \tau_w, g_m, \tau_c, t) = (1 - \tau_w)w - \tau_q H - (g_m + \tau_c t)\bar{x} + u_2(E - t\bar{x}) + u_3(t\bar{x}) \tag{3}$$

The value of time (VOT)[2] is $VOT = u_2' = (1 - \tau_w)w$ and the value of commuting-travel time savings (VTT) is $VTT = VOT - u_3'$, where u_3' is the

[2] In the time use literature, often called "value of time as a resource" or "value of leisure time" (VOL), (DeSerpa, 1971; Jara-Diaz et al., 2008).

value of intrinsic value time (VTAT), that is the monetary equivalent of the direct dis(utility) of travel time (DeSerpa, 1971; Jara-Diaz et al., 2008).)

Assuming identical utility of all office workers (outside option), wage bargaining (collective or individual) implies that the reservation wage equalizes indirect with outside utility (fallback position), i.e., $V^A = \bar{U}$. This implies

$$w = \frac{\bar{U} + \tau_q H + (g_m + \tau_c t)\bar{x} - u(E - t\bar{x}) - u(t\bar{x})}{1 - \tau^w} \tag{4}$$

2.2 Employee's decisions with contract B

Now assume an employee is working under a contract B, giving him the opportunity for WFC. In that case, the firm's V offers an autonomous car (AV) with an office inside (provides him with a mobile office). The AV picks up the employee every morning at home and drops her at home at the end of the working day. In contrast to the standard company car paid by the employer, we assume that the AV is only temporarily available. The AV can be used for working and private use while on the travel-to-office trip (former commuting trip). The firm pays all costs but demands a payment of btx for private use. There is a fringe benefit if this payment is below private travel costs. Following De Borger and Wuyts (2011b) there may be an imputed value ρ of this fringe benefit for calculating the income tax.

In contract B, the time structure of the model changes as shown in Panel B in 1. The mobile employee chooses non-WFC commuting distance x, i.e. indirectly basic WFC v_c, and additional WFC, i.e. v_o. We distinguish two time periods spent in AV: time needed to travel the home-to-office distance (equivalent to commuting time in contract A) and additional WFC time. The first can be either spent for WFC or private activities. However, we do not consider leisure time spent in AV[3] as equivalent to the leisure outside the car implemented in the labor supply decision (Pudāne and Correia, 2020; Correia et al., 2019). Instead, we assume that this type of leisure lowers the intrinsic value of time.[4] We assume that the employee chooses x, i.e., vehicle distance traveled (VDT) during private use of the firm's AV. WFO hours are $h = H - v_o$ and WFC hours are $v = v_c + v_o$ where $v_c = t(\bar{x} - x)$.

We assume that employees are identical except for their intrinsic preference for WFC. They derive utility or disutility from consumption z, leisure ℓ, travel distance, and v_o. The deterministic utility function is

$$U(z, \ell, tx, v) = z + u_2(\ell) + u_3(tx) + u_4(v_o) \tag{5}$$
$$u_2', u_4' > 0;\ u_3' \lesseqgtr 0;\ u_2'', u_3'', u_4'' < 0,\ \phi > 1.$$

[3]In contrast to contract A, the employee can perform other activities in the AV, e.g., read, rest, sleep, or use ICT to reduce the utility loss from pure commuting and shrink the VTT.(Pudāne and Correia, 2020)

[4]We do not consider other activities like consumption from AV because we do not learn much from that distinction.

Referring to recent findings of Lee et al. (2021), we assume that the VTT increases with distance.[5]

$u_4(v_o)$ is concave utility arising from additional WFC. WFC may be more comfortable than WFO because there is more flexibility in organizing work, fewer disturbances with colleagues, or the possibility to stop for private errands in between. We assume that these effects occur only for v_o because this is the time one could alternatively be at the office.[6] However, there is a trade-off because WFC may lower career prospects, information exchange, and links to colleagues. These cost increase with intensity of WFC, v_o.[7]. We assume that some of these adverse effects add to the concavity of utility. The other negative WFC effects impose costs on the employees that we consider in the budget constraint.

We further assume identical travel behavior on the home-to-office route at both contracts. There is the same distance traveled and the same speed choice behavior. Further, there is no cruising with additional WFC. [8]

The monetary budget constraint is

$$z = (1 - \tau_w)\omega - \tau_w \rho \bar{x} - btx - p\, e(v_o) \tag{6}$$

where ω is the individual hourly wage with contract B, $\tau_w \rho \bar{x}$ is the tax liability for the fringe benefit of private use of firm's car with ρ as imputed tax value per unit of home-to-work distance, and btx is the employee's payment to the firm as compensation for the private use of the firm's AV. The daily wage may differ between both contracts. In addition, we assume some effort is needed to compensate for the loss of communication and information, e.g. call and invite colleagues. Its price is p.[9] $e(v_o)$ is the effort function indicating the effort per hour of additional WFC. It is usually increasing with absence from office $e' > 0$, $e'' > 0$.

[5]Lee et al. (2021) find that this happens between 10 to 100 km. They do not provide results for shorter distances. They also find that for people who are indifferent between AV and other car types, the VTT is constant between 10 and 50 km and increases for longer distances. We simplify and use their average finding.

[6]This is analogous to the telecommuting literature. According to the review of Allen et al. (2015), there is a positive value (satisfaction) of telecommuting that is concave. There are two drivers: work-family conflicts and coworker relationships (Gajedran and Harrison, 2007). While telecommuting improves the work-life balance, a high level of telecommuting may impose conflicts due to the interference of family with working at home. The latter is absent with WFC while the first may be slightly weaker.

[7]Golden and Eddleston (2020) provide evidence that the number of promotions and wage growth decline with the intensity of WFH.

[8]Tscharaktschiew and Reimann (2021) emphasize that empty autonomous cars may drive slower. Since speed raises WFC's monetary travel and sickness costs, reducing speed may also be a realistic outcome in the case of WFC. We do not model this to simplify matters.

[9]Golden and Eddleston (2020) provide evidence that telecommuters face a higher wage growth if they have more often face-to-face contact with supervisors and do more extra work.

The employee maximizes utility (1) subject to (6) and several non-negative restrictions

$$\max_{v_o,x} (1-\tau_w)\omega - \tau_w \rho \bar{x} - btx - p\, e(v_o)$$
$$+ u_2\,(E-tx) + u_3(tx) + u_4(v_o)$$
$$\text{s.t.: } v_o \geq 0 \perp \mu_v;\ x \geq 0 \perp \mu_x;\ \bar{x} - x \geq 0 \perp \mu_c.$$

where we used $G \equiv g_x + (g_h + \tau_c)t$. The first order conditions (FOCs) are:

$$u_4' = p\,e' - \mu_v \tag{7a}$$
$$(-u_2' + u_3')\,t = b\,t - \mu_x + \mu_c \tag{7b}$$
$$v_o \geq 0 \qquad \text{if '>' } \rightarrow \mu_v = 0 \tag{7c}$$
$$x \geq 0 \qquad \text{if '>' } \rightarrow \mu_x = 0 \tag{7d}$$
$$x \leq \bar{x} \qquad \text{if '<' } \rightarrow \mu_c = 0 \tag{7e}$$

where μ_i are the shadow prices of the non-negative and the maximum restrictions.[10].

Applying the theorem of implicit differentiation to the implicit demand functions (7a) and (7b) gives us partial derivatives of v_o and x with respect to cost and policy parameters, travel time, and traffic flow. Implicitly differentiating (7a) yields

$$\begin{aligned} \frac{\partial v_o}{\partial i} &= 0,\ \forall i \neq p \\ \frac{\partial v_o}{\partial p} &= \frac{e'}{-p\,e'' + u_4'} < 0 \end{aligned} \tag{8}$$

The choice of additional WFC hours v_o depends exclusively on the effort costs p.

By applying the theorem of implicit function to (7b) the derivatives of non-work travel distance x w.r.t. to the different parameters are:

$$\begin{aligned} \frac{\partial x}{\partial b} &= \frac{1}{t(u_2'' + u_3'')} < 0; \\ \frac{\partial x}{\partial i} &= 0,\ \forall i \notin \{b, t\} \\ \frac{\partial x}{\partial t} &= -\frac{x}{t} + \frac{b + u_2' - u_3'}{t^2(u_2'' + u_3'')} \end{aligned} \tag{9}$$

where $u_2'' + u_3'' < 0$ and $\partial \ell / \partial x = -t$. The commuting travel leftover in a WCB contract declines with the costs of private use of the firm's AV (b), while the inverse speed (inverse travel time per km) may have an ambiguous effect. Other variables, including taxes and fees, do not matter.

[10] All μ_i are monetary values since MUI = 1

Indirect utility of employee j is $V^B + \varepsilon$ where ε is the idiosyncratic preference for contract B (note, we drop index j). We assume that the mean of ε is zero.

$$\begin{aligned}
V^B(\tau_w, \omega, b, t, p, \rho, \mu_x, \mu_v, \mu_c) = \Big\{ &(1-\tau_w)\omega - \tau_w \rho \bar{x} - btx - p\, e(v_o) \\
&+ u_2\big(E - tx\big) + u_3(tx) + u_4(v_o) + \varepsilon \\
&+ \mu_v v_o + \mu_x x + \mu_c(\bar{x} - x) \rightarrow \max_{v,x} \Big\} \\
= (1-\tau_w)\omega &+ V_x^B(\tau_w, b, t, p, \rho, \mu_x, \mu_v, \mu_c) + \varepsilon
\end{aligned} \tag{10}$$

We define $V_x^B \equiv V_j^B - (1-\tau_w)\omega - \varepsilon_j$.

The reservation wage ω of an employee j of type B equalizes $V^B = \bar{U}$, hence

$$\bar{U} - (1-\tau_w)\omega - V_x^B - \varepsilon = 0 \tag{11}$$

where $\bar{U}$ is the reservation utility. Using $\varepsilon = 0$ yields the reservation wage of the median employee

$$\omega = \frac{\bar{U} - V_x^B}{1-\tau_w}, \tag{12}$$

while the reservation wage of an individual of type j is

$$\omega_j = \omega - \frac{\varepsilon_j}{1-\tau_w} \tag{13}$$

Assume $\varepsilon > 0$, an employee with an above-average preference for WFC. This employee accepts a wage discount compared to the median employee because the preference partially compensates for the utility difference. ε is the net monetary value of the preference. Writing the compensation in gross terms implies that $\varepsilon/(1-\tau_w)$ is the gross preference for WFC. The wedge between the individual and the average reservation wage increases with an increasing gross preference, e.g., caused by a higher wage tax rate.

2.3 Employer's Decision

The employer decides on the contract B's components while considering the employee's participation constraint (reservation wage). The components are the wage offer of the firm, the payment for the private use of the firm's car, and the WFC option, i.e., $B \equiv \{\omega, b; WFC\}$. Think about a firm deciding on hiring a marginal mobile worker. It faces two problems: first, which wage to offer, and second, which payment to set for the private use of the firm's AV. We assume the firm determines the payment without any bargaining on it. We, further, assume that the payment is set prior to wage bargaining. The firm chooses the payment by maximizing net profits for a mobile worker given the wage. The firm knows productivity, office and mobile work costs, WFC hours, and travel demand.

Concerning wages, we follow De Borger and Wuyts (2011b) and assume that the firm determines its maximum wage offer. The marginal worker just hired earns a wage equal to the worker's reservation wage. For all other employees with a WFC contract, the wage earned is in the interval limited by the offer and reservation wages. The specific wage paid to any other mobile employee is the outcome of wage bargaining.

2.3.1 Net Benefits and its Components

There are the following costs to the firm. r is the gross costs of office space per hour per worker, encompassing rents or capital costs, energy costs, maintenance, equipment, taxes, and overhead costs.

Firms face organization costs d^i because congestion may induce employees to arrive too late at meetings or customers or since it is costly to organize internal processes, such as meetings, allocating tasks to specific time slots, etc. These costs may differ between office work and mobile work. In the latter case, there are more actions available to avoid or reduce delays.[11] On the other side, employees cannot perform all tasks in the mobile office. Hence, WFC implies more effort to allocate tasks. We assume these organizational costs to be constant but contract specific and to depend on congestion: $d^B(F)' > 0$, $d^A(F)' > 0$.

