ABSTRACT

Daniel Donin for the degree of Master of Public Policy

Title: Fare-less public transit and its impact on ridership: Policy review of Corvallis, Oregon's recently implemented fare-less transit system.

Abstract Approved:

Due to the current cultural paradigm that incorporates the desire to be environmentally friendly and mitigate rising fuel costs, arguments about the cost of public transit systems, ridership rates, and methods to increase use are frequent topics of public policy concern. In response to these cultural and economic concerns, the City of Corvallis created a fare-less transportation program to increase ridership on Corvallis Transit buses. This project examines Corvallis Transportation System (CTS) ridership count data for 54 months (July 2008 through December 2012). Our multivariate regression models determined that the fare-less program increased ridership during this time period by 9-10 %. The models used to determine ridership change include two different measures of ridership. The first included main bus routes only and the second included main and alternative routes. These models controlled for Oregon State University (OSU) student population, average temperature, and the average cost of gasoline in the Corvallis area. However, further research is needed to determine what other factors might influence a person's transportation mode choice and how these factors might impact ridership.

Fare-less Public Transit, Impact on Ridership: Policy Review of Corvallis, Oregon's Recently Implemented Fare-less Transit System.

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Abstract

Due to the current cultural paradigm that incorporates the desire to be environmentally friendly and mitigate rising fuel costs, arguments about the cost of public transit systems, ridership rates, and methods to increase use are frequent topics of public policy concern. In response to these cultural and economic concerns, the City of Corvallis created a fare-less transportation program to increase ridership on Corvallis Transit buses. This project examines Corvallis Transportation System (CTS) ridership count data for 54 months (July 2008 through December 2012). Our multivariate regression models determined that the fare-less program increased ridership during this time period by 9-10 %. The models used to determine ridership change include two different measures of ridership. The first included main bus routes only and the second included main and alternative routes. These models controlled for Oregon State University (OSU) student population, average temperature, and the average cost of gasoline in the Corvallis area. However, further research is needed to determine what other factors might influence a person's transportation mode choice and how these factors might impact ridership.

I.   Introduction

Despite rising costs of gasoline and the push for ecologically friendly methods of transportation, persuading the general population to use public transportation can be a difficult challenge. One major factor affecting the use of public transportation is how an individual chooses his or her mode of transportation. This choice is dependent on a set of prioritized characteristics. Some characteristics that have a strong influence on commuter mode choice include the following: (1) proximity to stores or restaurants for midday shopping or lunch, (2) transportation travel time, (3) schedule reliability, (4) cost, and (5) ease of access (Bhat & Sardesai, 2006; Zhou, 2012).

Compared to other modes of transportation, public transportation does not score highly on these five characteristic in the Corvallis area. For example, time spent traveling via public transit is still generally longer than driving a personal vehicle, which makes it less convenient and less desirable. In large communities, infrastructure investment, such as more buses and increased frequency of stops, can be implemented to minimize the impact of travel time, convenience of route use, and schedule reliability of the public transportation mode choice. However, in smaller communities like Corvallis, raising the funds to build that infrastructure can be challenging. Smaller communities rely on general public use in order to create revenue for public transportation. At the same time, it is only through a more efficient and comprehensive system that smaller communities are able to increase ridership and thereby revenue. A critical question faced by many smaller communities that lack system-external funding is how can ridership increase without

improved infrastructure and how can improved infrastructure be created without funds from increased ridership?

The solution to the ridership-infrastructure-funding problem that was implemented by the City of Corvallis was to invest in a "fare-less" program for the City's public transportation system. The intent of this program was to make the public transportation system more affordable and more convenient and therefore more desirable to the population of Corvallis. Under this system, passengers on buses are not required to pay a fare. Consequently, the immediate cost is taken out of the transportation mode decision, so everyone can afford to ride the bus. This fare-less program also minimizes the time spent at stops as there is no waiting for passengers to pay their fare or show proof of prior payment. This, in turn, increases schedule punctuality, thereby reducing travel time. The fare-less program allows passengers to simply get on the bus and go to their destination without encumbrance.

To fund the fare-less program, in February 2011, the Corvallis City Council adopted the Corvallis Transit Operations Fee, which added a small fee onto each existing domestic, commercial, and industrial water bill. The system allowed the city to avoid having to hire additional office personnel to manage a new payment system, minimizing overhead costs. These fees were calculated from a trip generation methodology developed by the Institute of Traffic Engineers (City of Corvallis, 2013). The new fee was set at $3.73 per month for single-family residences (individual houses), and a $2.58 fee per housing unit per month for buildings with multi-family residences (apartments). The fee for commercial and industrial businesses varied based on the type of business and

its customer base. These fees were calculated from a trip generation methodology developed by the Institute of Traffic Engineers (City of Corvallis, 2013).

The trip generation methodology estimates that a single-family residence generates an average of 9.6 trips per day. In contrast, a business will have a greater impact because its trip generation is based on employees, vendors, and customers combined. The transit operation fees for both residential dwellings and businesses are reassessed every year and may increase or decrease depending on operational costs and other external factors; however, the fee cannot drop below $2.75 per month for single-family dwellings (City of Corvallis, 2012).

