CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

Public Transit in Los Angeles

Analysis of Transit Services Provided by the Los Angeles Department of Transportation

A thesis submitted in partial fulfillment of the requirements

For the degree of Master of Science in Interdisciplinary Studies

By

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ABSTRACT

Cost Effectiveness of Public Transit in Los Angeles

Analysis of Transit Services Provided by the Los Angeles Department of Transportation

By

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Master of Science in Interdisciplinary Studies

Transportation has many political, economic, and social facets that have led to a complicated history of private companies and public agencies working with, for, and sometimes against each other in Los Angeles. In this paper comparative analysis is used to evaluate the transit services provided by the Los Angeles Department of Transportation (LADOT). LADOT's DASH and Commuter Express bus services compare favorably to the aggregate of all transit agencies in the United States across a variety of performance measures. LADOT's demand responsive service, in the form of the Cityride program, does not compare as favorably. As a public agency managing private transit providers, LADOT has internal evaluation processes and measurements used to eliminate, expand, or alter service. This research relies heavily on comparing existing data sets, performance measures, reports, and a broad combination of other historical and contextual information to provide a robust understanding of a modern public transit agency and the corresponding geographical transportation network. Using the data and analysis on fixed-route bus services, the development of a multi-modal

transportation network company focused on specific demographics of potential riders is recommended. Finally, a measure that aims to quantify and compare the cost and time to an individual person to travel a mile by a given mode of transportation is introduced and developed. Overall this paper aims to develop an understanding of contracted transportation, as well as the broader transportation network of Los Angeles.

INTRODUCTION

Transportation has many political, economic, and social facets that have led to a complicated history of private companies and public agencies working with, for, and sometimes against each other in Los Angeles. Public transportation, municipally owned, has existed in Los Angeles since 1951 when the California State Legislature created the Los Angeles Metropolitan Transit Authority to address a broad range of transportation challenges. Prior to that, privately owned and operated rail, trolley, bus, and even horse drawn lines existed since the late 1800's. As the transportation of people is a necessary function that leads to productivity and the creation of wealth, it was profitable to operate transit services accessible to the general public in return for reasonable fares. With the creation and expansion of the use of the private automobile, along with inefficient operations of the major privately owned transit companies – the Southern Pacific (SP), Pacific Electric (PE), and Los Angeles Railway (LARY) -- the 1920's through the 1960's saw dramatic changes in the way that Angelenos traveled. Some of the changes involved the shift from rail to motor-bus transit vehicles. Many of the overarching transportation developments from the 1920's to present day Los Angeles reflect aspects of Gomez-Ibanez and Meyer's (1993) history of the pattern of urban bus service; their research helps illustrate the evolving nature of transportation systems outlined in Table 1.

Trends in Urban Transit Service	**Los Angeles Example (foot note)**
1. Entrepreneurial	The Pacific Electric and the Los Angeles Railway began utilizing motor coaches in 1917 and 1923 respectively. They received competition from other private transit providers operating buses.
2. Consolidation	National City Lines (NCL) augmented their networks with the purchase of the Los Angeles Railway in 1944. NCL

	controlled 46 transit networks by 1947. The Pacific Electric sold its passenger service in 1953 to the Metropolitan Coach Lines.
3. Regulation of Fares and Franchises	Pacific Electric (PE) requested permission to raise its fares in the late 1940's, but the California Public Utilities Commission required PE to upgrade its equipment as a condition to raise fares. The cost of capital improvements was too large a barrier, preventing PE from raising fares.
4. Decline in Profitability	In Los Angeles, this was a general trend across transit providers starting in the 1910's and continuing through to the shortages in rubber and fuel of the 1940's due to World War II. During the war time scarcity period, public transportation in the United States was healthy. Once the post war industrial boom led to the further expansion of the automobile, public transportation has not come close to profitability.
5. Withdrawal of Capital and Services	After being prevented from raising fares in the late 1940's, the PE decided to eliminate its passenger rail service altogether. The large debt burdens carried by the SP, PE, and LARY prevented them from acquiring loans to expand service.
6. Public Takeover	American City Lines, a subsidiary of National City Lines, was forced to cede control of Los Angeles Transit Lines to the Metropolitan Transit Authority in 1958. The MTA continued to purchase individual bus lines from Pasadena to San Pedro.
7. Public Subsidies	With the creation of the Metropolitan Transit Authority and later the Southern California Rapid Transit District, local, state, and federal money was used to operate transit services.
8. Declining Efficiency	With increase in the acceptance and utilization of the automobile, public transit was moving people at increasing cost from the 1950's to the 1980's.
9. Dilemma of subsidy cuts, fare increases, and service cuts	These are ongoing struggles as the MTA and LADOT are both in the process of

	seeking fare increases while evaluating the efficiency of routes on a regular basis. Public funds and budgets for transportation have always been tied to the broader economy.
10. Privatization	Currently the Los Angeles Department of Transportation contracts out the operations of 32 DASH and 13 Commuter Express Routes.

Table 1: How Los Angeles Fits Gomez-Ibanez and Meyer's (1993) Urban Transit Pattern.

*The information in this table has been compiled through a combination of sources detailed in the History and Background section of this paper.

Competition between private transit companies saw rail lines transition to bus lines and private motorbus companies merge and acquire other companies. At the same time, the development of Los Angeles' Major Traffic Streets Plan in the 1920's ran into little opposition as the private automobile captured the culture, imagination, freedom, and democratic impulse of the politically-influential and middle-class population of Los Angeles (Bottles, 1987). Private transit companies grew increasingly less profitable and disjointed, eventually precipitating the need for a public transit authority capable of planning and operating a transit system able to move hundreds of thousands, and eventually millions of people across the global metropolis of Los Angeles.

Automobiles, Public Transit, and Privatization

Automobile registration in Los Angeles County went from 0.28 vehicles per resident in 1920 to 0.54 vehicles per resident in 2010 (U.S. Census) – instead of 1 car for every 4 people, there is now 1 car for every two people. This increase in the number of automobiles parallels an even more dramatic decline in public transit ridership from over 50% of the population utilizing public transit on a regular basis in the 1920's to 7.2% in 2010 (Census). Automobile ownership is inextricably linked to income (Deka, 2002;

Nolan, 2010), which emphasizes the fact that transportation has been and continues to be an issue of socio-economic equity.

Today, public transportation in Los Angeles is dominated by the Metropolitan Transit Authority (MTA), a public agency at the county level. Its governing board includes appointed experts as well as elected officials from different cities within Los Angeles County. As LA County encompasses 88 individual cities of varying geographies, populations, and economies – this thesis will delve into a complicated landscape of different political bodies spending tax money on projects and priorities based on varying philosophies on transportation, economics, and politics. This landscape has, over the last half century, led to a transportation-culture that depends on and prioritizes the private automobile. However, with the City of Los Angeles' 2014 Mobility Plan, there is a pronounced shift towards a multi-modal approach that recognizes the limitations of the automobile, the benefits of rapid mass transit, and a focus on streets designed for people. A more detailed History and Background section of this paper will provide context to the current transportation network of Los Angeles.

Outside of the Metropolitan Transit Authority, many different cities within Los Angeles County operate their own transportation agencies providing services to the public, including Long Beach Transit, Montebello Bus Lines, Norwalk Transit, Santa Monica's Big Blue Bus, Santa Clarita Transit, Torrance Transit, Foothill Transit, Antelope Valley Transit, and the Los Angeles Department of Transportation (LADOT), whose transit services this research will focus on.

With Transit being critical to the achievement of a wide range of social, economic and environmental objectives (Gilliam, 2008), the $54,475,000,000 spent by public

transit agencies in 2012 should be evaluated. The privatization of public transportation, most notably through the contracting out of fixed-route bus services, was reintroduced in the 1980's and expanded to the point that over a third of public transit agencies contracted out some of their services by 2002 (Iseki, 2004). This research will focus on Los Angeles City's Department of Transportation. Specifically, LADOT operates three major transit programs 1) DASH Bus, 2) Commuter Express Bus, and 3) Cityride Demand Responsive Paratransit. The DASH and Commuter Express bus services are operated by private companies that must win contracts through a competitive process to earn the right to operate the City's bus services. Additionally, LADOT's demand responsive transit service is operated by a private company under the Cityride program. As LADOT is a public agency managing private companies that provide services to the public, LADOT has developed evaluation processes and measurements used to eliminate, expand, or alter service. This research utilizes LADOT's Line-by-Line analysis conducted in 2010 along with a combination of other data to provide a robust understanding of a modern public transit agency and evaluate its service.

Unlinked Passenger Trips, Route Analysis, and Cost Effectiveness

The efficiency of transportation can be measured in many different ways, which is why terminology used by the National Transit Database (NTD) will be used throughout this thesis. The term 'unlinked-passenger-trip' refers to a single boarding of a transit service – if an individual needs to get on a bus and then transfer to another bus to get to their destination that would count as two unlinked passenger trips. Using 'unlinked-passenger-trip' helps to clarify and simplify the issue of unique passengers, transfers, and ridership by giving a specific term to represent a single trip on a specific mode of

transportation. Ridership, a broader term that describes the number of unlinked trips made on a given route or on an entire transit system, is a crucial factor to any reasonable measure of transportation service efficiency.

Unfortunately, public agencies and private corporations considering cost as the primary factor when evaluating transportation services. The purpose of public transit is not to claim money spent on transportation, but to actually move people from an origin to a destination. The methods and strategies used to evaluate public transportation are so focused on cost, that the time it takes to use public transit is not considered in most academic research on the privatization of fixed-route bus services as discussed in the Literature Review of this paper.

There are many technical terms used to describe service supply, service consumption, and financial information that will be briefly outlined in the Methodology section and thoroughly analyzed in the Data and Results section of this paper. Service supply is measured using the number of hours, or miles, of bus service are available to the public; the terms for this concept are 'vehicle-revenue-hours' or 'vehicle-revenue-miles.' Service consumption is measured by the number of passengers or the number of miles traveled; the terms for this being 'unlinked-passenger-trips' or 'passenger-miles.' Financial information for transit services is mostly comprised of operating and capital expenses. Capital expenses describe the amount of money it takes to build or purchase transit equipment and facilities. Operating expenses describe the money it takes to pay workers, organizational costs, and fuel. This paper will evaluate transit in Los Angeles as provided by the Los Angeles Department of Transportation using measurements of service supply, service consumption, and financial information.

In the Data and Results section, a combination of data from the National Transit Database, the Los Angeles Department of Transportation, and California Public Records Act Request are presented and analyzed. This research will analyze existing transportation services at multiple levels, comparing the services of LADOT to all transit agencies in the country, between different private companies operating LADOT's routes, different modes of transportation offered by LADOT, and individual routes.

