"The War for the Fare":

How Driver Compensation Affects Bus System Performance

Ryan M. Johnson, David H. Reiley, and Juan Carlos Muñoz [1]

First version: January 2005
This version: March 2014

Abstract

Prior to 2007, two systems of bus driver compensation coexisted in Santiago, Chile: one paid drivers per passenger transported, while the other paid a fixed wage. Per-passenger drivers engaged in "The War for the Fare," altering their driving patterns to compete for passengers. Examining these systems on similar routes in Santiago, we reach two key findings. Compared with the fixed-wage system, the per-passenger system leads to (1) 13% shorter passenger wait times, via reduced bunching of buses, and (2) 67% more accidents per kilometer driven, via more aggressive driving. We discuss implications for the design of incentives in public transit.

Keywords: bus bunching, mass transportation, employee incentives, passenger welfare

---

[1] Johnson: Harvard Business School, <RyanMJohnson@gmail.com>. Reiley: Google, Inc., <david@davidreiley.com>. Muñoz: Department of Transportation Engineering, Pontificia Universidad Católica de Chile (Santiago, Chile), <jcm@ing.puc.cl>. Johnson acknowledges the United Nations Economic Commission for Latin America and the Caribbean and Ian Thomson for an internship enabling him to work on this project. He also acknowledges funding from the University of Arizona Honors College for a grant used to fund this study. Reiley gratefully acknowledges support from National Science Foundation grant SES-0094800. Muñoz acknowledges the support of CEDEUS, CONICYT/FONDAP 15110020, the Chilean Fund for Scientific and Technological Development (FONDECYT) through Project 1110720 and the Bus Rapid Transit Centre of Excellence funded by VREF. We also thank Manuela Angelucci, Oriana Bandiera, Jim Cox, Greg Crawford, Price Fishback, Austan Goolsbee, Kei Hirano, Tom Hubbard, Phillip Leslie, Preston McAfee, Tom Mroz, Mike Urbancic, and participants in presentations at the NBER IO meetings, the University of Cologne, the European University Institute, Université Laval, George Washington University, the University of Arizona, Georgia State University, the University of North Carolina, the University of Maryland, and the University of Chicago for their helpful suggestions.

While riding a public bus in Santiago, Chile, one of us noticed an interesting phenomenon. A man with a notepad got on the bus and yelled some numbers at the driver. The driver then gave the man a coin and the man got back off the bus. Careful subsequent observation indicated that a number of similar men, called *sapos*,[2] likewise stood at bus stops in Santiago for hours at a time, recording the arrival times of buses on a notepad, and selling their data to drivers.

This presented a puzzle. Why would bus drivers want to pay for information about the timing of other buses? It turns out that, unlike the typical system in the United States, many Santiago bus drivers receive compensation based on their passenger receipts.[3] Such drivers therefore have an incentive to drive in a way that maximizes the number of passengers they transport. This depends significantly on the time interval (called *headway* in the transportation literature) between a driver's bus and the bus immediately ahead on the same route. If the bus in front is far ahead, many passengers will have accumulated since the last bus came by, thus providing high profits for the driver. By contrast, if the bus in front is very close then the driver can expect to pick up few passengers and earn a relatively low profit.

For their part, the *sapos* provide valuable headway information to the drivers. Each time a new bus arrives, a *sapo* marks the minute on his notepad as well as telling the driver (for a fee) his headway, in minutes, behind the immediately previous bus. Given this information, the driver can choose to drive somewhat faster or slower in order to create more profitable spacing. For example, if the typical headway on a route is 10 minutes, but for a particular driver it has grown to 20 minutes, more passengers will be waiting and that driver will make more money. However, the bus behind that driver will then have a short headway, thus giving that second driver a strong incentive to change the spacing. Initially we conjectured that drivers would improve their spacing

[2] The term literally translates as "frogs." *Sapo* is a derogatory term in Chile, generally referring to a tattletale, a spy, or someone who minds other people's business. In Peru, similar entrepreneurs are called *aaeros* (data men), with a more neutral connotation.

[3] At the time of the study, the fare cost 310 Chilean pesos, or roughly 50 cents American. Drivers earn 10-20 percent of this fare under their incentive compensation, according to conversations we had with drivers and bus owners.

by slowing down if they got too close to the bus immediately ahead, but this turned out to be incorrect. In fact, once they get sufficiently close, they typically attempt to *speed up and pass* the bus in front.[4]

Unlike drivers paid a fixed hourly wage, drivers receiving per-passenger compensation play a strategic game with each other. Drivers alter their driving in order to maximize profits given other drivers' behavior. In Santiago, this game is commonly known as "*La Guerra por el Boleto"*, or "The War for the Fare." The incentives for strategic driving are substantial, as a driver who finds himself stuck behind another bus will earn nearly zero revenue unless he passes the bus ahead.

The driver's strategic incentives are designed to benefit the owner of that bus; potentially at the expense of the competing owners and drivers on the same route. The per-passenger incentive system bears an important relationship to the market structure and the boundaries of the firm in this setting. Santiago always had a highly fragmented organization of bus owners: the 8,000 buses were owned by as many as 3,000 separate owners (Transantiago website, 2005). These owners grouped together to form "paper companies" of 20 to 30 owners comprising a single numbered route. These associations enabled individual owners to purchase from the government (at auction) the right to operate. They also enabled owners to share overhead such as inspectors, depots, maintenance facilities, and office space. However, these associations neither coordinated route operation nor shared revenues. Owners did not share revenues with each other (perhaps out of fear of free-rider problems), and they each paid their drivers individually. The per-passenger incentive contracts were reinforced by this market structure. If one owner of a single bus were to deviate from this system and pay his driver a fixed wage, that driver would likely have lost passengers to other drivers, thus costing the owner significant revenues. Thus, the nature of competition supported an

[4] A strategy of slowing down turns out to be a bad idea in general, because this opens the driver to the risk of being passed from behind. In a survey we administered to drivers paid per-passenger (see section 3.B below), 63 percent said that they "always" tried to pass the bus in front of them when the two buses were traveling together.

equilibrium where each owner offered per-passenger incentives to her drivers.

What are the effects of this game on passenger welfare? First, let's consider a common complaint about bus systems. Passengers of many bus systems worldwide complain about the spacing of buses. A typical complaint drawn from an Internet message board for the city of New York is, "I remember many mornings of waiting for the bus only to have 4 or 5 buses arrive right behind each other" (Rider Diaries, 2005). The Chief Strategy Officer of the New York bus system says that bus bunching is in fact one of the most frequent complaints of passengers and is seen as a barrier to wider adoption of bus transit.[5] Similarly, a transit operator for the city of Chicago indicates that "bus bunching is the number one complaint that I hear from our customers" ("CTA Expands Efforts to Reduce Bus Bunching," 2000). Passenger advocate groups in Chicago and New York have conducted studies of bus bunching, respectively claiming 40 percent ("The Late State of Buses," 2004) and 60 percent (Pearson, 2003) of the buses on the routes they examined arrived bunched. Such groups often accuse bus dispatchers of incompetence, saying that they allow such bunching to occur, but in fact there are mathematical reasons why, even if dispatched precisely evenly, buses should evolve towards a state of bunching.

Could a per-passenger compensation system improve passenger welfare by producing more regular arrivals of buses? By giving drivers incentives to monitor and change their spacing, per-passenger compensation might relieve the bunching problems commonly observed. In response to the payment incentives, drivers may use their discretion to make longer or shorter stops or to drive faster or slower. This may, in turn, correct a natural instability in the system and produce more regular arrivals of buses for passengers. For instance, suppose a relatively empty bus passes a relatively full bus. This ameliorates the problem of bus bunching: an empty bus proceeds more

quickly (making quicker and fewer stops to drop off passengers) than a bus full of passengers, so putting the empty bus in front of the full bus tends to even out the spacing. Whether incentive payments tend to reduce bunching is a central question of our paper.[6] The other central question is whether incentive payments lead to less safety and comfort for passengers by encouraging more aggressive driving.

Absent detailed knowledge about the drivers' control variables, we find it impractical to construct a precise mathematical model of the game between the drivers. We prefer to abstract away from the significant complexities involved in creating a dynamic model of endogenous (that is, drivers reacting to each other) and exogenous perturbations in bus spacing. Instead, we have taken an empirical approach to the question, taking advantage of the coexistence of both forms of compensation in Santiago.