The CTS mission statement provides justification for the fare-less program: To preserve the environment and enhance neighborhood livability of Corvallis by providing a viable transportation alternative for all citizens, reducing air pollution, reducing energy consumption and reducing automobile traffic, thereby reducing the number of accidents, including fatalities […] Provide community access as a social service by providing transportation to youth and elderly, persons with disabilities, and low-income citizens and promote economic vitality for Corvallis (City of Corvallis, 2013b).

As CTS strives to fulfill its mission of preserving the environment and enhancing neighborhood livability by providing Corvallis with a viable transportation alternative for all citizens, the organization also has defined department goals.

These goals include providing riders with safe and reliable bus service, delivering punctual performance, and meeting the evolving transportation needs of the Corvallis community, while at the same time not increasing the cost of services (City of Corvallis, 2013b). The fare-less program was implemented to increase ridership and create an economically viable transportation alternative to help achieve all the above CTS goals. By increasing ridership, the program was also expected to reduce the number of people driving and the number of trips in the city via private automobile. This in turn would help reduce air pollution and overall energy consumption. In September of 2012, CTS implemented the first infrastructural changes by adding extra pickup times to six of the eight main routes and three of the alternate and peak-hour routes. This was accomplished through the stabilized revenue that the fare-less program generated (City of Corvallis, 2013).

There is a lack of recent research on the impact of cost, fare levels and changes, on transit ridership, that is price elasticity. Most of the relevant studies were conducted before the 1980s (Curtin, 1968; Domencich & Kraft, 1970; Kemp, 1974; Schneiner & Starling, 1974; Singell & Schifferli, 1983). Few of these studies produced similar results, indicating that price elasticity differs not only across time periods but also from city to city. In Corvallis, transit system ridership is impacted by the large student population. The transit system has been free for student riders and anyone with a OSU ID well before the time periods this research is looking at, as a result of an agreement between the university and the city. Before the fare-less program, count estimates indicated that

college students accounted for over 48% of ridership and that about 60% of total transit riders rode the bus for free either as students or from other group arrangements with the city (City of Corvallis, 2010). Once the fare-less program was implemented, it was no longer possible to track student riders because they were no longer required to show their student identification in lieu of payment.

Cost is not the only factor people consider when deciding to use public transportation. Other factors include availability of alternative transportation, weather, time, and quality of the experience (Schneider, 2013). Corvallis, Oregon is a small college city with a population of approximately 54,000. Major alternative sources of transportation that compete with public transportation include driving, biking, and walking. Due to Corvallis' small size, low crime rate, and mild climate, biking and walking are significant contenders for the public's choice of transportation options. In 2011, the city received a gold rating as a bicycle-friendly community from the League of American Bicyclists (League of American Bicyclists, 2011). Corvallis also has one of the highest percentages of the population who bike to work on a daily basis at 9.3% (McKenzie & Rapino, 2011).

Another factor influencing the use of public transit in Corvallis pertains to the city's commuter population. Although there are two cities within ten miles of Corvallis (Albany and Philomath), the current public transit between these cities is limited to one bus route to and from each city. This is an impediment for the many people who work in one of these cities but reside in another; the limited infrastructure and resulting

inconvenience riders going to or from the surrounding cities results in, many people commuting by car.

Finally, the city growth rate is also presenting issues due to an increasing student population. An increase in the number of vehicles is concomitant with the population increase, which has created vehicle related issues including parking and traffic concerns. If the current fare-less program works in the city of Corvallis, then expanding the program to other cities and inter-city buses might be a worthwhile solution to fixing some of the concerns without increasing infrastructure.

This research examines the impact of the fare-less system on CTS ridership. Using 54 months of ridership data collected by CTS drivers, this research estimated time-series linear-elasticity regression models to estimate how much the fare-less program contributed to increased ridership, while controlling for other important determinants of ridership. The city found a 37.9% increase in ridership after the implementation of the program (City of Corvallis, 2013); however, the city did not differentiate between how much the program itself increased ridership and how much other factors influenced ridership. Factors other than the fare-less program likely contributed to the 37.9% increase. By controlling for the quarterly Oregon State University (OSU) student population, monthly average gasoline prices, and average monthly temperature, this research examined to what extent the fare-less program itself increased ridership.

II.   Literature Review

Proponents of public transportation subsidies argue such systems are an efficient use of public dollars where the cost to the local and federal government is lower than the benefits generated, while opponents believe these subsidies should be discontinued because they are inefficient and costs to local and federal governments are much greater than the benefits that are generated (Netzger, 1974). Others call for additional public subsidies to help fund lower fares and completely fare-less systems because they increase ridership (Domencich & Kraft, 1970; Kemp, 1974; Parry & Small, 2009; Singell & Schifferli, 1983). According to Parry and Small (2009: 700), "The results support the efficiency of the large current fare subsidies; even starting with fares at 50 percent of operating costs, incremental fare reductions are welfare improving in almost all cases."

An example of a price-inelastic item is oil because price changes have little effect on the quantity of oil purchased. It would take a very long time or an extreme price change for the quantity consumed to change. For a price-elastic item, such as eating out at restaurants, changes in price have large effects on the quantity of restaurant meals purchases. Previous research shows variability when examining price elasticity and its impact on public transportation.   These studies indicated that price elasticity rates range from extreme inelasticity (0.04) to high elasticity (2.0) (Kemp, 1974; Schneiner & Starling, 1974). Inelastic ticket prices would indicate that it is not the ticket price that gets people to use public transportation, while highly elastic ticket prices would indicate that ticket price would contribute significantly to increases or decreases in ridership.