The amount of money spent by a transportation provider to move a person is a fundamental measure of efficiency and is a good indicator of productive efficiency (Hensher, 1987). However, costs vary tremendously across transit providers and even within a transit provider as different routes are affected by a multitude of factors. This research will also make a broad assessment of the existing transportation network by using cost, time, and ridership across modes of transportation.

After analyzing and comparing existing contracted fixed-route bus operations, a solution focused on improving the quality of transportation for a specific demographic of commuters – students, staff, faculty, and administration at California State University Northridge – is included in the Conclusion and Recommendation section of this paper.

BACKGROUND AND HISTORY OF TRANSPORTATION IN LOS ANGELES

Transportation in Los Angeles has a long history that includes privately owned rail companies, mergers of transit providers, public outrage leading to new transit policy, and a car culture that has been evolving since the 1910s.

Throughout the 19th century American cities developed around a city center as walking, horses, and later omnibuses were the only modes of transportation. This meant that traveling long-distances was not feasible on a daily basis, which led to unhealthy population densities as sanitation infrastructure was often lacking. Los Angeles, on the other hand, developed post 1900 along with the advent of electric rail, streetcars, and the trolley. This allowed Los Angeles' population to grow in a dispersed and decentralized fashion making it home to the most extensive interurban rail system in the world by the 1920s (Hanson, 2004; Bottles, 1987).

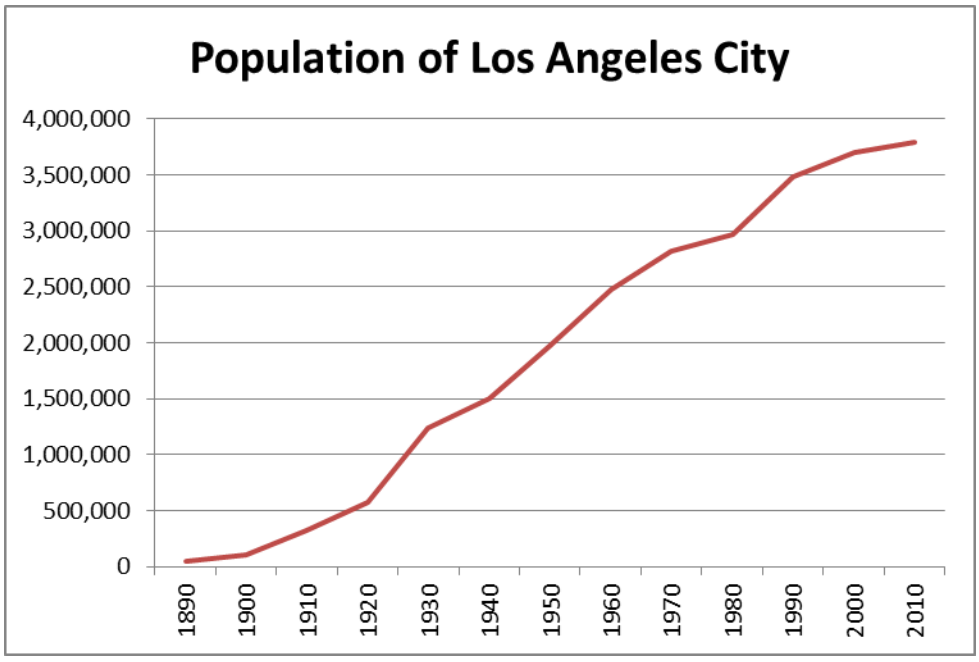

Figure 1: Historical Population of Los Angeles

Public transportation in Los Angeles started with the chartering of horse drawn rail lines in the 1870s -- the City Council would issue franchise to an individual who would incorporate a company to operate a route or a rail line. Routes on individual streets were often the only piece of transit operated by a given company. With new lines opening and closing, consolidation, buyouts, and other transactions, by 1905 the major operators of rail were Los Angeles Railway (LARY), Southern Pacific (SP), and Pacific Electric (PE).

From Rail to the Automobile

Before the private automobile dominated the transportation policy of Los Angeles, politics and the drive for profit combined to turn what used to be the largest electric rail system in the world into an overcrowded yet unprofitable, unpopular, disjointed, and inefficient utility. Even though the Southern Pacific, the Pacific Electric, and the Los Angeles Railway provided much needed service, they were often used by their owners to improve the value of their personal real estate holdings while the public complained about overcrowding and a lack of connectivity.

In the case of Los Angeles transportation, one major figure was Henry Huntington who incorporated PE in 1901 after he was denied leadership of SP when his uncle, who was the President of SP, died in 1900. Huntington, like many electric streetcar builders throughout the United States, used his railway system to increase the value of his real estate holdings. This was done by building lines to connect specific holdings of real estate to the Central Business District or Downtown. After 9 years of unprofitable railway building, which allowed Huntington to make millions on his real estate, he sold much of his transit interests to his rival, the Southern Pacific. Out of this "Great Merger" PE

became a subsidiary of SP and Huntington gained control of the LARY. The LARY was itself a valuable component of the transportation network; at the start of the 20th century the LARY accounted for 90% of all rail traffic in Los Angeles (Bottles, 1987). With the tremendous growth of Los Angeles at the start of the century, population behaviors shifted frequently with the introduction of new technology.

By 1910, rail companies across the country were trending towards unprofitability weighed down by a debt burden that averaged around 50% of total assets. It proved expensive to build rail infrastructure and only fare revenue in a few high-traffic areas was enough to turn large profit. This made it nearly impossible to find more investment to expand; even though Los Angeles' population doubled between 1913 and 1925 the LARY only built 24 miles of new track. The Pacific Electric averaged annual losses of $1,500,000 for 29 years between 1912 and 1940.

As the Pacific Electric was a for-profit private company, it abused laws and provided poor service to passengers in order to increase profit by reducing costs. PE hauled freight on lines that were supposed to be only for passengers and laid track before getting permits from the city. As the relationship between politicians and the heads of transit companies was in the news, the general public grew restive. The most common criticism was that the railways did not run enough trolleys or cars leading to worse than standing room only conditions during rush hour. The public argued transit vehicles were not in use to increase profit, while the rail companies argued it was a combination of factors including the cap on $0.05 fares. Traffic and congestion caused by the combination of private automobiles, pedestrians, and rail vehicles prevented public transit to operate on schedule further aggravating the situation.

Another major failing of the PE and LARY was to not allow transfers from one company's lines to the other's, in fact the "PE even refused to issue transfers between its interurban trains and its own streetcars" (Bottles, 1987). For over a decade, from 1916 to 1926, the building of a 'union station' where intercontinental railroads would connect was fought vehemently by the private rail companies in order to protect their monopoly on rail traffic to Los Angeles.

While the public grew more and more disenchanted with transit service, the Southern Pacific Railroad and public utility companies dominated the local Democratic and Republican political machines through a not so subtle combination of economic pressure and outright bribery (Bottles, 41). This led to citizens organizing to win political office, which then led to the creation of the Board of Public Utilities Commissioners, which validated the public's complaints about the transit companies. Even with this validation, the Board of Public Utilities could not force the rail companies to provide better services.

The public's frustration led many to look for transportation alternatives. The jitney, an early entrepreneurial version of the taxicab, provided what was to come with the flexibility of the automobile. After being introduced in Los Angeles in 1914, Jitneys were moving 150,000 people a day in Los Angeles by the end of 1915. The jitney was expanding across the country and counted over 60,000 operators, but was getting pushback from transit companies and political bodies. In Los Angeles, the City Council moved to dramatically limit the free reign that jitneys were enjoying through regulations.

By 1917, Ford's Model-T was being sold for between $345 and $360 and began being widely adopted. Traffic and congestion were mentioned by local papers as early as

1912, but by 1918 the Board of Public Utilities and the Engineering Department of the City of LA noted in a report that "traffic speed along Broadway was frequently lower than walking speed" during evening rush hour. As the automobile was becoming more popular, and the rail companies were not improving the quality of their service, automobile registration in Los Angeles nearly doubled the year after World War I (Bottles, page 59), and quadrupled from 110,000 in 1918 to 440,000 in 1924.

Streets for the Automobile

The "democratic impulse" that led individuals to start adopting the automobile soon led to collective action on the part of Angelenos to facilitate the passage of policy that would improve auto infrastructure. There were several different plans that focused on the building and improvement of roads, each of these plans targeting the improvement of specific streets with the intention of developing a comprehensive Los Angeles road plan. Citizen groups, public organizations, and business associations began pushing for legislation and a comprehensive plan to improve streets.

With the traffic problem becoming so painful that it needed to be dealt with, the Los Angeles City Council proposed a ban on parking in Downtown in November of 1919. This unleashed a broad debate that eventually saw the ordinance amended repeatedly to favor the use of private automobiles with some restrictions. This was one of the first major policy battles that foreshadowed the supremacy of the automobile in the eyes of policy makers, supported by influential constituents, for the decades to come. Even though 90% of traffic entering Downtown was entering on rail lines, supporters of the automobile were able to rally support from influential business interests and the well-organized affluent middle classes to win legislation that alleviated congestion while still

allowing the automobile wide access to the crucial business district of Downtown Los Angeles.

The new legislation that limited parking in Downtown, was effective for only a few months. As the post war population boom saw the suburbs gain huge numbers of people, the rail companies were still in no position to build new lines, meaning that the only viable mode of transportation for the influx of people was the private automobile. With congestion again quickly becoming a major issue, the solution trumpeted was the expansion and modernization of streets and roads across Los Angeles.

As the increased use of the automobile lead to exponential traffic, the problem became focused on Downtown Los Angeles. In Downtown the traffic approached approximately 500,000 people per day [239,202 passengers between 7am and 6pm by car and 261,637 by rail] (Bottles, 1987). The influential political demographic that used the automobile was also the force that gave the Traffic Commission the ability to present the Major Traffic Streets Plan to the City Council. The Los Angeles City Council was quick to put the measure on the ballot. The newspapers of the time including the Los Angeles Times, Herald, and the Examiner supported the plan as the way to build the world-class infrastructure that Los Angeles needed to fulfill its destiny as a global metropolis.

A $5,000,000 street bond accompanied the Major Traffic Streets Plan and the voters of Los Angeles approved both in 1924 even though none of the other bond measures passed. Unfortunately, the $5,000,000 bond would only cover about 10% of the cost of the entire plan. Traffic and taxes have regularly been able to get citizens to the polls to vote for policy -- this is true of the highest turnout election in Los Angeles City history, which came after the Major Traffic Street Plan and gave voters the choice on a

potential location for Union Station, elevated rail, and a continuing battle in regulatory standards around what a government can demand from private companies. Eventually, the people voted 61.3% to 38.7% in favor of a Union Station for Los Angeles after long legal battles between the private companies who refused to build a single major terminus for Los Angeles (Bottles, 1987). All of these transportation issues of the time enjoyed long debate in the public conscious through publications and advertisements. Even with voters supporting Union Station, the infrastructure, politics, and culture of Los Angeles had shifted towards the automobile.

