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Team-based incentives in transportation firms: An experiment☆

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ABSTRACT

Providing the right incentives to bus drivers has become an issue in many cities worldwide. Liberalization experiences and research have shown that high-powered incentives lead to safety hazards, lack of service in low-demand areas, and poor service quality. Fixed-wage schemes, common in tendered systems, are among the leading causes of increased fare evasion, as drivers do not control payment adequately. In a controlled experimental setting, we show that team-based incentives induce levels of effort similar to those provided by an individual pay-for-performance scheme but without undesirable operational decisions. We find that team contracts eliminate the conflict of interest between drivers, causing drivers to control the passengers' payment while maintaining more regular speeds. Consequently, reducing safety hazards and rushing through low-demand stops, avoiding excessive waiting times, and keeping a uniform distribution in the passenger load. These characteristics are absent in the individual contract and are a crucial part of the quality of service.

1. Introduction

There is an extensive literature in economics, management, and operations that shows the importance of considering the effects of employees payment schemes on individual and team performance (see, e.g., Lazear, 1995). Individual pay-for-performance contracts effectively induce high levels of effort and productivity (Mookherjee, 1984; Itoh, 1991; Lazear, 2000). However, by rewarding individual production, the contract discourages cooperation and coordination of efforts among agents, potentially causing unwanted strategic effects (Holmstrom and Milgrom, 1991; Brahm and Poblete, 2018).

The public transportation industry is no exception. Many issues observed in the public transport liberalization experiences worldwide are linked to drivers' output-based incentives. Briones and Gómez-Lobo (2013) provide a detailed review of experiences showing that inefficient frequency decisions, poor quality of service, safety hazards, and violent conflict between drivers are all

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caused by the individual high-power incentives that are natural to competition and low entry barriers. These and other reasons have led many cities to embrace a model of competition “for the market”.

Nevertheless, the problem with individual incentives, or lack thereof, persists, as drivers’ effort is also desirable in tendered services. While desirable from many standpoints, tendering has led to issues with drivers not facing enough incentives to transport passengers and manage fare evasion. To control payment, drivers need to make an effort beyond the one required for driving safely and fulfilling the operational program. As is typical in moral hazard problems, the effort could thus be lower than socially optimal. For example, Bogotá, Boston, London, and Santiago currently rely on effective supply contracts and have been unable to manage fare evasion adequately. The cost of fare evasion has been estimated at £116 million per year in London (Transport for London, 2019), and at US$60 million and more than ten deaths per year in Bogotá (Guzman et al., 2021). The evasion rate in Santiago has been between 20% and 35% since 2013 (DTPM, 2018) and in Boston it has been estimated at 22% (Prokosch and Gartsman, 2017).

This paper studies the performance and system implications of a team-based contract relative to a fixed-wage and an individual scheme experimentally. We are interested in examining which contracts can provide the correct incentives to drivers to control evasion and transport passengers when demand is low while avoiding the safety hazards and poor quality of service inherent to competition in the industry. We develop a controlled experimental setting in which subjects take the role of a public transport bus driver and must play in 10 consecutive periods, presented as subsequent bus stops along a route. The 157 participants were randomly assigned to three different incentive schemes: fixed-wage, individual pay-for-performance, and team-based output. At the beginning of each period, individuals know the distance (in units of time) of the rear and front bus and the state of demand regarding passengers’ arrival rate to the coming bus stop. They must decide the speed at which the bus will travel to the next stop and the level of effort to exert to control passengers’ payment. The effort is costly, but choosing the driving speed is not; however, a low speed may imply a penalty if the rear bus gets too close. A higher effort and a lower speed mean more passengers, as the control is more effective and more passengers accumulate at the bus stop, respectively. Thus, both actions together determine the resulting productivity and quality of service. The experiment participants were all professionals of the transportation sector, and thus the problem’s primary structure and their trade-offs are well understood by them.

Our results for the fixed-wage and the individual contract are entirely in line with the documented evidence reviewed above. Subjects receiving a fixed payment maintained a regular speed profile, implying a regular headway and providing service quality, but spent the lowest amount of time at bus stops. This translates into the lowest amount of paying passengers transported among the three contracts. Those assigned to an individual scheme were paid a constant amount per (paying) passenger transported and, as expected, spent, on average, the highest amount of time controlling passengers. Importantly, subjects’ speed profile in the individual performance contract is highly irregular, exhibiting rear bus sabotaging and low-demand stop skipping patterns, resulting in an uneven headway along the corridor. In other words, these contracts fail to align the planner’s objective of providing an adequate quality and collect revenue.

The team-based scheme subjects were paid proportionally to the paying passengers transported by their bus and those by the rear and front bus. Our main result is that a joint production contract leads to results similar to those obtained under a personal contract in terms of effort and production but significantly different in terms of operational behavior. Drivers under team incentives spent an amount of time at bus stops controlling payment comparable to those under the individual performance scheme, but providing a significantly more regular speed profile and headway. Drivers under the team contract, on average, did not engage in rear-bus sabotaging and did not rush through low-demand stops. Furthermore, the team-based contract is the one that manages to obtain the largest system-wide ridership among the three schemes.[1]

Our results are relevant for several reasons. First, although subjects engage in laboratory tasks, we believe that they matter for real-world experiences. Armantier and Boly (2013) provide evidence that laboratory experiments on corruption have empirical relevance and Cohn and Maréchal (2018) that experimental measures of cheating generalize to rule-violating behavior in naturally occurring environments. More importantly, a recent study by Dai et al. (2018) shows that the diversity of behavior in the laboratory and the field correlate in the context of public bus transportation. Second, our results may have substantial implications for policy. We show that team-based contracts may decrease the level of fare evasion in systems that use effective supply concessions, thus releasing costly public funds. They can also increase service quality and reduce negative externalities such as those associated with accidents and hazard problems, especially in systems designed without a strong monitoring capacity that must rely on strong incentives. Finally, team-based incentives can help public transport firms improve their drivers’ management and potentially reduce monitoring costs.