We collected our field data in June 2004. At the time, per-passenger compensation occurred on 96 percent of Santiago's then 8000 buses and 300 bus routes. However two bus companies[7] with 332 buses on 25 routes, paid their drivers a fixed wage as a result of the government creating some new routes in 2001 to serve new subway stations. Because of complaints about comfort and safety in the per-passenger compensation system (similar to what we found in our survey of passengers, reported in Section 3.B below), the government auctioned off these route contracts with the stipulation that drivers receive fixed wages. Assuming these fixed-wage routes and their drivers are representative of the overall population of routes and drivers in Santiago, we can compare outcomes between the two types of routes in ~~order to estimate the effects of~~ the incentive pay.

[6] Krbálek and Seba (2000) have previously noted the existence of *sapos* and of strategic interaction between drivers on a bus route in Cuernavaca, Mexico, for which they recorded 3500 bus arrivals to estimate the empirical distribution of arrival intervals. However, as physicists rather than economists, they did not focus on consumer welfare effects, but rather on demonstrating consistency of the data with a quantum chaotic model of a one-dimensional gas. In order to relate bus arrival data to consumer welfare, we use a theoretical expression for the expected waiting time for a random passenger showing up at a bus

[7] The two companies are RedBus, S.A. and Alsa, S.A. Both operated under the Metrobus brand name.

stop[8]. Waiting time is especially significant in passenger welfare, given the estimate by Mohring *et al* (1987) that the disutility of time spent waiting for a bus is three times as high as that of time spent riding a bus. It can be shown that independent of the functional form of the distribution of bus-arrival intervals, the expected waiting time is a simple expression of just the mean and variance of this unknown distribution. We use this result to guide our empirical model.

We estimate a regression model based on 10,824 hand-collected observations of bus arrivals collected from multiple points along each of 32 different bus routes. Half of the routes use per-passenger incentive contracts with drivers, while the other half use fixed-wage contracts. We model headway variance as a linear function of the distance from the route's starting point, which allows passengers' expected wait times to be longer towards the end of the route. We include fixed effects and clustering by route to account for heterogeneity across routes, and ask whether passenger wait times increase more slowly over the course of an incentive-contract route than over the course of a fixed-wage route.

The answer to our question proves to be yes: the per-passenger incentive contract results in more regular bus headways than the fixed-wage contract does. However, the benefits of per-passenger driver compensation do come with negative side effects for passengers. Drivers frequently attempt to pass the bus in front of them, which involves aggressive driving, which can lead to decreased comfort and safety for passengers. To estimate the size of these negative effects, we conducted opinion surveys of several hundred Santiago bus passengers and drivers. We also managed to collect accident data for all Santiago buses, broken down by bus company, in order to discover whether incentive-contract buses are more prone to traffic accidents than fixed-wage buses. The answer again turns out to be affirmative, and we produce a

[8] We do not equate wait time with consumer welfare. In particular, this equation doesn't include the increased risk of death or injury associated with differing accident rates.

quantitative estimate of the net effect of the compensation system on deaths and injuries.

Our work's primary contribution is to document interesting and important institutional features in the economics and policy of public transportation. Among the features of interest to economists in this market are the relationship between market structure and employee incentive contracts, the strategic interactions between bus drivers in this transportation system, the entry of information entrepreneurs (*sapos*) into this market, the mathematical instability of regular bus spacing, and the ability of an incentive system to correct the bus-bunching problem created by this instability. Then, after empirically estimating the effects of the incentive systems on two measures of driver behavior, we go on to estimate the resulting costs and benefits to passenger welfare.

Our work also contributes to the literature on incentive compensation of employees. Lazear (2000) analyzed a natural experiment to demonstrate that piece-rate compensation improved productivity in windshield installation relative to fixed hourly wages; he estimated that half of the effect was a direct impact on existing workers' incentives, while the other half was due to selection of higher-productivity workers. A field experiment by Shearer (2005) in the timber industry found that piece-rate compensation improved tree-planting productivity 20 percent relative to a fixed wage. Bandiera, Barankay, and Rasul (2006) demonstrated via a field experiment that pickers of fruit considerably increased their productivity after a switch from relative-performance compensation to piece-rate compensation. While most research on incentive pay has focused on the single-dimensional output, our study enables us to measure two different key dimensions of output: passenger revenue and traffic safety. [9] While the firms are primarily interested in incentivizing passenger revenue, we show that the incentives also have unintended consequences on traffic safety, consistent with

theoretical work by Holmstrom and Milgrom (1991).[10]

Our results also have relevance for policymakers, as government agencies may regulate the contractual arrangements of bus companies. The question of contract design is an important one for bus transportation policy. Indeed, we were told by Santiago policymakers that our results contributed to their decision to mandate fixed wages rather than per-passenger compensation in the new Transantiago transit system they subsequently implemented. In Latin American cities, bus travel accounts for more than half of all passenger trips (Wright, 2001), so the safety and service characteristics of urban buses have a significant impact on the quality of life. Bus transportation remains important in many cities outside Latin America as well, and developments in global-positioning technology may make it possible to design new types of contracts that benefit passengers in new ways. In our concluding section, we speculate about possibilities for new types of technology-enabled contract design that might provide the benefits of the Santiago incentive system without as many of the costs.

The remainder of this paper is organized as follows. In section 2, we present a theoretical framework for relating passenger wait time to the irregularity of bus arrivals, in order to translate our subsequent empirical estimates into a meaningful welfare measure. Section 3 presents our main results, empirical estimates of the effects of driver incentive compensation on three different passenger welfare measures: wait time, perceived service quality, and traffic accidents. Section 4 describes the Transantiago policy change that subsequently converted all routes to fixed-wage compensation, and concludes with some possible policy implications of this work for future transportation policy.

---

[9] Another recent empirical paper with this feature is by Kapoor (2010), who conducted a field experiment to measure the effects of incentives for generating increased quantity of customers versus quality of customer service.

2. Bus Bunching and Expected Passenger Wait Time

At periods of constant demand, buses should ideally arrive at evenly-spaced intervals. For a frequency of 6 buses per hour, a bus should arrive exactly every 10 minutes at any given point along the route. In practice, however, various factors contribute to uneven spacing, including changes in traffic congestion, varying driving patterns, and unpredictably lumpy arrivals of passengers at stops. As noted above, passengers commonly report dissatisfaction with the bunching of buses.

In fact, it turns out that even spacing is mathematically unstable, so that buses tend to bunch, or "platoon," along the route (Newell and Potts, 1964). Buses may start out with even intervals, but a small random shock, such as local traffic congestion or the arrival of a sudden influx of more passengers, causes one bus (say bus A) to be stopped longer than usual at a stop. This may cause the bus to fall behind schedule. As it falls behind schedule, more and more passengers arrive at stops to wait for its arrival, which slows it down even more. The driver must spend extra time boarding those passengers and collecting their fares and later unloading them.[11] Meanwhile, Bus B, immediately following A on the same route, starts collecting fewer passengers than usual because the interval between A and B has diminished. The small initial change thus gets amplified, as Bus A makes longer and longer stops to pick up and drop off more passengers, while Bus B similarly makes shorter and shorter stops. This process continues until Bus B completely catches up to Bus A.

The more uneven the intervals between buses, the more time the average passenger has to wait.[12] To see this intuitively, suppose that the buses on a route have an average spacing of 10 minutes. Suppose that at some point we observe the interval between Bus A and Bus B to be 15 minutes long, with the subsequent interval between Bus B and Bus C only 5 minutes long. The passengers waiting for Bus B will be waiting

longer than average, while the passengers waiting for Bus C will be waiting shorter than average. However, more passengers will accumulate in line for Bus B than for Bus C, causing the (weighted) average number of minutes to be higher than if the buses were equally spaced.

This phenomenon is known in the transportation literature as the inspection paradox: a passenger arriving at the bus stop will likely have to wait during a longer-than-average bus interval. Let us call h the random variable representing the length of a headway, and let its first and second moments be μ and σ^2 Then, the expected waiting time, $E(w)$, has the following expression (Welding, 1963):

$$E(w) = \frac{E(h)}{2} + \frac{Var(h)}{2E(h)} = \frac{\mu}{2} + \frac{\sigma^2}{2\mu} = \frac{\mu}{2}(1 + c^2) \quad (1)$$

where $C = \sigma/\mu$ represents the coefficient of variation of the waiting time. Equation (1) holds for any bus arrival distribution. Note that with completely regular spacing, $\sigma^2 = 0$. In this case, $\mu/2$ represents the average passenger wait time: intuitively, the average passenger will wait for half the time interval between buses. Since C^2 is nonnegative, we can see that passenger waiting time is minimized with completely even spacing. With irregular spacing, C^2 corresponds to the percentage of wait time attributable to uneven spacing.