Fixed-Route Bus Services and Public Transit Agencies

As the rail lines continued to lose prominence, competition from private bus lines began to multiply while reorganization, mergers, and takeovers of these bus lines was a regular occurrence. There was the Los Angeles Motor Bus Company (renamed Los Angeles Motor Coach Company circa 1930), LA CBD & Westside Lines (1923-1949), Motor Transport Company (1922-1939), Original Stage Line (Los Angeles-San Fernando), Pasadena Ocean Park State Line, Studio Bus line (Hollywood-Culver City, started in 1913), and the Asbury Rapid Transit System (which subsumed other lines between the 1930's and 1954). National City Lines (NCL) was a major player that bought, sold, and reorganized Lines in Glendale, Pasadena, Inglewood, and Long Beach. NCL also bought a majority stake in the Los Angeles Railway and renamed it the Los Angeles Transit Lines (LATL) around 1945. The NCL acquired the Los Angeles Motor Coach Company in 1949. The Metropolitan Coach Lines was the successor to the Pacific Electric Railway and consolidated some minor bus operators. The details of the routes

and operators are not particularly relevant, just the fact that there were many private for-profit companies competing to provide transit services to the public.

The MTA itself has operated as different forms throughout the years, and was initially formed as a transit-planning agency by the State of California in 1951 dubbed the Los Angeles County Metropolitan Transit Authority (LACMTA). It wasn't until 1958 that it was given the capital and authority to acquire existing privately-owned bus lines. This followed a general trend throughout the country where the increased productivity of transit systems during the early 1940's due to shortages of fuel and rubber during World War II was completely reversed by the 1950's as people left public transit for the now abundant private automobile. The LAMTA acquired the Los Angeles Transit Lines, Metropolitan Coach Lines, and the Asbury Rapid Transit System to "create the first publicly-owned and publicly-governed transit system in Los Angeles effective March 3, 1958" (MTA, Transit History).

The LACMTA later acquired the Crosstown Suburban Bus Lines in 1961, the Foster Transportation Company in 1962, Glendale City Lines in 1962, and Riverside City Lines in 1963. By 1964, LACTMA's limited ability to levy taxes, limited political clout, and inability to acquire property through eminent domain led the California State Legislature to create the Southern California Rapid Transit District (SCRTD) on August 22, 1964. The SCRTD superseded the LACMTA and was given more powers to design and build a transit system for Los Angeles. It acquired several local suburban bus companies including Pasadena City Lines, Inglewood City Lines, Blue & White Bus Company, Eastern City Transit, San Pedro Motor Bus Association, Highland Transit, San Pedro Transit Lines, Western Greyhound Lines, Ontario-Upland Bus Lines, and the

Pomona Valley Municipal Transit System. Many of those routes comprise some part of the 191 local bus lines operated by the modern MTA.

In 1976, the State Legislature created the Los Angeles County Transportation Commission (LACTA), which was to oversee public transit policy in the county and was to approve funding plans and highway capital development. In 1993 the State Legislature created the modern Los Angeles County Metropolitan Transit Authority via a merger of the LACTA and the SCRTD. Even with an organization such as the MTA with so much history and broad authority, Los Angeles currently has many publicly funded transit services and agencies including Metrolink, Culver City Municipal Lines, Long Beach Transit, Santa Monica Bus Lines, Foothill Transit, Los Angeles Department of Transportation, La Mirada Transit Service, Montebello Bus Lines, and the Norwalk Transit System to name a few.

The modern Los Angeles Department of Transportation (LADOT) was created through an ordinance of Los Angeles City in 1979 and began functioning in 1984. However, transportation functions of the City can be traced back to the Major Traffic Streets Plan adopted in the 1920's and the many departments that shared piecemeal responsibilities dealing with transportation such as the Bureau of Street Traffic Engineering that existed in the 1930's and the Department of Traffic Engineering created in 1949, which became the Department of Traffic after a change in the City Charter in 1953. By the 1970's it was clear that the City of Los Angeles needed a single department with a broader mission that could manage everything from gasoline rationing and car pool efforts to rail system goals and environmental quality compliance. The creation of LADOT allowed the City to operate its own fixed-route bus services in addition to the

existing dial-a-ride services for seniors and wheelchair bound people that would now be consolidated into one department.

Currently, the Los Angeles Department of Transportation operates 1) local bus service under the DASH moniker, 2) long distance bus service under Commuter Express, 3) a demand responsive service for seniors and the disabled under the Cityride program, and 4) a demand responsive taxi service that allows registered Cityride clients to use their discounted fare values on City-franchised taxi cabs. LADOT's functions also include a range of transportation issues that include parking, ticketing, and traffic signals.

From LADOT's FY 2013-2014 Short Range Transit Plan:

> "**DASH** service comprises 85% of total fixed-route weekday revenue hours and 71% of total fixed-route weekday revenue miles in the LADOT system. DASH operates twice as many vehicles as Commuter Express and carries over nine times as many passengers on an average weekday. DASH routes typically operate between 6:30 AM and 7:00 PM, Monday through Friday, with selected routes operating as late as 10:00 PM. Many DASH routes also operate on Saturdays and a few offer service on Sundays/holidays."
>
> "The **Commuter Express** program is a suburb-to-Downtown, or suburb-to- suburb, line haul weekday peak hour service. Commuter Express service is provided primarily during peak commute periods on weekdays from 5:00 am to 9:00 am and 3:00 pm to 7:00 pm. Commuter Express Line 142 is the exception; it operates from 5:20 AM to 11:40 PM on weekdays and from 5:30 AM to 11:15 PM on weekends/holidays.

> Headways typically vary from 15 to 60 minutes among the thirteen Commuter Express lines."
>
> "The **Cityride** program is a user-side subsidy transportation program and dial-a-ride transportation service for seniors and persons with disabilities offered by the City to supplement the federally-mandated Access Services paratransit program. Cityride began as a program to consolidate several dial-a-ride and subsidized taxi services. Cityride clients can purchase a specific amount of subsidized fare value each quarter of the year which is redeemable for trips on the Cityride dial-a-ride service and/or City-franchised taxicabs. There are currently 40,000 active clients in the Cityride program."

The operations of the Los Angeles Department of Transportation and its contracted fixed-route bus services is colored by a century of history where private companies have evolved along with the changing demographics, technology, and public sentiment towards transportation.

LITERATURE REVIEW:

PUBLICLY VERSUS PRIVATELY OPERATED TRANSIT SERVICES

The belief that private corporations can provide services more efficiently than government has resulted in a broad trend across the country, and world, where public transit agencies hire private sector companies to provide transit services to the public.

As the conflict between capital and labor is translated into a neoliberal ideology that pushes for the privatization of public services, the operation of fixed-route bus services has been a well-documented, industry-wide example with conflicting research sometimes showing that privatization lowers costs and other times shifts costs with variations in service quality.

The trend towards privatization of public transportation began in the early 1980's in the United States as the Reagan Administration promoted private-sector involvement in public transit as a way to reduce costs, specifically in relation to federal funding. Federal agencies including the Urban Mass Transportation Authority vigorously promoted the privatization of public transportation highlighted by the example of Denver in 1990, where the Denver Transportation Authority was required to contract 20% of its fixed-route bus service to private corporations (Peskin, 1993). By 2003, almost 40% of public transit agencies that used federal funds to provide fixed-route bus services were partially contracting services (Iseki, 2010), and in 2005 contracted transit accounted for $2.1 billion out of the $15.6 billion spent on bus operating expenses by public transit agencies.

In addition to fixed-route bus services, a major component of the transportation network is demand responsive operations, which grew after the Americans with

Disabilities Act of 1990 forced public transit agencies to make services accessible to people in wheelchairs (Zullo, 2008; McCullough et al., 1998). Different modes of transportation each have different evolutionary histories, but this literature review will focus on the research around fixed-route bus services and this particular mode of transportation's role in the broader transit network.

Contracted Bus Services

As the contracting out of fixed-route bus operations by public agencies has been going on for decades and is a multi-billion dollar industry, contract negotiations are often a key factor in the efficiency of transit service delivery (Hensher, 2010). Recounting public meetings where contracts were discussed and voted on, such as Los Angeles City Council Meetings, would make for an interesting research question that will, unfortunately, not be included in this paper.

There are a few examples of research in the literature that look at specific instances of private transit services in comparison with those that are publicly operated in the same geographic area. In New York, the cost per passenger on privately operated bus services was $1.07 in 1982 and $1.32 in 1984 while the New York City Transportation Authority was at $1.25 per passenger in 1982 and $1.49 per passenger in 1984 (Downs, 1988). Even though the private companies were moving people for less money than their public counterparts, Downs (1988) shows that other variables -- the cost and impact of new vehicles, the quality of service (cleanliness, waiting time, temperature), route characteristics, scale of operations, and factor costs paid, specifically labor, could easily change the cost per passenger equation, and more broadly, the economic and social value produced by transportation. Also, the cost of administering the contract, processing

grants, procurement, planning, marketing, and evaluation often are not considered (Sclar, 1989; Downs, 1988). Even though the cost to operate a given bus network has been the primary focus of the literature while the cost per passenger is barely mentioned (Zullo, 2008; McCullough et al., 1998; Teal, 1991; Iseki, 2010; Downs, 1988), the number of people that are moved per dollar via public transit it is recognized by many researchers as significant.

Because of a multitude of variables specific to a given transit agency, whether contracting actually saves money, is an empirical question. Even though a series of studies from the 1980s and early 1990s collectively found that per vehicle-mile or vehicle-hour a savings of 10-40% was realized by contracting out fixed-route services (Peskin et al., 1993; Richmond, 1992; Karlaftis et al., 1997; Nicosia 2001), those same authors, and others (Iseki, 2010) have found that a multitude of variables, including partial or full contracting of transit services can impact the cost-efficiency of contracting out services.

Even amongst proponents whose position generally lies on the side of privatization, the broad conclusion on cost-efficiency is that the single variable of 'publicly-versus-privately' operated is not statistically significant (Teal, 1991). Many other factors are regularly found to have more of an impact, but the way that impact is measured is usually based on some sort of cost-efficiency, often in the form of 'cost per vehicle revenue hour' (Teal, 1991; Zullo, 2008; McCullough et. al, 1998; Iseki, 2010). Many contracts with private companies that provide transit service make payments based on the number of hours that the provider is operating the bus, which is referred to as vehicle-revenue-hour.