Kemp (1974) used aggregate data for the bus system in Atlanta over a 12-month

period to examine fare reduction in 1972 and estimated the corresponding elasticity to be 0.15 to 0.2. In Kemp's model of a free-fare system, however, the estimated elasticity fell to 0.04, a very inelastic value. Kemp speculated that a 100% fare reduction cannot be modeled linearly.

Schneiner and Starling (1974) looked at data from Atlanta, Tulsa, Denver, and San Diego and found very different elasticities for each city. The elasticity coefficient was 0.21 for Atlanta, 0.24 for Tulsa, 1.84 Denver and 1.90 San Diego. Schneiner and Starling argued that because transit markets differ, the effect of a 100% fare-reduction program is hard to predict and that is why you can have markets with 0.21 like Atlanta but others at 1.90 like San Diego. Demand, for example, might be more influenced by the service than the cost of the service. Never the less, Schneiner and Starling found the lowest elasticity coefficients to be in the inelastic mid-range, results that align with results from the majority of the studies examined in this review.

In the late 1980s the Denver transit system suspended fares for a one year period and total ridership increased by 74% (Singell & Schifferli 1983) Singell & Schifferli (1983) estimated an ordinary least squares multiple regression model for the period in which fares were not changed. The researchers used a model that was logarithmic (all variables that could be were log transformed) and followed the standard measures of elasticity. The model controlled for income, working population, price of substitutes, date the program became active, and seasonality (that is summer or not). The model had an R^2 of 0.85, explaining 85% of the variance in ridership, while the estimated elasticity was 0.27, so by removing the fare, ridership increased by 27%. They also estimated

models for a selection of subsections of Denver and surrounding areas to see if the elasticity would be the consistent. However, the circulator routes Boulder had an elasticity of 0.30, while for Longmont the elasticity was 0.13, and the intercity routes had an elasticity of 0.19. In aggregate, these coefficients represented the 0.27 coefficient of elasticity for the entire system. This study aligned with previous studies of bus transportation price elasticity. The study also showed that people who did not use public transit because of misconceptions about the transit system were willing to try it when there was no monetary cost involved (Singell & Schifferli, 1983). Even after fares were re-established, people continued using public transit as their previous misconceptions had been replaced with positive experiences. As a result, potential riders no longer perceived price to be a barrier to future use of the transportation service (Singell & Schifferli, 1983).

Another study by Curtin (1968) looked at a 20 year period with 77 bus fare increases from transit systems throughout the United States and found very high correlation between percent fare increase and percent net loss in ridership (R=0.92). Curtin looked only at ridership and fares. Examining the relationship with the goal of maximizing revenue at an optimal price, he noted that with each fare increase there is a decrease in ridership regardless of how small the fare increase might be. The price elasticity for the 77 fare increases was -0.33, which can also be viewed as the shrinkage ratio because there was a decrease in ridership for each fare increase. By looking at quantity of service ($\frac{\text{Annual revenue miles of transit service}}{\text{population in transit service area}}$) that previous research linked to level of service, once this was found he isolated the cases of quantity of service change

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and found that 30 substantial fare changes happened in 12 of the 77 cities during the study period. The results varied greatly between cities but a median elasticity of -0.67 was found, almost double what was originally found. The author then came to the conclusion that level of service was the most important influence on the price elasticity.

Domencich and Kraft (1970) using data from the Boston Regional Planning Project looking at bus routes estimated two price elasticity models from data in the late 1960s and found the price elasticity to be 0.17 for passengers using transit for work trips and 0.32 for those using it for shopping trips. Unlike the ridership data used by other researchers, Domencich and Kraft used data from a mail survey for a sample of representative transit lines.

While lowering prices has a positive effect on ridership the amount varies by transit market the generally accepted figure is around .2 to .3 for elasticity. So for a 100% fare reduction there would be an expected 20% to 30% increase in ridership. Many of the studies found that service plays a key role in ridership even more so than price (Singell & Schifferli, 1983; Curtin 1968; Schneiner and Starling, 1974). Singell & Schifferli (1983) also included the cost of substitute's modes of transportation and found an elasticity of .54 where the price only had a .268. These factors that have a direct impact on ridership can help explain why people choose the transportation they do.