3. Empirical Estimates of the Effects of Incentive Compensation

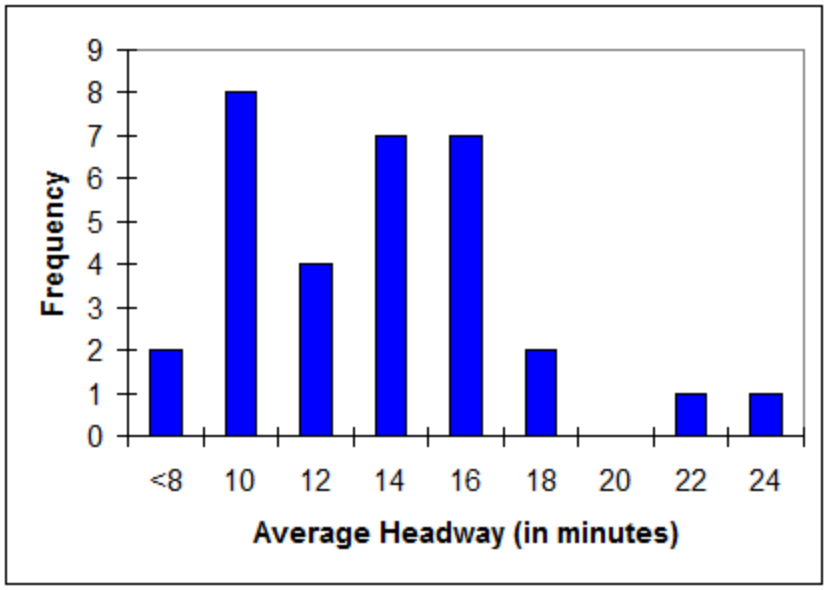
We compare three different passenger outcome measures across the two compensation systems: wait time due to bus bunching, perceptions of service quality, and traffic accidents.

3.A. Wait Time due to Bus Bunching

We initially planned to simply compare mean expected passenger wait times

across compensation systems. However, we realized that different routes have very different baseline means and variances of bus intervals depending on traffic patterns. The distribution of average intervals across routes appears in Figure 1.

Figure 1. Distribution of Mean Headway Across the 32 Bus Routes



Furthermore, we cannot guarantee that the routes we observe are randomly assigned to a compensation scheme: there may be correlation between these baseline numbers and the form of the compensation system, which would cause spurious correlation between the compensation system and average passenger wait times. Therefore, instead of relying merely on variation between routes, we choose to rely on variation within routes. In particular, we exploit the coexistence of both compensation systems to examine the differences in rate of deterioration of even spacing.

Routes start off with a low variance of intervals because an inspector regulates departures.[13] This variance grows as the buses proceed along the route. Our goal was to measure the rate at which the variance increases, separately for the two different

compensation systems.

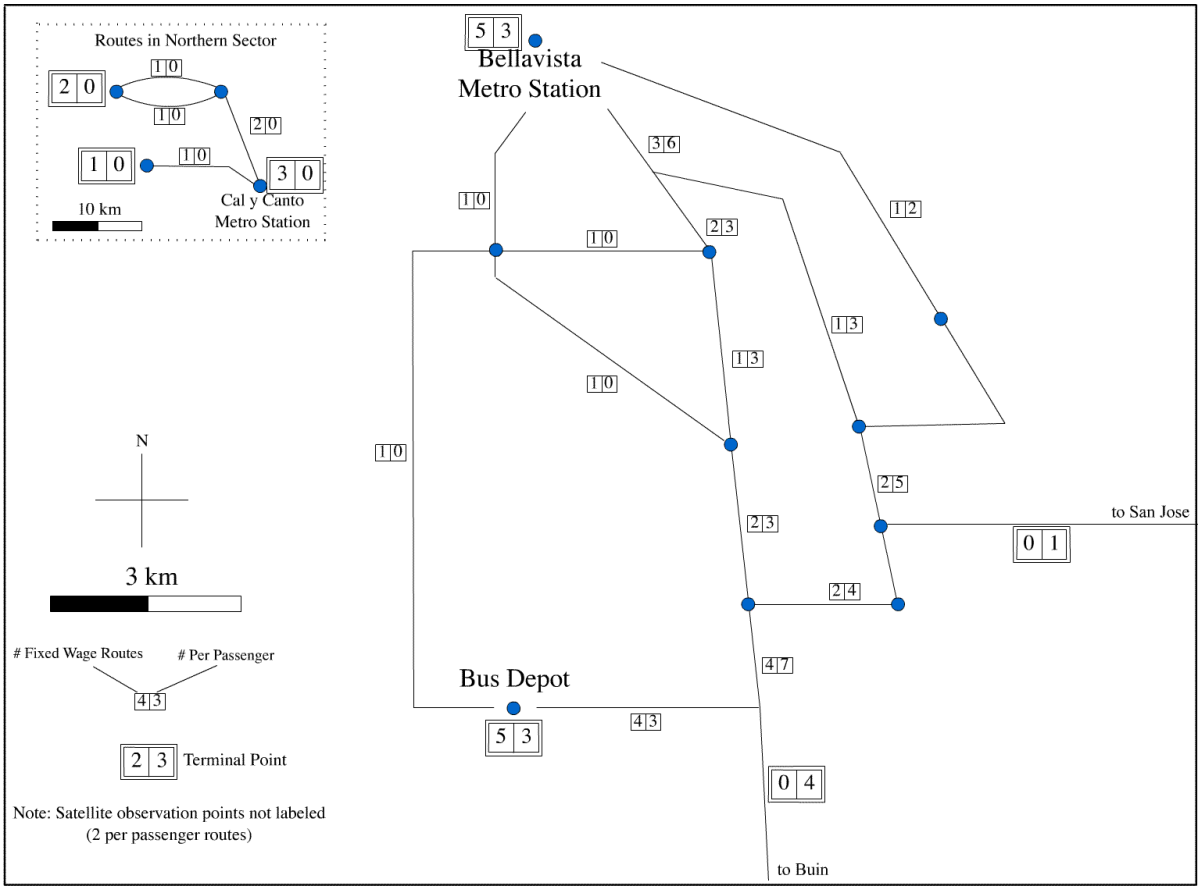
To collect the appropriate data, we isolated a sector in the city that had fixed-wage and per-passenger routes of similar trajectories. We chose 5 fixed-wage lines and 8 per-passenger lines with similar trajectories, exhausting the number of comparable fixed-wage lines in that sector. We also added data on three additional fixed-wage lines in the northern sector of the city, for a total of 8 fixed-wage and 8 per-passenger lines. We then measured each line in both directions of travel, giving us 32 effectively different "routes" in total[14].

We restricted attention to the hours between 6 am and 1 pm, measuring only Monday to Thursday and only on days with good weather. We started our data collection by paying *sapos* for their notebooks of data. However, few *sapos* had notebooks with data of sufficient quality for this analysis.[15] Instead, we hired measurers that could be supervised and would focus only on the specific routes we were studying. One of us also took a number of measurements himself in order to audit the data. Finally, we also obtained Global Positioning System (GPS) data on bus arrivals on four per-passenger routes, and data from six fixed-wage routes that the operating company collected by hand. [16] Figure 2 shows a stylized map of the routes and observation points.

In the map, we see lines representing the routes of travel, and shaded points representing our measurement points on each route. Boxes show the number of routes whose buses travel through a given road segment. We deliberately chose measurement locations in the city that would allow us to measure multiple routes at once; in addition to convenience in data collection, this feature also guarantees a high degree of geographic comparability between fixed-wage and per-passenger routes. The left number in each box shows the number of fixed-wage routes, while the right number of

per-passenger routes traveling there. The shaded points represent measuring points. A separate map in the upper left of the figure shows the six fixed-wage routes we measured in a northern sector of the city. Note that the map represents one direction of each of the 16 lines. In our data we use both directions for an effective 32 “routes”.

Figure 2. Map of Observed Routes and Measuring Points



Note: In each box, the left number is the number of fixed-wage routes passing through that road segment. Similarly, the right number is the number of per-passenger routes driving through that road segment.

We aimed to observe intervals at 5 measurement points for each route and measured over three to five days, depending on the route. We began by collecting data simultaneously across points on a route for several days. For about a third of the routes, we selectively added additional measurement days for route-points where we felt more observations would be helpful.[17] We also tried to position the measurement points as evenly as possible throughout the route. Table 1 gives descriptive statistics of the number of measurements and points per route.

Table 1. Descriptive Statistics of Measurements.