There are variable costs per VDT[12] of an AV. g_x is gross costs per VDT.[13] They include all taxes, fees, and subsidies.[14]

In addition, there are fixed monetary gross costs per hour traveled, g_h, including, e. g., sales taxes, subsidies to sale, or daily leasing costs.

There may be a congestion toll τ_c levied per time unit of driving. We assume the AV moves with an average speed on the home-to-office trip. Generally, we assume that each employee travels to the office in the morning. Hence, WFC while parking is no option on the home-to-office trip. In contrast, the AV can cruise or park during additional WFC, v_o.[15]. We define

[11] E.g., the timing of the start of a trip, no wasted time of earlier drive off to avoid late-arriving, etc.

[12] We do not distinguish between AV with a single user and other AVs but only look at costs per employee. Hence, the cost per VDT and costs per person kilometer traveled are equivalent.

[13] These differ from net costs per km of private use. We calculate the private-use costs as average costs per VDT. However, the AV may not always drive in the case of WFC. Then time and distance are no longer closely linked. Therefore we distinguish between fixed and variable costs.

[14] Implicitly, we assume that energy use depends on congestion via speed, implying that $g_x(F)' > 0$, $g_x(F)'' > 0$.

[15] It is likely, that speed will be lower due to reduced travel costs (Tscharaktschiew and Reimann, 2021, analoguous to cruising instead of parking) and motion sickness. We do not consider this here. However, note that this effect would lower the relative costs of

the share of parking time s_p with a parking fee per hour of τ_p. The fee may differ from the parking fee near the office location arising with WFO, τ_q, because the AV can park everywhere and, thus, can drive to a zero-parking-fee place. Thus, VDT during additional WFC is

$$x_o = (1 - s_p)v_o/t; \quad t_p = s_p v_o, \tag{14}$$

where v_o/t is maximum distance traveled during v_o-hours (at average velocity)and $t_p = s_p v_o$ is the parking time during additional WFC. Any change in x_o changes the total distance traveled. Accordingly, an increase in effort costs or travel time per km (decline in speed) plus the share of parking while WFC lowers distances traveled at the optimum. No other determinant matters.

The daily non-wage costs per office worker, i.e., an employee entitled only to work in the office, is

$$c^A = rH + d^A, \tag{15}$$

while the expected daily non-wage cost per mobile worker, i.e., an employee with contract B, is given by

$$c^B = r(H - v) + (g_x + \tau_c t)x_o + (g_h + \tau_p s_p)v_o + [g_x + (g_h + \tau_c)t]\bar{x} \tag{16}$$

There are office costs per hour of WFO ($r(H - v)$, monetary travel costs per VDT, g_x, congestion tolls per travel time, leasing, g_h, and parking fees, s_p, all per hour of additional WFC, and travel costs per VDT in AV on the home-to-office trip.

Further, labor is the only endogenous and variable input that matters to the pricing and hiring decision of the firm. There is a decreasing marginal productivity of labor per standard hour: $f(L)$, $f' > 0$, $f'' < 0$. The productivity of an hour of WFC differs by β from the productivity of WFO. WFC is more or less productive than a standard labor hour. Therefore, the marginal daily productivity of a WFC hour differs by $v\beta$ from the productivity of a standard office hour.

2.3.2 Optimal payment for private use of the firm's AV

b is the employee's payment per hour of private use of the firm's AV on the home-to-office trip, while the firm forbids private use outside the original commuting trip. Accordingly, the firm chooses b to maximize net profits (NP) from AV's private use tx. We further assume that only the cost components directly differentiated according to x and v_c matter for this decision. For instance, indirect effects on v_o do not occur because v_o only depends on p. Further, wages are not relevant because wage bargaining does not occur

WFC and makes WFC even more likely.

at this decision stage. Since we model quasilinear utility, wage differences across individuals affect consumption but neither x nor v_o. Therefore, the objective function includes productivity changes βv_c minus the firm's net car costs for private car use. The corresponding decision problem is

$$\begin{aligned}
\max_{b} \; NP = t(\bar{x} - x)\beta + btx - [g_x + (g_h + \tau_c)t]\bar{x} \\
\text{s.t.: } b \geq 0, \quad \perp \mu_3 \\
\text{s.t.: } [g_x + (g_h + \tau_c)t]x \geq btx, \quad \perp \mu_4
\end{aligned} \tag{17}$$

where productivity depends on x since $v_c = t(x) \bar{-} x$ and the revenue from employee's payment bx lowers the firm's net costs of private AV use. The optimal price b (with an interior solution) is

$$b = \frac{\varepsilon_{xb}}{\varepsilon_{xb} - 1}\beta, \quad \varepsilon_{xb} = -\frac{\partial x/\partial b}{x/b} > 0 \tag{18}$$

We define the price elasticity of x in positive terms while $\partial x/\partial b < 0$ (see (9)). Further, the elasticity is below unity. While the firm pays the car, the employee's payment is proportional to the returns from the change in productivity. If the productivity gain of WFC is positive, private use is a loss to the firm and $b > 0$.

2.3.3 Wage for mobile work and probability of mobile work

Next, we derive the WFC wage and the probability of mobile work contracts. Our model builds upon the work of De Borger and Wuyts (2011b). The marginal daily net profits of an additional office or mobile worker a firm wants to hire at its profit maximum in per-day units are

$$\begin{aligned}
MP_o &= f'(L) - c^A - w \\
MP_v &= f'(L) + v\beta - c^B - \omega
\end{aligned}$$

Hence, the firms hires a mobile worker if $MP_v > MP_o$. This implies

$$w - \omega_j + v\beta - \Delta c > 0 \tag{19}$$

where the non-wage cost difference between contracts B and A is

$$\Delta c \equiv c_B - c_A = -vr + v_o \Delta_{mc} + \Delta_{fc} - btx \tag{20}$$

The difference in variable travel costs per WFC hour is

$$\Delta_{mc} \equiv (1 - s_p)\left(\frac{g_x}{t} + \tau_c\right) + s_p \tau_p + g_h \tag{21}$$

and the difference in the non-wage fix costs per employee is

$$\Delta_{fc} \equiv [g_x + (g_h + \tau_c)t]\bar{x} + d^B - d^A \tag{22}$$

Remember, the reservation wage of a worker j is (13). Substituting into (19) yields for the cut-off preference parameter (marginal worker)

$$\varepsilon = (1-\tau_w)\big(\omega - w + \Delta c - v\beta\big) \tag{23}$$

A mobile-work contract is given to the marginal worker j if this condition is fulfilled.[16]

Assume there is a uniform distribution of preferences for a WFC contract in the interval $[-a, +a]$, we get the share of mobile employees (WFC contracts) as

$$\alpha = \frac{1}{2} - \frac{(1-\tau_w)(\omega - w + \Delta c - v\beta)}{2a}, \tag{24}$$

The share of WFC employees in the firm's labor force, i. e. the average probability of hiring a mobile worker, depends on the average gross wage, average cost, and productivity differences.

If marginal profits from hiring a WFC employee are below those of a WFO employee ($\omega - w + \Delta c - v\beta > 0$), firms demand a wage discount to offer a mobile-work contract. Consequently, only employees with a positive enough WFC preference (ε) accept the contract, and there is a relatively low share of mobile employees. The labor tax mitigates this channel because net wages are relevant for the mobile-working employee while the firm sets a gross-wage restriction.

α depends on several parameters. The marginal impacts are (see Appendix C)

$$\begin{aligned}
&\frac{\partial\alpha}{\partial w} > 0; \quad \frac{\partial\alpha}{\partial t} \lesseqgtr 0; \quad \frac{\partial\alpha}{\partial \bar{x}} \lesseqgtr 0; \quad \frac{\partial\alpha}{\partial g_m} > 0\\
&\frac{\partial\alpha}{\partial g_x} < 0; \quad \frac{\partial\alpha}{\partial g_h} < 0; \quad \frac{\partial\alpha}{\partial \eta} \lesseqgtr 0; \quad \frac{\partial\alpha}{\partial r} > 0;\\
&\frac{\partial\alpha}{\partial \beta} \geq 0; \quad \frac{\partial\alpha}{\partial s_p} \geq 0; \quad \frac{\partial\alpha}{\partial d_B} < 0 = -\frac{\partial\alpha}{\partial d_A};
\end{aligned} \tag{25}$$

3 Data and Calibration

In the following, we describe the choice of functional forms, data collection, and calibration of the model subsequently used for simulations.

[16] We can interpret $\omega - w + \Delta c - v\beta$ as the discount or supplement the firm demands or offers in a mobile-work contract from/to the marginal employee. Then $\varepsilon/(1-\tau_w)$ is the gross preference value or the reservation discount or supplement this worker needs to accept the contract. The wage tax drives a wedge between the gross offer wage and the net reservation wage. It lowers the reservation offer price from the employee's point of view.

We specify the sub-utility functions as

$$\begin{aligned} u_2(\ell) &= \delta_1 \log \ell = \delta_1 \log (E - tx) \\ u_3(tx) &= \delta_2 \phi tx - d_2 (tx)^2 \\ u_4(v_o) &= \delta_3 \log(d_3 + v_o) \end{aligned} \tag{26}$$

where the utility components for leisure, u_2, and from additional WFC, u_4, are log-linear, while the intrinsic utility of travel time, u_3, is quadratic.

The intrinsic utility of travel time differs between both contracts because more secondary activities are available and since less effort is required to travel in an AV (Pudãne and Correia, 2020). $\phi, 0 \leq \phi \leq 1$ is a weight factor. We set $\phi = 1$ in contract A but it may be lower with AV (Pudãne and Correia, 2020, see).[17]

We calibrate the parameter of the utility function such that the benchmark (contract A) VOT and VTT fit the corresponding value found in the literature (see Appendix A). According to Small (2012), the VTT for commuting is about 50% of the gross wage and the VTT for commuting travel is about 110% higher than for other travel Wardman et al. (2016)[18].

We assume that there is an optimal commuting time $(tx)^*$, called *ideal commute time*, that results from maximizing utility without restrictions. There is a scarce literature on the ideal commute time. We use 16 min for $(tx)^*$ (Redmond and Mokhtarian, 2001). Knowing average commuting time $t\bar{x}$, we get d_2.

The VTT of commuting in an autonomous car (VTT^B) is proportional to VTT, i.e. $VTT^B = \varphi VTT$, where φ is the reduction parameter of the VTT. We use $\varphi = 0.5$ (see Compostella et al., 2021; Kolarova et al., 2019).

$u_4(v_0)$ measures the utility of WFC instead of WFO. There is no literature on that. A major advantage is that WFC allows working alone with fewer disturbances from colleagues. Maestas et al. (2020) find an average WTP for working alone of about 8.4% of the wage if an evaluation for teamwork is based on the teams' performance, but 2% if one own's performance is the basis for an evaluation of teamwork. Therefore, we set δ_4, the parameter of the positive component of u_4, to the average of these WTP, i. e. 5.2% of the daily wage in the benchmark ($\delta_4 = \{10.7619, 10.6995\}$).[19] d_3 is set to unity to avoid a negative direct utility of v_o.

[17] This weight implies that utility discounting increases with distance. We follow Lee et al. (2021) who state that the advantage of AV is getting more relevant with increasing distance.

[18] Wardman et al. (2016) find a range between 1.02 for busy, 1.05 for light congestion and 1.21 for heavy congestion in the U.S. while their overview of 38 studies provides 1.3-2.0 as multipliers for different countries including stop-start and gridlock. Jokubauskaitė et al. (2019); Schmidt et al. (2021) provide recent estimates of VOT, VTT, and VTAT for Austria and Switzerland. They find a wide variety of values. The average VTT to VOT ratio in the non-representative studies is about 1.07 in Austria and 1.21 in Switzerland.

[19] Note, MUI is unity in our case. Hence, utility from wage income is equivalent to the monetary value.

The uniform distribution parameter, a, is set such that the maximum WTP for WFC is below 50% of the benchmark WFO wage (45 for D, 60 for the U.S.).