More broadly, the differences between publicly and privately operated transit services are not obvious to the rider (Downs, 1988; McCullough et. al, 1998) as fares are regulated, routes are regularly redrawn across transit systems as a matter of protocol, and similar buses are used regardless of the geography, agency, or operator. In addition to the research conducted on the factors that lead agencies to contract out services, there is a large body of research examining whether contracting does in fact reduce costs. Some of the studies have examined the same transit operator and resulted in conflicting conclusions (Peskin 1993; Sclar, 1997; Denver RTD Public Financial Management 2001), highlighting the contentious nature of contracting fixed-route bus services to private companies. Past literature has also disagreed on what effects of contracting should be measured and how best to measure them, sometimes because of political bias (Kim, 2005). Early research focused on cost per vehicle-hour of contracted service compared to directly provided service.

Impacts of Privatization

Peskin, Mundle, and Varma (1993) reported cost savings of 12.5% based on an incremental cost analysis and a 25.8% savings based on a fully allocated cost analysis in one year for fixed-route bus services. The Denver RTD Public Financial Management (2001) claims that it saved at least $40.1 million (31%) over nine years based on a fully allocated cost analysis. For the Indianapolis transit system, Karlaftis, Wasson, and Steadham (1997) found a cost efficiency increase of 22% on contracted routes over a six-year period using monthly data and a cost efficiency indicator. Teal (1985) and Teal and Giuliano (1986) find significant cost savings across a dozen cases of privatization where the average savings were 39% for fixed-route bus services and 43% for commuter bus

services. As all of these researchers used different cost allocation models and even different variables the results are unsurprising in their variation. Opponents of privatization, namely Sclar (1989, 1997, 2000) argues that most studies ignore or underestimate the transaction costs that public agencies incur through the bidding, evaluation, negotiation, and monitoring processes of private contracts. Along with a host of externalities that are also outside calculations and difficult to identify and even harder to quantify such as lost wages, inefficiency, and lost income taxes.

Service quality and safety records of privately contracted service do appear to be a problem, often because low wages paid by private companies due to a higher turnover rate amongst drivers. Higher turnover rates lead to less experienced drivers, who are more likely to get into accidents (McCullough et. al., 1998). The data on other service reliability factors such as on-time performance, missed trips, late trips, road calls, and passenger complaints is not robust, and has mixed results depending on the specific instance of contracting. Even so, many privately operated bus networks employ unionized drivers as different unions were able to follow the privatization trend and organize workers (Kim, 2005).

The cost of transitioning from in-house service to outsourced bus services can itself eliminate potential savings for public agencies (Teal, 1991; Sclar, 1989). Even though the cost will vary from transit agency to transit agency, empirical research shows that in Suffolk County the estimated cost of administering and monitoring the contracted service was 1.3%, in San Diego County 9.9%, Orange County Transit District 3.9%, and according to Teal (1991) ranges between 3 and 10%, with most system not exceeding 5 to

6%. Other costs that usually aren't reduced through contracting include planning, marketing, and customer information (Teal, 1991; Downs, 1988).

Generally, the literature is pretty clear that individual variables that are not dependent on private or public operations have more of an impact on the cost of operating fixed-route bus services. The most studied and influential aspect on the cost benefits of privatization revolves around labor costs.

Differences between Private and Public Labor Costs

When contracting out bus service to private companies has been found to save money, it is often at the expense of labor (Black, 1991; Peskin, 1993), due to both the hourly wage gap and the fringe benefits that public employees generally receive (McCullough et. al, 1998). Black (1991) goes on to argue that even though some cost savings are realized, the exploitation of labor is not a position that should be espoused by individuals that believe in collective bargaining and "the privatization of public transit implies an oppositional stance to labor unions" (Black, 1991). However, the broader political atmosphere -- elected representatives' and major news media's anti-union rhetoric – has allowed the conversation, and literature, around the privatization of transportation to fall into a debate centered on the cost to the public rather than the benefit to the public.

The wage gap between privately employed drivers and publicly employed varies tremendously, with Teal (1991) finding private employers paid as little at $5 per hour and as much as $9 per hour for bus drivers. In 1987, the difference between public and private drivers in Dallas was 25%, in Denver the difference was more than 30%, and in Houston the difference was over 100% ($5 per hour paid by privates versus $11.75 per hour by the

public agency). The issue of productivity and the efficient use of labor is also a recurring theme where Teal (1991) found that publicly employed drivers were paid 23.4% more hours than they actually worked while their private counterparts were paid 3.5% more hours worked in Fort Wayne between 1985 and 1987.

Until Kim (2005), there were few studies that focused on the effects of privatization on labor, but Peterson et. al (1986) found that the difference between unionized bus drivers and non-unionized drivers who were working for private companies, were on average making 21% and 45% lower than their respective counterparts in public agencies. Fringe benefits and work rules, which are slightly more complicated to calculate than simple wage gaps, also account for an important difference in cost when considering privatization of transit services (Kim, 2005).

When considering labor implications, the context is broader than just wages as labor unions are inextricably linked to politics and politicians. Transit worker unions are regularly opposed to any kind of privatization effort because it threatens union members' wages, benefits, and ultimately their jobs. Also, legal regulations come into consideration surrounding labor protection as described in Section 13 (c) of the Urban Mass Transportation Act (O'Leary, 1993). Contracting also tends to have a "ripple effect" lowering the costs of public services (Bladikas, 1992) as the process weakens the bargaining position of unions (Giuliano and Lave, 1985). Most poignantly, workers at public agencies have often agreed to wage concessions when competing with private transit operators as documented by Hurwitz (1992), McCullough (1997), and Morlok (1996).

The difference between workers employed directly by government and those workers employed by a private company are manifested in the literature around the contracting out of transit services, but the overall trend, regardless of public or private employment, has been a stagnation of wages and reduced benefits for transit workers (Savage, 2004).

Contracts: Negotiation, Evaluation, and Competition

Different agencies have different processes for soliciting bids on services. The conditions under which these bids are solicited, as well as the components of the contracts agreed to, can have major impacts on certain aspects of contracted fixed-route bus service (Hensher, 2010; Hensher, 2013).

Differences between competitively procured, negotiated contracts, and franchise agreements have been linked to variability in real unit costs for contracted service (Teal, 1991). The fact that it is up to the private company to put in bids has led to transit contractors with a national scope restricting their bids to large contracts, which sometimes produces very few bids for major contracts. In Dallas, Houston and Snohomish County, Washington, the respective transit agencies received only 2 and 3 bids for commuter bus service contracts (Teal, 1991). This is particularly a limiting factor if the private company has to purchase its own vehicle fleet, as that would create a large barrier to enter the marketplace. This also leads to private companies depreciating the value of their vehicles more rapidly and increased risk premiums due to uncertain disposal value (Teal, 1991). Overall, without robust competition for contracts, public agencies may be taken advantage of by private operators that are aware of market conditions.

The fact that private operators are in competition with each other often leads to unrealistically low bids as a major evaluation factor is the proposed cost to the public transit agency. The service quality (on-time performance, missed trips, late trips, road calls, and passenger complaints) was impacted by such "very low bids" by the same contractor in New Orleans and Miami (Teal, 1991). Once a private company wins a contract, it becomes difficult for the public agency to hold that private provider accountable without great cost and upheaval, especially if the contract was written without appropriate performance conditions as has been the case according the Hensher (2010). Well-designed contracts with competitive bidding and adequate oversight should theoretically provide service at lower costs compared to public agencies (Savage, 1986; Black, 1991; O' Looney, 1998; Sclar, 2000), because public agencies must deal with redundant staff, high labor costs, and political pressures (Black, 1995). However, a lack of competition, contracts that do not connect contractors' performance to pay, and inadequate oversight, may reduce efficiency of contracted service (Iseki, 2010). Also, many costs associated with developing "requests for proposal, evaluating bids, negotiating contracts, and monitoring contracts could offset or even exceed cost savings from contracting" out transit services (Sclar et al., 1989; Sclar, 1997, 2000).

In addition, competition between transportation providers is cultivated through the practice of Contract Tendering (CT), criticized by Sclar (1989) for fundamentally changing the priorities of public transportation away from ridership and public good towards a focus on reducing the cost to government. Private companies cannot be counted on to prioritize the quality of service above profits, but a public agency that develops measures, contracting procedures, and evaluation standards that are used to hold

a private contractor accountable can benefit from the practice of contracting out transit services.

Methods and Approaches from the Literature

Basic statistics and data on the movement of people can be easily conveyed and quickly understood, but verifiably knowing the number of people that boarded a given vehicle and traveled for some distance is not as simple. Major transit agencies, including the Los Angeles County Metropolitan Transit Authority have had discrepancies in their ridership numbers (Los Angeles Times, Jon Schleuss, Nov 2013). Regardless, many public agencies use varying methods of estimation, sampling, or measures of fare payment to generate statistics that are generally accepted and reported to the National Transit Database, which serves as an official hub for statistics on transportation in the United States. Many transit studies, including those on the cost-efficiency of contracted out bus service, utilize data from the National Transit Database. Even though ridership is considered at least briefly in most studies, the amount of time a passenger spends waiting for the bus, or in transit, is hardly mentioned in any of the previous studies on the efficiency of private bus service providers.

In analyzing the cost efficiency of fixed-route bus services and the impacts of privatization, researchers have identified several major factors and variables that impact the overall cost function. Building on that, other researchers, particularly Iseki (2004) developed a systematic approach to evaluate the determinants of transit service contracting through the application of regression analysis methods and specifically analyzing the level of contracting as a dependent variable. Many studies focus on individual factors that influence contracting, specifically economic factors. Many studies

have relied on the National Transit Database for information and statistics, which has regularly updated what data it collects, perhaps in response to the published research and gaps in data.

An entire vein of research focuses on the decision of contracting out bus services. Regression studies on the likelihood that a transit agency will contract out services have included variables that represent potential cost saving factors, agency operational characteristics, agency financial characteristics, service area characteristics, and labor related factors (Luger and Goldstein, 1989; Reja, 1999; Nicosia, 2001).

Luger and Goldstein (1989) used a survey asking transit managers about their sentiments towards labor unions, toward contracting, power orientation for decision making, openness towards innovations in operations, flexibility to pursue innovations, the system peak to base ratio, the proportion of dedicated funding in their agencies' budgets, and the strength of labor in their agencies. Luger and Goldstein (1989) then tested them along with factors described in the previous paragraph and found that only transit managers' sentiment toward contracting and the residential density of a service area are statistically significant to determine the likelihood of contracting bus services.

Reja (1999) examined fleet size, annual ridership, federal operating subsidy per vehicle mile, dedicated operating subsidy per vehicle mile, and total wages and benefits per vehicle hour to test a series of hypotheses about an agency's likelihood of contracting out bus services. Reja (1999) used the Ordinary Least Squares model as well as a logit model. Nicosia (2002) modeled agencies' contracting decisions as the first step of the simultaneous equation model using NTD data on 319 firms over 5 years using variables such as vehicle hours, number of modes, median vehicle capacity, lagged number of

contracts, number of contractors in a metropolitan statistical area, level of unionization, number of Democrats in the state legislature, and if the governor was a Democrat. Nicosia (2002) applied a logit model to a cross-sectional time-series data set.