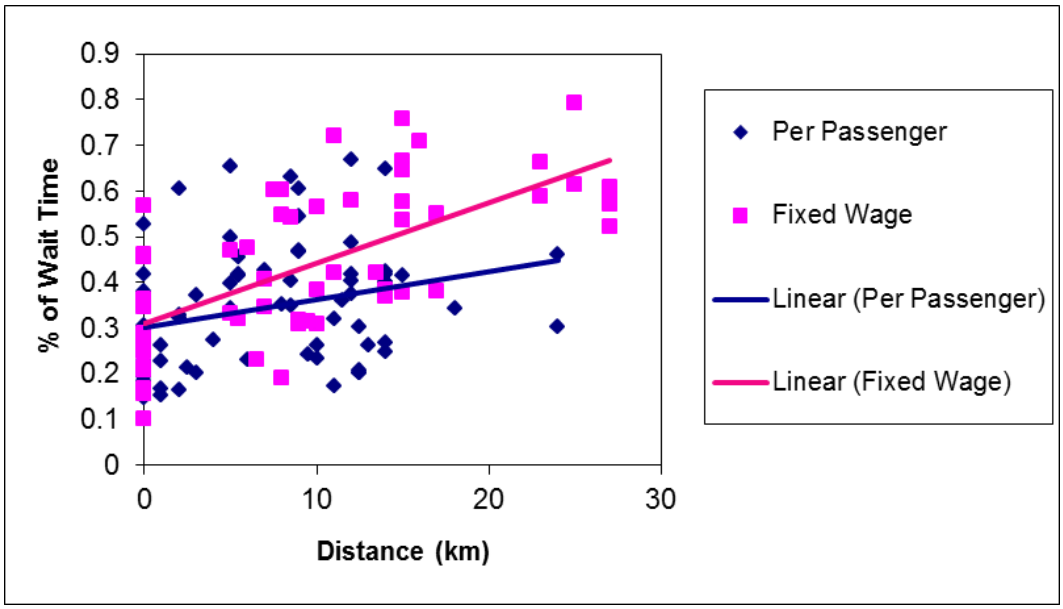
	Mean	Median	Minimum	Maximum
Total km of the observed portion of the route	17.6 km	15 km	12 km	27 km
# of measurement points per route	4.1	5	2	6
# of observations per measurement point	82.6	61	21	376
# of km between measurement points on the same route	5.6 km	4 km	.5 km	25 km

In all, we obtained 10,824 observations of bus arrival times at 130 route-points on 32 routes[18]. We choose to focus on average passenger wait times, which we showed above to depend both on the mean and the variance of bus time intervals. At each route-point, we aggregate our arrival observations to compute a sample estimate for the square of the coefficient of variation: $C^2 = \sigma^2 / \mu^2$, which is equal to the proportion of wait time attributable to nonzero variance. This interpretation of C^2 makes it a natural outcome measure for our analysis.

Figure 3 shows a scatterplot of the values obtained at the 130 different route-points. We plot our sample estimates of C^2 versus distance along the route. For each route, we have a first measurement point; we arbitrarily define the first point's distance to be zero. For other points along a given route, the distances are measured in number of kilometers from that route's zero point. By comparing the best-fit lines for the two different compensation systems, we can see our first indication that expected

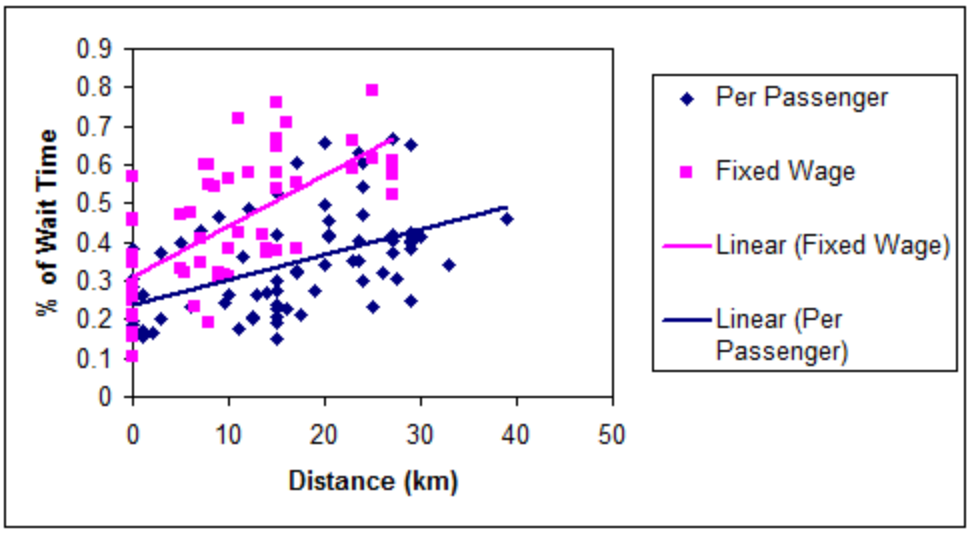
passenger wait times grow faster on fixed-wage routes. We can also see from the plot that a linear fit is not an unreasonable modeling assumption.

Figure 3. Proportion of Wait Time Attributable to Uneven Intervals (treating first measurement on each route as distance zero).



Treating the initial measurement point as the zero-distance point on each route is somewhat arbitrary because these points were chosen mainly for convenience of measurement. Of the 32 routes, 9 have unmeasured starting points, all of them per-passenger routes. This could introduce bias in our results, especially if the squared coefficient of variation truly grows nonlinearly, and we mistakenly estimate a linear model. For example, if C^2 starts higher in per-passenger routes than in fixed-wage routes and if it tends to approach an asymptote rather than increasing linearly with distance, then we could mistakenly conclude that the per-passenger incentive system generates more even spacing of buses. As a robustness check, we also consider distance as defined from the starting point of each route.[19] The resulting scatterplot appears in Figure 4.

Figure 4. Proportion of Wait Time Attributable to Uneven Intervals (treating bus dispatch point as distance zero)



Fortunately, this graph appears qualitatively similar to Figure 1, which uses our preferred measurements of distances. We also checked to see whether starting values of our dependent variable C^2 (at our first measurement point on each route) differ across compensation schemes. Table 2 shows that the two compensation schemes have very similar starting values for our variable of interest, which we find reassuring in terms of the robustness of our results.

Table 2. Starting C^2 Values (Standard error of the mean in parentheses)

Type of Compensation	**Average Starting C^2 Value**
Per Passenger	.277 (.024)
Fixed Wage	.294 (.031)

Next we develop a regression model with route fixed effects, in order to identify the effect of the compensation on the change in variance over the course of a given route. We assume that C^2 increases linearly with the distance traveled over the course of the route. Our research question is to measure the extent to which this rate of increase depends on the drivers' contract form.

To do so, we define the following variables:

f_r = value of $C^2 = \sigma^2 / \mu^2$ at the first place where route r enters the area of measurement; this acts as a regression fixed effect for route r

d_{mr} = distance, in kilometers, traveled by buses of route r from the first place where they enter the area of measurement to measurement point m.

pp_r = dummy variable corresponding to one if drivers of route r are paid per passenger, and 0 if paid a fixed salary.

Our regression model then explains the proportion of average passenger wait time due to uneven spacing as:

(2) $$(\tfrac{\sigma^2}{\mu^2})_{mr} = f_r + a * d_{mr} + \beta * pp_r * dm_r + \varepsilon_{mr}$$

Table 3 displays the results of this regression. The dependent variable increases with distance at a rate of .0136 per kilometer for fixed-wage buses, but the coefficient is smaller by 0.076 for per-passenger buses. That is, the variance of bus-arrival intervals increases only about half as fast for per-passenger routes as for fixed-wage routes, confirming our hypothesis.

Table 3. OLS Regression for dependent variable C^2.*

Explanatory Variable	**Coefficient (SE)**
DISTANCE	.0136 (.0015)

PP * DISTANCE	-.0076 (.0024)

R^2=.9647, n=130

*Fixed-effect estimates have been suppressed. Standard errors are in parentheses.

3.A.1. GLS Estimation

Since we observed very different numbers of bus arrivals at different route-points, we might be concerned that our dependent variable was measured less precisely for some routes than for others, thus causing heteroskedasticity.[20] To correct for this heteroskedasticity, we choose to estimate the uncertainty in our estimates of C^2 and run the regression using generalized least squares.

We find it an interesting technical point that because each of our regression observations is an aggregate statistic on many individual bus arrivals, we can compute GLS using a direct estimate of the variance-covariance matrix of the regression, rather than the usual technique of estimating FGLS based on the residuals of the regression. Since C^2 is a function of the first two moments of the bus arrival intervals, its variance turns out to be a function of the first four moments of the bus arrival intervals. We use the Delta Method to combine well-known formulas for the variance and covariance of the first two sample moments of the distribution, in order to obtain a formula for the sample variance of the error term in our regression.

