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Abstract

We study hours worked by drivers in the peer-to-peer transportation sector with cross-side network effects. Medallion lease (regulated market), commission-based (Uber-like pay) and profit-sharing ("pure" taxi coop) compensation schemes are compared. Our static model shows that network externalities matter, depending on the number of active drivers. When the number of drivers is limited, in the presence of positive network effects, a regulated system always induces more hours worked, while the commission fee influences the comparative incentives towards working time of Uber-like pay *versus* profit-sharing. When the number of drivers is infinite (or close to it), the influence of network externalities on optimal working time vanishes. Our model helps identifying which is the pay scheme that best remunerates longer working times and offers insights to regulators seeking to improve the intensive margin of coverage by taxi services.

Keywords: working time, Uber, network effects, ride-sharing, pay schemes.
JEL classification: L91; J22; J33

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1 Introduction

The peer-to-peer (P2P) transportation sector, possibly mediated by digital platforms (Spulber, 2019), where drivers provide on-demand transport to riders using their personal vehicles, over the last five years has experienced an impressive rise in the use of smartphone-based applications for ride-hailing (Hall and Krueger, 2018). Uber and Lyft are the two largest and best-known companies providing on-line ride-hailing platforms.

Within a broader literature on the economics of the so-called "sharing economy" (Hu, 2019), the economic analysis of internet-based platforms that operate e-hailing services has rapidly emerged as an autonomous and rich field of study. From an economic point view, the main feature of the P2P sector is that it is a two-sided market, where two groups of agents (drivers and riders) interact providing each other with network benefits (for influential works on the economics of two-sided markets see Rochet and Tirole (2003, 2006), among others). This general feature has several implications on operational strategies in the P2P sector, that include dealing with the frictions caused by spatial and temporal factors (Yang *et al.*, 2002; Zha *et al.*, 2018a), the mechanisms for static and dynamic "surge" pricing (Sayarshad and Chow, 2015; Zha *et al.*, 2018b; Guda and Subramanian, 2019), the strategic determination of platform service capacity and supply (Sun *et al.*, 2019; Xu *et al.*, 2020), and that in turn generate a number of regulatory issues (Harding *et al.*, 2016; Zha *et al.*, 2016).[1]

At the intersection of this body of works and the standard labour economics literature on the intensive margin of labour supply[2] is the problem of the optimal drivers' decisions concerning working time (i.e. the supply of hours of driving). Related to this, specific attention so far has been mainly directed to measuring working-hours elasticity with respect to hourly income rates (Camerer *et al.*, 1997; Farber, 2005 and 2015; Zha *et al.*, 2018b; Sun *et al.*, 2019). While these studies have greatly contributed to the understanding of the empirical functioning of drivers' incentives, surprisingly they have also neglected how alternative compensation schemes adopted by alternative platforms (typically, taxi companies *versus* ride-hailing) may influence drivers' working time in the presence of cross-side network effects, which may cause strict concavity in the product

[1]A systematic review over this literature is provided by (Wang and Yang, 2019).
[2]See, e.g., the seminal paper of Barzel (1973).

demand with respect to hours of driving when working time reflects into aggregate product supply. This issue is of some importance, particularly when regulators are concerned with improving coverage by P2P transportation services, such as in small urban areas or in peripheral zones of large cities, where the number of drivers is small enough that platforms have some market power.

Loosely speaking, when the the supply is below a critical level, the network externality dominates, causing marginal value of rides to grow with quantity due to reduced wait-times;[3] when the supply exceeds the critical level, the network externality is exhausted and demand has a standard shape (i.e. negative slope). Against this background, P2P rides may be supplied under alternative driver contracts. On the one side, traditional taxi drivers in most US cities and in Europe must own or lease one of a limited number of medallions granting them the right to drive. So, they keep every dollar earned, but need to pay for the medallion. On the other side, ride-hailing platforms (like Uber) base drivers' pay on a proportional compensation scheme, according to which, in return for a commission fee, drivers can set their work schedule without having to worry about covering a lease. In addition, also "pure" taxi coops may be possible, with total earnings divided evenly among drivers-members, with or without leasing.