We model the negative effects such as loss of career chances and knowledge exchange with coworkers as costs because they imply additional effort required to compensate for these issues. We assume that costs are convex $pe(v_o) = pv_o^{\eta}$ where $\eta = 2$ in the benchmark and that these costs depend only on additional working from car (v_o). Additional WFC is the time the employee is absent during standard office hours in addition to the trip to work. Opportunity costs arise due to time invested to compensate This time is not wasted because it increases future earnings. To simplify we set $p = 0.582$. This price equalizes benefits and costs of additional WFC at $v_o = 2/3H$. There is a zero net benefit v_o if the employee spends 2/3 of the workday outside the office.

There is evidence that the productivity of happy commuters is higher than that of other commuters. Short-distance commuters are therefore more productive (Ma and Ye, 2019, study case, commuters in Melbourne). Consequently, we assume that $\beta > 1$ and use a benchmark level of 1.05.

U()	specific	parameter {DE,U.S.}	reason
$u(z)$	$\delta_0 z$	$\delta_0 = \{1, 1\}$	MUI set to unity
$u(\ell)$	$\delta_1 ln(\ell)$	$\delta_1 = \{85.45, 82.97\}$	VOT is about 110% of VTT[1]
$u(tx)$	$\delta_2(tx)$	$\delta_2 = \{13.86, 10.10\}$	VTT: $u_\ell - u(tx)) \approx 50\%$ of gross wage[2]
$u(tx)$	$-d_2(tx)^2$	$d_2 = \{19.15, 17.08\}$	Ideal commute time $\approx$ 16 min/day[3]
$u(v_o)$	$\delta_3 v_o$	$\delta_3 = \{10.76, 10.70\}$	WTP for working alone[4]
$u(v_o)$	$-d_3(v_o)^2$	$d_3 = \{5.33, 5.33\}$	$u(v_o) = 0$ if 2/3 of workday not in office
$e(v_o)$	$p\, v_o^2$	$p =$ endogenous	price is $0.25\times$ VOT

Parameters of utility. [1] see Wardman et al. (2016); [2] Small (2012); [3] Redmond and Mokhtarian (2001); [4] Maestas et al. (2020).

Table 1: Calibration

Benchmark data are the following:

- Parking fee at the workplace. Since a large share of employers provides employer-paid parking (Brueckner and Franco, 2018, 80% in the U.S.), we assume that average parking fees per hour are $\tau_q = 0.5\, e$ in both countries.
- We assume daily working time amounts to 8 hours per day. Workdays per month are 18.2 in Germany and 19.58 in the U.S. (251 non-weekend days in 2019 minus paid leave days and holidays) (see Maye, 2019)

- The average aggregate wage tax rates from federal, states and local taxes plus social security contributions are 0.2015 in the U.S. and 0.4836 in Germany on the gross wages (OECD, 2020, own calculations).[20]

Concerning other parameters, we perform Monte-Carlo simulations with 10.000 draws from the probability densities we choose based on data found in the literature.

To get the parameter *variable monetary commuting costs per VKT*, g_m, we choose a truncated normal distribution where we take the highest and lowest price of current prices of 73 types of electric cars in Germany (ADAC, 2020a) as limits of a symmetric 95% confidence interval.[21] For the U.S. we use the overview in Compostella et al. (2021) to take the lowest and highest value for monetary travel costs per VMT in the U.S (Small SUV ICEV 0.50 $/VMT, ridesource BEV 2.35 $/VMT)[22]

The *firm's variable travel costs per VKT*, g_s, are drawn from a truncated normal distribution based on the limits of the symmetric 95% confidence interval. We assume that the AVs are electric cars with 18 kWh/100 km as average energy consumption (Deloitte, 2019). Energy consumption and operating costs for a selection of electric cars is taken from ADAC (2020b).[23] For the U.S., we also use a truncated normal distribution due to the small number of observations in the data of Compostella et al. (2021). We take the energy costs of ridesource vehicles because these are commercial cars (Compostella et al. (2021), Tab. A3/A4).

We do not know the distribution of a *AVs' fixed monetary travel costs per hour*, g_h. Instead, we assume a uniform distribution of Germany's g_h. ADAC (2020b) gives 171.83 € as BMW i3's monthly fixed costs from insurance, taxes, and maintenance. We add a monthly leasing rate of 180 € for 30000 km/a including environmental subsidies ('Eco-grant' is 5000 €) and assume that the car is used 12 hours on each of 19 workdays per month. The result is $g_h = 1.54\, e/h$. Usually, we would take this as median and assume a uniform distribution between 1.04 and 2.04 €/h. To consider that AVs may be more expensive than standard BEVs, we double the upper limit to 4.08 €/h. For the U.S., we follow Compostella et al. (2021) and assume that the firm rents the car per km (like a driverless taxi). Compostella et al. (2021) provide calculations for the U.S. With a 80000 mileage per year the lower price limit is 0.33 $/VMT and the upper price limit is 0.37 $/VMT.[24]

[20]Gross wages are wages net of social security contributions of the employers.

[21]0.306 € CitiGo e IV Ambition Skoda, 1.208 € Model X Performance Tesla

[22]Calculated as VKT and in € with an exchange rate of 0.84 €/$ from March 19, 2021.

[23]BMW i3, 830 €/year, assumption: 15.000 km/year. A small firms' average power price is 21.19 €-ct. It is the retail average power price at the firm's location that we take as use as charging price in Germany .

[24]$/VMT are taken from Tab A3 and Tab A4 in Compostella et al. (2021) after netting out fuel costs. The year has 52 weeks implying 104 free days, plus six days to consider

The *average two-way commuting distance* $\bar{x}$ is 21 km in Germany (Dauth and Haller, 2018). We approximate the commuting distance histogram (Dauth and Haller, 2018) with a gamma distribution.[25] For the U.S., we also approximate the distance distribution of commuters with a gamma distribution.[26]

We determine the *average commuting travel time* $t\overline{x}$ as follows. Germany's average one-way commuting time was 22 minutes in 2010 (Gimenéz-Nadal et al., 2020). 24% of the population aged 18-64 doesn't commute, 19% one-way commute less than 15 minutes, 31% between 15-29 minutes, 20% 30-59 minutes, 5% 60-120 minutes and 1% less than 120 minutes (Statista, 2021a). Using these data, a shape parameter of 1.35 and a rate parameter of 0.04 provide a strongly right-skewed gamma density for one-way commuting time. U.S. data are from citeBurdEtAl2021 report an average two-way commuting time of 27.6 minutes in 2020 (54.2 two-way) (US Department Transport, 2020). The gamma density is right-skewed with a 2.5% percentile of 5 minutes, a 50% percentile of 27.6 minutes, and a 96.5% percentile of 89 minutes, the shape parameter is 0.71, and the rate parameter is 0.3.

Since there is a high correlation between speed and distance (0.78 in NL in the 1990s, Rietveld et al. (1999)), we choose the Rietveld et al. (1999) approach to calculate *average speed in a city*, $(1/t)$. We use average speed in large cities and all commutes. Statista (2020) provides average speed during peak hours in German cities in 2018, which is between 11 and 18 mph. The average trip length of car trips in Berlin is 7.4 km (Gerike et al., 2020). However, this is average speed. Since commuting is mainly occurring during peak hours, speed is lower. To calculate the average travel time for Berlin, we use the average speed provided by (Statista, 2020) which is 17.7 km/h (11 mph). Consequently, the average travel time is 25 minutes. According to Rietveld et al. (1999), travel speed increases considerably with distance mainly due to high costs for the first km and the increasing share of highways used at longer commutes. Distances below 25 km are usually traveled at a slower speed. We assume a uniform distribution of travel speed and calculate average speed following Rietveld et al. (1999) with parameters $a = 8$, $b =$ (average time $- a$)/(average distance), and $c = 0.6$. We apply the same procedure to the U.S., where the average rush-hour speed in major U.S. cities ranges from 19 mph in Washington D.C. to 41 mph in St. Louis (Geotab , 2018).

holidays (Christmas, labor day) and some days of illness. These assumptions yield 110 non-commuting and $365 - 110 = 255$ commuting days. We assume that the firm uses an AV 12 hours per day.

[25] Assumptions: the 7.6% level is 2 km, the mean is 10.5 km, and the 99.5% level is 90 km. We use 0.91 and 0.06 as shape and rate parameters, respectively.

[26] We choose 2.0 and 0.10 as shape and rate parameters. 29% of employees one-way commute less than 5 miles, the mean distance is 15.3 miles, and 99,84% of employees travel less than 200 miles.

	DE	US	Calculation
g_m	0.28–1.18 €/km[1]	0.37–2.35 €/km[2]	trunc. normal distrib.
g_s	0.038–0.055 €/km[1],[3]	0.016–0.07[2]	trunc. normal distrib.
g_x	1.04–2.04 €/h[4],[3]	7.24–8.12[2]	uniform distrib.
$\bar{x}$	2–100 km [5]	2–213 km[6]	Gamma distrib
speed			Rietveld et al. (1999) uniform distrib.
wage	9.15–73.18 €[9]	8.4–56.39 €[10]	Gamma distrib.
r	7.98–45.31 €/sqm[11]	22.78–159.79 €/sqm[12]	trunc normal, shares A-D cities
sqm/n	18.8–34.9 m^2/n[14]	9.30–27.87 m^2/n[14]	uniform distrib.

[1] ADAC (2020a); 2 Compostella et al. (2021); [3] Deloitte (2019);
[4] 9000 € purchase subsidy - VW announced 7€/h
[5] Two-way Dauth and Haller (2018); [6] BTS (2017)
[9] DeStatis (2021, 2018); [10] US DoL (2021); Gould (2020);
[11] CBRE (2019); Colliers (2019); JLL (2021);
[13] Henger et al. (2017); [14] Twardowski (2019)

Table 2: Data used

The *average labor productivity*, (β), is GDP divided by total working hours per year. Average annual hours worked in 2019 are 1386 and 1779 h, employment is 41061 and 147194 k, and GDPs are 4.6 and 21.4 trillion \$ in Germany and the U.S respectively. (OECD, 2021). We calculate average productivity with these data.

To get the *hourly wages*, $\bar{w}$, we calculate the empirical density for Germany's wages (DeStatis, 2018) and use it for the parameter draws. The U.S. hourly gross wage of the 10% percentile is 10.07 \$ and the 95% percentile is 67.14 \$ (Gould, 2020). Assuming eight work hours per day, we get mean daily gross wages of 205.76 € in the U.S. and 206.96 € in Germany. We use a Gamma distribution to calculate the U.S. wage density[27].

There are no public data on Germany's *monthly office rent per sqm*, (r), but private firms offer a small number of statistics (see Table 9). We assume that rents in each i-City-Segment follow a probability density function of a truncated normal distribution around the mean gross rent, where the minimum and maximum rent levels in the A-city data segment give the support. The office rents of the cities of Essen and Leipzig mark the maximum and mean in B-cities' distribution. Since A-cities' minimum is low, we also use it as B-cities' minimum and a slightly lower value, i. e., five €, as the bottom rent in C- and D-cities. The data gives us the maximum rents of C- and D-cities. Eventually, we draw for each i-City segment its share of 10000 random draws from the assumed i-City density to get the 10000 draws of

[27]The shape parameter is 2.61 and the rate parameter 0.10

office rents. The share of each i-city segment is its share on all newly rented sqm in 2019/20. We calculate the shares of C- and D-cities assuming that C-cities' accumulated share of newly rented square meters is three times as large as the D-cities' share of square meters. This procedure results in the average rent of 21.391 €/sqm.

We calculate the density of the *U.S. monthly office rent per sqm*, (r) from a truncated normal density for U.S. occupancy costs of the 25 most expensive city districts in the U.S. (CBRE, 2019; Colliers, 2019; JLL, 2020a,b, 2019). Occupancy costs are the lowest in Denver Suburban (30.25 \$) and the highest in Mid Manhattan (212 \$). The U.S. average is 91.26 €/sqm, respectively.

A critical parameter is the *square meter of office space per employee*. Henger et al. (2017) provide office area per employee for several branches and types of cities in Germany. We assume a uniform distribution from 18.8 to 34.9 sqm. For the U.S., we use a uniform distribution from 9.20 to 27.87 sqm (Twardowski, 2019). Averages or benchmark values are 26.83 sqm in Germany and 18.557 sqm in the U.S.

