Waiting for the Bus

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Abstract

In a natural experiment, college students riding public transit to UCLA were presented with the opportunity to pay for time savings. They could pay 75¢ to travel right away, or wait an average of 5.3 minutes for a free ride. Eighty-six percent of riders chose to wait rather than pay. Their behavior suggests that the disutility of time spent waiting for a free ride is less than $8.50 per hour. Riders overestimated their wait time by a factor of two when it was imposed by the transit system, but accurately estimated their wait time when they chose to wait for the free bus ride.

Introduction

> *To realize the value of one minute, ask the person who has missed the train, bus or plane.* —*Author unknown*

How much is time worth? Transportation engineers and planners often need to answer this question because they use the value of travel and/or wait time savings to justify public investment in many transportation projects (Heggie and Thomas 1983). Highway engineers and planners use projected motorist travel time reductions to justify increases in road capacity. Transit planners frequently use passenger travel and/or wait time savings to justify more frequent and/or higher speed transit service. With so much public money at stake, it is important that engineers and planners use an accurate estimate of how much the savings are actually worth.

This study contributes to the literature on the value of time by reporting the results of a natural experiment. The study shows how bus riders responded when presented with the opportunity to pay for wait time savings. They could pay 75¢ to travel right away, or wait an average of 5.3 minutes for a free ride. Eighty-six percent chose to wait rather than pay. Since they waited 5.3 minutes to save 75¢, their behavior suggests that their time spent waiting for the bus is valued at less than $8.50 per hour. Riders overestimated their wait time by a factor of two when it was imposed by the transit system, but accurately estimated their wait time when they chose to wait for the free bus ride.

Perceptions and Valuations of Wait Time

When making decisions about the merits of different public investments, transportation engineers and planners frequently rely on the value of time savings attributable to a specific project. Public transit planners are particularly interested in how their agency's riders (or potential riders) experience, perceive, and value their time, and sizable literature has developed around these issues.[1] Of primary interest to transit planners are the values individuals place on time spent waiting for a transit vehicle to arrive at a stop, because evidence suggests that patrons view wait time as a much more onerous burden than an equivalent amount of time spent in travel (Lam and Morrall 1982). Transit agencies can reduce passenger wait times by increasing the frequency and reliability of their service.

The actual time passengers spend waiting for a bus or rail transit vehicle is known to be a function of service headway (the elapsed time between consecutive buses) and reliability.[2] Conventional wisdom holds that actual wait time equals, on average, one-half of the expected headway when transit service is reliable (Ceder and Marguier 1985, Chang and Hsu 2001, Lam and Morrall 1982). When transit service reliability is poor, however, average wait times are much longer than half of the expected headway (Chang and Hsu 2001). Studies have consistently shown that the average wait time tends to increase as a share of the expected headway, particularly when headways are longer than 30 minutes (Lam and Morrall 1982, Salek and Machemehl 1999). The potential for significant schedule deviation, and thus added wait time, is necessarily larger for routes with longer headways.

Naturally, passengers might alter their behavior in a conscious effort to reduce wait time. Passengers facing long headways often attempt to reduce their wait time by timing their arrival at transit stops to an optimal period before vehicle departure or by exhibiting "see-and-rush" behavior. In the latter instances, passengers do not wait but instead rush to board a transit vehicle as soon as it comes into view. Most studies report that passengers facing shorter headways will generally not pursue these strategies to reduce wait time (Ceder and Marguier 1985).

Studies have suggested that passenger perceptions of wait time often differ significantly from observed actual wait times (Moreau 1992). Passenger perceptions of wait time appear to vary depending on whether the passenger makes a conscious decision to wait or others impose the wait on them. This tendency to either overestimate or underestimate the time spent waiting depends on whether the passenger experiences time drag (Moreau 1992). Time drag is a condition that makes time seem to pass more slowly than it actually does. Time drag may arise when passengers view time spent waiting as a particularly unproductive and/or burdensome experience. For example, wait times may seem longer when the passenger is not engaged in other activities while waiting, when arrival or departure delays are not explained, when the passenger feels poorly served, or when the passenger travels alone (Moreau 1992).[3]