III.   Theory

When it comes to transportation choices for the public, including the choice to use public transit and other alternative transportation, many theories explore the reasons why and how people make their choices. The primary focus of this analysis will be the Theory of Routine Mode Choice Decisions (Schneider, 2013). This theory not only investigates some pertinent socioeconomic factors, but also emphasizes habit changes required to increase and maintain ridership. Figure 1 gives a visual breakdown of the main components of this theory.
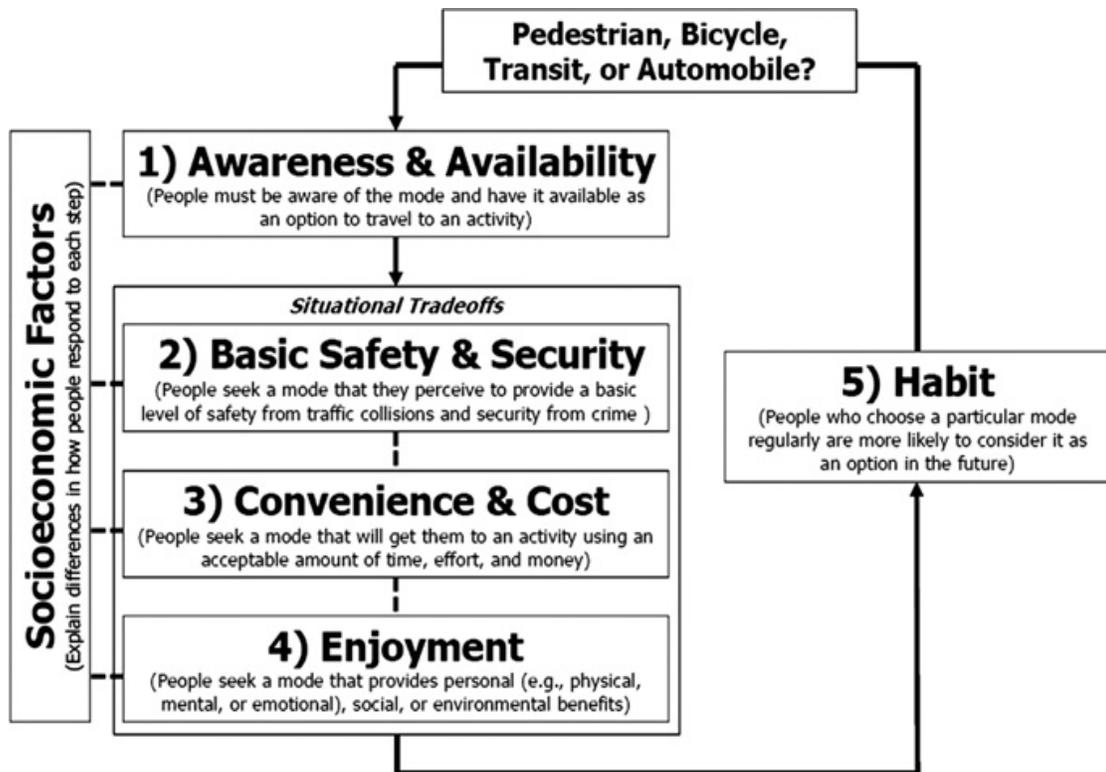

Figure 1. Theory of Routine Mode Choice (Adapted from Schneider 2013).

The Theory of Routine Mode Choice Decisions framework helps explain what the Corvallis Transit fare-less program did in an attempt to change the public's transportation habits. The first step of the Framework Theory is awareness and availability. The fare-less program addressed this by publishing the program information in the City Newsletter, in a press release, on the CTS website, and in a slideshow on public access television. These were all done during the last week of March 2010 in an attempt to obtain input from the public on how they felt about the policy. Most of the publicity came from the media attention in the Daily Barometer, the local OSU newspaper, and the city newspaper, The Corvallis Gazette Times. This publicity ultimately gave the transit system the public awareness and interest it needed to reach the general population of potential riders.

The next component of the Routine Mode Choice Decisions framework include basic safety and security, convenience and cost, and enjoyment, all of which are considered to be situational tradeoffs, meaning that normally higher marks in one category can be traded for lower marks in another. These factors can be discussed separately or all together (Schneider, 2013). This analysis broke them apart and focused specifically on convenience and cost factors because the fare-less program can only directly affect these factors. Convenience and cost, at least in part, were derived from the economic side of travel behavior and mode choice. The fare-less program by definition is free, so the monetary value of the system was no longer considered part of the equation when choosing between transportation modes.

In addition to costs, the Routine mode choice model suggests that convenience affects choice of transportation modes. So, while walking and biking might also be free like the bus system in Corvallis, they can present some inconvenience. For example walking and bicycling are normally much slower methods of travel, take place outdoors, and can be considered less convenient. These modes of transportation are also less convenient for long distances and/or when an individual has to make multiple trips during the day (Cervero & Duncan, 2003; Kim & Ulfarsson, 2008). Natural factors, like hills and weather, can also be deterrents to walking or biking (Cervero & Duncan, 2003).Other possible convenience factors for individuals include a lack of facilities like transfer centers, fewer bus stops, and lower frequency of bus pick-ups and drop offs. Arriving at a destination very early or late may ultimately discourage people from choosing to use the transit system.   Convenience ranks high for many passengers. If taking public transportation is perceived as inconvenient, potential riders are likely to choose another mode of transportation.

Over time, improving infrastructure could mitigate some of the convenience issues raised for both current and potential bus riders. New and improved infrastructure could add new routes and increase frequency of buses during peak hours, which would then improve accessibility and make bus travel more convenient. The first upgrade in infrastructure in Corvallis was added frequency of buses during peak hours and was implemented in September 2012 with funds from the transit operations fee.

Enjoyment, another factor described in the framework, refers to the personal benefit individuals get from the transportation mode they choose. Increased ridership can

lead to transit friendships forged while interacting with people when waiting for the bus and while in transit. At the same time, people feel good knowing they are being good stewards of the environment because through their transportation choice they are minimizing their carbon footprint (Mokhtarian & Salomon, 2001).