For other parameters we assume a triangular distribution. These are $\beta \in \{-40, 40\}$, $sp \in \{0, 1\}$, $b \in \{0, 1\}$, $d_A \in \{0, 20\}$, $d_B \in \{0, 10\}$, and effort parameter η from $e = v_0^{\eta} \in \{1, 3\}$.

4 Simulations

We run Monte-Carlo simulations with 10.000 draws of the densities of the non-policy parameters presented in the above section. We draw the WFC preference parameter, ϵ, from a uniform distribution over the intervals [-45,+45] and [-60,60] for Germany and the U.S., respectively. Our choice assigns a significant role to wages and other parameters, enough variety in decisions, and a relevant influence of unobserved heterogeneity.[28].

Tables 3 and 4 summarize the results of the Monte-Carlo simulations. First, have a look at column α. While we expect that 50% of the employees would choose contract B if idiosyncratic preferences are the only determinant, our finding is a probability of 76% in the U.S. and 80% in Germany that more than half of the employees choose contract B (see columns α and 'value'). The probability that more than three-quarters of the employees choose contract B is 49% in the U.S. and 52% in Germany. Both median and mean are above a share of 0.5. The median is 0.74 in the U.S. and 0.77 in Germany. The mean share of α is 0.68 and 0.72 in the U.S. and Germany, respectively. Accordingly, at least some non-marginal level of WFC contracts (contract B) is a likely outcome when self-driving cars enter the

[28]There is evidence that individual, work-related, and household characteristics are essential determinants of the probability of WFH (E.g., Singh et al., 2013; Sarbu, 2015)

value	α	sv	svc	svo	sx	sxo
0	0.06	0.00	0.03	0.00	0.19	0.00
0.1	0.07	0.00	0.91	0.00	0.67	0.01
0.2	0.10	0.00	0.97	0.05	0.94	0.06
0.25	0.11	0.11	0.98	0.32	0.95	0.10
0.3	0.13	0.35	0.99	0.55	0.95	0.14
0.4	0.18	0.68	1.00	0.78	0.95	0.24
0.5	0.24	0.82	1.00	0.88	0.96	0.33
0.6	0.34	0.89	1.00	0.92	0.96	0.46
0.7	0.46	0.94	1.00	0.95	0.96	0.60
0.75	0.51	0.95	1.00	0.96	0.96	0.68
0.8	0.57	0.96	1.00	0.97	0.96	0.73
0.9	0.66	0.97	1.00	0.98	0.97	0.86
1	1.00	1.00	1.00	1.00	1.00	1.00
median	0.74	0.34	0.04	0.29	0.08	0.63
mean	0.69	0.39	0.05	0.34	0.11	0.61

Column 'value' and rows 'median' and 'mean' display shares on MC-results. All other date are cumulative probabilities. The share related to α is the share of employees with contract B; sv, svc, svo are shares of WFC hours, v_c and v_o, on working hours; sx and sxo are ratios to basic commuting distance. α = probability of choosing contract B (50% do it by chance), v = WFC hours, v_c = basic WFC hours, v_o = additional WFC hours, x = commuting distance, x_o = distance traveled with additional WFC.

Table 3: Results of Monte-Carlo Simulation: US

markets.[29].

The probability that total WFC hours (column 'sv') exceed 25% of average daily working time is 89% (96%) in the U.S. (Germany). In the U.S. (Germany), the probability of spending more than 90% of working time outside the office is 3% (5%). Results for basic WFC hours v_c/h are printed in column 'svc'. Basic WFC is, on average, 5% of work hours in the U.S. (13% in Germany). Overall, the mean of WFC (see column 'svo') is 34% of daily work time in both countries. In any case, these findings suggest that WFC is a relevant feature of working life.

Column 'sx' displays commuting left as a share of initial commuting distance. The probability that employees spent more than 20% of benchmark commuting distance not working is 6% in the U.S. (26% in Germany). Column 'sxo' shows the ratio of additional WFC-distance traveled beyond initial commuting distance as a ratio to the latter. It reveals that the average increase in distance traveled in U.S. amounts to 61% of initial commuting distance (52% in Germany). To summarize, WFC contracts are likely to be a common feature of the future, mainly the white-color labor market in medium and large cities when self-driving cars enter the market. Given current data, WFC substitutes most commuting time, and the total VKT

[29]Note that 50% would choose contract 'B' if the idiosyncratic preference is the only choice determinant

value	α	sv	svc	svo	sx	sxo
00	0.03	0.00	0.02	0.00	0.06	0.00
0.1	0.04	0.00	0.57	0.00	0.51	0.02
0.2	0.06	0.00	0.76	0.05	0.74	0.10
0.25	0.07	0.06	0.81	0.31	0.85	0.16
0.3	0.09	0.20	0.86	0.54	0.94	0.22
0.4	0.14	0.45	0.94	0.77	0.98	0.36
0.5	0.20	0.64	0.99	0.87	0.98	0.49
0.6	0.30	0.77	1.00	0.92	0.98	0.61
0.7	0.42	0.86	1.00	0.95	0.98	0.71
0.75	0.48	0.90	1.00	0.96	0.98	0.77
0.8	0.53	0.92	1.00	0.97	0.98	0.82
0.9	0.62	0.95	1.00	0.98	0.98	0.92
1	1.00	1.00	1.00	1.00	1.00	1.00
median	0.77	0.42	0.08	0.29	0.10	0.51
mean	0.72	0.47	0.13	0.34	0.14	0.52

Column 'value' and rows 'median' and 'mean' display shares on MC-results. All other date are cumulative probabilities. The share related to α is the share of employees with contract B; sv, svc, svo are shares of WFC hours, v_c and v_o, on working hours; sx and sxo are ratios to basic commuting distance. α = probability of choosing contract B (50% do it by chance), v = WFC hours, v_c = basic WFC hours, v_o = additional WFC hours, x = commuting distance, x_o = distance traveled with additional WFC.

Table 4: Results of Monte-Carlo Simulation: Germany

traveled exceeds, on average, the initial commuting distance. As a consequence, the WFC option leads to an increase in traffic.

We can draw some tentative conclusions. Our results confirm that WFC is a likely outcome of the future world. There will be demand for WFC contracts and WFC hours, and a share of firms offer both. While we assume a constant number of trips, there is the probability that travel distances will increase. Hence, WFC will induce additional traffic while office space demand declines. To understand the channels for our findings, we next look at the relevance of different parameters for the outcome. After that, we look at the impact of different policies on the probability of WFC.

5 The impact of non-policy parameters

While comparative statics reveal the marginal signs of the impacts, the question is how strong effects are if other parameters vary simultaneously. This question is relevant since comparative statics show that a parameter's impacts usually depend on other parameters' magnitude. We run censored (Tobit) regressions with the Monte-Carlo results and calculate the marginal effects to identify the relevance of the parameters and their average impact.

Tables 5 and 6 show the marginal effect.[30].

	Dependent variable:			
	alpha	sv	svc	svo
	(1)	(2)	(3)	(4)
log(wage)	0.038***	−0.0002	0.00003	−0.0004
	(0.002)	(0.001)	(0.001)	(0.001)
log(tkm)	−0.016***	0.009***	0.037***	−0.001
	(0.002)	(0.001)	(0.001)	(0.001)
log(eff)	0.026***	−0.692***	0.008***	−0.698***
	(0.010)	(0.004)	(0.002)	(0.003)
log(xbar)	0.010***	0.014***	0.038***	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
log(gm)	0.074***	−0.003	0.001	−0.003
	(0.005)	(0.002)	(0.001)	(0.002)
beta	0.017***	0.00000	0.00003*	0.00002
	(0.0001)	(0.00003)	(0.00002)	(0.00003)
log(r)	0.163***	−0.002	−0.001	−0.001
	(0.003)	(0.002)	(0.001)	(0.001)
log(gx)	−0.015**	−0.0004	−0.0002	−0.0002
	(0.005)	(0.003)	(0.001)	(0.002)
log(gh)	−0.149**	−0.028	−0.009	−0.004
	(0.064)	(0.031)	(0.014)	(0.025)
log(sp)	0.013***	−0.002	−0.00000	−0.002
	(0.003)	(0.001)	(0.001)	(0.001)
dB	−0.007***	−0.0008*	−0.0003	−0.0004
	(0.001)	(0.0004)	(0.0002)	(0.0003)
Observations	10,000	10,000	10,000	10,000

Note: *p<0.1; **p<0.05; ***p<0.01
Results of marginal effects of censored (Tobit) regressions. Observations are the 10,000 results from the Monte-Carlo simulation. Dependent variables are α, and 'sv', 'svc', and 'svo', i.e. the shares of v, v_c, v_o on daily working hours.

Table 5: Regression results: marginal effects (U.S.)

Subsequently, we discuss the parameters that directly affect employees' choices (see (25)). These are the WFO wage, WFO commuting distance, inverse speed, effort costs, monetary travel costs, and the firm's payment to private AV use.

According to our model, the WFO wage negatively affects the probability of contract B, i.e., α, but not WFC hours and, thus, not distance (see row 'log(wage)'). The higher the wage, the more likely is the choice of A. The highly significant average semi-elasticity implies that a one percent increase

[30]Note, the regression coefficients from the censored regression are the marginal effects of the control variable on the *predicted value* of the outcome variables. The regression tables are provided as Tables 10 and 11 in the Appendix.

	Dependent variable:			
	alpha	sv	svc	svo
	(1)	(2)	(3)	(4)
log(wage)	0.052***	−0.001	−0.0001	−0.001
	(0.004)	(0.002)	(0.001)	(0.001)
log(tkm)	0.12***	0.113***	0.1904***	−0.005***
	(0.004)	(0.002)	(0.001)	(0.001)
log(eff)	0.066***	−0.683***	0.009***	−0.68***
	(0.007)	(0.004)	(0.002)	(0.003)
log(xbar)	0.116***	0.010***	0.165***	−0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
log(gm)	0.035***	−0.003	−0.002	−0.0006
	(0.005)	(0.003)	(0.001)	(0.002)
beta	0.016***	0.00002	0.0001***	0.00002
	(0.0001)	(0.00005)	(0.00002)	(0.00003)
log(r)	0.063***	−0.001	−0.0003	−0.002
	(0.004)	(0.002)	(0.001)	(0.001)
log(gx)	−0.025	−0.011	−0.004	−0.003
	(0.014)	(0.009)	(0.004)	(0.005)
log(gh)	−0.054***	0.002	0.001	−0.004
	(0.003)	(0.002)	(0.0001)	(0.001)
log(sp)	0.005	−0.001	−0.0001	−0.002
	(0.003)	(0.002)	(0.0001)	(0.001)
dB	−0.005***	−0.0003	−0.00002	−0.0001
	(0.001)	(0.0005)	(0.0002)	(0.0003)
Observations	10,000	10,000	10,000	10,000

Note: *p<0.1; **p<0.05; ***p<0.01

Results of marginal effects of censored (Tobit) regressions. Observations are the 10,000 results from the Monte-Carlo simulation. Dependent variables are α, and 'sv', 'svc', and 'svo', i.e. the shares of v, v_c, v_o on daily working hours.

Table 6: Regression results: marginal effects (DE)

in the WFO wage increases the share of WFC contracts by 0.038 in the U.S. (0.052 in Germany). Hence, high-wage earners are more likely to choose a WFC contract, but their working time allocation hardly differs from lower-wage earners' time use.

Initial commuting distance (row 'log(xbar)') and inverse travel speed (travel time per km, see row 'log(tkm)') have, on average, a significantly and strong positive impact on Germany's α. The semi-elasticities are 0.116 and 0.12 for speed (inverse 'tkm'). However, in the U.S., home-to-work distance has a weak but significant positive impact while travel time slightly lowers α. Both parameters increase WFC time ('sv'). While they do not affect additional WFC time in the U.S. but decrease it in Germany, both parameters increase basic WFC time in both countries. Accordingly, people with longer commutes are more likely to choose contract B, while the impact of speed is positive in the U.S. but negative in Germany.

The fourth important determinant is the effort employees exert to avoid negative consequences of being away from work (row 'log(eff)'). A one percentage increase in log(eff) implies a higher share of WFC contracts in both countries and a substantial reduction in additional WFC hours. Further, a higher effort reduces basic WFC hours.