Comparative empirical evidence on working time in the P2P transportation sector is available. By using administrative data on drivers using the Uber platform from 2012 to 2014, Hall and Krueger (2018) documented that drivers who reported having no other job in 2014 worked more than 35 hours per week on the Uber app. Hall *et al.* (2018) measured how supply of hours worked by drivers reacts to ride fares and reported that for a 10% increase in the fare, drivers eventually work 6% more hours. Uber drivers have been found to have higher capacity utilization (the fraction of time a driver has a fare-paying passenger in the car while he or she is working) compared to taxi drivers (Cramer and Krueger, 2016); however, taxi drivers are shown to work slightly more hours (Berger *et al.*, 2018). With data from an experiment on random samples of Boston Uber drivers, Angrist *et al.* (2017) found that drivers who work more hours are better off having a taxi-like reward structure, while drivers with low hours prefer work on a ride-hailing platform with a proportional compensation scheme.

[3] Empirical measures of reduced waiting-times are provided, among others, by Alonso-González *et al.* (2020).

While these empirical figures tell that drivers' working time varies with the fare and the pay scheme, they do not allow to understand to which extent it is so under the same market entry conditions (i.e. under a given size of the market and with utilization rates being equal between platforms) and which are the implications of network effects.

With this paper, we shed some light on this from a theoretical point of view, which allows us to circumvent important empirical issues, including data availability constraints (e.g., the lack of empirical measures of cross-side externalities). We analyze comparatively driver optimal working time under three pay schemes or contracts: medallion lease (regulated market), commission-based (Uber-like) and profit-sharing ("pure" taxi coop). We do so with a simple short-run model, where both the number of drivers and capacity utilization are exogenous. As a static exercise, moreover, we abstract away from surge dynamics.

We find that network effects may matter crucially, depending on the number of active drivers. Precisely, the analysis presented here argues for a simple but useful result. That is, when the number of drivers is not infinite (or close to it), in the presence of positive network effects, a regulated system always induces more hours of work, while a Uber-like fee influences the comparative incentives towards hours worked of commission-based pay *versus* profit-sharing, with the fee having to be sufficiently low for Uber to provide more hours worked than a "pure" taxi coop. The reason behind this finding is intuitive: with positive network effects, the pay scheme providing the strongest labour incentives is the one that allows drivers to internalize the largest share of the revenues they create. When the number of drivers is very high, the influence of network externalities on optimal working time tends to disappear (i.e. the elasticity of prices with respect to hours of work is reduced), and a pay scheme based on medallion lease continues to induce more hours worked than both a Uber-like platform and "pure" taxi coops. In this case, Uber-like pay induces more hours worked than profit-sharing for nearly any level of the commission. Hence, the model offers insights to regulators seeking to improve coverage by P2P transportation services, as it shows that, thanks to network effects, "pure" taxi coops may induce larger coverage per driver than ride-hailing platforms when the market is relatively small. In such contexts, regulating the commission of on-line ride-hailing platforms operating next to standard taxi companies, for instance by means of a cap, may be an easy to implement and effective measure to rise hours of driving, thereby improving the intensive margin of taxi services. In large markets (or in large urban areas), "pure" taxi coops provide sub-optimal levels of service nearly always. Therefore, here the instruments in the hands of regulators may be confined to classical entry barriers mitigating the tension between new ride-hailing platforms and incumbent (standard) taxi companies. Simple intuitions for explaining these results are provided. Caution however is required before deriving direct regulatory instructions from our findings, since the model relies on assumptions that might not hold in specific industrial contexts and some of the results crucially depend on the parameters.

Having clarified what we do analyze in the paper, it is worth emphasizing what we do not. Whilst our analysis on individual optimal working decisions clearly has implications for social welfare, we do not tackle a welfare analysis directly. This is because the scope of the paper is about the incentive mechanisms activated by alternative pay contracts, not to neglect that longer working time may have indirect negative consequences from both an individual worker and a social perspective beyond the simple cost of effort modeled in our paper. At the same time, the model is flexible enough to be applied to other types of worker effort generating network externalities, including innovation effort and quality improving practices that have external effects on the product price of partner productive units.

The remaining of the paper proceeds as follows. Section 2 introduces the basic comparative statics referred to a relatively small market, while Section 3 presents the results in a market where the number of drivers is very large. Section 4 concludes.