Clearly, a major concern of most transportation engineers, planners, and policymakers is the value of the time that might be saved by a particular public investment. Most studies have been consistent in their estimates of the value of time. It is widely recognized that a person's value of time is a function of his or her wage rate. An early study concluded that travelers valued time spent engaged in commute travel at around 50 percent of their wage rate and time spent engaged in noncommute travel at up to two-thirds their wage rate (Watson 1974). After reviewing several travel studies, Small (1992) reported that motorists tended to value their travel time at one-half their wage rate.[4] This particular estimate of the value of time is the most widely reported. But a more recent study of commuter behavior in a heavily congested travel corridor in Orange County, California, estimated the value of motorists' time spent traveling to work to be nearly three-quarters their wage rate (Lam and Small 2001).[5]

The particular focus of this research is the value of wait time. Most studies have relied on observations of actual behavior to derive implicit individual values of wait time. In a widely cited study, Deacon and Sonstelie (1985) estimated that motorists who waited in line for low-priced gasoline valued their wait time at between $11.95 and $18.31 per hour (2002 dollars).[6] In another study, Bein et al. (1994) estimated a value of bus wait time of $12 per hour for a sample of Chicago transit riders. Not unexpectedly, Mohring et al. (1987) reports that as incomes rise, the value of time spent waiting increases—for both wage earners and nonwage earners alike.

The literature review provides some background and context for the natural experiment presented below. The study focused on two issues of particular importance to transportation engineers, planners, and policy-makers: (1) the value of wait time and (2) differences between actual and perceived wait time for a sample of public transit patrons.

A Natural Experiment

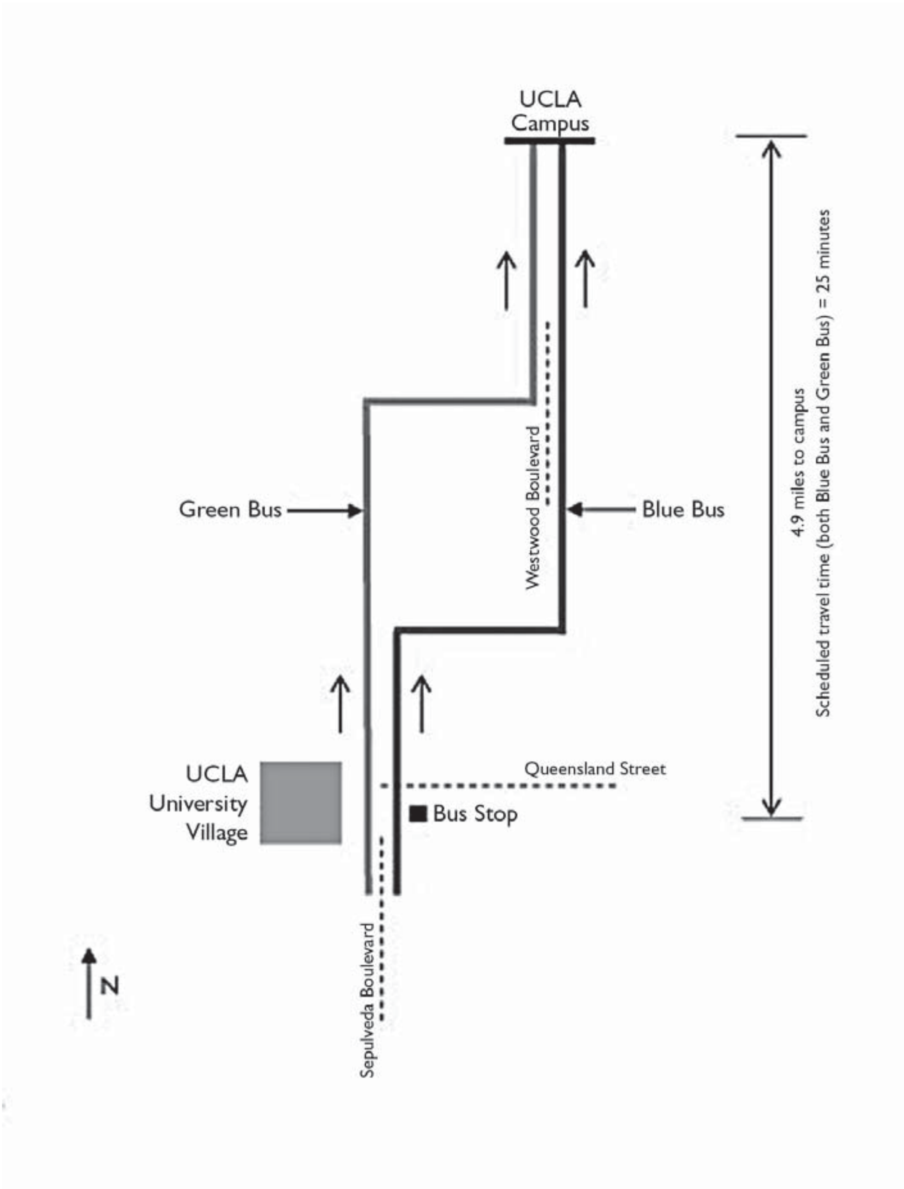
UCLA students traveling from a graduate student apartment complex (University Village) to campus can choose to ride either the Santa Monica Municipal Bus Lines (Blue Bus) or the Culver CityBus (Green Bus). Both the Blue Bus Line 12 and Green Bus Line 6 provide direct service to UCLA, and travel time is the same on both routes (see Figure 1). The main difference between the two lines is the fare: UCLA students, staff, and faculty can ride any Blue Bus without paying a fare when they swipe their university identification card through an electronic card reader, and UCLA pays the Blue Bus for their rides.[7] The Green Bus fare is 75¢. These divergent fares make this natural experiment possible.