Monetary private travel costs g_m positively affect alpha but no other outcome variable. A one percent raise in g_m implies that alpha increases, on average, by 0.074 points in the U.S. (0.035 in Germany).

Concerning the parameters on the firm's side, productivity ('beta'), office rent per employee ('log(r)') positively influence α, while traveling costs per hour (g_h) and d_B lower α. The impact on WFC hours is negligible. The most relevant parameters are rents and office size.

To summarize this section. The Monte-Carlo simulation demonstrates the relevance of several determinants of WFC contracts and hours and gives clear signs for almost all dependencies.

6 Policy Issues

A finding of the above sections is that the adaption of WFC contracts implies an increase in aggregate travel distance because commuting distance, x_o, added to the home-to-office travel is positive. On an aggregate level, this induces additional traffic. On the other side, we find a high probability of declining office-space demand. These changes induce overall economic, traffic and welfare effects that one may study in a spatial general equilibrium approach with office markets and traffic. However, this is out of the scope of this paper. Instead, we discuss the role of policy parameters on the choice of WFC contracts, hours, and commuting in our partial equilibrium approach. This discussion gives a basic intuition on the power of current transport-policy instruments to affect the consequences of these choices.

In particular, we examine whether policy intervention can affect WFC choices' extensive and intensive margins. If this is possible, policy intervention can lower transport-caused externalities related to WFC and increase the positive effect on the office markets. Though we do not simulate the intervention effects in the general equilibrium, we can derive some results from comparative statics. Table 7 summarizes the findings.

We implement several policy instruments that give us an idea of whether and how the policy can affect WFC contracts, WFC hours, and distance traveled. To quantify the impact of the instruments, we run a simple experiment: we perform a partial equilibrium simulation of our model where each policy instrument is varied based on the benchmark parameter choice.

The policy instruments are the wage tax rate τ_w, the imputed tax parameter of the fringe benefits ρ, the parking fee for on-street parking near the workplace τ_q, and the parking fee for parking during WFC, τ_p. The latter may differ from τ_q because the AV can move to cheaper parking lots. Further, some instruments, such as fuel taxes, miles taxes, or a congestion toll, change travel costs. We define these instruments as additional tax or subsidy rates on the benchmark transport costs. τ_m denotes a fuel, respectively, a CO_2 tax rate levied on g_k such that $g_m = (1+\tau_m)g_k$; τ_s refers to a tax or subsidy rate on the variable travel costs in AV, hence, $g_h = (1+\tau_s)g_s$; and τ_d is a tax rate imposed on the average travel costs per hours, such as a sales tax or a subsidy that lowers leasing costs, this is , $g_d = (1+\tau_d)g_x$.[31]

How do *fringe benefits*, i.e. τ_W and ρ, affect the above decisions? Analytically we have (see Appendix (D.1) and (D.8))

$$2a\frac{\partial \alpha}{\partial \tau_w} = \Delta c - v\beta - \rho \left\{ tx + (1-\tau_w)\frac{(r+\beta)t - b}{t(u_{txtx} + u_{\ell\ell})} \right\} \tag{27}$$

$$2a\frac{\partial \alpha}{\partial \rho} = -\tau_w \left\{ tx - (1-\tau_w)\frac{b + (r+\beta)t}{t(u_{txtx} + u_{\ell\ell})} \right\} < 0 \tag{28}$$

Since $u_{\ell\ell} + u_{txtxt} < 0$, the term in curled brackets is positive. Nonetheless, there is an ambiguous effect of τ_w on α. From (9) and since $\partial v_c/\partial i = -t\partial x/\partial i$ we derive a positive impact of τ_w on basic WFC hours (v_c). Despite that, the wage tax rate does not affect additional WFC hours as shown in (8). While the share of fringe benefits subject to an income tax, ρ, positively affects v_c (see (9)) and v_o (see (8)) it has a negative impact on α (see (28)).

Table 7 shows the results of the comparative static simulations.

First, look at the *income tax rate* τ_w. Its impact depends on the taxation of fringe benefits. We vary the marginal wage tax rate from 0 to 0.67, a level far above the current maximum marginal tax rates in Germany and the U.S. This variation includes social security contributions. We find a positive impact of τ_w on α and negligible effect on v_c and v_o.

[31] $g_k = g_m$ if $\tau_m = 0$ and so on.

Policy	α	v	v_c	v_o
τ_w	0.06 | 0.061			
ρ	-0.032 | -0.065			
τ_m	0.1 | 0.089			
τ_s	-0.007 | -0.004		0 | 0.001	-0.023 | -0.004
τ_d	0.024 | 0.01		-0.001 | -0.001	
τ_p	-0.024 | -0.019			
τ_q	0.21 | 0.12			
τ_c	-0.039|-0.015	0|0.002	0|0.007	

The table shows the median intervention semi-elasticities of the respective outcome variable. The first number in a column provides the U.S. elasticity and the second after the "|" sign is the German elasticity. An empty cell indicates zero elasticity. Suppose there is a single value but no "|" sign there is the same elasticity in both countries. Elasticities below 0.0005 are not printed.

Table 7: Comparative Statics

The influence of ρ on contract B's share is analytically and numerically negative. Its impact on WFC is negligible, too. Hence, we can conclude that taxing fringe benefits does not affect WFC demand. WFC allows people to approach their ideal commuting time, almost independently from the employer subsidy to private car use.

The subsequent formula display the analytical impacts of other taxes on α (see Appendix D), while the impact on v_c and v_o are derived in (9). Note that we use $\partial v_c/\partial i = -t\partial x/\partial i$ and (8).

$$2a\frac{\partial\alpha}{\partial\tau_m} = g_k\bar{x} > 0 \tag{29}$$

$$2a\frac{\partial\alpha}{\partial\tau_q} = H > 0 \tag{30}$$

$$2a\frac{\partial\alpha}{\partial\tau_s} = -(1-\tau_w)g_s\left[(1-s_p)x_v + \bar{x}\right] < 0 \tag{31}$$

$$2a\frac{\partial\alpha}{\partial\tau_d} = -(1-\tau_w)g_d(v_o + t\bar{x}) < 0 \tag{32}$$

$$2a\frac{\partial\alpha}{\partial\tau_p} = -(1-\tau_w)s_p v_o < 0 \tag{33}$$

$$2a\frac{\partial\alpha}{\partial\tau_c} = t\left[\tau_w\bar{x} - (1-\tau_w)(1-s_p)x_v\right] \tag{34}$$

The impact of the tax multiplier on private commuting costs, τ^m, on α depends on the monetary net-travel cost of commuting of an office employee (tax base) (see (29)). An increase in this tax multiplier, e.g., due to a higher carbon price, a congestion toll, a city toll, a fuel tax increase, lowers the reservation wage of an office worker and, thus, strengthens the cost reduction of a firm from mobile-work contracts. Consequently, an increase in this tax multiplier increases the probability of mobile-work contracts. There is neither an effect on v_o nor on v_c.

Table 7 shows on average strong responses of α on a percentage change in τ_m, and while there is a negligible effect on WFC hours for variation in τ^m. There is no effect on WFC hours and, thus, not on miles traveled. This finding implies that an instrument aiming at lowering private VKT is not relevant for WFC distance traveled. If the policy aims at achieving a transformation to AV use, this instrument may work.

Parking fees (τ_p) may matter because the AV is parking half of its WFC-use time outside the standard commuting route. Since τ_p increases the parking costs it theoretically reduces α (see (33)). We vary the parking fee from 0 to 4.50 € per hour with, on average, marginal effects on α and no effects on WFC hours and additional distance traveled. However, note we do not implement the parking choice but fix the share of parking. A remark is in order. We do not implement a parking choice in our model. Hence, implementing this instrument is worthwhile if the aim is to avoid parking or driving.

Next, consider τ^q *the parking fee while working.* (30) shows that a higher fee increases the probability of choosing contract B because it makes commuting with a private non-AV car (EV) more expensive. Again, there is, on average, no impact on WFC hours.

Eventually, we consider a fee per hour traveled such as a *congestion toll.* In that case, the costs difference is strongly affected, as is the reservation wage. Parking fees lower the probability of mobile-work contracts. The reason is that parking fees decrease the possibility to reduce WFC costs (see (34)). The congestion toll increases the travel costs for commuting but also the costs of AV's use. It, thus, hardly discriminates between both car types. Hence, it is not surprising that there is no effect on α or WFC hours and distances traveled.

To summarize, all travel-related taxes affect the extensive margin of WFC. However, only the AV's cost components impact WFC hours, and only a tax or subsidy on VKT related costs of AV affect additional WFC and travel distance. Taxes on private travel costs per km (τ_f) and parking fees near the workplace (τ_q) are the most effective instruments concerning the extensive margin. Taxes that affect distance and hourly travel costs of an AV (τ_s, τ_d, τ_c) are the only policy parameters affecting the intensive margin. For instance, a subsidy on AV distance traveled (τ_s) may increase additional WFC. This subsidy frees office space lowering the scarcity of land. Adding a congestion toll may reduce the increase in travel distance caused by additional WFC.

This exercise shows that standard tax or subsidy instruments affect the extensive margin. Some increase the choice of WFC contracts, others reduce it. However, several instruments do not affect the intensive choice and, thus, are not suited to reduce land scarcity or traffic-induced externalities.

7 Conclusions

We study the impact of AV on the spatial re-organization of work due to the possibility of working from the car (WFC). Our study uses various benefits and costs and shows that WFC may become a reality in large agglomerations once AVs enter the market. Simulations of our model suggest that working from the car is a likely feature of tomorrow's labor market, given current data and expectations on costs for self-driving cars. They also suggest that WFC increases the overall distance traveled and reduces demand for office space. Eventually, we see that standard non-differentiated policy instruments on car use, traveling, and parking affect the share of WFC contracts, while most are purely suited to affect WFC hours or distance traveled with WFC. Consequently, taxes or subsidies affecting the AV's costs are the only effective instruments to steer WFC hours.

Our study bears some shortcomings. We do not consider telecommuting by working from home (WFH). Thus, we may miss some relevant effects of WHO. First, employees opting for WFH may reduce the number of commuting trips. In that case, our finding that WFC is used to substitute commuting time will survive. However, fewer commuting trips means that the amount of WFC hours per week is lower than our model suggests. Second, the above findings imply that a longer commuting distance is associated with a higher probability of choosing a WFC contract and more WFC hours. Since WFH is likely to increase commuting distances, considering WFH will increase the probability of WFC contracts and the number of WFC hours. Adding WFC to WFH is likely to reinforce relocations because WFC lowers commuting costs. The overall effect of fewer trips but longer distances on WFC is ambiguous. Hence, there are incentives to choose WFC contracts and transform commuting to WFC even when considering WFH.

Further interesting extensions may include choices of routes and parking locations. In addition, it may be interesting to add speed choice and the decision to park or cruising (Tscharaktschiew et al., 2022). Another interesting extension is the use of WFC on a business trip to a client or another work-related activity. It is reasonable to assume that this lowers production costs, increases productivity, and eventually raises the probability of WFC.

Finally, while we study individual decisions, the impact on society is an open issue. Considering WFC may induce aggregate changes in office space, commuting decisions, WFC hours and distances, and wage discounts on welfare and market outcomes in a full general equilibrium model. We left this extension to future research.