We note that the Y variable in our regression is the square of the coefficient of variation, which can be rewritten as a function of the first two noncentral sample moments:

$$Y = \frac{\hat{\sigma}^2}{\hat{\mu}^2} = \frac{\overline{x^2} - (\bar{x})^2}{(\bar{x})^2} = \frac{\overline{x^2}}{\bar{x}^2} - 1 \tag{3}$$

For simplicity of notation, we let A and B equal the first two noncentral sample moments

of the bus arrival data, and note that our dependent variable Y is a simple nonlinear function of A and B:

(4)
$$A = \overline{x}$$
$$B = \overline{x^2}$$
$$Y = \frac{B}{A^2} - 1$$

Defining α_k (k = 1, 2, 3, 4) to be the population parameter equal to the k^{th} non-central moment of the distribution, we know from van der Vaart (1998) that the variances and covariance of the two sample moments A and B can be written as follows:

(5) $Var(A) = \frac{1}{m}(\alpha_2 - \alpha_1^2)$

$Var(B) = \frac{1}{m}(\alpha_4 - \alpha_2^2)$

$Cov(A,B) = \frac{1}{m}(\alpha_3 - \alpha_1\alpha_2)$

We combine these expressions using the Delta Method to obtain the desired variance of Y:

(6) $Var(Y) = (\frac{dY}{dA})^2 Var(A) + 2(\frac{dY}{dA})(\frac{dY}{dB})Cov(A,B) + (\frac{dY}{dB})^2 Var(B)$

$= (\frac{-2B}{A^3})^2(\frac{1}{m})(\alpha_2 - \alpha_1^2) + 2(\frac{-2B}{A^3})(\frac{1}{A^2})(\frac{1}{m})(\alpha_3 - \alpha_1\alpha_2) + \left(\frac{1}{A^2}\right)^2\left(\frac{1}{m}\right)(\alpha_4 - \alpha_2^2)$

$= \left(\frac{1}{m}\right)\left[\left(\frac{4B^2}{A^6}\right)(\alpha_2 - \alpha_1^2) - \left(\frac{4B}{A^5}\right)(\alpha_3 - \alpha_1\alpha_2) + \left(\frac{1}{A^4}\right)(\alpha_4 - \alpha_2^2)\right]$

To estimate the variance of each individual observation Y_i, we replace the population parameters with their sample estimates from the bus arrival data. We then re-estimate the previous regression using generalized least squares, where the regression error variance is assumed to be a diagonal matrix with elements given by our estimates. The result of this regression is shown in Table 4.

Table 4. Generalized Least Squares Regression. *

Explanatory Variable	Coefficient (SE)
DISTANCE	.0132 (.0015)
PP * DISTANCE	-.0067 (.0019)

R^2=.9719 n=130

* Fixed-effect estimates have been suppressed. Standard errors are in parentheses.

Note that correcting for heteroskedasticity does not change the results significantly.[21], [22] We will continue to use GLS for the remainder of our analysis of this data.

3.A.2. Robustness Checks

One robustness check concerns the six fixed-wage routes we drew from the northern sector of the city.[23] All sixteen of our per-passenger routes came from the same southern sector of the city, as did ten of our fixed-wage routes. If traffic conditions are very different in the northern sector, we might mistakenly attribute some of this difference to the fixed-wage system, thereby biasing our results on compensation schemes. To check this, we re-ran the GLS regression with those six routes omitted. Table 5 shows those results.

Table 5. Weighted Least Squares After Omitting 6 Northern Routes.*

Explanatory Variable	Coefficient (SE)
DISTANCE	.0111

	(.0022)
PER PASSENGER * DISTANCE	-.0046 (.0024)

R^2=.9714 n=114

* Fixed-effect estimates have been suppressed. Standard errors are in parentheses.

Note that both coefficients decrease in magnitude and the standard errors increase, but the interaction term remains statistically significant at the 10% level (p=0.062). Thus, including the northern routes might be causing us to overestimate the effects of incentives somewhat, but the incentive effect does seem to be robust to excluding those routes. Because we have no reason to believe the northern routes to be particularly unrepresentative, we prefer our original specification, using the full dataset.

A second robustness check involves heterogeneity across time during the day. We expect mean arrival rates to vary over the course of the day, which might make our interval-variance estimates relatively large and noisy. We therefore separate our observations for peak versus off-peak periods. Because the earliest data we gathered didn't contain hour-of-day information (data purchased from *sapos* indicate only the minute of the hour), we ended up with complete hour-of-day information for only 12 of the 32 routes. We define the peak period during our data to be from 6am to 10am and off-peak to be from 10am to 1pm. We then create two observations (peak, off-peak) for each of the 12 routes and redo the regression with those 24 observations. Results are in Table 6.

Table 6. Comparison of Weighted Least Squares Results of splitting versus not splitting peak and off-peak periods. *

Explanatory Variable	**Coefficient (SE)** **For 12 unsplit routes**	**Coefficient (SE)** **For 12 routes split into 24**

DISTANCE	.0154 (.0022)	.0153 (.0023)
PER PASSENGER * DISTANCE	-.0094 (.0037)	-.0182 (.0035)
	R^2=.9633 n=46	R^2=.9196 n=92

*Fixed-effect estimates have been suppressed. Standard errors are in parentheses.

Splitting the twelve routes into peak versus off-peak periods, we find even stronger results: the magnitude of the effect of the per-passenger compensation scheme nearly doubles, and the standard errors remain roughly the same. However, because we have to throw out nearly two-thirds of the data to run this specification, this is not our preferred specification. One troubling feature of this final specification is that the point estimates predict *improvement* of the variance over the course of a per-passenger route (0.015-0.018=-0.003). However, an F test shows that the sum of the two coefficients is not statistically significant at any conventional level of confidence. Notice also that the full sample of route observations yields lower standard errors (Table 4) than the restricted sample (Table 6), indicating that the econometric efficiency gains of retaining the full sample outweigh the efficiency gains of splitting into peak versus off-peak routes. We therefore prefer our original specification (Table 4).[24] Overall, the results demonstrate that there is a robust correlation between per-passenger compensation and passenger waiting time.

How large might we expect to be the overall benefit of the per-passenger spacing to passengers in Santiago? Because we do not model the level of wait time, but rather the rate of change of wait time over the course of the route, we produce a rough estimate based on the average passenger's distance from the dispatch point. One-way route lengths in Santiago range from 30km to 50km. If the average passenger

boards halfway through the route, then the bus may have traveled about 20km by the time the passenger boards. The fixed-wage system thus adds 20*(0.0067) = 13.4 percent to the average wait time relative to the per-passenger system. While a very rough estimate, this gives some idea of the magnitude of the effect. The average Santiago passenger waits 4.5 minutes for each bus,[25] and Santiago government officials estimate the value of a citizen's time at 724 Chilean pesos (US $1.13) per hour,[26] which likely underestimates the disutility of time spent waiting.[27] So if all routes in Santiago started on a fixed-wage system and converted to a per-passenger system, we estimate that passengers would save 32 million Chilean pesos (US $50,000) worth of waiting time each day.[28] Assuming 300 days of travel per year, this comes out to a savings of roughly US $15 million per year.[29]

3.B. Perceptions of Service Quality

To understand service quality from the passenger point of view, we administered a survey of 300 passengers. We approached 200 customers of the per-passenger buses, both at bus stops and on the buses themselves, and orally administered a 7-question survey in Spanish. We administered the same survey to 100 passengers of fixed-wage routes. The two samples reported a distinct difference in service quality. In particular, users of regular (per-passenger) buses were far less likely to feel that the driver waits until they are safely on board before starting, as shown in Table 7. These results back up a larger survey that showed that the bus system is the least popular public service in the city (Adimark 2001).

Table 7. Survey of Passengers on Driver Behavior

Q: When you get in the bus, how often does the driver wait until you're safe to continue?

Response	**Users of Metrobus (fixed-wage comp.)**	**Users of yellow buses (per-passenger comp.)**
Always	59 percent	14 percent
Almost Always	25	31
Half the Time	4	8
Rarely	9	33
Never	3	14

100 users of Metrobuses and 200 users of regular buses surveyed July and August, 2004. p<.005.