When the Blue Bus arrives first, riders board it and enjoy the free ride. But when the Green Bus arrives first, riders must choose: pay to board it, or wait for a free ride on the next Blue Bus.[8] In this situation, riders can spend money to save time, or spend time to save money. The value of the wait time is often difficult to estimate directly because there is no market where it is bought and sold, but this natural experiment presents an unusual case where a market does exist.

Methodology

We selected a bus stop located at the corner of Queensland Street and Sepulveda Boulevard, adjacent to the University Village apartments, as the site for this experiment because we learned from observation and interviews that most riders boarding the bus at this stop are students traveling to UCLA.[9] Riders who did not appear to be students (elderly, letter carriers, etc.) were excluded from the analysis.[10]

Figure 1. Map of Blue Bus and Green Bus Routes to UCLA Campus



We collected data during the morning peak (7:00 A.M. to 10:00 A.M., weekdays) when riders were traveling toward UCLA. We counted the number of riders who boarded each bus and recorded their wait times; in cases where riders let the Green Bus pass and waited for the next Blue Bus, we then noted the *additional* time they waited for a free bus ride.[11]

To learn the reasons for their particular travel choices and gauge their perceptions of wait time, we surveyed a random sample of riders.[12] We asked riders whether they usually board the Blue Bus or the Green Bus and why, and how long they normally wait for the bus; this allowed us to compare their perceptions of wait time with actual observed wait times.[13] Throughout the study, we assumed that riders only considered the difference in fare when deciding which bus to take, and were neutral regarding any differences in the quality of service offered by the two lines.[14]

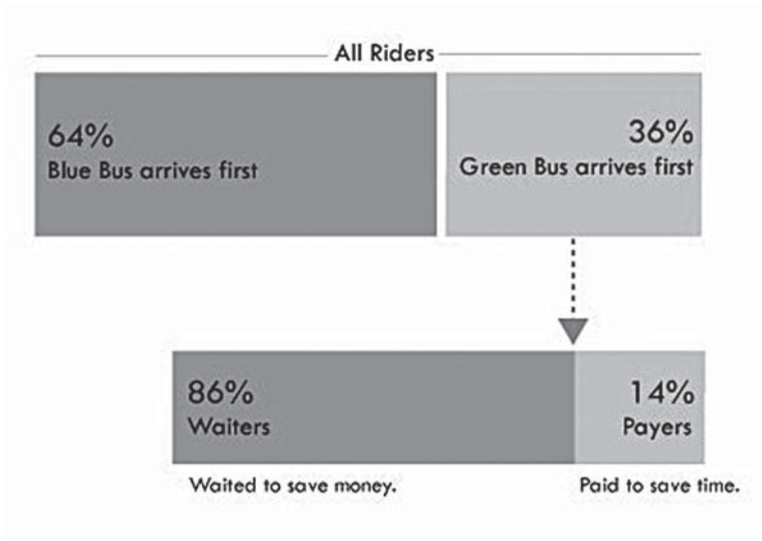
Results

Because the Blue Bus operates on a 10-minute headway and the Green Bus on a 12-minute headway, we expected a Blue Bus to arrive first most of the time. In 64 percent of observed cases (179 out of 281), the Blue Bus arrived first and the rider boarded the bus for a free ride. These riders waited an average of 3.8 minutes, and we did not consider them further.[15]