Iseki (2004) improved on the above analyses by expanding the categorization level of contracted services to include no contracted services, partially contracted services, and fully contracted services. While Iseki (2004) acknowledged the logit regression model with a dichotomous variable is methodologically correct, he goes on to use the unordered multinomial logit model. Iseki (2004) also used a Tobit model because a range of values, he argues, is more appropriate than the OLS.

The unionization rates have been found to be a factor when transit agencies are considering privatization (Nicosia, 2001), specifically in areas where government worker unionization rates are high and private sector unionization rates are low, transit agencies will choose to contract out. Additionally, Lopez-de-Silanes, Shleifer, and Vishny (1997) find that factors outside of cost, particularly anti-union laws and state laws that restrict government financing can also push transit agencies towards privatizing fixed-route bus services.

The many factors that determine if a transit agency will contract out service only touch the many functions and roles of public transportation in a metropolitan city in the United States of America. As publications and research tend to have a narrow focus on a specific question within larger societal issues, the literature on the likelihood of a transit agency privatizing its services often does not put the role of fixed-route bus service in context of the broader transportation network.

Summation

The broader literature on transportation theory is robust, ranging from the algorithms that govern traffic lights to the most efficient way to deliver packages. With so many academic papers being published, the Transportation Research Record itself has published 9,000 peer reviewed papers on transportation (Transportation Research Record). There are dozens of peer reviewed scientific journals that have been publishing for decades. Without getting too much into the details of academic peer reviewed publications, we must recognize the millions of news stories, public comments, business deals, that are not well reflected in the academic research. With 34,800 hits on Google Scholar for the search term 'airline deregulation' is a microcosm on how the capitalist university incentivizes and in some way steers academic production. Unfortunately, the depth of analysis given to the route of a plane along its 3 or 4 stops is not applied to the most utilized mode of public transit, the bus. The bus route is unique to its geography and has unique characteristics from route to route. Recognizing this complexity in different ways, the bulk of the literature acknowledges, develops, and expands our knowledge and understanding of different metrics used to measure and evaluate transportation.

The literature has started to recognize the connectivity between different levels and layers of the transportation network. However, much of academia focuses on narrow research questions that, academics hope, have broad application or relevance. In the literature on the privatization of fixed-route bus service across the United States, a clear process in the development of ideas and research focus is hard to distinguish.

This Literature Review did not delve into the global literature on the privatization of public transportation, specifically fixed-route bus service. In fact, the biennial Thredbo Conference focuses on the competition and ownership of land passenger transport and

has produced. The Thredbo Conference has produced or has been the place where hundreds of peer reviewed articles have been presented, a large vein of the research on contracted bus services. However, in their last conference, the concept of 'formal' and 'informal' transport was discussed at length. The transportation network includes all modes and forms of transport, all the way to the infrastructure that facilitates walking. The concept of transportation network does not seem to be well developed and is difficult to apply. This paper also aims to develop the concept of the transportation network, utilize data from LADOT, and produce a multi-model transportation network recommendation capable of getting commuters to their destination cheaper and faster than before.

The literature also acknowledges that the pollution emitted by our current transportation infrastructure will change the global ecosystem more dramatically than we will be able to adapt to as a species. This does take into account the evolving transportation behaviors of India and China. We need a dramatic rethinking of the way transportation services are provided and utilized, and the global metropolis of Los Angeles has seen the cultural focus on the automobile start to weaken. The broad deprecation around Los Angeles' transportation network is paralleled by a silence of applicable literature specific to the transportation geography of Southern California. This thesis tries to outline the broad issue of transportation in Los Angeles, analyze data on a specific segment of the transportation network, apply that information to produce a recommendation, and hopefully lay groundwork for future research on a complicated constellation of transit behavior, public transportation agencies, and modes of transportation.

METHODOLOGY

In this section data from different sources will be presented, variables will be briefly described, and methods of comparative analysis explained. The National Transit Database (NTD) collects, organizes, and archives massive amounts of data on an annual basis from transit agencies across the United States. From the NTD, robust data on LADOT from 1999 to 2012 will be compared to the national average. My research focuses on the Los Angeles Department of Transportation, specifically on contract packages awarded to the corporations that operate the DASH and Commuter Express Bus services detailed in Tables 2 and 3. This paper will also analyze the individual Northridge DASH route. In addition to the publicly available information from the NTD, data on detailed ridership and cost figures for specific LADOT bus contracts through the California Public Records Act was acquired. Information from LADOT's 2014 Short Range Transit Plan, Transportation Management and Design's 2010 Line-by-Line Analysis of all City transit services, published public budgets, and information from transit agency websites was also included. Using this combination of information and data, this paper will present an analysis of contracted bus and demand responsive services in the City of Los Angeles in the following Results and Analysis section.

Terminology

Modes of Transportation

The National Transit Database collects and publishes information on 18 different modes of transportation operated by public agencies. Out of those different modes of transportation, this paper will focus on 1) bus, 2) commuter bus, 3) demand responsive, and 4) demand responsive taxi. LADOT only provides these 4 modes of transportation. The regular bus category refers to local buses operating on a fixed-route time schedule.

Commuter bus refers to long distance buses that often go from suburbs to central business districts at rush hour. Demand responsive services are characterized by small and medium sized vehicles dispatched to service passengers who specifically request transportation by phone or scheduled appointment. Demand responsive taxi service is a form of demand responsive service operated through private taxicab providers. 'Demand responsive' was bifurcated into 'demand responsive' and 'demand responsive taxi' in 2010 when the Federal Transit Authority created new rules to help evaluate smaller agencies operating in more rural communities. In 2011, the National Transit Database split the category of 'bus' into 'bus' and 'commuter bus.'

Transit Operations

Transportation statistics are regularly categorized by service supplied, service consumption, financial information, and performance measures. The following paragraphs outline the information collected by the NTD in terms of supply, consumption, and finance.

Service supplied refers to how much transit service is being provided by a given agency. Some basic measures of service supply are vehicle-revenue-miles, vehicle-revenue-hours, and vehicle fleet characteristics.

Service consumption refers to how much people are actually utilizing the transit service. Typical measures for service consumption include passenger miles, unlinked trips, and fare revenues earned. Fare revenues are both a measure of consumption and impact financial information.

Financial information for public transit agencies and the money they spend is broken down into operating expenses and capital expenses. Operating expenses include a

wide range of costs including salaries, wages, benefits, and fuel. Capital expenses include all purchases of vehicles and construction of facilities.

Performance measures are functions of transit supply and consumption that indicate efficiency. Performance measures are broken down into categories of service efficiency, cost effectiveness, and service effectiveness. Service efficiency is measured by a function of operating expense per vehicle revenue mile and operating expense per vehicle revenue hour. Cost effectiveness is measured by a function of operating expense per passenger mile and operating expense per unlinked trip. Service effectiveness is measured by a function of unlinked passenger trips per vehicle revenue mile and unlinked passenger trips per vehicle revenue hour.

One of the major issues at the heart of my study is the difference between directly operated transit services and purchased transportation. These terms differentiate between services that are operated by a transit agency and those that are operated by a private company through contract. The data on this is robust as transit agencies across the nation operate different modes of transportation using different governing strategies. Many technical terms have briefly been mentioned here, but a detailed explanation and analysis of these terms along with corresponding data is included in the following section of this paper.

Comparative Analysis

LADOT is a small part of the transportation network of Los Angeles, but even so, it has a budget of $131,085,453 (City of Los Angeles Budget Fiscal Year 2013-2014, page 161). LADOT operates 32 DASH Routes and 13 Commuter Express Routes, but does not directly employ a single bus driver. LADOT contracts out the operation of its

fixed-route bus services to private corporations through varying competitive processes. Different private companies such as Veolia, MV Transit, and Coach America operate different routes for LADOT under different contracts. Table 2 shows the 32 DASH Routes while Table 3 shows the 13 Commuter Express Routes, their region, and the private company they are operated under. Much of the information on the contracts that LADOT has agreed to with private corporations to operate bus services has been acquired through an employee of the Los Angeles Department of Transportation. This employee's contact information was made available after a California Public Records Act Request was filed with the Los Angeles City Controller's Office.

DASH Route	Region	Operator
1. Beachwood Canyon	Mid-City	Veolia Transportation
2. Boyle Heights	Central	MV Transit
3. Chesterfield Square	South	MV Transit
4. Crenshaw	Mid-City	Veolia Transportation
5. Downtown - A	Downtown	Veolia Transportation
6. Downtown - B	Downtown	Veolia Transportation
7. Downtown – D	Downtown	Veolia Transportation
8. Downtown – E	Downtown	Veolia Transportation
9. Downtown - F	Downtown	Veolia Transportation
10. El Sereno / City Terrace	Central	MV Transit
11. Fairfax	Mid-City	Veolia Transportation
12. Highland Park / Eagle Rock	Mid-City	Veolia Transportation
13. Hollywood / Wilshire	Mid-City	Veolia Transportation
14. Hollywood	Mid-City	Veolia Transportation
15. King East	Mid-City	Veolia Transportation
16. Larchmont Shuttle (Hollywood / Wilshire)	Mid-City	Veolia Transportation
17. Leimert / Slauson	Mid-City	Veolia Transportation
18. Lincoln Heights / Chinatown	Mid-City	Veolia Transportation
19. Los Feliz	Mid-City	Veolia Transportation
20. Midtown	Mid-City	Veolia Transportation

21. Northridge	North	Coach America
22. Observatory Shuttle	Mid-City	Veolia Transportation
23. Panorama City / Van Nuys	North	Coach America
24. Pico Union and Echo Park	Central	MV Transit
25. Pueblo Del Rio	Mid-City	Veolia Transportation
26. San Pedro	South	MV Transit
27. Southeast	Mid-City	Veolia Transportation
28. Van Nuys / Studio City	North	Coach America
29. Vermont / Maine	South	MV Transit
30. Watts	South	MV Transit
31. Wilmington	South	MV Transit
32. Wilshire / Koreatown	Mid-City	Veolia Transportation

Table 2: LADOT DASH Routes, Region, and Operator

Commuter Express Route	Region	Operator
1. 142 – Long Beach	South	MV Transit
2. 409 – Sylmar/Sunland to Civic Center	North	Coach America
3. 419 – Chatsworth to Downtown	North	Coach America
4. 422 – Thousand Oaks / Woodland Hills	North	Coach America
5. 423 – Thousand Oaks / Parkway Calabasas / Encino to Downtown / USC	North	Coach America
6. 431 – VA Medical Center / Loyola HS to Financial District	South	MV Transit
7. 437 – Venice to Financial District	South	MV Transit
8. 438 – Palos Verdes / Imperial-Aviation to Financial District	South	MV Transit
9. 448 – Rancho Palos Verdes to Financial District	South	MV Transit
10. 534 -- Westwood	South	MV Transit
11. 549 – Pasadena	North	Coach America
12. 573 – Century City	North	Coach America
13. 574 – Redondo	North	Coach America

Beach		
14. Union Station / Bunker Hill Shuttle		

Table 3: LADOT Commuter Express Routes, Region, and Operator

In LADOT's Line-by-Line Analysis of 2010, the agency created a performance index to compare routes, and then ranked them according to the results. The index for an individual route used scores from three functions:

1) *Passengers/hour score* = (route passengers/hour)/(average passengers/hour)

2) *Subsidy/passenger mile score* = LOG [(route subsidy/passenger mile)/(average subsidy/passenger mile)] + 1

3) *Operating ratio* [all revenue/operating cost] *score* = route operating ratio/average operating ratio.