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Indices			
A	choice set A (WFO only)	B	choice set B (WFC option)
$i \in A, B$	index for contract type		
Employee's choice		Prices, costs, taxes	
E	daily time endowment (non-work)	α	share of contracts B
$e(\cdot)$	effort function	δ_j, d_j	parameters utility function
H	daily working hours	d^i	expected delay costs in i
h^i	daily office hours in i	ϵ	preference parameter (WFC)
h	office hours in B	g_d	daily average costs of AV
ℓ^i	leisure in choice set i	g_m, g_k	monetary VDT cost EV
t	travel time per km	g_s, g_x	monetary VDT costs of AV
v^i	aggregate WFC hours in set i	λ	marginal utility of income
v_c	basic WFC hours	$\mu_2,\ \mu_v,\ \mu_x$	rationing parameters
v_o	additional WFC hours	p	effort price
$\bar{x}$	home-to-office distance	r	office rent per worker
x^i	commuting time in i	$\rho_2,\ \rho_v,\ \rho_x$	shadow prices due to rationing
x	commuting dist. in choice set B	ρ	tax parameter fringe benefits
x_c	commuting dist. basic WFC	θ^i	value of time
x_o	commuting dist. additional WFC	τ_c	congestion charge rate
Ui	utility in choice set i	τ_d	tax per day of AV usage
u_j	sub-utilities	τ_p	parking fee at suburbs
V^i	indirect utility	τ_q	parking fee near office
V^i_x	non-wage indirect utility	τ_m	tax per VDT with EV
z^i	consumption in choice set i	τ_s	tax per VDT with AV
Employer		τ_w	income tax rate
β	relative TFP of WFC	w	market wage contract i
b	fee for private use of AV	ω	wage in choice set B
π	profits per employee	ω_j	reservation wage

EV is private non-autonomous electric vehicle; AV is firm's autonomous vehicle

Table 8: List of symbols

A Calibration and Data

We calibrate the parameter of the utility function such that the benchmark (contract A) VOT and VTT fit the corresponding value found in the literature. According to Small (2012), the VTT for commuting is about 50% of the gross wage and the VTT for commuting travel is about 110% higher than for other travel Wardman et al. (2016)[32].

Since $VOT \equiv u_2' = \delta_1 \ln(E - t\bar{x})$ and the VOT is 1.1×0.5 of the gross wage per hour (w/H) we get $\delta_1 = (1.16 * 0.5) * (w/H) * (E - t\bar{x})$.

The negative derivative of indirect utility V_A (see (3)) w.r.t. $t\bar{x}$ gives the value of commuting travel time savings $VTT = \tau_c + u_2' - u_3'$. In the

[32] Wardman et al. (2016) find a range between 1.02 for busy, 1.05 for light congestion and 1.21 for heavy congestion in the U.S. while their overview of 38 studies provides 1.3-2.0 as multipliers for different countries including stop-start and gridlock. Jokubauskaitė et al. (2019); Schmidt et al. (2021) provide recent estimates of VOT, VTT, and VTAT for Austria and Switzerland. They find a wide variety of values. The average VTT to VOT ratio in the non-representative studies is about 1.07 in Austria and 1.21 in Switzerland.

benchmark $\tau_c = 0$, therefore

$$VTT = VOT - u_3 tx \Rightarrow VOT - d_2 = VTT - 2\delta_2 t\bar{x} \tag{a}$$

We assume that there is an optimal commuting time $(tx)^*$, called *ideal commute time* that results from maximizing utility without restrictions, i.e.

$$\begin{aligned} &\max_{tx} u_2(E - tx) + u_3(tx) \\ &\Rightarrow - u_2' + u_3' = 0 \\ &\quad - 2\delta_2(tx)^* = VOT - d_2 \end{aligned} \tag{b}$$

Substituting (a) and rearranging gives

$$\delta_2 = \frac{VTT}{2t(\bar{x} - x^*)} \tag{A.1}$$

Substituting back into (a) yields

$$d_2 = VOT + \frac{tx^*}{t\bar{x} - tx^*} VTT \tag{A.2}$$

There is a scarce literature on the ideal commute time. We use 16 min for $(tx)^*$ (Redmond and Mokhtarian, 2001). Knowing average commuting time $t\bar{x}$, we get d_2.

The VTT of commuting in an autonomous car (VTT^B) is proportional to VTT, i.e. $VTT^B = \varphi VTT$, where φ is the reduction parameter of the VTT. We use $\varphi = 0.5$ (see Compostella et al., 2021; Kolarova et al., 2019). Assuming the VOT is independent from the contract yields at initial commuting time and from using (a)

$$\begin{aligned} VTT^B &= \varphi VTT \\ \Rightarrow\ VOT - d_2 + 2\delta_2\phi t\bar{x} &= \varphi(VOT - d_2 + 2\delta_2 t\bar{x}) \\ \Rightarrow\ \phi &= \varphi - \frac{(1-\varphi)(VOT - d_2)}{2\delta_2 t\bar{x}} \end{aligned} \tag{A.3}$$

Since mobile work is the only way to substitute commuting, there is no specific utility component for this part of mobile work. However, people can choose either WFO or WFC concerning time outside the original commute. $u(v_0)$ measures the utility of WFC while there is no specific utility component of WFO. There is no literature on that. However, there is literature on the preference for WFH. Given that WFH implies some conflicts with family work, we consider the preference for WFH as the minimum utility value.

Rents office space 2019-2020 [€/m²]						
City	average €/qm	max. €/qm	lowest €/qm	avg.add. costs sqm	available mill.sqm	newly rented mill.sqm
Berlin	28.70[c]	38,00[k]	9.00[k]	3.68[m]	20.80[k]	0.999[k]
Cologne	15.90[h]	26.00[k]	6.50[k]	3.51[m]	7.84[k]	0.291[k]
Düsseldorf	16.80[f]	28.50[g,k]	7.00[k]	3.57[m]	9.24[k]	0.550[k]
Frankfurt (Main)	22.89[a]	41.50[k]	9.00[k]	3.81[m]	11.63[k]	0.580[k]
Hamburg	17.40[e]	31.00[k]	6.00[k]	3.64[m]	15.14[k]	0.530[k]
Munich	20.50[b]	41.00[k]	9.50[k]	3.82[m]	20.96[b,k]	0.760[k]
Stuttgart	20.40[i]	25.50[k]	9.00[k]	3.51[m]	8.84[k]	0.319[k]
Essen (B-City)	12.00[e]	16.00[e]				
Leipzig (B-City)	10.80[e]	15.50[e]				
A-Cities		34.30[n]				4.03[o]
B-Cities		15.20[n]				1.2[o]
C-Cities		13.40[l]				
D-Cities		10.50[l]				
All 127 cities						6.1[o]

[a] Source: Statista (2021c), Rent 2020 [b] Source: Statista (2021c), Rent 2019
[c] Source: Statista (2021e), Rent 2019 [d] Source: Statista (2021f), Rent 2020
[e] Source: Statista (2021g), Rent 2020 [f] Source: Statista (2021h), Rent 2020
[g] Source: Statista (2021i), Rent 2020 [h] Source: Statista (2021j), Rent 2020
[i] Source: Statista (2021k), Rent 2019 [j] Source: Statista (2021l), Rent 2019
[k] Source: JLL (2021), Rent 2020 [l] Source: BNP (2021), Rent 2020
[m] Source: JLL (2018), 2018 [j] Source: Statista (2021m), 2019, 3% in highest segment
[o] Source: (Feld et al., 2020(@) , 2019

Note A-cities account for about 66% of new rent are in 2019, B-cities for 10%, C-cities for 5%. (Feld et al., 2020(@)
B-Cities (14): Bochum, Bonn, Bremen, Dresden, Dortmund, Duisburg, Essen, Hannover, Karlsruhe, Leipzig, Mannheim, Nürnberg, Münster, Wiesbaden

Table 9: Office rents of new contracts, Germany, 2019 and 2020

B Some Derivatives

The reservation wage ω of an employee j of type B equalizes $V^B = \bar{U}$, i.e.

$$\bar{U} - (1-\tau_w)\omega - V_x^B - \varepsilon = 0 \tag{B.1}$$

where the reservation utility is $\bar{U}$.

B.1 Employees' decisions: derivatives

From (3) we get for later use

$$\begin{aligned}
&\frac{\partial V^A}{\partial \tau_w} = -w < 0; \quad \frac{\partial V^A}{\partial g_m} = -\bar{x} < 0; \\
&\frac{\partial V^A}{\partial \bar{x}} - g_m - t(\tau_c + u_2' - u_3') < 0; \quad \frac{\partial V^A}{\partial \tau_q} = -H < 0; \\
&\frac{\partial V^A}{\partial \tau_c} = -t\bar{x} < 0; \quad \frac{\partial V^A}{\partial w} = (1-\tau_w) > 0; \\
&\frac{\partial V^A}{\partial t} = -\left(\tau_c + u_2' - u_3'\right)\bar{x} \lesseqgtr 0; \\
&\frac{\partial V^A}{\partial i} = 0, \ \forall i \in \{g_x, g_h, \tau_h, g_d, p, \rho, r, \beta, b\}
\end{aligned} \tag{B.2}$$

Further, we get from (4)

$$\begin{aligned}
&\frac{\partial w}{\partial g_m} = \frac{\bar{x}}{1-\tau_w} > 0; \quad \frac{\partial w}{\partial \tau_w} = \frac{w}{1-\tau_w} > 0; \\
&\frac{\partial w}{\partial \tau_q} = \frac{H}{1-\tau_w} > 0; \quad \frac{\partial w}{\partial \tau_c} = \frac{t\bar{x}}{1-\tau_w} > 0; \\
&\frac{\partial w}{\partial \bar{x}} = \frac{g_m + (\tau_c + u_\ell - u_{tx})t}{1-\tau_w} \gtreqless 0; \\
&\frac{\partial w}{\partial t} = \frac{(\tau_c + u_\ell - u_{tx})\,\bar{x}}{1-\tau_w} \gtreqless 0; \\
&\frac{\partial w}{\partial i} = 0, \ \forall i \in \{g_x, g_h, \tau_h, \tau_x, p, \rho, r, \beta, b\}
\end{aligned} \tag{B.3}$$

In general $v = v_o + t(\bar{x} - x)$ and since $\frac{\partial v}{\partial i} = \frac{\partial v_o}{\partial i} - t\frac{\partial x}{\partial i}$ we get

$$\begin{aligned}
&\frac{\partial v}{\partial p} = \frac{\partial v_o}{\partial p} = \frac{e'}{-pe'' + u_4''} < 0 \\
&\left.\frac{\partial v}{\partial i}\right|_{i \neq p} = -t\frac{\partial x}{\partial i}, \quad \forall i \notin \{p, t, \bar{x}\}
\end{aligned} \tag{B.4}$$

Substituting (9) (note: $u_{23} = u_{\ell\ell} + u_{txtx} < 0$) yields

$$\begin{aligned}
\frac{\partial v}{\partial b} &= -\frac{1}{u_2'' + u_3''} > 0; \\
\frac{\partial v}{\partial p_e} &= -\frac{e'}{-pe'' + u_4''} > 0; \\
\frac{\partial v}{\partial t} &= \bar{x} - \frac{b + u_2' - u_3'}{u_2'' + u_3''} \\
\frac{\partial v}{\partial \bar{x}} &= t \\
\frac{\partial v}{\partial i} &= 0,\ \forall i \notin \{b, p_e, t, \bar{x}\}
\end{aligned} \tag{B.5}$$

By applying the envelope theorem and Roy's theorem to (10) and using (9), the partial derivatives of the indirect utility component V_x^B become:

$$\begin{aligned}
&\frac{\partial V_x^B}{\partial p} = -e(v_o) < 0; \qquad \frac{\partial V_x^B}{\partial b} = -tx < 0; \\
&\frac{\partial V_x^B}{\partial \rho} = -\tau_w \bar{x} < 0; \qquad \frac{\partial V_x^B}{\partial \tau_w} = -\rho \bar{x} < 0; \\
&\frac{\partial V_x^B}{\partial \bar{x}} = -\tau_w \rho + \mu_c; \\
&\frac{\partial V_x^B}{\partial t} = -\left(b + u_2' - u_3'\right) x = \begin{cases} -\mu_x \frac{x}{t} & \text{if } x = 0 \\ 0 & \text{if } 0 < x < \bar{x} \\ \mu_c \frac{x}{t} & \text{if } x = \bar{x} \end{cases}; \\
&\frac{\partial V_x^B}{\partial i} = 0, \forall i \notin \{p, b, t, \tau_w, \rho, \bar{x}\}
\end{aligned} \tag{B.6}$$

Since x is chosen considering travel time per km (t), any change in travel time only has an impact on indirect utility under contract B if x is a corner solution.