The Green Bus arrived first in 36 percent (102 out of 281) of cases. Riders in these cases had to decide whether to pay 75¢ to ride the Green Bus or wait to ride free on the next Blue Bus.[16] We divided the riders who faced this choice into two groups: (1) those who paid to ride the Green Bus (payers), and (2) those who waited for a free Blue Bus (waiters).

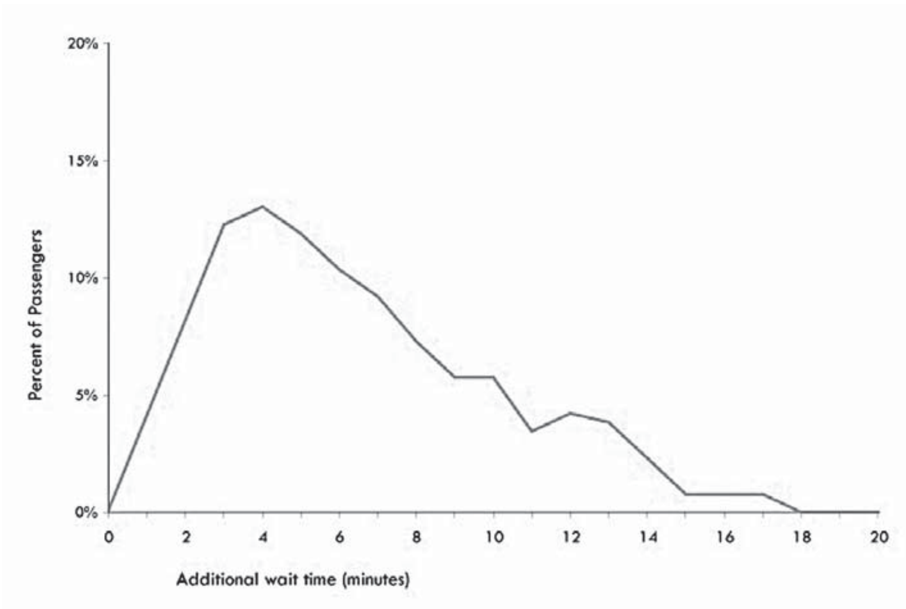
We found that 14 percent (14 out of 102) of riders who faced a choice paid 75¢ to board the Green Bus and reduce their wait time, while 86 percent (88 out of 102) waited for the Blue Bus (see Figure 2).[17] The average elapsed time between each departing Green Bus and the next arriving Blue Bus was 5.3 minutes for all waiters; the median elapsed time was 4.5 minutes. Riders thus chose between paying a 75¢ fare and waiting an average of 5.3 minutes for a free ride. Paying 75¢ to reduce wait time by 5.3 minutes is equivalent to paying \$8.50 per hour (75¢ x 60 minutes ÷ 5.3 minutes). Savings on bus fares are after-tax income for riders, so the time spent waiting for the Blue Bus produced \$8.50 per hour in after-tax income. A traveler whose opportunity cost of time was \$8.50 per hour should be indifferent between paying to ride the Green Bus and waiting for a free ride on the Blue Bus. A traveler with a higher value of time should pay to ride the Green Bus and one with a lower value should wait for a free ride on the Blue Bus.

Figure 2. A Natural Experiment



Regular commuters should have a rough idea of the additional wait time they would spend if they chose to wait for a free Blue Bus ride. Figure 3 shows the distribution of additional wait time for passengers who waited for the Blue Bus. Riders who waited gambled that their additional wait time would be an average of 5.3 minutes, and the standard deviation of additional wait time was 3.3 minutes. The median waiter spent 4.5 minutes of additional wait time to save 75¢, and thus earned $10.00 per hour for time spent waiting. One unlucky waiter spent 18 minutes of additional wait time, and earned only $2.50 per hour for time spent waiting.

Figure 3. How Much Longer Did Students Wait for a Free Ride?