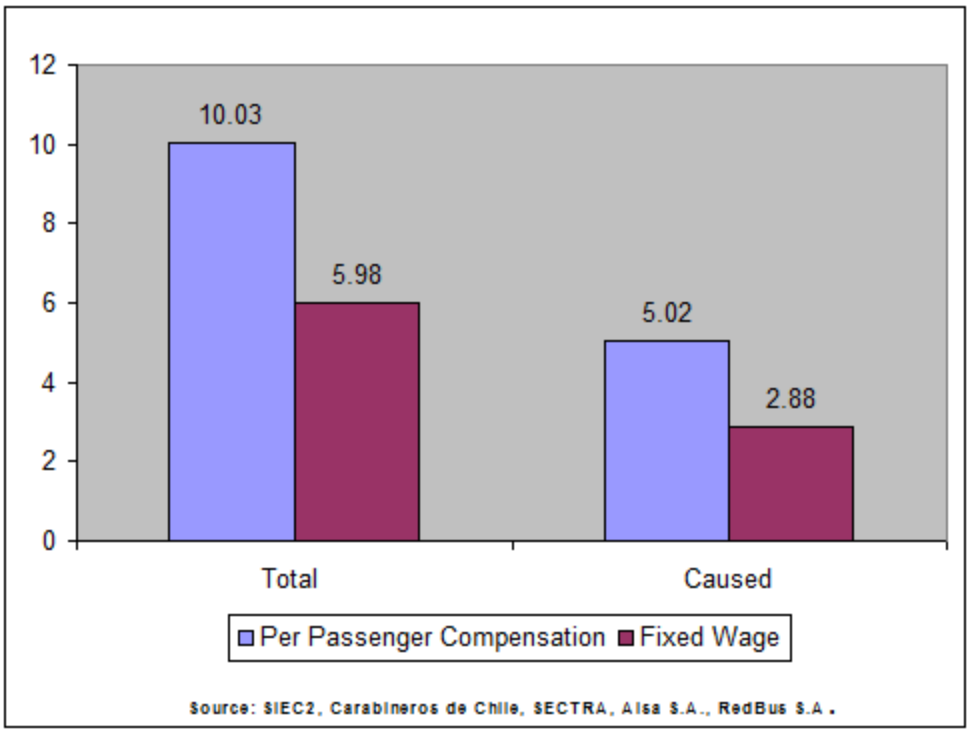
Another negative side effect of incentive contracts involves buses occasionally failing to stop to pick up passengers, behavior we have personally observed on numerous occasions.[30] When a passenger is waiting at a stop alone, sometimes the driver won't stop because the opportunity cost of the time spent picking up that passenger is greater than the income from the fare. In fact, often times a single passenger waiting will have to wait for several buses or until more passengers arrive at the stop (Naudon Dell'Oro, 2004). Once a bus finally does stop, the driver quickly gets the bus moving at full speed, often in complete disregard for the stability or comfort of the passenger. These rapid stops and quick accelerations can occur for the entire duration of the trip.

We also administered a 22-question[31] survey to 50 per-passenger drivers[32] and 46 fixed-wage drivers at various bus depots. Per-passenger drivers talked about the demands that the per-passenger compensation system puts on them. On the other hand, 83 percent of fixed-wage drivers who responded agreed with the statement: "Being paid a fixed wage makes you drive more safely."[33]

3.C. Traffic Accidents

In the first 6 months of 2004, 3,960 buses were involved in an accident and 1,960 buses caused an accident. After analyzing the accidents by license plate to find out which driver compensation system applied in each case, the results show that routes with drivers paid per passenger are involved in and cause relatively more accidents, as is shown in Figure 5. These results are consistent with the prediction of Holmstrom and Milgrom (1991): with two kinds of output (passenger revenue and traffic safety), incentivizing one type of output causes the other type of output to decline as a side effect.

Figure 5. Number of Accidents per Million Kilometers Traveled.



To calculate these results, we obtained data on all police reports of traffic accidents involving buses during the six-month period from January through June, 2004.[34] We separately obtained license-plate data on all buses in the fixed-wage companies and received a second police report on the number of accidents involving these fixed-wage buses. We subtracted the number of fixed-wage accidents from the total number of accidents to infer the number of per-passenger accidents.[35] During our six-month time period, we find that fixed-wage buses accounted for 81 out of 3,960 total accidents involving buses, and 39 out of 1,980 total accidents *caused* by buses. After normalizing by the total number of kilometers traveled by each type of bus,[36] we arrive at the numbers found in Figure 5.

These results likely understate the true difference in accident rates between the

two compensation systems due to differences in reporting of minor accidents. The organizational structure of the per-passenger companies is relatively informal, and local transportation experts believe that its drivers are less likely to report accidents to the police. By contrast, the fixed-wage Metrobuses belong to more reputable firms that are more likely to report accidents.

This difference in accidents should have considerable impact on passenger welfare. If we assume that all of the difference in accident rates is due to the difference in compensation schemes,[37] then we estimate that switching all buses in Santiago from per-passenger to fixed-wage driver compensation would save 55 lives per year. It would also eliminate 227 serious injuries, 210 less serious injuries, and 1,293 light injuries.[38]

Finally, we make an important caveat about our results. Ideally, we would have randomized the assignment of drivers and routes into the two compensation systems in order to control for unobserved heterogeneity that might be correlated with the incentive-compensation scheme. In the absence of such an experiment, our econometric identification may be suspect. One potential problem is route selection: for example, the new routes created by the government with fixed-wage compensation might have been more or less accident-prone than average. Another potential problem is driver selection: for instance, relatively risk-averse drivers might tend toward fixed-wage compensation, and this set of drivers might drive more conservatively, and thus have fewer accidents without the compensation scheme, for reasons other than the difference in incentive compensation. Our interviews with drivers, bus owners, and government employees gave us no indication of selection bias, but this of course does not rule it out. Our causal inference is only as good as our assumption that the populations of routes and drivers were identical across compensation schemes.

4. Discussion

We find our most interesting result to be the fact that per-passenger compensation yields more regular spacing of buses, and hence lower expected waiting time for passengers, than does fixed-wage compensation. However, this does not indicate superiority of per-passenger compensation; we find significant costs to the per-passenger system as well. In particular, per-passenger compensation exhibits much higher incidence of accidents and much lower passenger comfort.

After we completed the first draft of this paper,[39] the transit authority eliminated per-passenger compensation of bus drivers in Santiago. In fact, transportation authorities cited our results on accidents as evidence supporting the decision to mandate a fixed wage. This policy change took place as part of a broader restructuring of the entire bus system, called Transantiago, phased in during the period from October 2005 to February 2007. Transantiago eliminated thousands of small bus companies, reducing the number of bus companies to just fourteen. The reforms also redesigned nearly all the bus routes, and replaced most of the capital stock with newer, larger buses.

Of particular interest to our paper is that all drivers are now paid a fixed wage. In October 2005 the fourteen new companies took over operations of the existing bus routes using existing buses and existing drivers. Five of these fourteen firms switched immediately to fixed-wage compensation,[40] while the remaining firms complied with the fixed-wage regulation, along with other sweeping changes, when the full-blown Transantiago system launched in February 2007. We decided to take a look at the results of this policy change to see whether it upheld the results of the predictions we made from cross-sectional data in 2004.

From 2004 to 2008, bus accidents declined 50% in Santiago.[41] This accords favorably with our prediction of a 67% reduction. However, this figure does not normalize for the number of kilometers traveled. Because of route redesigns and the adoption of larger buses, we know that the number of kilometers traveled also decreased, so the 50% reduction is likely an overstatement of the reduction in accidents purely due to the incentive-compensation change.[42] However, we are pleased with the confirmation of the predicted direction of change.

Another noteworthy development is that, consistent with our predictions, bus bunching became a central complaint of the system (Quintana 2008), even spawning a new word, *trencitos*, or "little trains of buses". For example, the Minister of Transportation said, "One of the most crucial problems of Transantiago today is the lack of regularity of bus arrivals. Today people frequently see *trencitos* of three or more buses together, and if you miss one *trencito*, you will have to wait a long time for the next *trencito."* (Quintana 2008).

The same newspaper suggested it was a predictable outcome, noting, "When Transantiago was designed, it was thought that it was possible to replace the (per-passenger) incentives with monitoring of the buses. But it's unlikely that, even in the best case, the system would have functioned well… given that drivers should flex to respond to changes in current demand" (El Mercurio 2008). *Sapos*, once ubiquitous, disappeared from their street corners. Drivers lamented the "need for *sapos* to provide information" (*El Mercurio* 2008).

The *trencitos* contributed to the perceived failings of the implementation of Transantiago, which also included poor public communication and tactical errors, causing a significant societal disruption. In the month after Transantiago was fully

implemented, the president's approval rating, dropped 12% in Santiago (*El Mercurio* 2007), despite increasing 2% nationwide. Time Magazine called it "The mass transit system from hell" (Long 2007). We empathize with those disrupted by irregular bus arrivals, and take some pride in the fact that both of our major predictions seem consistent with the aftermath of the policy change.

Having quantified the advantages and disadvantages of the two systems, we aim to help transportation planners make more informed policy decisions. In the remainder of this section, we consider the advantages and disadvantages in detail, and consider an alternative that might combine the best of both systems we have studied.