By using (B.6) and (B.6) we get the total change in the reservation wage of the average worker ($\varepsilon = 0$) from implicitly differentiating (11)

$$\begin{aligned}
&\frac{\partial \omega}{\partial b} = \frac{tx}{1-\tau_w} > 0; \qquad \frac{\partial \omega}{\partial p} = \frac{e(v_o)}{1-\tau_w} > 0; \\
&\frac{\partial \omega}{\partial \tau_w} = \frac{\omega + \rho \bar{x}}{1-\tau_w} > 0; \qquad \frac{\partial \omega}{\partial \rho} = \frac{\tau_w \bar{x}}{1-\tau_w} > 0; \\
&\frac{\partial \omega}{\partial \bar{x}} = \frac{\tau_w \rho}{1-\tau_w} > 0; \\
&\frac{\partial \omega}{\partial t} = -\frac{\partial V_x^B / \partial t}{(1-\tau_w)H} \begin{cases} \frac{\mu_x x}{t(1-\tau_w)H} > 0 & \text{if } x = 0 \\ 0 & \text{if } 0 < x < \bar{x} \\ -\frac{\mu_c x}{t(1-\tau_w)H} < 0 & \text{if } x = \bar{x} \end{cases}; \\
&\frac{\partial \omega}{\partial i} = 0, \; \forall i \notin \{b, p, \tau_w, \rho, \bar{x}, t\}
\end{aligned} \tag{B.7}$$

B.2 Derivatives of cost differences

For later use (where we used (8), (9), (B.15)):

$$\begin{aligned}
\frac{\mathrm{d}\Delta c}{\mathrm{d}r} &= -v - r\frac{\partial v}{\partial r} + v_o \frac{\partial \Delta_{mc}}{\partial r} + \Delta_{mc}\frac{\partial v_o}{\partial r} + \frac{\partial \Delta_{fc}}{\partial r} - bt\frac{\partial x}{\partial r} \\
&= -v < 0
\end{aligned} \tag{B.8}$$

$$\begin{aligned}
\frac{\mathrm{d}\Delta c}{\mathrm{d}t} &= -r\frac{\partial v}{\partial t} + v_o \frac{\partial \Delta_{mc}}{\partial t} + \Delta_{mc}\frac{\partial v_o}{\partial t} + \frac{\partial \Delta_{fc}}{\partial t} - bt\frac{\partial x}{\partial t} - bx \\
&= (r-b)t\frac{\partial x}{\partial t} + v_o \frac{\partial \Delta_{mc}}{\partial t} + (\Delta_{mc} - r)\frac{\partial v_o}{\partial t} + \frac{\partial \Delta_{fc}}{\partial t} - bx
\end{aligned} \tag{B.9}$$

$$\begin{aligned}
\frac{\mathrm{d}\Delta c}{\mathrm{d}b} &= -r\frac{\partial v}{\partial b} + v_o \frac{\partial \Delta_{mc}}{\partial b} + \Delta_{mc}\frac{\partial v_o}{\partial b} + \frac{\partial \Delta_{fc}}{\partial b} - bt\frac{\partial x}{\partial b} - tx \\
&= (r-b)t\frac{\partial x}{\partial b} + v_o \frac{\partial \Delta_{mc}}{\partial b} + (\Delta_{mc} - r)\frac{\partial v_o}{\partial b} + \frac{\partial \Delta_{fc}}{\partial b} - tx
\end{aligned} \tag{B.10}$$

and $\forall i \notin \{r, b, t\}$

$$\begin{aligned}
\frac{\mathrm{d}\Delta c}{\mathrm{d}i} &= -r\frac{\partial v}{\partial i} + v_o \frac{\partial \Delta_{mc}}{\partial i} + \Delta_{mc}\frac{\partial v_o}{\partial i} + \frac{\partial \Delta_{fc}}{\partial i} - bt\frac{\partial x}{\partial i} \\
&= (r-b)t\frac{\partial x}{\partial i} + v_o \frac{\partial \Delta_{mc}}{\partial i} + (\Delta_{mc} - r)\frac{\partial v_o}{\partial i} + \frac{\partial \Delta_{fc}}{\partial i}
\end{aligned} \tag{B.11}$$

Using the variable travel cost per WFC hour (21), the differences in non-wage fix costs per employee (22) and (9) are

$$\begin{aligned}
&\frac{\mathrm{d}\Delta c}{\mathrm{d}b} = \frac{r-b}{u_2''+u_3''} - tx;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}p} = \Big(g_h + (1-s_p)(\frac{g_x}{t}+\tau_c) + s_p\tau_p - r\Big)\frac{e'}{-pe''+u_4''} \gtreqless 0;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}g_x} = x_o + \bar{x} > 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}g_h} = v_o + t\bar{x} > 0;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}\bar{x}} = g_x + (g_h+\tau_c-r)t; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}d^A} = -1;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}d^B} = 1;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}r} = -v - t(\bar{x}-x) < 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}s_p} = -(\frac{g_x}{t}+\tau_c-\tau_p)v_o\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}\beta} = 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}i} = 0, \ \forall \in \{g_m, \tau_w, \tau_q, \rho, w, \beta\}
\end{aligned} \tag{B.12}$$

Eventually,

$$\frac{\mathrm{d}\Delta c}{\mathrm{d}t} = (g_h+\tau_c-r)\bar{x} - \frac{g_x}{t}xo + (r-b)\frac{b+u_2'-u_3'}{t(u_2''+u_3'')} \tag{B.13}$$

B.3 Definitions

With policy parameters, the non-wage variable costs is

$$\Delta mc \equiv (1-s_p)\left(\frac{(1+\tau_s)g_s}{t}+\tau_c\right) + s_p\tau_p + (1+\tau_d)g_d \tag{21$'$}$$

and the difference in the non-wage fix costs per employee is

$$\Delta fc \equiv [(1+\tau_s)g_s + ((1+\tau_d)g_d+\tau_c)t]\bar{x} + d^B - d^A \tag{22$'$}$$

The derivatives for policy parameters are

$$\begin{aligned}
&\frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_w} = 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_q} = 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_m} = 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}\rho} = 0;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_p} = s_p v_o > 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_s} = g_s(x_o+\bar{x}) > 0;\\
&\frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_d} = g_d(v_o+t\bar{x}) > 0; \quad \frac{\mathrm{d}\Delta c}{\mathrm{d}\tau_c} = (1-s_p)v_o + t\bar{x} > 0;
\end{aligned} \tag{B.14}$$

Note for later use (using (8)):

$$\begin{aligned}
&\frac{\partial x_o}{\partial p} = (1-s_p)\frac{1}{t}\frac{1}{u_{v_o v_o}} < 0;\\
&\frac{\partial x_o}{\partial t} = (1-s_p)\frac{1}{t}\frac{\partial v_o}{\partial t} - (1-s_p)\frac{v_o}{t^2} < 0;\\
&\frac{\partial x_o}{\partial i} = (1-s_p)\frac{1}{t}\frac{\partial v_o}{\partial i} = 0, \ \forall i \notin \{p, t\}
\end{aligned} \tag{B.15}$$

C Comparative statics of parameters on contract probability

The general derivative of α (24) w.r.t. to any parameter i (except τ_w) is

$$\begin{aligned} 2a\frac{\partial \alpha}{\partial i} &= -(1-\tau_w)\left[\left(\frac{\partial \omega}{\partial i} - \frac{\partial w}{\partial i}\right)H + \frac{\partial \Delta c}{\partial i} - \beta\frac{\partial v}{\partial i}\right], \forall i \notin \{\tau_w, \beta\}\} \\ 2a\frac{\partial \alpha}{\partial \beta} &= -(1-\tau_w)\left[\left(\frac{\partial \omega}{\partial \beta} - \frac{\partial w}{\partial \beta}\right)H + \frac{\partial \Delta c}{\partial \beta} - \beta\frac{\partial v}{\partial \beta} - v\right] \end{aligned} \tag{C.1}$$

The marginal change in α depends on the change in the wage differential, costs, and productivity that depends on the change in WFC hours. In the following, we use this derivative and substitute (B.3), (B.5), (B.7), and (B.11)–(B.14).

Impact of the market wage w in case of WFO. Since the wage does neither affect the non-wage cost difference, nor WFC hours and distances x_c and x_o, we get

$$\frac{\partial \alpha}{\partial w} = \frac{1-\tau_w}{2a} > 0 \tag{C.2}$$

The higher the WFO wage the higher the probability of choosing contract B.

Impact of g_m

$$\frac{\partial \alpha}{\partial g_m} = 0 > 0 \tag{C.3}$$

A change in private travel costs does not change the probability of choosing a WFC-contract (contract B).

Impact of g_x

$$\frac{\partial \alpha}{\partial g_x} = -\frac{(1-\tau_w)(x_o + \bar{x})}{2a} < 0 \tag{C.4}$$

An increase in variable travel costs of the AV lowers α.

Impact of g_h

$$\frac{\partial \alpha}{\partial g_h} = -\frac{(1-\tau_w)(v_o + t\bar{x})}{2a} \leq 0 \tag{C.5}$$

An increase in the AV's travel costs per hour (e.g. leasing cost) does not increase α.

Impact of p

$$\frac{\partial\alpha}{\partial p} = -\frac{1}{2a}\left\{e(v_o) + (1-\tau_w)\frac{\left[\beta - r + g_h + (1-s_p)\left(\frac{g_x}{t}\right) + s_p\tau_p\right]e'}{-pe'' + u_4''}\right\} \tag{C.6}$$

after using (B.7), (B.3), (B.12), (B.4), (9), (8), (B.12), and (B.14).

Impact of r

$$\frac{\partial\alpha}{\partial r} = \frac{(1-\tau_w)v}{2a} > 0 \tag{C.7}$$

after using (B.7), (B.3), (B.12), (B.4), (9), (8), (B.12), and (B.14). An increase in the office rent per hour raises the probability of mobile-work contracts.

Impact of β

$$\frac{\partial\alpha}{\partial\beta} = \frac{(1-\tau_w)v}{2a} \geq 0 \tag{C.8}$$

after using (B.7), (B.3), (B.12), (B.4), (9), (8), (B.12), and (B.14). An increase in the productivity parameter of working from car raises the probability of mobile-work contracts.

Impact of d_A

$$\frac{\partial\alpha}{\partial d_A} = \frac{1-\tau_w}{2a} > 0 \tag{C.9}$$

after using (B.7), (B.3), (B.12), (B.4), (9), (8), (B.12), and (B.14).

Impact of d_B

$$\frac{\partial\alpha}{\partial d_B} = -\frac{1-\tau_w}{2a} < 0 \tag{C.10}$$

after using (B.7), (B.3), (B.12), (B.4), (9), (8), (B.12), and (B.14).

Impact of $\bar{x}$

$$2a\frac{\partial\alpha}{\partial\bar{x}} = -(1-\tau_w)\left(\frac{\partial\omega}{\partial\bar{x}} - \frac{\partial w}{\partial\bar{x}} + \frac{\partial\Delta c}{\partial\bar{x}} - \beta\frac{\partial v}{\partial\bar{x}}\right)$$

$$\frac{\partial\alpha}{\partial\bar{x}} = -\frac{1}{2a}\left\{(1-\tau_w)\left[g_x + (g_h + \tau_c - r + \beta)t + g_x\right] + \tau_w\rho\right\} \tag{C.11}$$

Impact of t

$$
\begin{aligned}
2a\frac{\partial\alpha}{\partial t} &= -(1-\tau_w)\left(\frac{\partial\omega}{\partial t}-\frac{\partial w}{\partial t}+\frac{\partial\Delta c}{\partial t}-\beta\frac{\partial v}{\partial t}\right)\\
&= -(1-\tau_w)\left(\frac{(b+u_\ell-u_{tx})\,x}{(1-\tau_w)H}-\frac{(\tau_c+u_\ell-u_{tx})\bar{x}}{(1-\tau_w)H}\right.\\
&\qquad \left.+(g_x+\tau_c)\bar{x}-\frac{g_x x_0}{t}-rx+(r-b)\frac{b+u_\ell-u_{tx}}{t(u_{\ell\ell}+u_{txtx})}-\beta\left(x-\frac{b+u_\ell-u_{tx}}{t^2(u_{\ell\ell}+u_{txtx})}\right)\right)\\
&= -(1-\tau_w)\left[(b-r-\beta)x+(u_\ell-u_{tx})(\bar{x}-x)\right]\\
&\qquad -(1-\tau_w)\left[g_x(\bar{x}-\frac{x_0}{t})+\left(r-b+\frac{+\beta}{t}\right)\frac{b+u_\ell-u_{tx}}{t(u_{\ell\ell}+u_{txtx})}\right]
\end{aligned}
\tag{C.12}
$$

$$
\begin{aligned}
\frac{\partial\alpha}{\partial t} &= -\frac{1}{2a}\left\{(1-\tau_w)\left[(g_h-r+\beta+\tau_c)\bar{x}-\frac{g_x}{t}x_o\right]\right.\\
&\qquad \left.+(b+u_2'-u_3')\left[x-\frac{(1-\tau_w)(b-r+\beta)}{t(u_2''+u_3'')}\right]\right\}
\end{aligned}
\tag{C.13}
$$

after using (B.7), (B.3), (B.11), (B.4), (9), (8), (B.11), and (B.14).