2 Hours worked under alternative pay schemes

We model the P2P transportation sector as a two-sided market with cross-side network effects. In the short-run, there is a given finite number of active drivers $L > 1$. Denote with $\sum_{i=1}^{L} h_i = H$ the total amount of hours worked, with h_i being the hours worked for driver i. Too keep notation simple, denote the average hours worked with h, i.e. $H/L = h$, and assume that in the short-run the utilization rate is fixed. To simplify, we assume full capacity utilization.[4] Due to the cross-side externality, the average time

[4]This is not a critical assumption here.

$h \in [0, h^{max}]$, with $h_i^{max} = h^{max} \quad \forall i$, spent by drivers while driving (i.e. the amount of service supplied) increases the utility of riders and thereby their willingness to pay for a ride until a critical threshold in supply is reached; above the threshold, the marginal value for riders is decreasing and so is their willingness to pay. The inverse demand function for hours of service therefore is

$$p(h) = \alpha h^{1/2} - \beta h \tag{1}$$

The turning point is $\overline{h} \equiv (\alpha/2\beta)^{-1/2} < h^{max}$.[5] Notice that (1) is strictly concave.[6] If $h < \overline{h}$, network effects are positive; if $h > \overline{h}$, more hours worked generate negative externalities. With L being fixed, for any level of hours worked, supply is always met by available demand, with $p(h)$ being the corresponding willingness to pay. Suppose L is fixed by a regulator such that, when all the drivers work h^{max} hours, the willingness to pay of riders is zero.[7] The typical demand function for ride-sharing is represented in Figure (1).

[insert Figure (1) about here]

Obviously, once an equilibrium (market clearing) price $p(h)$ is determined, this will also reflect average revenues (i.e. revenues per hour of work), since the willingness to pay of riders translates into driver revenues.

The driver's problem is

$$\max_{h_i} \quad U_i = f(p(h), h_i) - c_i(h_i) \tag{2}$$

where $f(\cdot)$ is a function increasing in both price and effort and where $c_i(h_i)$ is a continuous and twice differentiable function for the cost of effort (with $c_i(h_i)' > 0$ and $c_i(h_i)'' > 0$).

[5] The upper limit h^{max} can be thought of as due to drivers' physical constraints or to a regulatory cap.

[6] The functional form we assume for the inverse demand function is not crucial for our argument; it is sufficient that $p((1-a)h_1 + ah_2) > (1-a)p(h) + ap(h)$ for any $a \in (0,1)$ and $h_1, h_2 \in [0, h^{max}]$, with $h_1 \neq h_2$.

[7] While a finite value of h^{max} is required in the model to have a finite upper limit on the supply side (where this limit reflects a physical constraint or exogenous institutional constraints), on the demand side in principle it is plausible that the willingness to pay of riders shows asymptotic reduction. We propose a strictly concave function with $p(h^{max}) = 0$ to simplify the notation, not to exclude that riders may continue obtaining positive welfare when $h^{max} \to \infty$.

We omit fixed costs (e.g. the fixed cost of the car) from (2) for simplicity, as they are irrelevent for the propositions here.

Next, we consider three alternative platforms or driver pay schemes.

Medallion lease (regulated market). With a medallion system, drivers must own or lease a medallion granting them the right to drive. Assume that the number of available medallions is $M = L$, with m_i being the price of one medallion for driver i (with $m_i = m_j \quad \forall i \neq j$). Then, the driver's utility is

$$U_i^m = p(h_i, h_{L-1})h_i - c_i(h_i) - m_i \tag{3}$$

where the notation $p(h_i, h_{L-1})$ (with $h_{L-1} = \sum_{j=1}^{L-1} h_j / L - 1$, $j \neq i$) is functional to make h_i explicit as an argument of $p(\cdot)$. By substituting U_i^m in problem (2), we obtain the following FOC:

$$p(h_i, h_{L-1}) + p'(h_i, h_{L-1})h_i = c_i'(h_i) \tag{4}$$

whose corresponding optimal level of effort is h_i^m.

Commission-based (Uber-like pay). Under a commission-based pay, drivers are paid the fare less a percentage retained by Uber. The driver's utility is

$$U_i^e = (1 - \varphi)p(h_i, h_{L-1})h_i - c_i(h_i) \tag{5}$$

where $\varphi \in (0, 1]$ is the proportional commission fee to be paid to Uber. After substituing U_i^e in problem (2), we obtain the following FOC:

$$(1 - \varphi)p(h_i, h_{L-1}) + (1 - \varphi)p'(h_i, h_{L-1})h_i = c_i'(h_i) \tag{6}$$

whose corresponding optimal level of effort is h_i^e.