The performance index allows LADOT to clearly see which routes, according to these indicators, were comparatively more efficient. The detailed results of LADOT's analysis are not included in this paper. Even though this paper will not explicitly utilize LADOT's methodology for comparison between routes, most factors that were utilized, such as passengers per hour and operating cost, will certainly impact my basic methodology of comparative analysis.

Cost and Time per Mile

It would be helpful to have a single function that indicates how long and how much it costs to travel a certain route. Another objective of this paper is to develop a rudimentary measure that includes both time and cost per mile and work towards an application of it in the Conclusion and Recommendation section. Even though my data and research reflects the combination of all routes among all transit agencies across the

United States, there is also a focus on the Northridge DASH route. The different layers of analysis in this paper narrow from a combination of all transit agencies down to a specific route; In between is the Los Angeles Department of Transportation, the 'bus' versus 'demand responsive' modal comparison, and the different private companies' operation of multiple routes.

As has been discussed, the value of travel time is often not considered in the research. This research will give travel time value by directly converting travel time into dollars using the per capita money income of Californians and extrapolating the value of a minute. The per capita annual money income for Californians between 2008 and 2012 was $29,551 (U.S. Census Bureau). If we consider employment to be distributed over 50 weeks of work a year and 40 hours a week, that equates to $0.25 per minute. Using this simple value will allow me to compare modes of transportation by both cost and travel time through a single cost measure.

In order to compare different modes of transportation on the same route, I was able to acquire the Northdridge DASH's Daily Performance Schedule (DPS). The DPS is a geocoded data sheet that keeps track of when the bus arrived at the scheduled time-point. The Northridge DASH has 6 time-points along its 8 mile route. The entire route and all of its stops are shown in Figure 2. This data will permit the calculation of the average trip length, but also the standard deviation for each trip. Higher level analysis could focus on the relationship between time-points. Having this data makes it possible to calculate a robust comparison across modes of transportation for travel time and its fluctuations throughout the day.

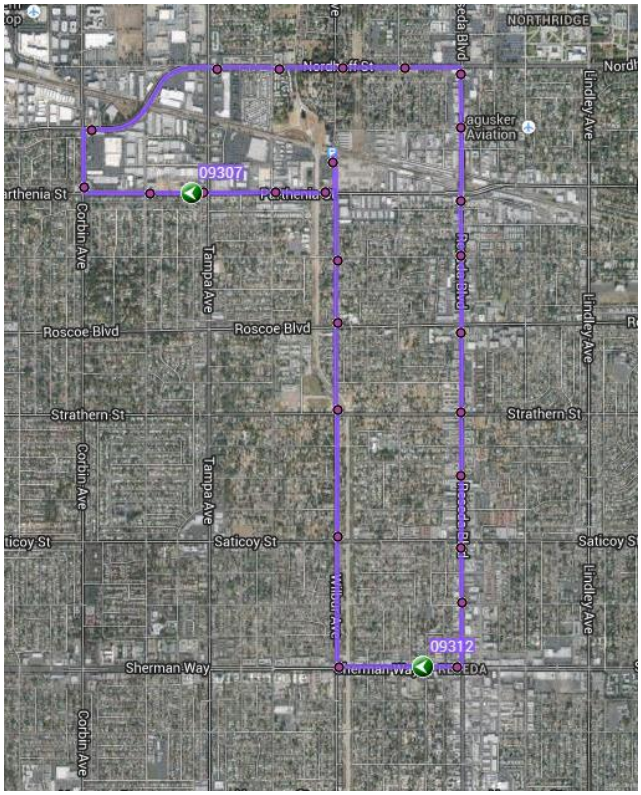

Figure 2: Northridge DASH Route and Real Time GIS Map

Another piece of information that I was able to acquire from LADOT was the Monthly Performance Statistics report. In this report information on passengers, revenue hours, operating costs, and passenger revenue is included for the Northridge DASH, as well as all routes operated by LADOT. In the next section I will use this data to help develop a multi-modal time-cost-distance comparison along the DASH Route.

In addition to the statistics on bus usage, collecting reliable information on the operations of a private automobile in terms of cost and time was required. In order to get a reasonable estimate of the cost of operating a private automobile, I utilized the 2013 American Automobile Association (AAA) Driving Cost Report (AAA, 2013). AAA has been calculating the cost to operate a vehicle since 1950. At that time, AAA found that driving a car for 10,000 miles cost $0.09 per mile. There proprietary methodology accounts for fuel, maintenance, tires, insurance, license, registration, taxes, depreciation,

and finance. The AAA also finds that costs significantly vary depending on the size of the vehicle and the number of miles driven, which is of paramount relevance to this study.

The time-cost of riding a bicycle is also considered as a viable transport option. Acknowledging the vast difference between cost, energy, and time of motor versus muscle transport, it is still a relevant comparison. By comparing the bicycle to the bus and the automobile, the broader issue of the environment and the pollution emitted through the burning of fossil fuels for transportation can be discussed. A more holistic understanding of the costs, benefits and necessities of transportation is the broader aim of this thesis. In order to calculate the cost to operate a bicycle per mile, I used the midpoint of the Victoria Transportation Policy Institutes' calculation (Litman, 2014). Included in the cost per mile is vehicle purchase, maintenance, tires, insurance, and depreciation -- but fuel, license, registration, taxes, and finance have been left out.

Already having robust time data on the Northridge DASH, in order to gather travel time data for the automobile and the bicycle, I turn to Google Maps. Empirical data would be preferable, but for the purpose of this paper, I will utilize different travel time data acquired on Google Maps. Data for the automobile and the bicycle will be collected at different times of day to establish an average travel time for different times of day along the Northridge DASH route.

Levels of Analysis

As discussed in the Literature Review, the current academic literature does not consider the time of the passenger or rider in much of the research. Even though money and time are interwoven in the economy, cost has been the most important variable in the academic research and literature. This is clearly manifested when we consider poor

people's time is not valuable. This study directly addresses that gap in the literature and develops rudimentary methodology to incorporate the standard deviation of travel time in calculating cost-time-distance.

In the following section, I will take nation-wide transit agency statistics and compare them to the Los Angeles Department of Transportation. I will then take the LADOT statistics and further break down operations by comparing the companies that operate different routes, against each other. However, I will not compare individual routes to other individual routes; the only route I specifically identify is the Northridge DASH. Every bus route, regardless of operator, is intrinsically geographically different, making a comparison between routes complex. In order to address the differences between routes, the multitude of variables and measurements mentioned in this section are relevant. The background on variables and measurements from this section will be utilized to provide a nuanced and comprehensive analysis of the operations of LADOT across modes of transit service, across individual transit providers, and a specific route.

DATA AND RESULTS

In this section, I will explain measurable transportation concepts such as ridership, operating expenses, vehicle revenue hours, fare recovery, and other relevant information that allows for a comparison and analysis of the urban transit operations of the Los Angeles Department of Transportation (LADOT) relative to other transit agencies and in context of the broader multi-modal transportation network.

Figure 3 gives some background to the scale of transit operations by number of vehicles operated in all transit agencies across the country. Figure 3 also shows how purchased transportation has increased from 25.6% of all transit vehicles to 35.2% from 2002 to 2012. Nationwide, there were 112,060 vehicles operated by public transit agencies in 2012. Out of those vehicles, 39,466 (35.2%) were purchased transportation, indicating that a private company was paid by a public agency to operate those vehicles.

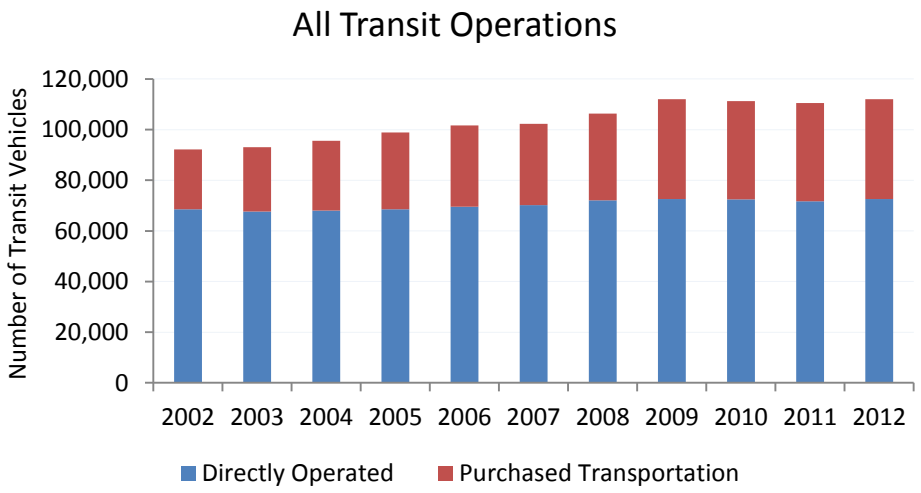

Figure 3: Total Public Transit Vehicles Operated in the United States

Out of those 112,060 transit vehicles operated by transit agencies across the United States in 2012, 51,090 were buses. When Figure 3 is compared to Figure 4, it is

clear that buses make up a substantial proportion of the public transit fleet, decreasing from 54.7% in 2002 to a still sizeable 45.6% in 2012. With the National Transit Database separating the category of 'commuter bus' from 'bus' starting in 2011, commuter bus service accounted for 1.9% of total bus operations in 2011 and 3.1% in 2012. The percentage of contracted out buses increased from 10.8% in 2002 to 18.8% in 2012.