The principal advantages of per-passenger compensation stem from motivating the drivers. Besides shorter waits for passengers, this makes managing drivers much easier for bus owners. While we were undertaking the study, we noticed a sharp difference in the behavior of drivers at their respective bus depots. Drivers paid per passenger were excited to get back on the road. They took quick bathroom breaks, quick meal breaks, and were always ready to depart when the inspector (who regulates departure times) called them. At the depots of fixed-wage bus companies, drivers were often not ready when the inspector called them. They took longer meal breaks, spent more time socializing, and often used the bathroom and other excuses to delay leaving.

The costs of per-passenger compensation come from drivers caring so much about maximizing their number of passengers that they impose externalities on others. The problems include more than just accidents due to aggressive or reckless driving. For example, per-passenger drivers might stop anywhere there is a passenger, not just at officially designated stops. This is illegal and presents high social costs relative to a system in which all passengers wait only at designated stops. Stopping at non-designated stops decreases traffic flow for everyone on the road, and lengthens overall passenger transport time because the buses stop too frequently. Can these

negatives be minimized without losing the benefits of a per-passenger system?[43]

It would be useful to find an alternative incentive system for drivers to maintain even intervals between buses, without the costs of lower service quality and more accidents. Giving drivers incentives to meet a fixed timetable, as is frequently done in the United States, is not likely to be valuable in keeping regular intervals because the timetable is static rather than dynamic. For instance, if one bus breaks down and other drivers follow their time goals, they will not adjust for the resulting gap in a way that would minimize average passenger wait time. On the other hand, in a dynamic system encouraging even intervals, other buses might adjust their driving in order to compensate for the broken-down bus. For example, a recent one-route test in Atlanta showed the potential for moving away from a fixed schedule and toward a system that dynamically adjusts spacing to reduce bunching (Bartholdi and Eisenstein, 2012). In the test, drivers no longer targeted a fixed schedule. Instead, students at control points along the route used an algorithm (based on departure times of previous buses as well as GPS estimates of subsequent bus positions) to instruct drivers how long to wait at that control point. They reported encouraging results at reducing interval variance.

The *sapos* are a major part of the incentive system's ability to improve bus spacing. According to our 2004 survey of 100 per-passenger drivers, the average driver paid 6.5 *sapos* a total of 570 Chilean pesos (US $0.90) each day. Furthermore, *sapos* are not unique to Santiago, and indeed they could be useful in other cities as well. *Sapos* act as key information providers, letting drivers know the locations of the other buses. We find it fascinating that the network of *sapos* springs up through a market process, especially given that both drivers and *sapos* tend to be relatively uneducated. The *sapos* provide the drivers with "knowledge of the particular circumstances of time and place" (Hayek, 1945), enabling them to make decentralized decisions that are in

some ways superior to the decisions that can be made by a centralized dispatcher.

Modern technology, however, offers a potential improvement over a network of *sapos*. With a full implementation of GPS technology, drivers could have information on the location of other buses at all times, not just on corners where *sapos* work. Drivers could have a real-time display showing the locations of other buses both in front of and behind them, enabling them to respond with adjustments to the spacing. GPS technology opens up a whole new realm of contractual possibilities. For example, one might pay drivers a bonus based on the continuous-time average spacing between their bus and other buses on the route, thus providing drivers with appropriate incentives to minimize passenger waiting time. Such systems could improve quality of passenger service in cities like Santiago, and could be potentially even more useful in the cities of developed nations.[44] While Bartholdi and Eisenstein have demonstrated the value of a command-and-control system focused on minimizing interval variance, we imagine further gains possible in a decentralized incentive system, where drivers can make use of local traffic or passenger information not apparent in GPS data. Appropriately designed contracts might even be able to provide improved bus arrivals without incurring the costs of aggressive driving, perhaps by encouraging drivers to cooperate with each other to earn bonuses while improving passenger welfare.

We believe additional research on the combined effects of information technology and contractual incentives could prove immensely valuable to city planning agencies in designing systems that provide better service to passengers.

References

Ackerberg, Daniel, and Maristella Botticini (2003). "Endogenous Matching and the Empirical Determinants of Contract Form." Journal of Political Economy, vol. 110, no. 3, pp. 564-591.

Adimark (2001). Presentación de Resultados Indice Nacional de Satisfacción de Consumidores Segundo Semestre . http://www.adimark.cl/calidad22001/index.htm October 1, 2002.

Bandiera, Oriana, Barankay, Iwan, and Rasul, Imran (2005). "Social Preferences and the Response to Incentives: Evidence from Personnel Data." *Quarterly Journal of Economics*. Vol. 120, Issue 3, pp. 917-962.

Bartholdi, John J., and Donald D. Eisenstein (2012). "A Self-coordinating bus route to resist bus bunching." *Transportation Research Part B*. Vol 46, pp. 481-491.

Chiappori, Pierre-André, and Bernard Salanié (2003). "Testing Contract Theory: A Survey of Some Recent Work." *Advances in Economics and Econometrics*, Mathias Dewatripont, Lars-Peter Hansen, and Steven J. Turnovsky, eds. Econometric Society Monographs, no. 35.

"CTA Expands Program to Reduce Bus Bunching." Chicago Transit Authority Press Release. October 4, 2000, <http://www.transitchicago.com/news/archpress.wu?action=displayarticledetail&articleid=125309>.

El Mercurio (2007). "Encuesta Adimark: Aprobacion de Bachelet registra una drastica caida en la capital." March 7, 2007. Santiago, Chile.

El Mercurio (2008). "Software del Transantiago". September 21, 2008. El Mercurio. Santiago, Chile.

Gatica Gutiérrez, Ramón (2003). *Actitud Hacia La Modernización de Los Choferes*

de la Locomoción Colectiva: Características de su Trabajo y Predisposición Hacia la Profesionalización de su Oficio. Tesis para optar al Título Profesional de Sociólogo. Universidad de Chile. Facultad de Ciencias Sociales. Departamento de Sociología. December 30, 2003.

Hayek, F.A (1945). "The Use of Knowledge in Society". Ameican Economic Review. XXXV, No.4. September, 1945. pp. 519-30.

Holmstrom, Bengt, and Paul Milgrom (1991). "Multi-Task Principal-Agent Analyses: Linear Contracts, Asset Ownership and Job Design," *Journal of Law, Economics and Organization*, vol. 7, pp. 24-52.

Holmstrom, Bengt, and Paul Milgrom (1994). "The Firm as an Incentive System." American Economic Review, vol. 84, no. 4, pp. 972-991.

Kapoor, Sacha (2010). "Incentive Provision in Multitask Jobs: Experimental Evidence from the Workplace," working paper, University of Toronto.

Krbálek, Milan and Seba, Petr (2000). "The statistical properties of the city transport in Cuernavaca (Mexico) and random matrix ensembles." *Journal of Physics A: Math. Gen.* 33 No 26 (7 July 2000) L229-L234

Lazear, Edward P (2000). "Performance Pay and Productivity." *American Economic Review*. 90(5), pp. 1346-1361.

Long, Gideon (2007). "The Transit System From Hell." Time magazine. December 14, 2007. Santiago, Chile.

Mohring, H., J. Schroeter and P. Wiboonchutikula (1987). "The values of waiting time, travel time, and a seat on the bus." *RAND Journal of Economics*. 1987. 18 (1), 40-56.

Naudon Dell'Oro, María de Los Ángeles (2004). "¿Y a mí qué me importa?" El

Mercurio. August 28, 2004. Santiago, Chile.

Newell, G.F. and Potts R.B. (1964) Maintaining a bus schedule. Proc., Second Conference Australian Road Research Board, Melbourne, Vol II, pp. 388-393.

MIDEPLAN (2004). Precios Sociales Para La Evaluación Social de Proyectos.

Pearson, Erica (2003). "Bus Bunching". The Gotham Gazette. May 5, 2003. New York. <http://www.gothamgazette.com/article/20030505/200/372>.

Quintana, Rodrigo Cerda. "El Plan Transantiago ha sido la peor politica publica de los gobiernos de la concertación." El Mercurio. February 9, 2008. Santiago, Chile.

Rider Diaries. Straphangers Campaign. Internet message board. January 11, 2005. <http://www.straphangers.org/ubb/ultimatebb.php?ubb=get_topic;f=25;t=001156>

SECTRA (2001) *Encuesta Origen Destino de Viajes: Informe Ejecutivo*. Chilean Ministry of Transportation Planning.

Shearer, Bruce (2004). "Piece Rates, Fixed Wages and Incentives: Evidence from a Field Experiment." *The Review of Economic Studies*, Vol. 71, No. 247 (April 2004), pp 513-534.