Payers

Fourteen percent (14 out of 102) of riders who faced a choice paid the fare to ride the Green Bus, indicating that they valued their time spent waiting at more than $8.50 per hour. Their average total wait was 5 minutes (standard deviation: 4.1 minutes). Many Green Bus riders told us that paying a fare is not a barrier to riding the Green Bus. They are more concerned with avoiding additional wait time:

> *I always ride whichever bus comes first. I don't care if I have to pay 75¢ on the Green Bus—I just want to get on the bus quickly without waiting around.*

> *I am always in a hurry to get there in the morning, so I take whichever bus comes first. Sometimes I luck out and get a free ride on the Blue Bus, other times I have to pay 75¢ on the Green Bus.*

Some Green Bus riders pay to ride the Green Bus only on days when they are in a hurry:

> *I have to pick up my kids from day care, and I ride the Green Bus when I am running late to avoid standing on the corner waiting for the Blue Bus.*

> *When I have something important that I have to be on time for, like an exam or a presentation, I ride the Green Bus if it comes first. If I let the Green Bus pass by, I don't know how long I might end up waiting for the next Blue Bus.*

Clearly, opportunity cost of time spent waiting for the bus can be high on some occasions, and low on others. Sometimes travelers are willing to pay to reduce their commute times, and other times travelers are willing to save money by lengthening their commute times. Paying to ride the Green Bus is worth the time savings for some bus riders on all occasions, and for others on some occasions.

Waiters

When a Green Bus was the first to arrive and riders faced a choice between paying and waiting, 86 percent (88 out of 102) who faced a choice waited for a free ride. On average, these riders waited a total of 10.4 minutes (standard deviation: 3.5 minutes) before a Blue Bus arrived, including 5.3 additional minutes (standard deviation: 3.3 minutes) after the Green Bus departed. Many Blue Bus riders reported that saving money was their paramount concern and that they always waited for a Blue Bus to avoid paying a fare:

> *I ride the Blue Bus because it's free, even though I am more likely to find a seat on the Green Bus.*

> *The two buses are going to the same place and take the same amount of time to get there, so I wait for the Blue Bus to get a free ride.*

> *I can't afford to ride the Green Bus, so I always wait for the Blue Bus.*

We also found that 28 percent (25 out of 88) of waiters allowed two Green Buses to pass before they boarded the Blue Bus. These "diehard waiters" added an average of 7.3 minutes to their wait time for a free bus ride, and their average wait was 13 minutes—more than twice the average 5.8-minute wait for all riders. Two unlucky waiters added an additional 14.2 minutes to their wait time, and let two Green Buses pass before they finally boarded a Blue Bus. They earned $3.17 per hour for time spent waiting.

We expected the marginal cost of time spent waiting to increase with the duration of wait time, so some passengers who chose to wait for a free ride might eventually pay to ride the Green Bus after a certain amount of time had passed. On one occasion six riders let a Green Bus pass and chose to wait for a free ride. But when the next bus arrived 7.5 minutes later, it was another Green Bus. Two riders chose to board the Green Bus, while the other four continued to wait. These four riders finally boarded a free Blue Bus after spending 11.5 minutes of additional wait time from when they let the first Green Bus pass. These riders earned $3.91 per hour for their time spent waiting.

To Pay or to Wait?

Some riders went to great lengths to make sure they did not pay a fare to board the Green Bus when waiting for a free Blue Bus ride would have delayed them only a short time. These individuals positioned themselves so they would be the last riders to board the Green Bus, thus giving them extra time to see if a Blue Bus was near. They craned their necks to look down Sepulveda Boulevard to see if an approaching Blue Bus came into view, and they stepped onto the Green Bus only when they could no longer delay boarding. Their behavior suggests that these riders were willing to lengthen their wait, but only when they were certain the wait would be a short one.

Some riders said they took note of the number of waiting passengers as they arrived at the bus stop when they made their traveling decision. If there were no waiting passengers, they assumed that they might have just missed a Blue Bus and they were more likely to pay the fare to ride the Green Bus. If there were several waiting passengers, they assumed that a Blue Bus would soon arrive and they were more likely to wait for it.

Some riders explicitly sought to minimize their wait time. We learned that although the buses operate on short headways, 42 percent of surveyed riders coordinate their arrival at the bus stop with the bus schedules. This finding is surprising because the short headways of the Blue Bus make it unlikely that riders could time their arrivals at the bus stop to appreciably reduce their average wait.