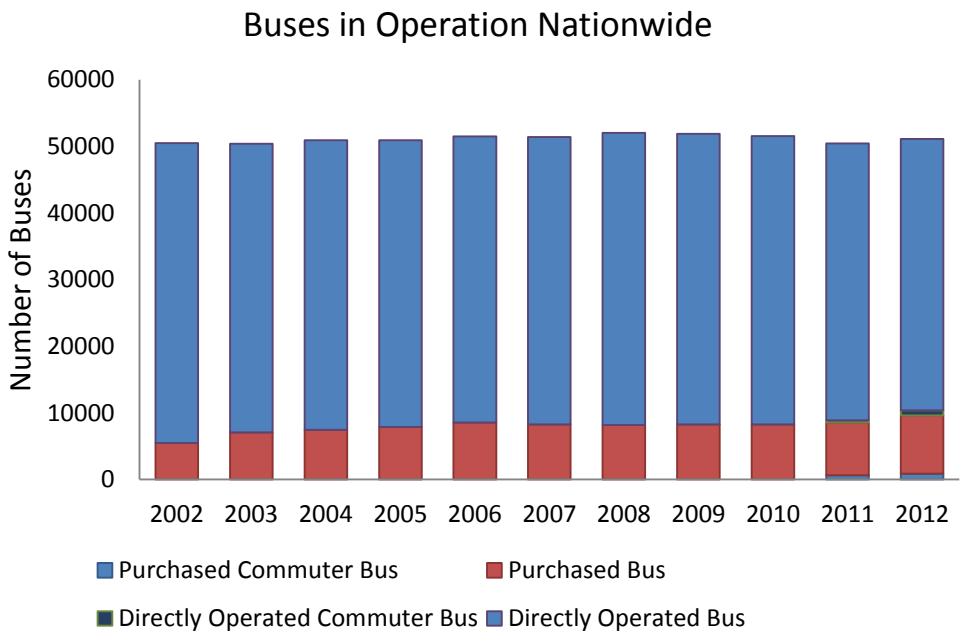

Figure 4: Number of Buses in Operation throughout the United States

The growth in privately-operated publicly-funded transit service is highlighted by the Los Angeles Department of Transportation. LADOT has had all of its buses and demand responsive services operated by private companies for years, totaling 450 vehicles in 2012. Those 450 vehicles include 233 DASH buses, 98 Commuter Express buses, 110 demand responsive vehicles, and 9 demand responsive taxi vehicles.

In addition to bus services, LADOT and many transit agencies across the country provide 'demand responsive' transit services. While buses constitute 45.6% of the public

transit fleet in 2012, demand responsive vehicles make up 25.7% of the total public transit fleet. Figure 5 translates that to 28,761 demand responsive vehicles, which can vary tremendously in vehicle characteristics. Throughout the rest of this section, data on transit operations and service from an aggregate of all transit agencies will be compared to LADOT's individual operations.

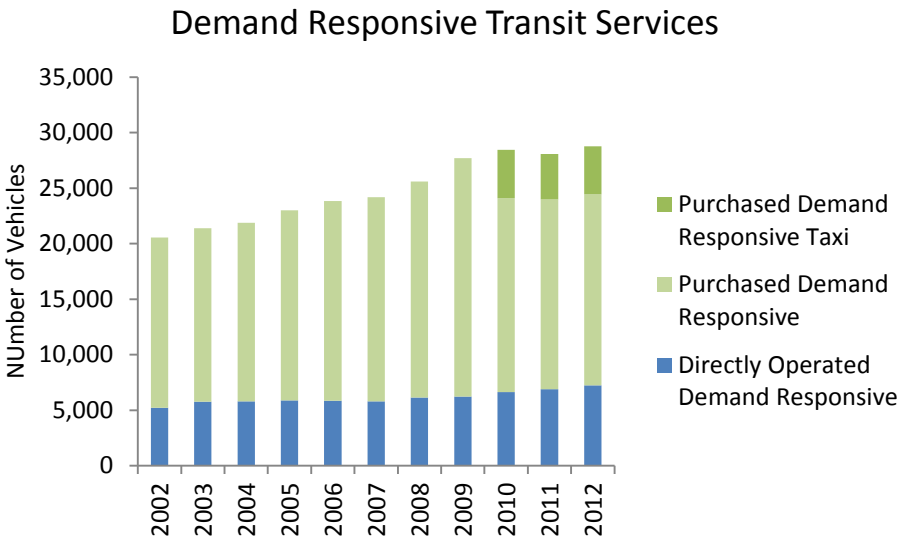

Figure 5 Demand Responsive Transit Vehicles Across All Transit Agencies

Financial Information

Source of Operating and Capital Funds

Money for transit can indicate priorities, politics, and generally determines service supply. Money can come from, local, state, federal, or "other" sources. It was actually because of the reduction of federal transit subsidies under the Reagan administration that the contracting out of bus services flourished. As public funding and budgets are highly political, there is tremendous variation on the source of funding. For LADOT's passenger transit services over the last decade, Figure 6 shows a complicated history. Also, the

NTD does not include all sources of funding for all operations of a transit agency. In order to obtain a full picture of the operations of LADOT, in addition to NTD information on the source of funds, a more thorough financial audit would have to go through the annual budget of LADOT published as part of Los Angeles City's budget process.

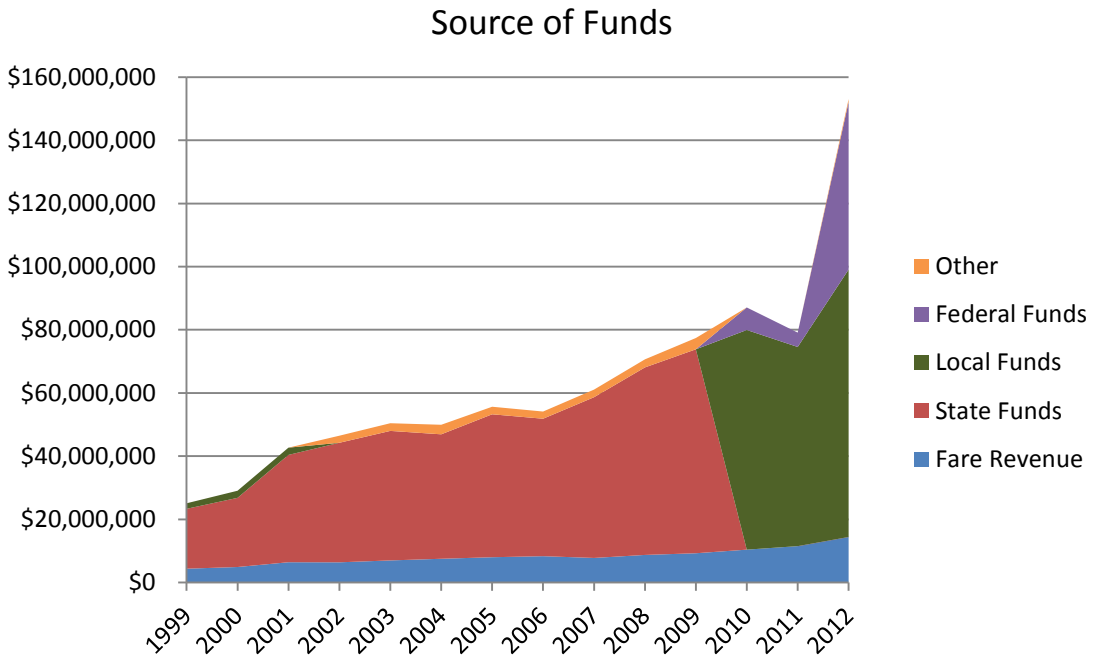

Figure 6: Source of Funding for LADOT as reported to the National Transit Database

Figure 6 shows the reported funding sources for LADOT since 1999. The dramatic shift in funding shows that state funds went from $64,577,874 in 2009 to Zero in 2010. The gap in funding was apparently picked up by local funds which went from $2,294,795 in 2001 to Zero between 2002 and 2009 and then increased to $69,559,581 in 2010. Federal funds were not a part of this reporting until 2010, but LADOT was receiving different funds from the federal government for different transportation projects and services prior to 2010. This confirms that the financial reporting of funds to the NTD does not provide a complete picture.

A major component of transportation funding in Los Angeles has been through voter approved sales tax measures. Proposition A (1980) and Measure R (2008) are both half-cent sales tax measures that generate revenue and funding for transportation in Los Angeles. Those funds are administered through the County and have different equations and formulas to determine which cities in the county receive how much money and which projects will be capitalized. Los Angeles City received $178,999,572 from Proposition A funding in 2013-14 and is expecting $265,091,723 in 2014-15. Only part of that money is used to pay for transit services as LADOT's budget is also responsible for traffic signals, road conditions, and a host of other expenses related to transportation in Los Angeles City.

Federal funds are usually used on capital expenditures, but connecting the source of funds to their end use can be complicated. Different policy from year to year and changes in reporting technique make following the money a complicated pursuit that deserves individual research and focused attention. In this paper, I will not go too much further into the source of funds except for fare revenue.

Operating and Capital Expenses

Where and how a transit agency spends its money is clearly an important factor in evaluating service. When a transit agency contracts out service, operating expenses generally indicate how much transportation service was purchased from a private company. The National Transit Database also collects information on salary, wages, and benefits of transit agency workers that are tasked with managing and supervising the purchased service. This is actually rather simple because money is paid directly to the private company to handle all aspects of route service. Capital costs include the

purchasing of new vehicles and facilities. Even though private companies operate buses and other vehicles, those vehicles are generally purchased and owned by the given transit agency. Through the NTD data in Figure 8, we can clearly see when LADOT purchases new vehicles, but it takes going through other documents and research to figure out how many buses were purchased and how they are going to be utilized.

In Figure 7 we see that the majority of capital expenditures made by transit agencies do not go to the four modes of transportation that this research focuses on. A large percentage of "other" includes capital expenditures on light and heavy rail. As the capital expenditures on buses have been between $2 and $4 billion annually, the number of new buses on the roads is a sizeable industry.