We deem it important to also discuss the relevance of our findings in the light of the recent technological advances in the public transport industry. For some years now, cities such as Paris, Gothenburg, and Berlin have been studying and piloting the use of autonomous buses (also called self-driving buses). Yet, the technology is still not available for driverless buses to operate in the complex environment of a large and congested city. We believe that our findings are relevant even if the technology is developed in the short run for at least two reasons. As has happened with other technologies such as contactless payment, self-driving buses will take a very long time to reach low-income countries that rely heavily on buses. In addition, the artificial intelligence platform will need to make decisions based on tradeoffs between regularity and passengers transported through real-time choices of speed and time spent at bus stops. Consequently, studying the impact of different individual incentives is relevant for developing algorithms.

Our analysis has to be qualified according to our experimental assumptions. First, we assume that drivers do not have a long-term strategy based on expected demand patterns. We believe that this is representative of bus systems with frequencies that are not too

[1] To compute a system-wide ridership, we aggregate, for each subject, the passengers transported by the rear and front bus. We then aggregate over contracts.

low. While the drivers can know the overall demand pattern, the actual demand at a bus stop depends more on the time elapsed since the last bus left the stop. Second, participants are always informed about the distance of the following bus. As drivers are aware of a general demand pattern, they could infer, in broad terms, whether the next bus is far or not. In addition, when such inference is not feasible, drivers may implement a more straightforward system that provides additional information. In fact, before 2007 in Santiago, the drivers under individual high-powered incentives created their control system using observers stationed at strategic intersections who kept track of passing buses and informed drivers on the time intervals separating them (Muñoz and Gschwender, 2008). This practice suggests that our assumption is reasonable even without sophisticated technology in place. Finally, as our experiment does not capture traffic congestion, results better represent services that operate primarily on dedicated infrastructure such as corridors and bus lanes than those under mixed traffic.[2]

Our paper also contributes to a growing literature on experiments and incentives in the transportation sector to improve service quality and decrease car usage. There are studies on the effects of randomizing full fare rebates in public transportation (Yang and Long Lim, 2018; Bull et al., 2021), and lottery tickets for paying the bus fare (Fabbri et al., 2019). Finally, we contribute to the literature studying incentive provision to transit operators and ridership (Mouwen and van Ommeren, 2016; Vigren and Pyddoke, 2020). We also add to the literature that studies performance incentives and their interrelation with objectives beyond productivity, such as innovation (Ederer and Manso, 2013; Manso, 2017), and creativity (Azoulay et al., 2011; Charness and Grieco, 2019), among others.

The paper is organized as follows. Section 2 describes the experimental design and the hypotheses to be tested. Section 3 shows the results regarding operational decision-making, while Section 4 discusses the system-wide results. Finally, Section 5 concludes.

2. Literature review

2.1. Incentives

Since the seminal paper by Holmström (1982) on moral hazard in teams, several studies have presented game theoretical models that describe the situations under which team-based incentives are efficient when compared to an individual agency. For example, previous studies have shown that team-based incentives are useful when there is a correlation between team members' tasks, as they induce cooperation and coordination of efforts among agents, maximizing team utility (Rasmusen, 1987; Itoh, 1991, 1992; McAfee and McMillan, 1991; Legros and Matthews, 1993; Macho-Stadler and Pérez-Castrillo, 1993; Che and Yoo, 2001). Also related to this paper, other game theoretical models study the conditions under which Profit sharing among team members is efficient because of their interaction with customers or clients. See, for example, Levin and Tadelis (2005) and Poblete (2015).

However, recent empirical evidence has shown mixed results for team-based incentives, highlighting the heterogeneity of their effect across firms, sectors, and technology of production. For example, Boning et al. (2007) provide evidence that team incentives raise productivity only in complex environments, and Blimpo (2014) that they have a similar impact as individual incentives in school students. Burgess et al. (2010) show that strategic reallocation of efficient workers to team contracts may drive the positive effect of such a scheme, and Burgess et al. (2017) that while team contracts, on average, do not have a significant effect, they may have a substantial positive effect in small teams.

2.2. Incentives for public transportation drivers

To the best of our knowledge, there is no experimental evidence about the effect of different incentive schemes on bus drivers' performance and quality provided. Instead, we review a few articles covering case studies or before-after comparison of contract implementation. In general, the studied outcomes are simple and do not draw detailed conclusions like ours.

Hartman (1994) surveys the use of employee incentive programs to enhance performance by mail to over 50 public transit organizations in North America. One of the main conclusions is that the results of incentive programs are not widely available, although some transit systems can show that real performance improvements have occurred (Hartman, 1994).[3]

Beaudry et al. (2006) attempted to estimate the effects of financial incentives on driver performance using a pre-post comparison design. The aim was to improve driver performance in attendance, at-fault accident rates, and valid customer complaints. Drivers were awarded an additional twenty-five cents per hour worked if they met the eligibility requirement of the incentive program by not incurring any written discipline in their employee file during the pertaining quarter. However, the minimal number of events before and after did not allow for estimating changes in accidents and complaints. However, Beaudry et al. (2006) did find that the incentives increased absenteeism, which they attribute to seasonality effects as the post-period included most of the summer and Christmas (July 1 to December 31).

Johnson et al. (2015) study the performance of a fixed-wage versus per-passenger payment to bus drivers in Santiago in 2004. The article exploits the introduction of fixed-wage routes by the government and the period in which both schemes coexisted. By collecting data at bus stops and using administrative accident data, they show that the per-passenger system leads to shorter

[2] Bus lanes, busways, and other types of dedicated infrastructure are important as they provide large benefits that can accrue to passengers and operators simultaneously and are increasingly used around the world (see, e.g., Basso and Silva, 2014; Basso et al., 2019; Russo et al., 2022).