Profit-sharing ("pure" taxi coop). With profit-sharing, total earnings are divided evenly between drivers.[8] Here, the driver's utility is

$$U_i^w = \frac{p(h_i, h_{L-1})h_i + p(h_i, h_{L-1})h_{L-1}(L-1)}{L} - c_i(h_i) \tag{7}$$

Again, after substituting U_i^w in problem (2), we obtain the FOC

$$\frac{p(h_i, h_{L-1}) + p'(h_i, h_{L-1})h_i + p'(h_i, h_{L-1})h_{L-1}(L-1)}{L} = c_i'(h_i) \tag{8}$$

whose corresponding optimal level of effort is h_i^w. It is worth noting that $h_i^w = 0$ when

$$U_i^w(h_i = h_i^w) < \frac{1}{L}p(0, h_{L-1})h_{L-1}(L-1), \tag{9}$$

i.e. when the utility that driver i obtains with zero hours of work, under some expectation that the other drivers work for a positive amount of time $h_{L-1} > 0$, is higher than the one with $h_i = h_i^w$. When condition (9) holds, if the drivers are identical, for all of them it is rational to work zero hours (or the minimum verifiable level, if $h_i > 0$ is a participation constraint to access to the profit sharing). We rule out this possibility here, by assuming that digital techniques in the P2P industry allow taxi coop members to cross-check who is working less than h_i^w. With perfect peer-monitoring, once h_i^w is obtained from (8), it can also be contracted upon.[9]

Proposition 1. *In the presence of positive network externalities (namely, $h \leq \overline{h}$), average hours worked are always higher under a medallion system compared to Uber-like pay; when $h > \overline{h}$, $h_i^m > h_i^e$ iff $|p(h_i, h_{L-1})| > |p'(h_i, h_{L-1})h_i|$. The fee used in the commission-based pay does not matter. Moreover, the medallion system always induces more hours worked than profit-sharing, regardless of network effects.*

[8] "Pure" profit sharing is rare in the taxi sector. More often, taxi coops use partnership contracts that are combinations of pay for performance and common fixed costs sharing, possibly under a medallion leasing. To emphasize the main differences between alternative types of contract, we consider here a "pure" taxi coop based on simple profit sharing.

[9] Clearly this is a strong assumption. Nevertheless, previous literature has clarified that peer-monitoring in worker cooperatives is more efficient than under other types of labour contract (e.g., Bai and Xu (2001)) and that digital app-based platforms allow measuring driver working time and capacity utilization very precisely (e.g., Cramer and Krueger (2016)). In any event, the assumption of perfect peer-monitoring in taxi coops does not affect the qualitative implications of our main propositions, that point to the medallion system as the one providing the most powerful incentives, particularly in the presence of network effects.

Proof. See Appendix A.1. ■

The intuition behind Proposition 1 is simple. By comparing (4) and (6) and manipulating, it is easy to see that $h_i^m > h_i^e$ when $p(h_i, h_{L-1}) + p'(h_i, h_{L-1})h_i > 0$, i.e. when $MR > 0$ (with MR denoting the marginal revenue). Since, under a medallion system, drivers enjoy full revenue extraction, whilst they are required to pay some proportional commission fee on revenues under a Uber-like pay, the latter will be superior only when $MR < 0$. Related to Proposition 1, in particular, MR is always positive in the upward sloping section of the demand curve (i.e., with positive network externalities). When the demand curve is downward sloping, then MR can be either positive or negative; in this case, therefore, the additional condition $|p(h_i, h_{L-1})| > |p'(h_i, h_{L-1})h_i|$ (which implies $MR > 0$) needs to be imposed for $h_i^m > h_i^e$ to hold.

Also, by comparing Equation (6) and Equation (8), we obtain that $h_i^e < h_i^w$ iff

$$\varphi > 1 - \frac{1}{L}\left[1 + (L-1)\frac{p'(h_i, h_{L-1})h_i}{p(h_i, h_{L-1}) + p'(h_i, h_{L-1})h_i}\right] \equiv \overline{\varphi} \tag{10}$$

Two additional propositions follow.