The Late State of the Buses: A Survey of Reliability of Service and On Time Performance of CTA Bus Routes. The Neighborhood Capital Budget Group's Campaign for Better Transit. Chicago, Illinois. February 2004. <http://www.bettertransit.com/bus_study.pdf>.

The Impacts of Subsidies, Regulation and Different Forms of Ownership on the Service Quality and Operational Efficiency of Urban Bus Systems in Latin America, CEPAL (Transport and Communications Division), with GTZ, report

LC/L.675, 7th August, 1992.

Transantiago Website (2005). http://www.transantiago.cl/descargas/transantiago_english.zip. 2005.

"Transantiago redujo en 48% los accidentes de buses". El Merucrio. October 16, 2008. Santiago, Chile.

van der Vaart, A.W (1998). Asymptotic Statistics. Pp 25-27. Cambridge University Press. 1998.

Welding, P.I. (1963). Time series analysis as applied to traffic flow. *Proceedings of the 2nd International Symposium on the Theory of Road Traffic Flow*, London, pp. 60-72.

Wright, Lloyd (2001). "Latin American Busways: Moving People Rather than Cars." Natural Resources Forum, JNRF 25:2, May 2001.

Appendix 1

Passenger Survey on Bus System Service Quality

1.Which system do you use normally? *[This question used to categorize responses]*

MetroBus

Yellow Buses

2. When the buses stop, they make a complete stop…?

Always

Almost Always

Half the Time

Rarely

Never

3. When you get on the bus, the bus waits until you are safely on the bus to continue…?

Always

Almost Always

Half the Time

Rarely

Never

3. How do you feel about the following statement? -Buses proceed in an aggressive manner

Strongly agree

Agree

Disagree

Strongly Disagree

4. When you need it, your bus stops…?

Always

Almost Always

Half the Time

Rarely

Never

5. If you had both options, MetroBus and Yellow Buses, which would you prefer?

The first to arrive

MetroBus

Yellow Buses

Why?

Cost

Safety

Comfort

Speed

Other (please explain)

6. How much time do you spent traveling by bus each day?

7. How much time do you spend waiting for buses each day?

Appendix 2

Bus Driver Survey

This survey is part of a study by the United Nations Economic Comisión for Latin America and the Carribean that aims to understand the impact of different forms of bus driver compensation on bus system performance.

The responses are absolutely anonymous and will only be used for academic ends. In particular, we are not interested in names of those who fill out a survey.

1. You can trust the information provided by "Sapos"…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Always	N=0	*0%*	N=1	2%
Almost Always	16	*32%*	10	22%
Half the Time	8	*16%*	4	9%
Rarely	15	*30%*	13	28%
Never	11	*22%*	17	37%

2. You can trust the information that some "Sapos" provide?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Yes	N=34	*68%*	N=21	46%
No	16	*32%*	24	52%

3. Do you work with “Sapos”?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Yes	N=38	*76%*	N=11	24%
No	12	*24%*	35	76%

4. How many “Sapos” do you pass each turn?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
0	N=3	*6%*	N=3	7%
1	0	*0%*	8	17%
2	3	*6%*	10	22%
3	2	*4%*	6	13%
4	2	*4%*	9	20%
5	2	*4%*	1	2%
6	5	*10%*	1	2%
7	0	*0%*	0	0%
8	3	*6%*	0	0%
9	3	*6%*	0	0%
10	9	*18%*	1	2%
More than 10	16	*32%*	1	2%

5. How many “Sapos” give you information each turn?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
0	N=7	*14%*	N=14	30%
1	1	*2%*	14	30%
2	3	*6%*	6	13%
3	3	*6%*	2	4%
4	5	*10%*	2	4%
5	2	*4%*	1	2%
6	3	*6%*	0	0%
7	0	*0%*	0	0%
8	8	*16%*	0	0%
9	2	*4%*	0	0%
10	6	*12%*	0	0%
More than 10	10	*20%*	0	0%

6. How many “Sapos” do you pay each day?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
0	N=10	*20%*	N=25	54%
1	0	*0%*	6	13%
2	1	*2%*	1	2%
3	2	*4%*	0	0%
4	4	*8%*	0	0%
5	4	*8%*	1	2%
6	10	*20%*	0	0%

7	0	*0%*	0	0%
8	7	*14%*	0	0%
9	2	*4%*	0	0%
10	4	*8%*	0	0%
More than 10	0	*0%*	0	0%

7. How much do you spend on "Sapos" each turn?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Nothing	N=9	*18%*	N=32	69%
CLP1 to 200	4	*8%*	7	15%
CLP201 to 400	10	*20%*	1	2%
CLP401 to 600	8	*16%*	0	0%
CLP 601 to 800	1	*2%*	0	0%
CLP 801 to 1000	9	*18%*	0	0%
CLP 1001 to 1200	5	*10%*	0	0%
CLP 1201 to 1400	0	*0%*	0	0%
CLP 1401 to 1600	3	*6%*	0	0%
More than CLP 1600	1	*2%*	0	0%

8. Other than the time since the last bus of the same route arrived at that point, what information do you ask for from the "Sapos"? (multiple or no responses allowed)

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
The bus two buses ahead in my route	N=8	*16%*	N=2	4%
The last bus from a	24	*48%*	13	28%

similar route				
The last two buses from similar routes	5	*10%*	4	9%
Other (please explain)	6	*12%*	0	0%

9. If a "Sapo" tells you that you are 2 or fewer minutes behind the next bus, you…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Try to pass that bus	N=27	*54%*	N=7	15%
Slow down to create a longer interval	6	*12%*	10	22%
Continue at the same speed	14	*28%*	22	48%

Please explain how you decide your course of action in this situation…

10. If a "Sapo" tells you that you are 15 minutes or more behind the next bus of your route, you…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Try to catch up with that bus	N=21	*42%*	N=2	4%
Slow down to create a longer interval	0	*0%*	1	2%
Continue at the same speed	21	*42%*	36	28%

Please explain how you decide your course of action in this situation…

11. How often do you pass buses from the same route as yours?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Every turn	N=11	*22%*	N=15	33%
Two or three times per day	14	*28%*	2	4%
One time per day	14	*28%*	0	0%
Once per week	8	*16%*	7	15%
Never	0	*0%*	17	37%

12. How often are you passed by other buses from your route?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Every turn	N=8	*16%*	N=12	26%
Two or three times per day	14	*28%*	1	2%
One time per day	14	*28%*	0	0%
Once per week	10	*20%*	10	22%
Never	1	*2%*	17	37%

13. If another bus from your route passes you, you…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Try to pass him	N=3	*6%*	N=1	2%
Slow down to create a longer interval	22	*44%*	6	13%

Continue at the same speed	22	*44%*	34	74%

Please explain how you decide your course of action in this situation…

14. If you are 10 minutes behind the next bus of your route, and a bus of your route passes you, you…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Try to pass him	N=11	*22%*	N=1	2%
Slow down to create a longer interval	8	*16%*	3	7%
Continue at the same speed	28	*56%*	36	78%

15. If you are 20 minutes behind the next bus of your route, and a bus of your route passes you, you…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Try to pass that bus	N=8	*16%*	N=3	7%
Slow down to create a longer interval	12	*24%*	0	0%
Continue at the same speed	27	*54%*	36	78%

16. If you are 2 minutes behind the next bus of your route, and a bus of your route passes you, you…?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Try to pass that bus	N=12	*24%*	N=4	9%
Slow down to create a longer interval	19	*38%*	3	7%
Continue at the same speed	16	*32%*	31	67%

17. How often do you give hand signals to other drivers?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Always	N=24	*48%*	N=10	22%
Almost Always	9	*18%*	9	20%
Half the Time	1	*2%*	0	0%
Rarely	11	*22%*	15	33%
Never	3	*6%*	7	15%

18. How do you feel about the following statement- Being paid per passenger/fixed wage causes me to drive more agressively/safely?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Strongly Agree	N=8	*16%*	N=21	46%
Agree	7	*14%*	13	28%
Neither agree nor disagree	20	*40%*	5	11%
Disagree	3	*6%*	2	4%
Strongly Disagree	9	*18%*	0	0%

19. How often do you pick up passengers that aren't at official stops?

Response	**Per Passenger Drivers**		**Fixed Wage Drivers**	
Always	N=10	*20%*	N=2	4%
Almost Always	13	*26%*	5	11%
Half the Time	3	*6%*	3	7%
Rarely	16	*32%*	20	43%
Never	6	*12%*	11	24%

20. How many times per day do you skip a stop at which there was at least one passenger that wanted on the bus?