[3] National Academies of Sciences, Engineering, and Medicine (2012) discusses nine case studies that offer insight on active and innovative practices and related issues on the use of reward and discipline programs to promote and improve bus transit safety.

Table 1
Examples of high-powered incentives.

Place	Detail	Reference
Nairobi, Kenia	Daily cash target payment to vehicle's owner	Behrens et al. (2017)
Hong-Kong	Red Minibuses (RMB). The vehicle is leased to the driver by the shift. The driver becomes the residual claimant.	Rusco and Walls (2004)
Philippines	Jeepneys. The driver rents the vehicle per day and becomes the residual claimant.	Rusco and Walls (2004)
Dar es Salaam, Tanzania	The bus drivers operate under a sort of daily franchise. The driver becomes the residual claimant.	Rizzo (2011)

passenger wait times and significantly more accidents per kilometer driven via more aggressive driving. The result fully aligns with the theory and is one of the hypotheses that we test.

Interestingly, after the entire system was changed in Santiago in 2007, the drivers' contracts changed as well. The entire bus operation was tendered to 14 companies whose payment that mainly depended on the programmed number of bus-kilometer (veh-km). To minimize the risk, the impact of the number of passengers transported on the total revenue was very small (Muñoz and Gschwender, 2008). As a consequence, the drivers' conditions changed to a fixed-wage scheme with legal shift lengths and proper contracts. The drivers no longer needed to compete and drive aggressively, which resulted in a significant drop in accidents. Moreover, students stopped being discriminated against, and assaults on drivers became a thing of the past (Muñoz and Gschwender, 2008; Muñoz et al., 2016).

Another study that is close to ours is Wu et al. (2019). They collected survey data from bus drivers and exploited that the contracts vary in work hours and financial incentives between companies, based on the different regulations. The three categories studied are: type A: ≥14 h worked/day, ≥6 round trips/day, and >70% of salary based on performance; type B: 8–13 h/day, 4 or 5 round trips/day, and 36%–70% of salary; and type C: <36% of salary and no other specified requirements. The main result is that crash rates were significantly higher in drivers under type A contracts than under type C. In line with our motivation, the conclusion is that drivers who work long hours and obtain salaries based on job performance are associated with elevated bus-related crash risks. However, it is impossible to disentangle whether the cause is the excessive work hours or the incentives scheme.

To conclude the review, we provide in Table 1 a set of examples where high-powered incentives are or have been used and have caused poor quality of service and safety hazards. For a more detailed discussion on existing incentives and reforms we refer the reader to Htun et al. (2012).

3. Experimental design

We establish an environment in which we can measure the effects of different incentive schemes on operational decision-making of agents in a public bus transportation context. For this purpose we conduct an experiment in which participants have to make decisions considering a trade-off between effort and individual production.

We implement the following incentive schemes that differ only in the way subjects are compensated:

1. Fixed-wage
2. Individual pay-for-performance (Individual P-f-P)
3. Team based pay-for-performance (Team P-f-P)

Subjects were randomly assigned to the different contracts, resulting in 52, 52, and 53 subjects in each of these three incentive schemes, respectively. There are no significant ex post differences in age, gender or educational level.

3.1. Procedures and subject pool

The experiments were programmed and conducted with the software z-Tree (Fischbacher, 2007) and z-Leaf via Zoom meetings, considering the sanitary measures resulting from the COVID-19 pandemic. Participants correspond to undergraduate and graduate transport engineering students, as well as professionals dedicated to the field of public bus transportation. The choice of this group is crucial for the experiment: Previous research shows that using a sample of professional or economically experienced subjects generates behaviors closer to rational equilibrium, giving external validity to the experiment results (Palacios-Huerta, 2003). Also, Harrison and List (2008) show that experience and role familiarity are key for the relevance of experimental findings from laboratory settings. We detail the expected behavior of a rational agent for each of the contract types in Section 3.5.

Recruitment was done online, through course platforms, postgraduate research groups and email lists of people linked to transportation. The invitation was open and voluntary. A total of 157 subjects participated in our experiment, each one assigned to a particular payment scheme.

A session lasted, on average, 20 min and to induce rational decisions by participants that maximize their expected utility, a prize of US$ 70 was given to the participant who obtained the highest amount of profit for each type of contract.

3.2. Task description

Subjects take the role of a public transport bus driver. Each participant knows his compensation scheme in advance and both the experimental sessions and the decisions made by the participants are individual, and do not influence the behavior of other subjects in the experiment.

The experiment lasts 10 periods, which can be interpreted as driving along a bus corridor where each stop is a period. Each period considers the situation in which the participant has just left a bus stop, so they must drive along a segment of the corridor and stop at the subsequent bus stop.

The subjects must make two operational decisions: the speed at which the bus will travel to the next stop and the level of effort made at the bus stop to attract and control the payment of more passengers. The effort is a discrete variable that can take five possible values, from zero to maximum effort. The speed is an integer variable that can take values between 20 km/h and 40 km/h. As participants choose the speed and, in reality, traffic congestion limits the ability of drivers to set it, our analysis and results are more representative of services that operate primarily on dedicated infrastructure such as corridors and bus lanes than those under mixed traffic.

Before making their decisions, agents have the following information regarding the state of their environment:

- Time interval in minutes between subject's bus and the front bus
- Time interval in minutes between subject's bus and the rear bus
- Next bus stop passenger arrival rate: very low, low, medium, high or very high.

To replicate typical operational constraints on bus operations, drivers must pay a penalty if the time intervals with respect to adjacent buses fall below the required minimum of 5 min. The penalty is proportional to the square of the difference between the current distance and the minimum distance. This makes the earnings obtained by the participants at the end of each period to directly depend on the distance between buses.