Proposition 2. *In the presence of positive network externalities (namely, $h \leq \overline{h}$), $\overline{\varphi}$ is always lower than 1, i.e. it always exists a value of φ in the interval $(0, 1)$ above which profit-sharing induces more hours worked compared to Uber-like pay.*

Proof. See Appendix A.2. ■

Proposition 3. *When positive network externalities are absent (namely, $h > \overline{h}$), it exists a value $h^* \in (\overline{h}, h^{max})$ such that $\overline{\varphi} = 1$ for any $h \geq h^*$; i.e., when the average of hours worked is sufficiently high, Uber-like pay always induces more hours worked compared to profit-sharing.*

Proof. See Appendix A.3. ■

The joint message of the three propositions can be summarized as follows. In the presence of positive network effects, the medallion system always induces more hours worked, while the commission fee influences the comparative incentives towards effort of

Uber-like pay *versus* profit-sharing, with the fee having to be sufficiently low for Uber-like pay to provide more hours worked than profit-sharing. This holds critically under the assumption of having the same number of drivers under the three pay schemes, with $L = M$ (in the short-run, we do not allow for free entry of drivers).

The intuition for explaining why the commission fee matters for $h_i^e < h_i^w$ to hold is that, under both Uber-like pay and profit-sharing, drivers do not fully enjoy individually raised revenues, with "pure" taxi coop drivers partly compensating the loss by capturing a share of the revenues raised by the other members of the team. When the average number of hours worked is sufficiently high (i.e., MR is relatively low) the compensation mechanism provided by profit-sharing has a lower power, thus Uber-like pay can be shown to be superior even with a higher commission fee. Phrased differently, profit-sharing works better than Uber-like pay in terms of effort when marginal revenues are higher. Figure (2) shows the pattern of $\overline{\varphi}$ along the range of hours worked.

[insert Figure (2) about here]

3 Optimal effort when the market is very large

Suppose that the number of active drivers L is very high or infinite. Assume that the number of riders is proportionally high, so that they continue to be concerned with h (i.e. average hours worked) and the demand curve again can be described by (1). Alternatively, the number of riders is very high and L is increased proportionally by a regulator. In this case, variation in the hours worked by driver i has no effect on prices, i.e. the first derivative of $p(\cdot)$ with respect to h_i is 0. Now, manipulating from (4), (6) and (8), optimal effort under alternative platforms needs to satisfy respectively:

$$\textit{Medallion lease:} \qquad p(h) = c_i'(h_i) \Rightarrow h_i^M \tag{11}$$

$$\textit{Commission-based:} \qquad (1-\varphi)p(h) = c_i'(h_i) \Rightarrow h_i^E \tag{12}$$

$$\textit{Profit-sharing:} \qquad p(h)/L = c_i'(h_i) \Rightarrow h_i^W \tag{13}$$

Proposition 4. *When the number of active drivers is very high or infinite, network effects do not influence optimal effort, under any pay contract. Moreover, a pay scheme based on medallion lease always provides higher hours worked than Uber-like pay and profit-sharing; Uber-like pay induces higher effort than profit-sharing iff* $\varphi < (L-1)/L \sim 1$.[10]

Proof. See Appendix A.4. ■

As one might intuit, the h_i^M equilibrium has some attractive welfare properties, as it corresponds to maximization of total surplus. In all the other instances, the number of hours worked will deviate from the socially optimal level. The reason is simple. When the number of drivers is very high, the market of rides is perfectly competitive and drivers are price-takers. So, both the Uber-like fee and the profit-sharing can be thought of as a tax on output influencing optimal supply decisions.

To improve clarity, in Table (1) we provide a summary of the main model results.

[insert Table (1) about here]

From (11), (12) and (13), it is easy to see that hours worked per driver are higher in a small market with respect to very large markets when network effects are positive (i.e. $h < \overline{h}$), under any pay scheme. When $h > \overline{h}$ and therefore $p'(h_i, h_{L-1}) < 0$, the opposite holds: $h_i^M > h_i^m$, $h_i^E > h_i^e$ and $h_i^W > h_i^w$.

It is worth emphasizing however that, due to temporal or spatial differentiation of P2P services, the labour supply may often show localized specifications even though the market is very large (Yang *et al.*, 2002). Hence $p'(h_i, h_{L-1}) = 0$ is unlikely to occur in reality, whilst it would be more realistic to refer to a reduction of the working time effect on prices as the size of the local market increases.