How Do These Findings Compare with the Literature?

Riders who waited for a free ride valued their time at less than $8.50 per hour. This value of wait time is lower than the estimates reported in the studies cited earlier, but so are student salaries. The minimum salary for graduate students employed by UCLA is $13.90 per hour, so the riders' value of wait time is consistent with the estimates reported in the literature that most people value time at between half and three-fourths their wage rates.[18]

Perception Versus Reality of Wait Time

We asked a sample of bus riders how long they usually wait to board the bus (Blue Bus or Green Bus) at this stop, and they told us that their average wait time was 11.1 minutes.[19] However, the observed average total wait for all riders who boarded either bus was 5.8 minutes. Bus riders therefore perceived their wait time to be almost twice what it actually is. We also asked riders who faced the choice of paying to ride the Green Bus how much longer they expected to wait for the next Blue Bus. They reported that they would wait an average of an additional 6.9 minutes for the next free Blue Bus, much closer to the observed additional wait time.

When riders were waiting for the first bus to arrive, they said they waited 91 percent longer than the time we measured. When riders chose not to board a Green Bus, and instead to wait for the Blue Bus, however, they estimated that the additional time they waited was only 19 percent longer than the time we measured. These findings suggest that the time that riders choose to wait for a free ride seems far more tolerable than the time someone else makes riders wait. This finding is consistent with the notion of time drag raised in the transportation literature (Moreau 1992). The clock runs faster when the wait is the fault of someone else.

Conclusions

In this experiment, 86 percent of graduate students who faced a choice between paying to reduce wait time or waiting for a free ride chose to wait for the free ride. The average wait for the free ride was 5.3 minutes—a savings of 75¢. Therefore, most riders valued the time they waited for a free bus ride at less than $8.50 per hour. These results are consistent with the transportation literature's estimate that passengers value wait time at approximately half their wage rate. Riders viewed wait time imposed by others as more burdensome than wait time they impose on themselves. Both findings are useful for assisting transit agencies weigh the costs and benefits of service upgrades, such as the use of bus rapid transit, to reduce wait times and speed travel.

Acknowledgments

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Endnotes

[1] See Beesley (1965), Calfee and Winston (1998), Gronau (1965), Hensher (2001), LGORU (1973), Lisco (1967), Miller (1989), Mohring et al. (1987), O'Farrell and Markham (1975), Quarmby (1967), Small (1992), Talvitie (1972), Victoria Transport Policy Institute (2003), Wardman (1998), and Wardman et al. (2001) for examples from this large body of literature. Ceder and Marguier (1985), Chang and Hsu (2001), Lam and Morrall (1982), and Salek and Machemehl (1999) investigate the relationship between passenger wait time and transit vehicle headway.

[2] Route type, stop location, and weather conditions are also important factors in determining wait time (Lam and Morrall 1982).

[3] Moreau (1992) reports that for short wait times, 10 percent of customers experience time drag and for longer wait times, 30 percent of customers experience time drag.

[4] See Small (1992) for a summary of the theory of the value of travel time and the influence of the traveler's opportunity cost of work on travel time. See also Victoria Transport Policy Institute (2003).

[5] Lam and Small (2001) developed a model that estimates time savings worth $ 22.87 per hour (72 percent of wage rates) for commuters in Orange County, California. On State Route 91, commuters can choose between using a free, congested road or an uncongested toll road in the same corridor.

[6] Deacon and Sonstelie (1985) surveyed motorists who were faced with the choice of trading wait time for money. Motorists were able to purchase gasoline at a high price without waiting in line, or to wait in a long line to purchase gasoline at a very low price. This experiment was possible because of gasoline price controls in the spring of 1980 that forced Standard Oil of California to charge a lower ceiling price (depending on service and grade) for gasoline. The regulations applied to stations owned and operated by integrated oil companies.

[7] In September 2000, UCLA and the Blue Bus launched BruinGO. The program allows UCLA students, staff, and faculty to board any Blue Bus without paying a fare when they swipe their UCLA identification card through an electronic card reader, and UCLA pays 45¢ per ride. In September 2002, the Green Bus joined BruinGO and began offering prepaid transit to UCLA students, faculty, and staff. In September 2003, UCLA riders began paying a 25¢ fare when they boarded the Blue Bus. For more information about BruinGO, see Brown, Hess, and Shoup (2003). For more information about university transit-pass programs, see Brown, Hess, and Shoup (2001).