Following Basso and Silva (2014), we assume that per-passenger boarding takes more time than per-passenger alighting, so that we do not need to model the alighting process for computing the time spent at the bus stop. We further assume that the bus' capacity is enough to transport the maximum number of passengers that a bus may face, given the arrival rate patterns and the behavior of the other buses.

At the end of each period, the subjects observe the number of passengers controlled by them, by the adjacent buses and the respective personal earnings. In the next period, the time intervals respect to adjacent buses are updated, based on the decisions made in the previous period, and the level of demand for the new next bus stop is displayed.

Note that even though the state of demand (very-low, low, medium, high, and very-high) for each period is defined ex-ante, each player only knows the state of demand for the next period before making decisions. The actual demand depends on the strategic decisions such as speed and effort, together with the arrival rate.

Although the agents have useful information regarding their environment in all periods, participants are not certain about the decisions made by the adjacent buses. A subject can only see the performance of the adjacent buses through their result, like the principal, which corresponds to the number of passengers transported in each period. The subject is not able to disaggregate or identify the level of effort exerted by them.

3.3. Decision variables and relevant tradeoffs

The variables of the experiment seek to replicate the context in which bus drivers make their operational decisions over time.

3.3.1. Speed

The speed chosen for a segment influences the headway between the subject's bus and adjacent buses. When a higher speed is chosen, the front headway decreases while the rear headway is increased. On the other hand, a lower speed increases the front headway and decreases the rear headway.

The speed also affects the number of users that accumulate at a bus stop. A lower speed implies that more passengers accumulate at the next bus stop, increasing the potential output for the agent, while fewer passengers will accumulate for the rear bus, sabotaging its performance. Choosing a high speed may not seem profitable at first sight because it decreases output, but it increases the distance to the rear bus, which may save a penalty or allow for decreasing the speed in a more profitable state of demand later on.

The speed profile chosen by participants not only affects their individual production, but also affects the performance of adjacent buses. This action, which is strategic, does not constitute a personal effort or cost for the driver. However, as the demand patterns are not known, there might be an incentive to drive relatively fast at early sections with low demand, to accumulate some reserve in headway for busier line sections.

Table 2
Parameters values for payment rate and variable dwell time for all effort levels (unknown to the subjects).

Effort level	Payment rate	Variable time per passenger
No effort	60.0%	0 s
Effort level 1	72.5%	2 s
Effort level 2	80.0%	5 s
Effort level 3	87.5%	9 s
Effort level 4	95.0%	14 s

3.3.2. Effort

Exerting effort to attract passengers is an expensive activity for public transport drivers, in terms of personal energy and time (Tiznado et al., 2014). With higher effort, the driver's energy decreases and she must spend more time at the bus stop.

The effort is decided together with the speed at the beginning of the period and it influences the proportion of users whose fare payment will be controlled when boarding the bus. If no effort is made, the time spent at the stop (dwell time) is constant regardless of the demand level, and only a 60% of the passengers at the bus stop pay and are counted as transported. The other four levels of effort induce higher rates of payment and take longer dwell times per passenger (up to 95% and 14 s for the maximum effort level); the details, not known to participants, are in Table 2:

To reflect the direct cost of effort, each participant begins the experiment with an energy level of 100%, which decreases proportionally with the time dedicated to control passengers in each period. At the end of the experiment, subjects receive a bonus of $12 per percentage point of residual energy.[4]

3.4. Contracts and proposed team-based setting

The structure of fixed-wage contracts and individual pay-for-performance are simple, since they are constant and based on individual performance, respectively. On the other hand, team-based settings must be previously defined and understood by individuals, as their structure determines the behavior of team members.

The team is defined as the bus operated by the subject and the rear and front bus. Their behavior, unknown to the subject, is programmed to be a constant speed of 27.5 km/h and a medium level of effort based on Cubillos González (2018).[5] The payment per period corresponds to the sum of the individual production of each of the team members, multiplied by a joint production parameter, P_G.

The three contracts are as follows:

1. Fixed-wage. "You will be paid a fixed amount of $230 per period".
2. Individual pay-for-performance. "You will be paid $35 per each passenger that you manage to transport individually per period".
3. Team based with joint pay-for-performance. "You will be paid $15 per each passenger that you, as a team, manage to transport per period".

3.5. Testable hypotheses

Fixed-wage scheme. Subjects choose a null effort strategy, as they do not benefit from increasing the number of passengers carried and lose their personal energy. In terms of speed, they tend to maintain regular intervals so as not to incur minimum distance penalties.

Individual contract. Subjects under the individual pay-for-performance scheme exert high levels of controlling effort to maximize their income. They also choose an extreme speed profile strategy; that is, agents are more likely to decide lower speeds and exert higher levels of effort on high demand bus stops, as a greater number of passengers will accumulate. This behavior generates negative consequences for a transportation system, such as higher waiting times, sabotaging between buses and bus-bunching. Speed profiles are extreme and variable, which can translate into road safety problems.

Team-based setting. Subjects under the joint production contract do not increase their profit by sabotaging their teammates performance, so they maintain regular time intervals with respect to adjacent buses. In terms of effort, a proportion of the sample act as a free-rider, exerting low or null efforts. The rest, chooses a high level of effort to increase the profits of the team at the cost of personal energy. A key empirical question here is how large the free-rider problem is relative to the benefits of coordination.

While it may seem straightforward to predict the agents' best response under each contract, it is crucial to address the problem from an experimental approach. Individuals' preferences, risk aversion, and the degree of altruism are key in determining the optimal response. These attributes strongly vary across individuals due to education and cultural differences that are not observable. Moreover, there are many situations where the individuals' behavior is not entirely rational, which, together with other common behavioral issues, makes the experimental approach relevant.