This has two main consequences for the interpretation of our model. First is the fact that Propositions 1, 2 and 3 are the most informative for regulatory policy, because they refer to contexts (where network effects play significant effects) which are the most likely

[10]The last part of the Proposition does not require that Uber-like platforms apply a commission fee close to 1 (this would be unrealistic), but it says that Uber-like pay is superior with respect to "pure" profit-sharing under nearly any value of the commission fee.

to be observed in the P2P sector. The analysis of large markets (Proposition 4) is helpful for benchmarking the implications of network effects on optimal working time, more than for informing policy making.

Related to this, second, the marginal impact of L (the fleet size) also deserves to be briefly discussed. Where local markets are very small (i.e. L is very small) and network externalities are positive, little increases in the fleet size narrow the difference between h_i^m and h_i^e (i.e. the medallion system is always superior but to a lesser extent); viceversa, where the fleet is small, further reductions of L widen the gap between medallion and Uber-like systems. When the market is large (under both positive and negative network externalities), variations in the fleet size are less relevant and the superiority of a medallion system is more stable (i.e. the magnitude of difference between h_i^M and h_i^E is less elastic).

4 Conclusions

Our analysis suggests that the driver pay scheme has implications for riders' welfare through two main mechanisms. The first mechanism is "pecuniary externalities": more hours worked influence the price for a ride, with this effect being positive or negative depending on whether the change in hours worked occurs below or above the turning point of the demand curve (i.e. positive network effects are present or not). The second mechanism is "quality externalities": since the hours worked positively correlate with lower wait-times for riders, a pay scheme induces longer or shorter wait-times depending on network effects and, for a Uber-like pay, the commission fee. The shorter wait-times for Uber riders compared to riders of traditional taxi companies documented for many US cities can be reconciled with our model also by noticing that the number of Uber drivers tends to be much larger than taxi drivers in local markets (Cramer and Krueger, 2016; Angrist *et al.*, 2017).

The key contribution of our study is that in small local markets (such as in small urban areas), where network externalities are positive, the medallion system is unconditionally superior: this points to the fact that service coverage may be more effectively improved by enlarging the fleet size under the medallion system, e.g. by introducing a cap to the cost of the medallion, rather than by incentivizing competing platforms.[11] In large

[11]Related to this, previous literature has showed that competition between ride-sourcing platforms

cities, to the extent that the intensive margin of the service is concerned, regulators should concentrate on more standard instruments favouring traditional companies using medallion lease, such as entry barriers for ride-hailing platforms; in these contexts, the strategic manipulation of the number of medallions may be less effective.

In addition, our analysis introduces an economic rationale for adopting taxi coop friendly regulations in small markets, where "pure" taxi coops paying drivers based on profit-sharing may induce a higher number of hours of service per driver compared to ride-hailing platforms, provided that the commission of ride-hailing platforms is relatively high. Alternatively, regulators may consider constraining the commission fee of ride-hailing platforms to be sufficiently low, by means of a cap. In any case, as we mentioned, "pure" profit sharing may be subject to free-riding (and its possible superiority with respect to Uber-like pay may be weakened) if peer-monitoring is impeded.

Clearly, our analysis is compatible with a market where more platforms are active at the same moment. In this case, the level of h will be a weighted average of the hours worked by drivers under the different work arrangements. Moreover, with non-crucial changes of the model, the comparative results presented here can be generalized to other types of quality improving effort and to other markets where network externalities are non-negligible. Extensions of this model in a dynamic context may possibly include risk bearing and platform competition.

does not necessarily improve social welfare (Zha *et al.*, 2016).

Appendix

A.1. Proof of Proposition 1

As for the first part of Proposition 1, by comparing (4) and (6) and manipulating, it is straightforward to observe that, for any $\varphi > 0$, $h_i^m > h_i^e$ when $p(h_i, h_{L-1}) + p'(h_i, h_{L-1})h_i > 0$. This is verified for any $p'(h_i, h_{L-1}) > 0$ and when $|p(h_i, h_{L-1})| > |p'(h_i, h_{L-1})h_i|$. As for the second part of Proposition 1, we need to compare (4) and (8). We obtain that $h_i^m > h_i^w$ when $p(h_i, h_{L-1}) + p'(h_i, h_{L-1})h_i > p(h_i, h_{L-1})/L + p'(h_i, h_{L-1})h_i$, with $h_i = h$. This always holds if $L > 1$.