Impact of s_p

$$
\frac{\partial\alpha}{\partial s_p}=\frac{(1-\tau_w)(\frac{g_x}{t}+\tau_c-\tau_p)v_o}{2a}
\tag{C.14}
$$

D Comparative Statics: Policy Instruments

In the following, we use (C.1) and substitute (B.3), (B.5), (B.7), and (B.11)–(B.14).

Impact of τ_w

$$
2a\frac{\partial\alpha}{\partial\tau_w}=\omega-w+\Delta c-v\beta-(1-\tau_w)\left[\left(\frac{\partial\omega}{\partial\tau_w}-\frac{\partial w}{\partial\tau_w}\right)H+\frac{\partial\Delta c}{\partial\tau_w}-\beta\frac{\partial v}{\partial\tau_w}\right]
$$

eventually

$$
\begin{aligned}
\frac{\partial\alpha}{\partial\tau_w} &= \frac{d_B-d_A-btx+[g_x+t(g_h+\tau_c)-\rho]\,\bar{x}}{2a}\\
&\qquad -\frac{(r+\beta)v+(g_x+t\tau_c)x_o+(g_h+s_p\tau_p)v_o}{2a}
\end{aligned}
\tag{D.1}
$$

after using (B.7), (B.3), (B.11), (B.4), (9), (8), (B.11), and (B.14). The impact of the wage tax on α depends on the difference in fixed costs of the contracts (sign ambiguous), the change in variable profits per WFC hour (negative), and the changes in wages due to the imputed value of fringe benefits (negative).

Impact of τ_m Note: $g_m = (1+\tau_m)g_k$

$$\frac{\partial \alpha}{\partial \tau_m} = g_k \frac{\partial \alpha}{\partial g_k} = 0 \tag{D.2}$$

Impact of τ_s Note: $g_x = (1+\tau_s)g_s$

$$\frac{\partial \alpha}{\partial \tau_s} = g_s \frac{\partial \alpha}{\partial \tau_s} = -\frac{(1-\tau_w)(v_o + t\bar{x})}{2a} g_s \tag{D.3}$$

after using (B.7), (B.3), (B.11), (B.4), (9), (8), (B.11), and (B.14).

Impact of τ_d Note: $g_h = (1+\tau_d)g_d$

$$\frac{\partial \alpha}{\partial \tau_d} = g_d \frac{\partial \alpha}{\partial g_d} = -\frac{(1-\tau_w)(x_o + \bar{x})g_d}{2a} \tag{D.4}$$

A change in the tax component of the firm's fixed monetary travel cost per WFC hour affect α via the tax base.

Impact of τ_c

$$\begin{aligned}\frac{\partial \alpha}{\partial \tau_c} &= -(1-\tau_w)\left(\frac{\partial \omega}{\partial \tau_c} - \frac{\partial w}{\partial \tau_c}\right) H - (1-\tau_w)\left(\frac{\partial \Delta c}{\partial \tau_c} - \beta \frac{\partial v}{\partial \tau_c}\right) \\ &= -\frac{(1-\tau_w)t(x_o + \bar{x})}{2a} \end{aligned} \tag{D.5}$$

Impact of τ_p

$$\frac{\partial \alpha}{\partial \tau_p} = -\frac{(1-\tau_w)s_p v_o}{2a} < 0 \tag{D.6}$$

after using (B.7), (B.3), (B.11), (B.4), (9), (8), (B.11), and (B.14). The impact of the parking fee depends on WFC while parking. This effect is negative because τ_p increases the parking costs.

Impact of τ_q

$$\frac{\partial \alpha}{\partial \tau_q} = 0 \tag{D.7}$$

The parking fee for private parking near the working place does not affect α.

Impact of ρ

$$\frac{\partial \alpha}{\partial \rho} = -\tau_w \bar{x} < 0 \tag{D.8}$$

after using (B.7), (B.3), (B.11), (B.4), (9), (8), (B.11), and (B.14).

D.1 Impact of Parameters: Full Regressions Results

	Dependent variable:			
	alpha	sv	svc	svo
	(1)	(2)	(3)	(4)
log(wage)	0.040***	−0.0002	0.00004	−0.0004
	(0.003)	(0.001)	(0.001)	(0.001)
log(tkm)	−0.017***	0.009***	0.044***	−0.001
	(0.002)	(0.001)	(0.001)	(0.001)
log(eff)	0.027***	−0.692***	0.009***	−0.698***
	(0.008)	(0.004)	(0.002)	(0.003)
log(xbar)	0.011***	0.014***	0.044***	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
log(gm)	0.079***	−0.003	0.001	−0.003*
	(0.005)	(0.002)	(0.001)	(0.002)
beta	0.018***	0.00000	0.00004**	0.00002
	(0.0001)	(0.00003)	(0.00002)	(0.00003)
log(r)	0.173***	−0.002	−0.001	−0.001
	(0.004)	(0.002)	(0.001)	(0.001)
log(gx)	−0.016***	−0.0004	−0.0002	−0.0002
	(0.005)	(0.003)	(0.001)	(0.002)
log(gh)	−0.157**	−0.028	−0.010	−0.004
	(0.067)	(0.031)	(0.017)	(0.025)
log(sp)	0.013***	−0.002	−0.00000	−0.002
	(0.003)	(0.001)	(0.001)	(0.001)
dB	−0.007***	−0.001**	−0.0003	−0.0004
	(0.001)	(0.0004)	(0.0002)	(0.0003)
	(0.009)	(0.007)	(0.007)	(0.007)
Constant	−0.402***	0.946***	0.121***	0.832***
	(0.142)	(0.065)	(0.035)	(0.052)
logSigma	−1.888***	−2.559***	−3.177***	−2.778***
Observations	10,000	10,000	10,000	10,000
Akaike Inf. Crit.	−3,265.583	−21,829.280	−33,918.230	−26,876.530
Bayesian Inf. Crit.	−3,171.848	−21,735.540	−33,824.500	−26,782.790

Note: *p<0.1; **p<0.05; ***p<0.01
Results of censored (Tobit) regressions. Observations are the 10,000 results from the Monte-Carlo simulation. Dependent variables are α and the shares 'sc', 'svc', and 'svo' of v, v_c, v_o on daily working hours.

Table 10: Regression Results (U.S.)

E Results of Variation of Policy Parameters

	Dependent variable:			
	alpha	v	vc	vo
	(1)	(2)	(3)	(4)
log(wage)	0.057***	0.001	−0.0001	0.001
	(0.004)	(0.002)	(0.001)	(0.001)
log(tkm)	0.130***	0.113***	0.191***	−0.005***
	(0.004)	(0.002)	(0.001)	(0.001)
log(eff)	0.073***	−0.683***	0.009***	−0.680***
	(0.008)	(0.004)	(0.002)	(0.003)
log(xbar)	0.127***	0.103***	0.165***	−0.004***
	(0.002)	(0.001)	(0.001)	(0.001)
log(gm)	0.038***	−0.003	−0.002	−0.001
	(0.006)	(0.003)	(0.001)	(0.002)
beta	0.017***	0.00002	0.0001***	−0.00002
	(0.0001)	(0.00005)	(0.00002)	(0.00003)
log(r)	0.069***	−0.001	−0.0003	−0.002
	(0.004)	(0.002)	(0.001)	(0.001)
log(gx)	−0.027*	−0.011	0.004	−0.003
	(0.015)	(0.009)	(0.004)	(0.005)
log(gh)	−0.059***	0.002	0.001	0.0004
	(0.003)	(0.002)	(0.001)	(0.001)
log(sp)	0.005*	−0.001	−0.0001	−0.002
	(0.003)	(0.002)	(0.001)	(0.001)
dB	−0.005***	−0.0003	−0.00002	−0.0001
	(0.001)	(0.0005)	(0.0002)	(0.0003)
	(0.009)	(0.007)	(0.007)	(0.007)
Constant	0.137**	0.949***	0.232***	0.792***
	(0.058)	(0.032)	(0.015)	(0.020)
logSigma	−1.898***	−2.372***	−3.159***	−2.843***
Observations	10,000	10,000	10,000	10,000
Akaike Inf. Crit.	−3,196.302	−17,791.260	−34,254.060	−28,446.640
Bayesian Inf. Crit.	−3,102.567	−17,697.530	−34,160.330	−28,352.900

Note: *p<0.1; **p<0.05; ***p<0.01

Results of censored (Tobit) regressions. Observations are the 10,000 results from the Monte-Carlo simulation. Dependent variables are α and the shares 'sc', 'svc', and 'svo' of v, v_c, v_o on daily working hours.

Table 11: Regression Results (Germany)

	id_r	id_c	tauq	e_alpha	e_v	e_vc	e_vo	e_xB
1	1	DE	0.5					
2	2	DE	1	0.062	1.5e-16	0.00	0.00	0.00
3	3	DE	1.5	0.12	-3e-16	0.00	0.00	0.00
4	4	DE	2	0.16	4.5e-16	0.00	0.00	0.00
5	5	DE	2.5	0.21	-6e-16	0.00	0.00	0.00
6	6	DE	3	0.25	7.5e-16	0.00	0.00	0.00
7	7	DE	3.5	0.28	-8.9e-16	0.00	0.00	0.00
8	8	DE	4	0.079	1e-15	0.00	0.00	0.00
9	9	DE	4.5	0	-1.2e-15	0.00	0.00	0.00
10	10	DE	5	0	1.3e-15	0.00	0.00	0.00
11	mean	DE	tauq	0.12	1.5e-16	0.00	0.00	0.00

Table 12: Parameter tauq DE

	id_r	id_c	tauc	e_alpha	e_v	e_vc	e_vo	e_xB
1	1	US	0					
2	2	US	1	0	0	0	0	0
3	3	US	2	-0.0093	0.00043	0.0015	3.8e-16	-0.076
4	4	US	3	-0.019	0.00034	0.0012	-3.8e-16	-0.067
5	5	US	4	-0.029	-4.2e-16	0	-5.7e-16	-7.3e-15
6	6	US	5	-0.039	1.1e-15	0	7.7e-16	-1.1e-14
7	7	US	6	-0.049	0	0	0	1.3e-14
8	8	US	7	-0.059	-8.3e-16	0	-1.1e-15	0
9	9	US	8	-0.07	1.2e-11	8.8e-16	1.7e-11	-3.7e-14
10	10	US	9	-0.081	0	-1e-15	0	6.5e-14
11	mean	US	tauc	-0.039	0	0	0	-7.3e-15

Table 13: Parameter tauc US

	id_r	id_c	tauc	e_alpha	e_v	e_vc	e_vo	e_xB
1	1	DE	0					
2	2	DE	1	0	0	0	0	0
3	3	DE	2	-0.0038	4e-04	0.0018	-1.9e-16	-0.016
4	4	DE	3	-0.0075	8e-04	0.0036	0	-0.033
5	5	DE	4	-0.011	0.0012	0.0054	5.7e-16	-0.05
6	6	DE	5	-0.015	0.0016	0.0072	0	-0.068
7	7	DE	6	-0.019	0.002	0.009	-9.6e-16	-0.086
8	8	DE	7	-0.023	0.0024	0.011	0	-0.11
9	9	DE	8	-0.027	0.0028	0.013	1.1e-11	-0.12
10	10	DE	9	-0.031	0.0032	0.014	-1.4e-14	-0.15
11	mean	DE	tauc	-0.015	0.0016	0.0072	0	-0.068

Table 14: Parameter tauc DE