[8] When faced with the decision of boarding the Green Bus and paying the fare or waiting for the Blue Bus, we observed riders looking upstream to see whether a Blue Bus was approaching or downstream to see whether a Blue Bus had just departed, providing the passenger with additional information about the potential length of wait time.

[9] We did not collect data on the age or sex of the survey subjects.

[10] We collected data during the months of May and June 2002. Weather conditions were generally sunny and mild, with an occasional drizzle. Because the observations were made on different days, it is possible that the same person may have been observed on more than one occasion. We were unable to control for this possibility without turning ourselves into potential intruders in the subjects' decision-making process. Our goal was to observe boarding and waiting behavior, and we were aware that transit riders make different decisions on different days based on a variety of personal factors.

[11] Specifically, we recorded the actual observed headways between all arriving buses, and calculated passengers wait times as one-half the headway until the first arriving bus, as suggested by the literature reported earlier (Ceder and Marguier 1985, Lam and Morrall 1982). If passengers did not board the first arriving bus, we added to their wait time the actual headway for each successive arriving bus until they boarded.

[12] Interview subjects were surveyed at random on different days, and no single subject was surveyed more than once. Most subjects that we approached answered the survey questions willingly.

[13] There were eleven survey questions: (1) How long do you usually wait for the bus? (2) What percentage of the time do you board the Green Bus if it comes first? (3) If you sometimes take the Green Bus, why? (4) If you let the Green Bus pass by and wait for the Blue Bus, how long is the wait usually? (5) Before BruinGO began (or during the summer when BruinGO is suspended) do you board whichever bus comes first? (6) The Green Bus and the Blue Bus take slightly different routes to campus, but is the travel time the same? (7) Do you read the bus schedule and coordinate your arrival at the bus stop to catch a specific bus? (8) Does the Blue Bus driver ever wave you on the bus before you have swiped your UCLA ID card? (9) Do you usually get a seat on the Blue Bus? (10) Do you receive any financial aid from UCLA? (11) Do you think UCLA should include the Green Bus in the BruinGO program?

[14] The two lines have the same 25-minute travel time from University Village to campus, although most of our survey respondents do not perceive this to be the case. Only 39 percent (16 out of 41) thought travel time was the same, while 29 percent (12 out of 41) thought the Green Bus was faster and 22 percent (9 out of 41) thought the Blue Bus was faster. Just under 10 percent (4 out of 41) either did not know or did not answer the question. Some respondents might have thought the Green Bus is faster because they have to pay for their ride, giving the appearance of a "premium" service. The Green Bus also tends to be less crowded than the Blue Bus and boarding passengers have a greater likelihood of sitting rather than standing for the ride to campus, which further contributes to its appearance as a premium service. But most UCLA riders still chose to wait for the free Blue Bus ride, which suggests that saving money is more important than both wait time and any perceived or actual service quality advantages the Green Bus might possess.

[15] The range of wait times was 0.3 minutes to 10.0 minutes, with a standard deviation of 2.1 minutes.

[16] We repeated the experiment in late June 2002, when BruinGO was suspended for the summer break. Riders then faced a choice between paying 75¢ to ride the Green Bus or waiting and paying 50¢ (the regular fare) to ride the Blue Bus. Forty-three percent of riders chose to wait for the Blue Bus, and save 25¢. These riders waited an average of 6.6 minutes, so they "earned" \$2.27 per hour (25¢ fare savings x 6.6 minutes ÷ 60 minutes) for time spent waiting.

[17] Fifty percent of waiters had a total wait of more than 10 minutes, while 50 percent of payers had a total wait of less than 3 minutes. We asked a random sample of riders (n=41) how often they are payers and they told us that on average they

pay to board the Green Bus 23 percent of the time. However, the boarding data reveal that only 14 percent of riders are payers. It appears that riders do not like to appear to be penny pinchers, and so they overestimated their willingness to pay for a Green Bus ride.

[17] The salary is reported in the agreement between UCLA and the Academic Student Employee Unit and is available online at *http://www.ucop.edu/humres/contracts/ase/ASEUCLA2.pdf*.

[18] This estimate is based on 41 interviews of riders waiting for the bus.

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