[4] These set of assumptions make the cost to be strictly convex.

[5] We considered using teams of three or more individuals, potentially communicating in real-time. Still, due to COVID restrictions and uncertainty about how the pandemic would evolve, we decided to use programmed team members.

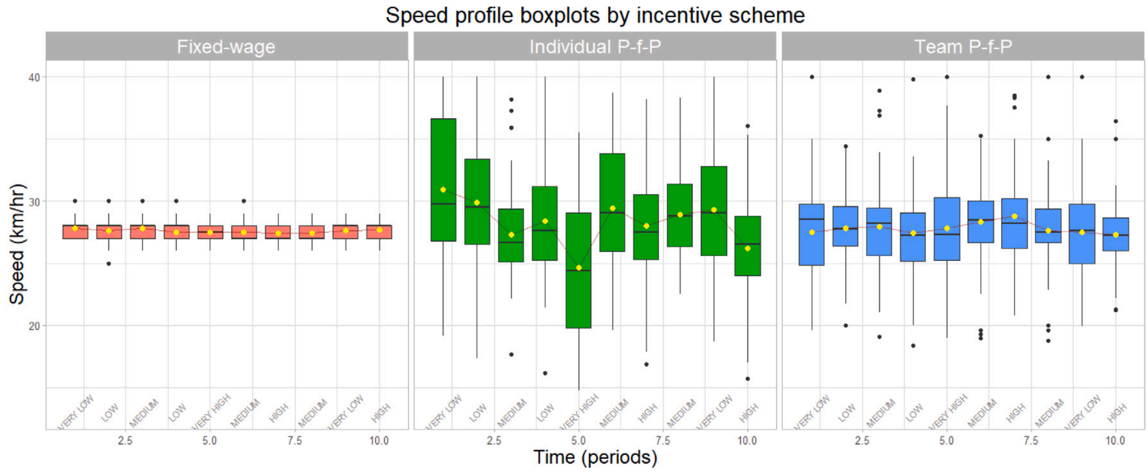

Fig. 1. Speed profile, given by speed decisions over time for the Fixed-wage, Individual Pay-for-Performance and Team based Pay-for-Performance. Horizontal black bars represent medians, yellow dots represents means, and black dots are outliers. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4. Results: Operational decision-making

In each period, before making their decisions, the agents know the time intervals with respect to adjacent buses, but not the actions of others, and the demand (arrival rate) of the coming bus stop. Demand, temporal distances, and the decision of speed and effort will directly impact the passengers transported by the individual and the adjacent buses' performance. We detail the agents' decisions in this Section and discuss the system's policy implications in Section 5.

4.1. Speed

In the experiment, participants could choose integer speeds between 20 km/h and 40 km/h. Fig. 1 illustrates the speed decisions made by agents over time together with the state of demand, by type of contract using boxplots, to observe the dispersion, mean and outliers.

There are significant differences for most periods. The fixed-wage contract, as predicted, induces a fairly constant speed. Indeed, the average speed was 27.6 km/h, and the standard deviation 0.69 km/h. This is remarkably similar to the programmed speed of the rear and front bus (27.5 km/h). The individual payment scheme results in a highly irregular speed profile, with a mean of 28.3 km/h but with a standard deviation of 4.9 km/h. The team-based contract achieves a speed profile similar to the fixed-wage payment, with an average of 27.8 km/h, but with significantly more variability (standard deviation of 3.7 km/h).

By adopting a low speed in a high demand period, it takes longer for the bus to reach the stop to accumulate more passengers waiting at the stop. This strategy is observed in the individual contract and is most noticeable in the "very high" demand state (period 5). There is also a tendency of adopting high speeds for very low arrival rates, which allows for distancing from the rear bus to have more room to lower speed in future high demand periods. As there is a penalty if buses get too close to each other, it is profitable in expected terms to leave room for slowing down in the coming periods. These two effects cause subjects to have an extreme and time-varying speed profile, as seen in Fig. 1.

On the other hand, subjects under the team setting get rewarded for the team's joint production, so slowing down to allow more passengers to arrive at the bus stop does not pay off. For this reason, speeds adopted by the participants with this type of contract are, in general, close to 28 km/h, without the large variances observed in the individual pay-for-performance scheme. This behavior generates the speed profile that is relatively stable over time, as seen in Fig. 1, which is a desirable attribute for a public bus transportation system.

For each period, we test whether the average speed induced by the team contract is significantly different to the others. The p-values of the test are in Table 3. The null hypothesis of equal means between the fixed-wage and the team-based scheme cannot be rejected in nine out of ten periods at the 5% level (p-value > 0.05) and in eight out of ten using 10%. This is evidence of the similarity of the operational decision between the two schemes. On the other hand, for the comparison with the individual contract, p-values are smaller and the differences are significant in three and five periods for a 5% and 10% level.

Table 3 shows the summary statistics of the speed choice by period, for the three different contracts. The Table also displays the p-values for a test of means between the team-based and the other two contracts.

Table 3
Speed statistics by period for the individual and the team-based Pay-for-Performance contracts.

General info.		Fixed-wage		Individual		Team		p-values	
Period	Demand	Average	SD	Average	SD	Average	SD	F = T	I = T
1	Very Low	27.79	0.57	30.89	6.26	27.51	4.09	0.626	0.001
2	Low	27.63	0.86	29.91	5.45	27.81	2.94	0.685	0.015
3	Medium	27.81	0.74	27.33	3.82	27.98	3.58	0.737	0.371
4	Low	27.50	0.83	28.42	4.69	27.42	3.44	0.879	0.219
5	Very high	27.50	0.64	24.66	5.59	27.81	4.57	0.627	0.002
6	Medium	27.50	0.70	29.42	4.72	28.33	3.50	0.097	0.181
7	High	27.44	0.61	28.00	4.74	28.80	3.94	0.016	0.350
8	Medium	27.46	0.67	28.94	3.61	27.62	3.43	0.740	0.058
9	Very low	27.60	0.63	29.27	5.64	27.48	4.32	0.844	0.069
10	High	27.69	0.73	26.20	4.10	27.30	3.25	0.404	0.127
Total		27.59	0.69	28.30	4.85	27.81	3.71		

Table 4
Estimates from a Linear Regression for Speed.