The final component in the theory emphasizes a person's habit. People choose a type of transportation that they are most likely to use again the next time they need transportation (Schneider, 2013). By making the socioeconomic factors of public transit more attractive, the hope is that CTS can create a habit change through different forms of utility.

The CTS program targeted changing the socioeconomic factors related to cost to create or influence habit changes thereby potentially increasing the number of people using the public transit system. Comparing data before and after the program's implementation will allow us to see if changes to ridership were significant and how much of an impact the fare-less system had in Corvallis.

IV.   Data and Methods

Corvallis Transit System (CTS) drivers count and record on paper forms the number of riders boarding the bus at every stop. These data were compiled into monthly ridership for the entire system and comprise the dependent variable in this study (see Figure 2). At the beginning of the fare-less system in February of 2011, ridership was at 75,496 for the eight main routes and increased to 102,080 by February of 2012, a 35.2% increase. However, during the period prior to the implementation of the fare-less system ridership increased 66.9% from a low of 45,230 in August of 2009.

Time-series multivariate regression models of ridership before and after the implementation of the fare-less program were used (data from July 2008 to December 2012) and controlled for *average gas price*, *OSU student population*, and *average temperature*; data sources are described below. Average gas price is an economic indicator that fits the Routine Mode Choice theory and captures the extent that the rising cost of automobile transport or price of substitutes has an effect on bus ridership. Singell & Schifferli (1983) used working population, concomitantly; our model used OSU student population to control for population change and for seasonality. While Singell & Schifferli (1983) controlled for summer or not, we used average temperature to control for the different weather conditions that might lead to different transportation mode choices. In addition to the control variables a dummy variable was created to capture the effect of the fare-less system with 0 indicating a month prior to the implementation of the fare-less system and 1 indicating post-implementation.
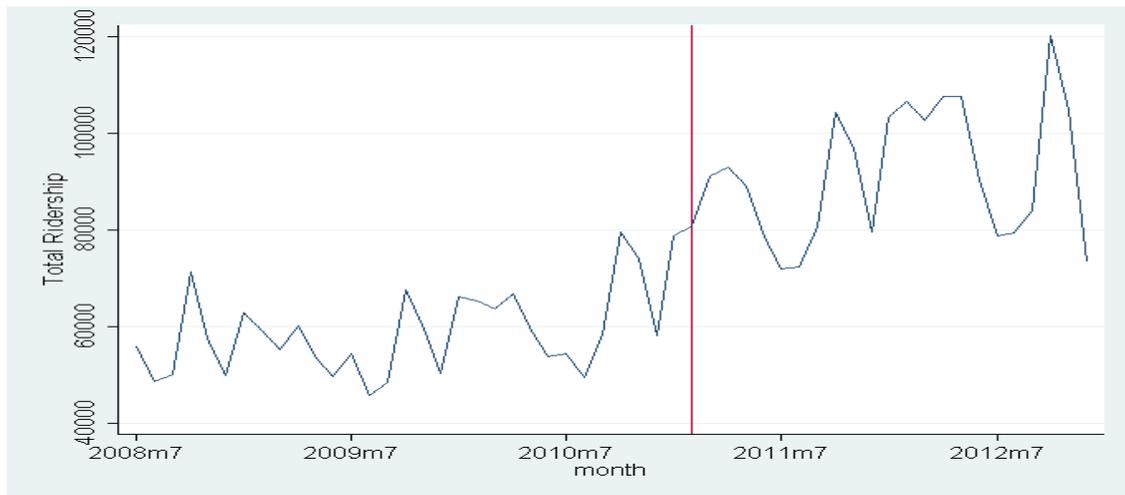
Figure 2. Total CTS Ridership over 2008-2012 red line indicates start of fare-less system.

Average gas prices were derived from the American Automobile Association's weekly reports on gas price from Salem, Oregon collected every Wednesday. Data from Salem was used because it is the closest city to Corvallis for which gas price are recorded. This weekly gas prices were used to calculate the average gas price for each month. Monthly gas prices are an economic control variable for why ridership might increase.

Oregon State University (OSU) student population was provided by the Institutional Research office of Oregon State University and includes graduate and undergraduate students. The count was conducted the fourth week of every quarter during the academic year and at the end of summer term. The student population for each quarter was assigned to each month of the term. The student population was highly correlated with seasonal dummy variables that were initially included in the models. Due to this multicollinearity, the seasonal dummy variables were not included in the final

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models. Therefore, OSU student population variable not only indicates the extent to which increased ridership was due to the increasing student population in Corvallis but also control for seasonality.[1]

Average temperature was derived from the weather station at Oregon State University. This variable was used to control for the months in which inclement weather could be a factor in increased ridership. The average temperature for July 2011 was missing from the weather station at Oregon State University so was taken from the Oregon Water Treatment plant station in South Corvallis, a distance of less than four miles.

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[1] The total Corvallis population count was left out of the model because the ridership and other variables are collected on a monthly or quarterly basis and the Corvallis population is only estimated on an annual basis. This variable was left out with the understanding that there would be increased omitted variable bias, meaning that variables that might be important to the study results were left out of the model.