A.2. Proof of Proposition 2

Manipulating (10), $\overline{\varphi}$ can be expressed as $1-(1/L)-\delta+(\delta/L)$, with $\delta = [p'(h)h_i]/[p(h)+p'(h)h_i]$. When $h < \overline{h}$, $p'(h) > 0$. Thus, we have that $0 < \delta < 1$. This implies that $1-(1/L)-\delta+(\delta/L) < 1$.

A.3. Proof of Proposition 3

Denote again $[p'(h)h_i]/[p(h)+p'(h)h_i]$ with δ. Then, from $\overline{\varphi} = 1-(1/L)-\delta+(\delta/L)$ it results that $\overline{\varphi} = 1$ when δ is lower than 0 and precisely equal to $1/(1-L)$. $\delta < 0$ when $p'(h) < 0$, that is when $h > \overline{h}$.

A.4. Proof of Proposition 4

As for the first part of Proposition 4, it is sufficient to notice that (11), (12) and (13) do not include $p'(h)$. As for the second part of Proposition 4, we need to compare (11), (12) and (13). With $\varphi > 0$, $h_i^M > h_i^E$. Moreover, $h_i^E > h_i^W$ when $(1-\varphi)p(h) > p(h)/L$, i.e. when $\varphi < (L-1)/L$, with $\lim_{L\to\infty}(L-1)/L = 1$.

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Table 1: Optimal working time in alternative market scenarios.

Small market: $L < \infty$	
$h < \overline{h}$	$h > \overline{h}$
$h_i^m > \underbrace{h_i^w > h_i^e}_{\text{if [1]}}$	$\underbrace{h_i^m > h_i^e}_{\text{if [2]}} \underbrace{> h_i^w}_{\text{if [3]}}$
Large market: $L = \infty$	
$h \lesseqgtr \overline{h}$	
$h_i^M > \underbrace{h_i^E > h_i^W}_{\text{if [4]}}$	

[1]: $\varphi > \overline{\varphi}$
[2]: $|p(h_i, h_{L-1})| > |p'(h_i, h_{L-1})h_i|$
[3]: $\varphi < \overline{\varphi}$
[4]: $\varphi < (L-1)/L \sim 1$

Figure 1: Demand function for hours of service in the P2P transportation sector.

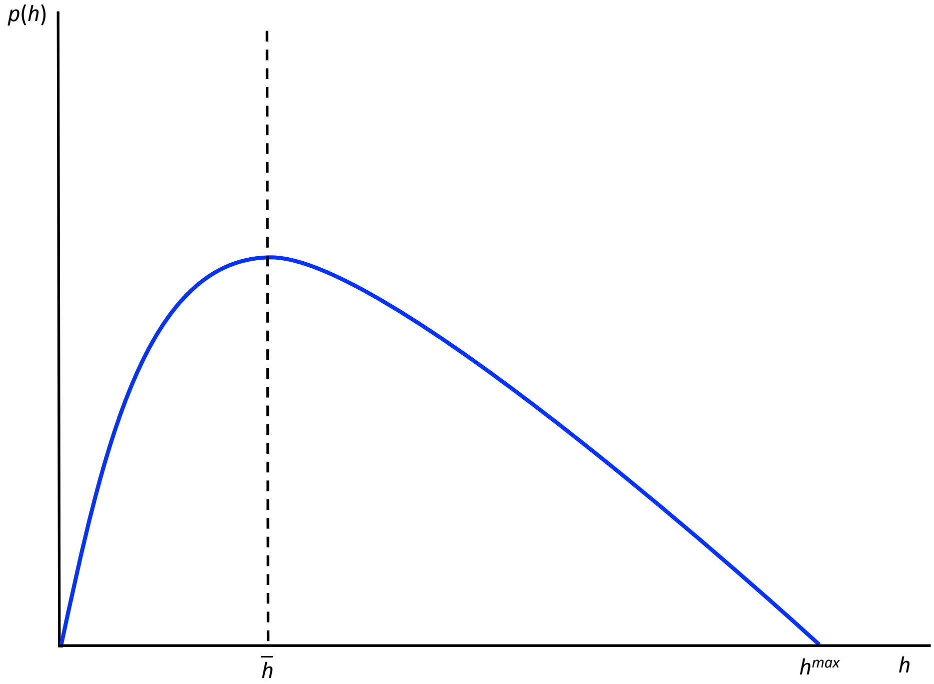

Figure 2: Fee threshold for Uber-like pay inducing more hours worked than profit-sharing.