Intercept	38.124***
	(0.590)
Individual P-f-P	−2.117***
	(0.399)
Team P-f-P	0.535
	(0.366)
High demand	−0.022
	(0.367)
Low demand	−0.009
	(0.344)
Individual x High demand	−1.934***
	(0.520)
Team x High demand	−0.137
	(0.517)
Individual x Low demand	1.443***
	(0.486)
Team x Low demand	−0.262
	(0.484)
Rear Distance	−1.055***
	(0.053)
R^2	0.245
N	1,570

Notes: Robust standard errors are reported in parentheses. *p < 0.1, **p< 0.05, ***p < 0.01.

While the test of unconditional means is useful, it does not allow for isolating the effects of the payment scheme, the level of demand, and the distance with respect to adjacent buses on the speed decision. To study these effects, we estimate the following regression:

$$\begin{aligned} Speed = \beta_0 + \beta_{IND} * X_{IND} + \beta_{TEA} * X_{TEA} + \beta_{DLO} * X_{DLO} + \beta_{DHI} * X_{DHI} + \beta_{IND-DLO} * X_{IND-DLO} \\ + \beta_{TEA-DLO} * X_{TEA-DLO} + \beta_{IND-DHI} * X_{IND-DHI} + \beta_{TEA-DHI} * X_{TEA-DHI} + \beta_{dist} * distance \end{aligned} \tag{1}$$

Payment schemes are included through dummy variables, as is the demand level for the bus stop. β_{IND} and β_{TEA} correspond to the coefficients for the dummy variables that take the value 1 when the subject is under the Individual P-f-P contract or the Team P-f-P payment scheme, respectively. β_{DLO} and β_{DHI} are the coefficients of the dummy variables that take the value 1 when the subject is facing a low demand and a high demand bus stop, respectively. In addition, β_{dist} represents the effect of the distance from the rear bus at the time of choosing the speed. The reference level corresponds to the fixed-wage contract and the medium demand level. Demand levels high and very high, and low and very low are grouped for ease of interpretation.[6] Also, cross-effects are considered by including the interaction between the type of contract and demand level.

Table 4 summarizes the results of the estimation of the regression. The results highlight the strong effect that the individual pay-for-performance contract has on the choice of speed, with respect to the fixed-wage scheme (coefficient −2.117, significant at the 1% level). They also confirm that the team-based contract's speed is similar to the one observed in the fixed-wage scheme (coefficient 0.535 not significantly different from zero).

[6] The estimation without grouping demand levels delivers disaggregated coefficients that are statistically the same between high and very high and low and very low.

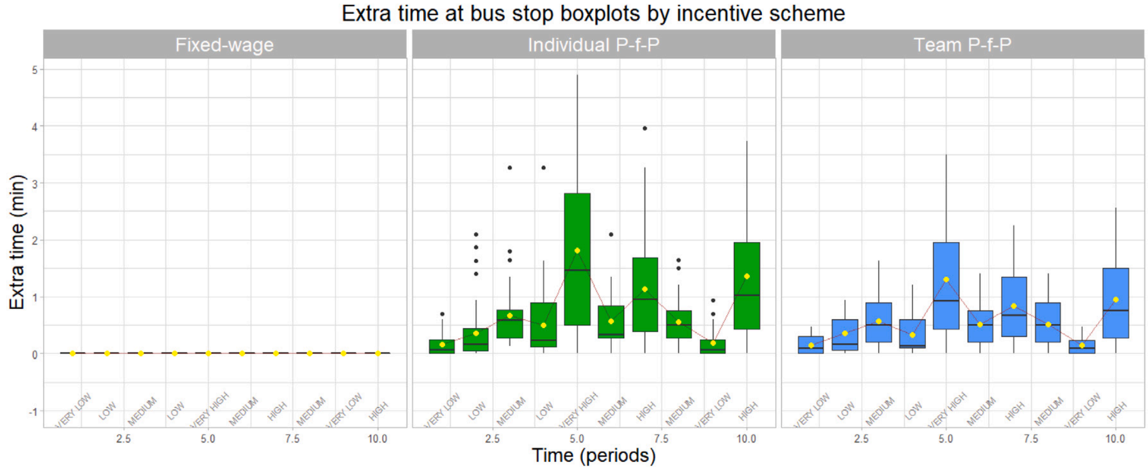

Fig. 2. Extra time dedicated to controlling passengers at bus stops in terms of boxplots, given by effort decisions over time for the Fixed-wage, Individual Pay-for-Performance and Team based Pay-for-Performance. Horizontal black bars represent medians while yellow dots represents means for each period. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The interaction terms show that, relative to those under fixed-wage, subjects under the individual pay-for-performance contract decrease their speed by 1.9 km/h when facing a high-demand bus stop and increase their speed by 1.4 km/h when facing a low-demand stop. Subjects under the group setting do not react differently according to the next bus stop's demand level, as the coefficients are small and not statistically different from zero.

Finally, the information about the distance to the rear bus has a substantial impact on the subject's speed decision. On average, a unit increase in rear distance translates into a decrease of 1.1 km/h. This makes sense for both types of contracts; when the rear bus is further away, reducing the speed allows for transporting more passengers (without sabotaging).