Table 1
Explanation of Variables used in Time Series Elasticity Models

Variables	Explanation	Type of Variable
Log Ridership	The monthly ridership recorded for each model.	Continuous Variable that has been Log Transformed
Program Active	Dummy variable to show when the program was inactive and when it was active	Dummy variable where 0 is inactive and 1 is active
Trend	Time series trend stationary control variable.	Coded starting at 0 and increasing by 1 for each month of the data.
Log Average Monthly Gas Price	Average monthly gas prices collected from AAA for Salem Oregon	Continuous Variable that has been Log Transformed
Log Monthly OSU Population	OSU term population assigned as monthly data	Continuous Variable that has been Log Transformed. Each month of a term has the same population used.
Log Average Monthly Temp	Average monthly temperature recorded from a weather station at OSU. July 2011 came from a different weather station in Corvallis.	Continuous Variable that has been Log Transformed.
N (Months)	The number of months used in the time series data starting July 2008	

Using this data, two different models were estimated, the first only included the

eight main routes of the CTS system and the second included all CTS routes (except the

OSU intra-campus bus, the Beaver Bus, a total of 12 routes. The routes that were not

included in the first model are mainly peak-hour, express lines that service high

employment density areas. For example, there is an express bus to the Hewlett-Packard

campus at the northeast edge of Corvallis that only runs a few times a day. These routes

were excluded from the first model due to changing schedules during the period of the

study, some routes were closed and new routes opened during the 54-month period. The Beaver Bus was excluded from both models due to changing routes, changing schedules, and its restricted campus route. The CTS excludes the Beaver Bus from its calculations of year-to-year ridership change (City Of Corvallis, 2013d).

The use of time series data facilitate examining the change that occurred after the program was implemented and also accounting for any trends that were already present before the program was implemented. The time series model looked at the levels but the data was not trend stationary. Trend stationary refers to the absence of an upward or downward pattern or trend in the data as a function of time. However, in order to use time series model, data must be trend stationary.

One way to deal with non-stationary data is differencing, that is, change in the dependent variable from one time period to the next rather than the absolute level of the independent variable. This technique was not used because one can only observe the direct impact right after implementation of the program. Instead, a trend variable (a count of months starting at zero) was created to control for any trend that was previously in the data and allowed the model to examine the levels or change over time of the program not just the change right after implementation of the program even though the data were not trend stationary.

In order to determine whether there was an increase in ridership over time due to a delay in public awareness or other marketing issues, an interaction term was created by multiplying the trend variable by the program variable to see if there was an increase in

ridership over time. The result associated with the interaction variable was not statistically significant, and so the variable was not included in the final model.

The dependent variable and the independent variables, except the trend variable and the dummy program variable, were log transformed. This log-transformation was needed to estimate the coefficient for the dummy program variable as price elasticity and also to remove any heteroskedasticity that might have been present in the data.

The closer to zero, the more inelastic the ticket price is and the less that ticket price has an impact on ridership. The further away from zero, the more elastic ticket price is and the more price fluctuations are likely to impact ridership. The other variables in the model will produce results in the form of percent changes that are used to understand what variables influence changes in ridership. Both models of ridership showed non-stationary trends, but because this research examined the impact of the program over a time period, a trend variable was used to deal with this issue.

The model had no first order auto-correlation but was found to have third and twelfth order auto-correlation. This meant that the model was able to predict the upcoming values based on values three and twelve months prior. This added error and bias to the model and might have been created by the way the OSU population was assigned in the model. The auto-correlation problem was corrected by using Newey-West standard errors to the twelfth lag (Newey and West, 1987). This increased the robustness of the model but did not allow for reportage of standard R^2 like most models. This means there was no way to rank the fit of the model but only an F statistic to measure the joint relationship of the model.

V.   Results

Table 2

Time series Elasticity Linear Regression on Bus Ridership

Variables	Model 1: Main 8 Route Ridership	Model 2: Main & Expanded Route Ridership
Log Intercept	4.48*** (.248)	4.40*** (.269)
Program Active	.101*** (.026)	.093*** (.024)
Trend	.001*** (.001)	.008*** (.0004)
Log Average Monthly Gas Price (USD)	.265*** (.096)	.297*** (.093)
Log Monthly OSU Population	.124*** (.031)	.143*** (.035)
Log Average Monthly Temp (Degrees Fahrenheit)	-.219*** (.073)	-.234*** (.075)
N (Months)	54	54
F(5, 48)	121.95***	148.64***

*P<.1 **p<.05 ***p<.01
Standard Errors in Parenthesis

The F tests of both models showed that these results would only happen from randomness 1% of the time, and the model has a 99% confidence level that the relationships between these variables are present. In both models, all the independent variables were significant at the $p <= 0.01$ level, so the researcher is 99% confident that the relationships are not random, that is with slopes of zero.

In Model 1, which only included the eight main bus routes, (Table 1) the coefficient for the fare-less program dummy variable (i.e. the elasticity) was 0.101, which is relatively low compared to previous studies. This elasticity indicated that the program was responsible for a 10.1% increase in ridership on the eight main bus routes during the period of the study. The trend variable coefficient indicates for each month that passed, there was a .001 or 0.1% increase in ridership, which was also significant at $p<.01$. The result for the *log average monthly gas price* was 0.265 and is interpreted as percent change. According to Model 1, for every 10% change in average monthly gas prices, there was a 2.65% change in bus ridership. The *log monthly OSU population* suggests that for every 10% increase in OSU Population there was a 1.24% increase in ridership. Lastly, the *log average monthly temperature* indicates that for every 10% change in average monthly temperature there was a 2.19% change in ridership and the relationship was negative, so an increase in temperature resulted in a decrease in ridership. The F statistic for this model was 121.95, which was significant at the $p<.=01$ level indicating that the model fits the data better than a model with only a y-intercept or mean.

In Model 2, which contains all CTS routes, the elasticity of .93 was slightly lower than in Model 1. This indicates that the fare-less program was responsible for a 9.3% increase in ridership among all CTS routes, again slightly less than the increase in the main routes. The trend variable coefficient of .008, means that for each month that passed there was a 0.8% increase in ridership. The *log average monthly gas price* coefficient suggests that for every 10% increase in average monthly gas prices, there was a 2.97%

increase in bus ridership. The *log monthly OSU population* coefficient indicates that for

every 10% increase in OSU population there was a 1.43% increase in ridership. Lastly,

the *log average monthly temperature* suggests that for every 10% increase in average

monthly temperature there was a 2.34% decrease in ridership. The F statistic of this

model was 148.64 and again it was significant at the p<.01 level, showing joint

significance; with the higher F value, Model 2 may fit the data better than Model 1,

although a difference of F-statistic test was not conducted. Running the models using

normal standard errors produced an R^2 of 0.73 for Model 1 and 0.81 for Model 2. While

these numbers are inflated by the trend variable, they still give a general goodness of fit

estimation. Model 1 was able to explain 73% of the variance in ridership, while Model 2

was able to explain 81% of the variance in ridership.

The differences in the models are minor, with the differences in the coefficients

being less than one percent for any variable. Interestingly, Model 2, which included the

alternate routes, had a lower overall fare-less program impact on ridership. The extra

routes included were mostly routes for work or school. However, both were considered to

be work travel. Domencich and Kraft (1970) estimated the price elasticity to be 0.17 for

passengers using transit for work, so that might explain some of the drop in the program

impact because these extra routes are mainly for work type travel where price might not

have as much of an affect as on other travel. Both models show that the broad goal of the

program as set by the City of increasing ridership was met with success because there

was between 9-10% increases in ridership due to the program. This differs from the year-

over-year 37.9% increase that CTS reported because other variables also contributed to

the observed increases.

VI.   Discussion and Conclusion

Although ridership increased by 37.9% after the implementation of the fare-less program, the models utilized in this study show that the program itself was only responsible for a 9-10% increase in ridership, approximately one quarter of the overall ridership increase. This study's results correspond to those of Domencich and Kraft (1970) who found the same results when looking only at those using bus transits for work trips. Kemp (1972), who examined the 1972 Atlanta fare cut, estimated the elasticity to be 0.04, but the other studies all estimated elasticity at least double what was found in Corvallis. The goal of the program, as set by the city, was to increase transit ridership. According to that goal, the policy has been a success. Further research should be done to investigate why the program saw lower ridership change than other studies. Looking back at the Routine Mode Choice Decision theory, this program directly influenced the third component of the framework, namely, *convenience* and *cost*, by removing the cost factor. By removing this factor, they were able to increase ridership through the changing of people's habits.

The program also had an infrastructure improvement in September 2012, but due to the minimal months of data observed by this research, determining the impact of the new infrastructure was not possible. Further research should be conducted in order to determine whether the new infrastructure would improve the overall convenience of the system and have statistically significant impacts on ridership.

It is also important to note that some of the bias in the model occurred because the Corvallis population was left out due to the unavailability of monthly data. A yearly

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model was run, but it was ineffective due to a low *n* representing only 5 years of data. Another bias is the fact that the OSU population was extrapolated from term data into monthly data, where each month in a term was given the same population. This might be the cause for the third order auto-correlation that was found in the model.

The following reasons likely affected the number of people who chose public transit as their preferred method of transportation and might be a reason for lower price elasticity than what other researchers found. Corvallis has one of the largest percentages (9.3%) of citizens in the country who bike to work (McKenzie & Rapino, 2011). Corvallis is also the only metro area that appears on both the top ten biking and top ten walking commute cities (McKenzie & Rapino, 2011) and ranks as a very friendly walking town, scoring eleventh in Oregon for "Walk Score" (WalkScore, n.d.). Walkscore is a private company that ranks towns on their walking friendliness, although it does not release the full methodology for how the scores are calculated.

Along with being an alternative transportation friendly town, a large percentage of Corvallis residents already had fare-less access to the bus system. The month before the fare-less system went active Corvallis had an estimated population of 54,998 (Census, 2010) while the OSU population was 23,157. Before the program went active about 40% of potential riders already had free access to the bus. This does not include businesses that also had deals with the city for their employees to ride the bus for free.

While the fare-less program was only responsible for a 9-10% increase in ridership the other factors that played a role in the increase may be more important in the future and bear continued monitory. For every 10% increase in average gas price

ridership went up by 2.65-3%. In December of 2012 the last point of data in the model

the average gas price was $3.35 per gallon. If gas were to increase to $3.69 per gallon

then there would be an expected increase of around 2000 more rides for the month of the

increase. OSU has been experiencing an approximately 5% student population increase

per year, so if this trend continues, ridership can be expected to increase by about one

half of one percent each year. That would be around 400 more rides per month. If gas

prices and the student population continue to trend upward this could lead to capacity

problems within the CTS system and may even saturate some of the more popular routes.