4.2. Effort

The second operational decision that subjects must make is how much extra time to dedicate to control the payment of each user present at the bus stop. Fig. 2 illustrates the effort decision, as the total extra time at bus stops, over time, and by contract type.

Naturally, the subjects under a fixed-wage scheme do not exert any effort in the experiment, so they spend zero additional seconds per passenger. Agents under the team-based contract exert similar levels of effort as those in the individual pay-for-performance scheme. The average additional time per stop was 35 and 44 s, for the team-based and individual contract, respectively. Both show significant variability, and more so in the high demand states.

The dispersion in the responses can be explained through the different profitable strategies. An agent under the team scheme can increase the team's joint production, the number of passengers transported by incurring costs, something especially profitable in high demand states. On the other hand, a subject may decide to exert a low or null effort, acting as a free-rider. Both strategies, clearly opposite, are profitable and cause the dispersion in the responses. Previous studies have highlighted that team-based incentives' performance is mostly an empirical question due to the tradeoffs described and the possibility of free-riding. We provide evidence that this may not be a big concern in the case of public transportation.

The individual pay-for-performance contract also presents dispersion in its responses. Although high levels of effort are expected for subjects under this arrangement, since their salary depends solely on their production, there is no clear-cut trend on when to make these efforts. A driver benefits by making high efforts to control passengers in high demand periods because more users are waiting at the bus stop. This action brings high costs but receives greater rewards. However, Fig. 2 reveals that it is the state with the highest dispersion in responses. The intuition comes from the interrelation with the speed decisions in past periods and other buses' behavior. If the state of demand is high, but the rear bus is close, an increased effort is more likely to result in the rear bus getting closer than the threshold that triggers a penalty. As the penalty is convex in the distance, a lower effort is expected in this case.

While the similarity is evident from Fig. 2, we show the results of a Kolmogorov–Smirnov (K–S) test of equality of the distribution function of the time spent at each bus stop, for the individual and team scheme, for each period (see Table 5). The tests show that for the vast majority of the cases (eight out of ten), there is no statistical evidence to argue that the distribution functions for the team-based contract's effort decisions are different from those of the individual scheme. This confirms that, in general, effort levels adopted under the team-based agreement are similar to those chosen under the personal scheme.

Table 5
K–S test using a significance level of $\alpha = 0.05$, comparing decision-making on effort through extra time at bus stops for the Individual Pay-for-Performance and the Team based Pay-for-Performance.

Period	Demand	D	p-value	Conclusion
1	Very low	0.163	0.489	Cannot reject
2	Low	0.204	0.223	Cannot reject
3	Medium	0.198	0.256	Cannot reject
4	Low	0.201	0.239	Cannot reject
5	Very high	0.234	0.114	Cannot reject
6	Medium	0.244	0.087	Cannot reject
7	High	0.276	0.036	Rejects
8	Medium	0.243	0.091	Cannot reject
9	Very low	0.136	0.716	Cannot reject
10	High	0.272	0.041	Rejects

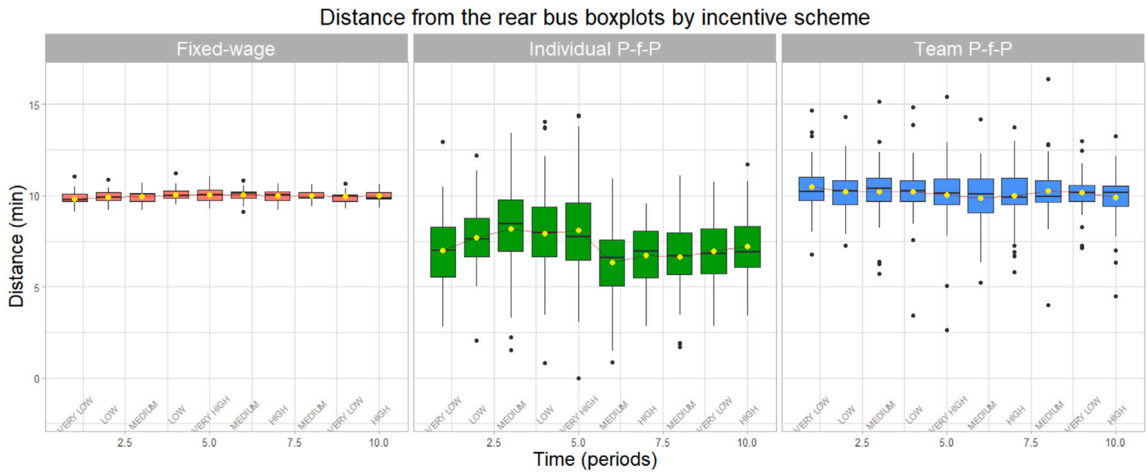

Fig. 3. Distance from the rear bus in terms of boxplots, given by operational decisions over time for the Fixed-wage, Individual Pay-for-Performance and Team based Pay-for-Performance. Horizontal black bars represent medians while yellow dots represents means for each period. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

5. Implications for the system

We now turn to analyze the implications of the agents' decision-making on the performance and operation of the transportation system as a whole.

5.1. Distance to the rear bus

By maintaining the distance center from adjacent buses, regular time intervals are generated between buses. This is a highly desirable characteristic in a public bus transportation system since there will be less variance in passengers' waiting time. As the rear and front buses drive at the same constant speed, it is sufficient to analyze the distance to one of them. We illustrate our results based on the distance from the rear bus, but an analogous set of results can be obtained by studying the distance to the front bus.

The distance from the rear bus is affected by the agent's speed and effort level. If the subject decides a relatively low-speed with respect to the adjacent buses, the period will end (and the next one will begin) with a shorter distance from the rear bus. If the agent decides to make a high level of effort to control passengers, the bus will have to remain a longer time at the bus stop, so the distance from the rear bus will decrease.