Further research should be done to expand on this project. The fare-less program

was implemented to increase ridership and stabilize revenue; a further consideration

would be to identify what other steps could be taken with the new revenue to further

increase ridership. Other studies found that the travel time investment ranks very high

when people choose how to get to and from a destination. Further research might

examine whether mode tendency is focused around travel time to and from work, school,

and recreational sites. Further, if the current use is primarily for work and school

transportation, then those factors that motivate people to use the public transit system for

when they travel for personal or leisure activities should be analyzed. Domencich and

Kraft (1970) found that the elasticity of price for work was 0.17, while for shopping it

was 0.32. This suggests that most riders are using public transportation for work/school

travel when travel time is very important. The question to be explored is why people do

not use the fare-less system for other activities.

Further research could also be done on expected externalities of increased ridership. Another goal of the fare-less program was to reduce single-occupancy vehicle trips, so testing whether or not this has happened is something that could be considered. Expanding the fare-less program to the two bus lines that connect Corvallis to Albany and Philomath is a possible next step for increasing ridership of public transit systems to decrease traffic and single occupancy trips between the cities. While the bus that goes to Albany already has free ridership for students of Linn Benton Community College and OSU students, potential overall increased ridership would be expected to mimic those of the Corvallis bus system. The bus that connects Corvallis to Philomath might show different results because it does not have the same rate of student ridership as the regular CTS routes or the bus to Albany.

Some of the policy implications that can be drawn from this study are that the current policy has achieved the goals set out by the policy makers. Other cities can implement a fare-less program and expect ridership to increase. One of the plans for the policy might be to extend it to Albany and Philomath systems. Questions arising from transit expansion include the following: (1) How many inter-city lines would be free? (2) How would expansion be funded? Related to question 2, the extent to which one or more of the three municipalities involved would shoulder the cost would be a primary consideration. The Transit Operations Fee (TOF) generated one million dollars in the 2011-2012 fiscal year. Almost half of the money generated from the TOF, $400,000, replaced funding from the City's general fund, which could then be spent on other elsewhere. In the 2011-2012 fiscal year CTS provided approximately 1.1 million rides.

The average ticket price before the fare-less system went into effect was 75 cents. In the 2009-2010 Fiscal year there were about 700,000 rides on the bus system. About 49% of those rides were students that rode for free and another 11% were various business employees that also rode for free. That left about 280,000 rides that generated around $210,000 in revenue.   If the 1.1 million rides from 2011-2012 were paid that would be around $330,000 generated from fares. Even with the increased number of rides in the 2011-2012 fiscal year, the TOF generated almost double the revenue that the previous fare system would have generated. That is, the average revenue per ride went from 75 cents to almost $1.50. For a fare-based system to generate the same revenue as the TOF a doubling of the fare would have been necessary. So from a certain fiscal perspective, the 9-10% increase in ridership that the fare-less program generated was a result of a near doubling of revenue/cost per ride. Whether that outcome was justified is a public policy question for the Corvallis public transportation system.

Going back to the mission statement and goals of CTS, the fare-less program did increase ridership. Through increasing ridership, CTS has taken a step in meeting many of the goals that the city has set, including providing a viable transportation alternative for all citizens as now anyone can afford to ride the bus. This research cannot make the claim that air pollution or energy consumption was reduced because data are unavailable. Further, the possibility exists that those who started using the system were not using private vehicles prior to accessing the system.

In conclusion, it is clear that the fare-less program in Corvallis, Oregon was a success because it increased ridership. Further studies need to be conducted to determine

how the new revenue could be spent to improve the system to help change people's travel habits. After more time has passed, infrastructure improvements should also be tested to ensure that the increased revenue is being used toward the goals of increasing ridership and decreasing single-occupancy vehicle trips. An additional evaluation of CTS is needed to see where else it can make policy changes in order to incorporate factors leading to altering the habits of the community based on the Routine Choice framework.

As the need for cities to revamp their public transportation systems to solve ever-increasing transportation problems arises. The fare-less program as adopted by Corvallis, Oregon is a success in relation to all of the targeted aspects of the policy. Other cities could see if there are ways that it could be implemented in their own area, not only to push the policy during an active time of change for transportation policy, but also to prevent and lessen the transportation issues of the future. This study finds that removing fares increases ridership by 9-10%, and while this suggests lower price inelasticity than other studies, cost is still a factor in getting people to break habits and use public transportation.

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Appendix: Non-Statistically Significant Models

Table 3

Interaction Term Showing Non-Significance

Variables	Model 1: Main 8 Route Ridership	Model 2: Main & Expanded Route Ridership
Log Intercept	4.51*** (.250)	4.43*** (.274)
Program Active	.045 (.049)	.047 (.047)
Trend	.001*** (.001)	.001*** (.0004)
Log Average Monthly Gas Price	.279*** (.098)	.308*** (.095)
Log Monthly OSU Population	.122*** (.031)	.141*** (.035)
Log Average Monthly Temp	-.239*** (.078)	-.251*** (.081)
Interaction (Trend*Program)	.0015 (.001)	.0012 (.001)
N (Months)	54	54
F(5, 48)	206.28***	227.72***

*P<.1 **p<.05 ***p<.01
Standard Errors in Parenthesis