Fig. 3 illustrates the resulting distance from the rear bus in each period, aggregated by contract type. Individuals under the fixed-wage do not exert effort to attract passengers and only care about keeping its distance interval far from possible penalties. Fig. 3 shows that they stay at the center of adjacent buses, which is reached at a distance of 10 min.

Subjects under an individual pay-for-performance contract do not coordinate and end up sabotaging the rear bus. This behavior involves adopting high speeds when facing a low-demand bus stop to obtain a slack distance to the rear bus. When the period's demand is high, they decide lower speeds to increase the number of passengers accumulated at the bus stop. Fig. 3 shows the results of variable effort combined with the irregular speed profile detailed in Section 4. The average distance for these individuals was 7 min. High-speed decisions in low demand periods translate into a higher distance from the rear bus in the next. In turn, when agents face high demand bus stops, as in periods 5 and 7, their lower speeds translate into an average decrease in their distance from the rear bus of 1.76 min.

Finally, subjects under the team-based contract present a relatively constant distance from the rear bus over time that is, on average, very similar to the fixed-wage scheme. Indeed, the average distance from the rear bus was 10.14 min. The main difference with respect to the result for the fixed wage is that the variance is significantly larger. As individuals in the team exert effort to control payment, they spend more time at bus stops, making it more challenging to maintain a regular interval.

5.2. Total passengers transported by the system

The agents' decision-making under each payment scheme influences the performance and operation of the transportation system. To compute the system ridership, we aggregate each subject's passengers with those of the rear and front bus and then sum over the stops. The results show that the team-based contract is the one that manages to obtain the largest bus ridership among the three schemes, with an average of 191 passengers. It is closely followed by the individual pay-for-performance system (190 passengers on average) with the fixed-wage transporting the least amount of passengers (182 passengers). The result that the fixed-wage performs worse in terms of output than the variable contracts is not surprising, as drivers do not make any effort. One of the most important results of our experiment is that the team-based contract makes the system transport more passengers than the individual contract. The larger ridership is a direct consequence of the team-based scheme inducing drivers to exert effort without sabotaging others. The result has parallel with general properties of game theoretical models discussed in Section 2.

In summary, there is no significant difference in the total number of passengers transported by the individual and team-based contracts. The group payment setting can induce efforts to attract passengers at a similar level as the individual payment scheme. The strategies generated by implementing a team-based agreement encourage coordination that benefits the system as a whole in terms of passengers transported.

6. Discussion and conclusions

Bus drivers' contracts based on fixed-wage and individual performance have been problematic for different reasons. Without incentives, bus drivers do not care about the output, especially about controlling fare evasion, which is an issue in developed and developing countries (see, for example, Guzman et al., 2021). High-powered incentives, on the contrary, have been challenging due to safety hazards, low quality of service, and drivers not providing service in low-demand areas (Briones and Gómez-Lobo, 2013).

This paper has compared these two contracts' performance with a team-based scheme through a controlled experiment. We find that subjects under a group contract setting can generate production levels similar to the individual pay-for-performance system but with different operational decisions, avoiding the undesired behavior exhibited by the subjects in the other contracts.

In particular, we observe non-uniform passenger load profiles, irregular time intervals between buses, and extreme speed profiles along the corridor in the individual scheme. However, the team-based contract induces decisions that lead to a uniform speed profile, enabling drivers to maintain regular time intervals to the adjacent buses. Thus, the group-based scheme generates regularity between buses and constant passenger load profiles while avoiding sabotaging other buses.

The main disadvantage of the team-based payment setting is the appearance of free-riders. A proportion of participants did decide to exert low or null efforts to attract passengers, obtaining lower effort costs. Nevertheless, on average, the system ridership, a direct consequence of effort decisions, is higher in the team-based scheme. The results suggest that the cost imposed by free-riding behavior is low compared to the benefits of coordination, and thus it may not be a substantial concern in the context of bus driving.

Therefore, from a normative perspective, our experiment and results suggest that a team-based payment scheme for bus drivers can get the best of the two contracts commonly used and avoid the problematic behavior they may produce. By rewarding the joint production of buses that would otherwise compete for passengers, the contract aligns the drivers' incentives to transport and control passengers' payments without competing and engaging in dangerous behavior.

More generally, our experiment shows that in complex tasks involving the need to exert effort and multitasking and coordination issues, such as public bus transportation, team-based incentive schemes perform better than other types of contracts.

A natural avenue for future research is to extend the framework and use teams of three or more individuals, potentially communicating in real-time. This would allow for studying the impact for different team sizes, among other interesting questions.

The framework and methods proposed in this paper can also help study other payment schemes or problems associated with a public bus transportation system. For example, how do agents choose their operational decisions with a mixed payment scheme? How does the system perform if a minimum threshold of individual production is considered in a team payment scheme? What would happen if the payment per transported passenger is dynamic over time, considering the past activity observed by the principal? How to incorporate passengers' complaints into the incentive scheme? We leave these questions for future research.

We also leave for future research to study the sensitivity of the results with respect to some key parameters such as the value of effort, the penalty for bunching, and the payment per passenger. We expect that a higher value of effort leads to less payment control and consequently more bunching as the sabotage strategy becomes relatively more attractive. A similar outcome would appear with a lower penalty for bunching as drivers exacerbate the irregular speed behavior.

Nevertheless, the most relevant avenue of future research is to take the experiment to the field.

CRediT authorship contribution statement

Vicente Ramírez: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – original draft, Investigation, Data curation, Visualization. **Patricia Galilea:** Conceptualization, Methodology, Validation, Investigation, Resources, Supervision, Project administration, Funding acquisition. **Joaquín Poblete:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Supervision, Project administration, Funding acquisition. **Hugo E. Silva:** Methodology, Validation, Formal analysis, Writing – original draft, Writing – review & editing.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.tra.2022.07.012.

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