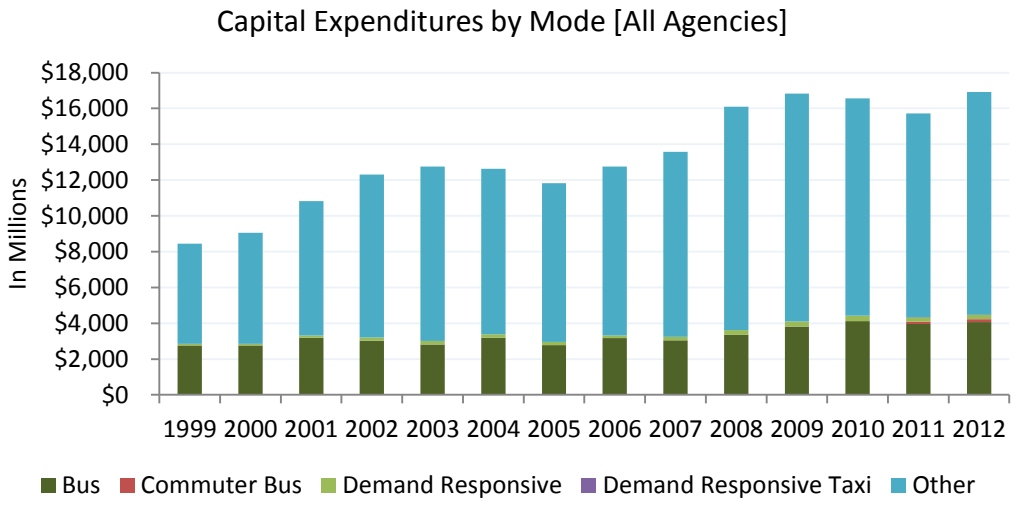

Figure 7: Capital Expenditures by All Transit Agencies

In Figure 7 we see LADOT's capital expenditures since 1999 and the huge spike in 2012. The amount of money spent on buses comes from a variety of sources, with $53,082,039 coming from the Federal Government to make the purchase of those vehicles in 2012. Most of that money was used to purchase commuter buses, but there was still $13,431,844 spent on regular buses in 2012, which was more than had been

spent on buses by LADOT in any one year since 1999. There are no capital expenditures for demand responsive taxi, while capital expenditures on demand responsive services total $13,469,814 since 1999.

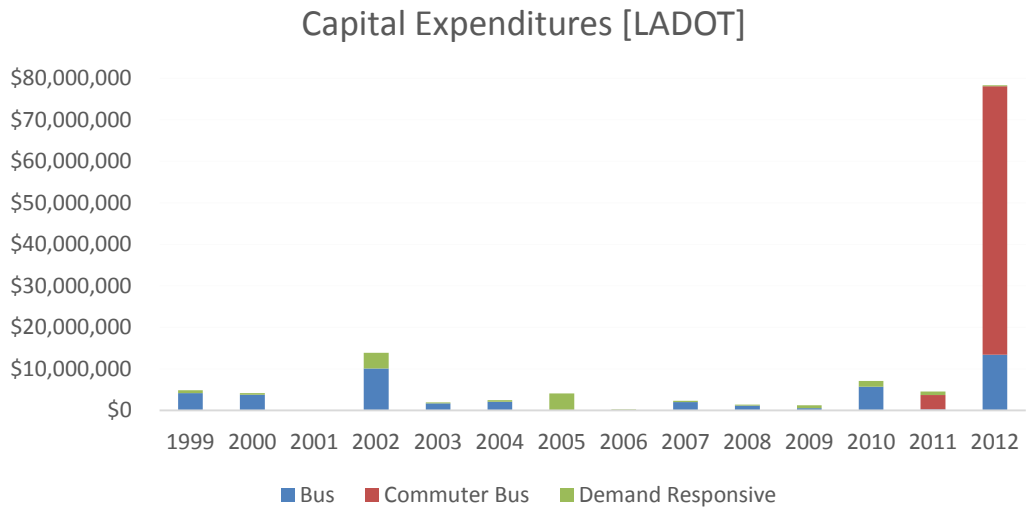

Figure 8: Capital Expenditures by LADOT

The different political and economic conditions around a transit agency's capital expenditures could prove important when considering purchased versus directly operated transportation. The types of vehicles purchased by a given transit agency - its fleet - is dependent on many factors, from the size and capacity of the vehicle to the fuel consumption. The purpose of the vehicle is another factor as there is tremendous difference in the vehicle needed for wheelchair bound demand responsive service, to peak hour fixed-route bus service, to local shuttle service. Additionally, private companies manufacture transit vehicles and regularly embark in competitive processes that may include lobbying elected politicians in order to win contracts and sell vehicles. Further research into the factors that determine why a transit agency purchases a certain fleet would be a worthy field of study.

In addition to the capital needed to purchase vehicles and to build & maintain facilities, operating expenses are the other major component in providing transit services. In Figure 9, we see that bus operations account for 51.4% of operating expenses of all transit agencies in 2012. Bus operations are the foundation of modern public transit systems across the country.

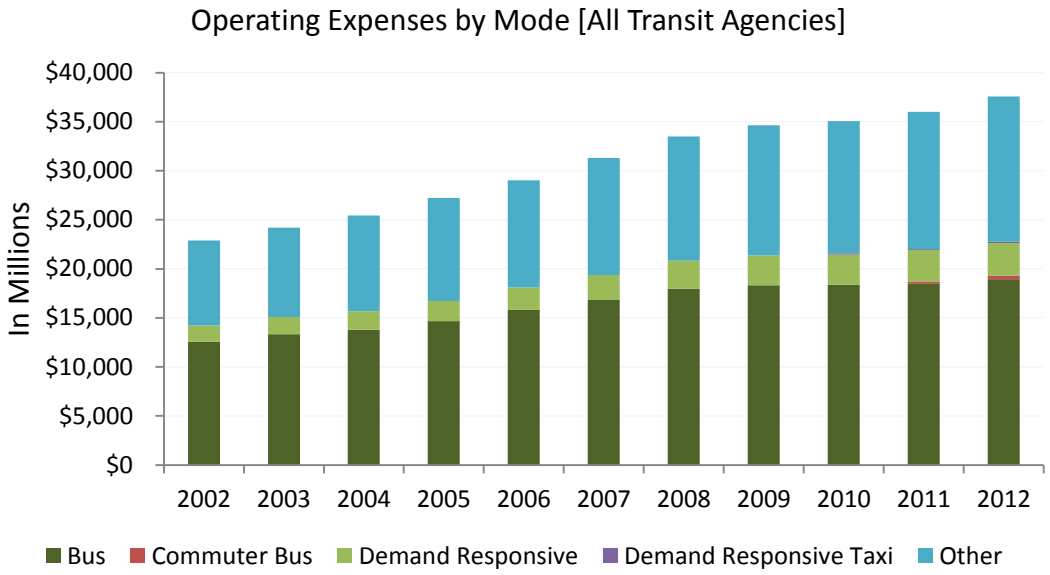

Figure 9: Operating Expenses for All Transit Agencies

In Figure 10, the operating expenses of the Los Angeles Department of Transportation show that spending has fluctuated recently with a clear upward trend from 1999 to 2009. A large boost in expenditures was made in 2001, but there was a 6.7% decline in spending from 2010 to 2011. The decline in funding in 2010 was anticipated due to changes in the way funds from Proposition A were going to be distributed. In preparation, LADOT conducted a Line-by-Line analysis of each of the 50 routes that were in operation at that time. The analysis was intentioned with identifying routes that were least efficient and candidates for reduction in service or full cancelation. The study

found several routes that were performing poorly in several measures that will be discussed in the Performance Measures subsection.

With the introduction of commuter bus service as a separate category in 2011, it is clear that local bus operations form the base of LADOT's bus service. Demand responsive service stayed relatively consistent between 2002 and 2009, but with the introduction and expansion of demand responsive taxi, money has been diverted towards that service.

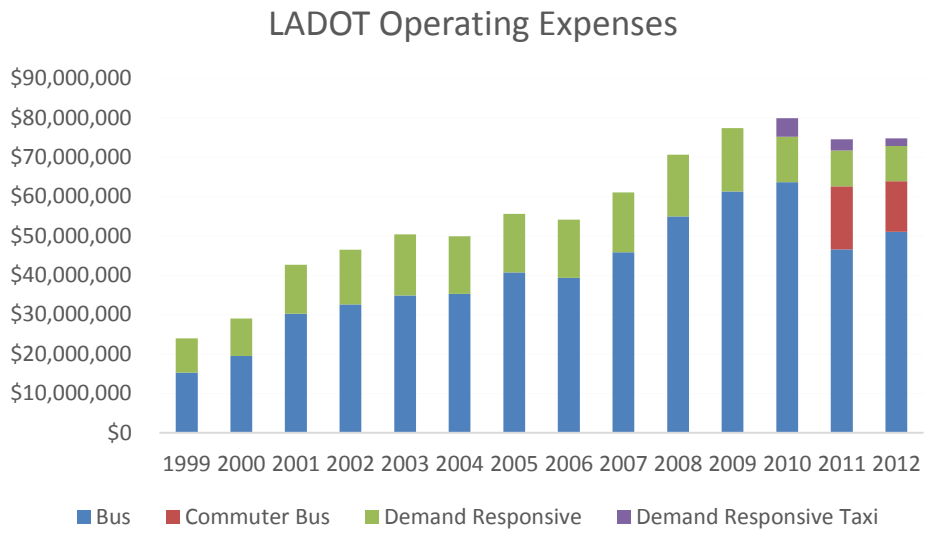

Figure 10: Operating Expenses of LADOT

The amount of money spent on public transit is a key measurement, but evaluating the effectiveness and efficiency of those dollars can be accomplished in many different ways. This paper embarks on that challenge by first defining technical terms, then presenting data from different sources, and finally analyzing the data through charts, graphs. The comparison of background information is the general strategy that I will utilize to connect the different levels of analysis from national trends to transit agencies to individual routes.

Fare Revenues Earned

Fare Revenue refers to the amount of money that passengers pay to utilize a given transit service. This is often paid in cash at the fare box, the machine at the entrance of a bus, and varies from agency to agency and even from route to route. The standard cash fare for LADOT's DASH is $0.50, but the Commuter Express charges based on zones starting at $1.50 topping out at $4.25 to travel across four zones. In addition to traditional cash fare, pre-paid fare in the form of daily, weekly, or monthly passes further complicate the issue. Even though passengers paying to utilize transit service are crucial to the profitable operation of transit services, this analysis does not include details of fares. At the end of this section, bus fares will be compared to the cost of operating a private automobile and a bicycle in order to develop a multi-modal basis for comparison.

Different modes of transportation will have different ways to pay for fare. Fare Revenue is also collected through pre-paid passes that can be daily, weekly, or monthly, which can make it hard to pinpoint which routes are earning revenue. To address this issue of tracking passengers with passes, most modern bus operators have a set of buttons that a bus driver can press to record a patron that has a pre-paid fare. Bus drivers also often collect information on the number of senior citizens, wheelchair bound, student, and other riders that pay discounted fares. However, data regarding the different types of commuters utilizing LADOT was not available, but is an area of potential research. As routes have been privatized, the money collected from citizens and constituents by these private companies is used to offset the cost incurred by the contracting public agency. Passenger fares can confuse the true cost of transit service as costs reported might

indicate the contracting cost, but exclude the fares paid by passengers to the private company operating the route.

In Figure 11, fare revenues across all transit agencies and across all modes of transportation are shown to total $13,717,000,000 in 2012. Compared to operating expenses of $37,556,500,000 and capital expenditures of $16,918,800,000 in 2012, fare revenue produced 25.2% of the cost to operate public transportation in the United States.

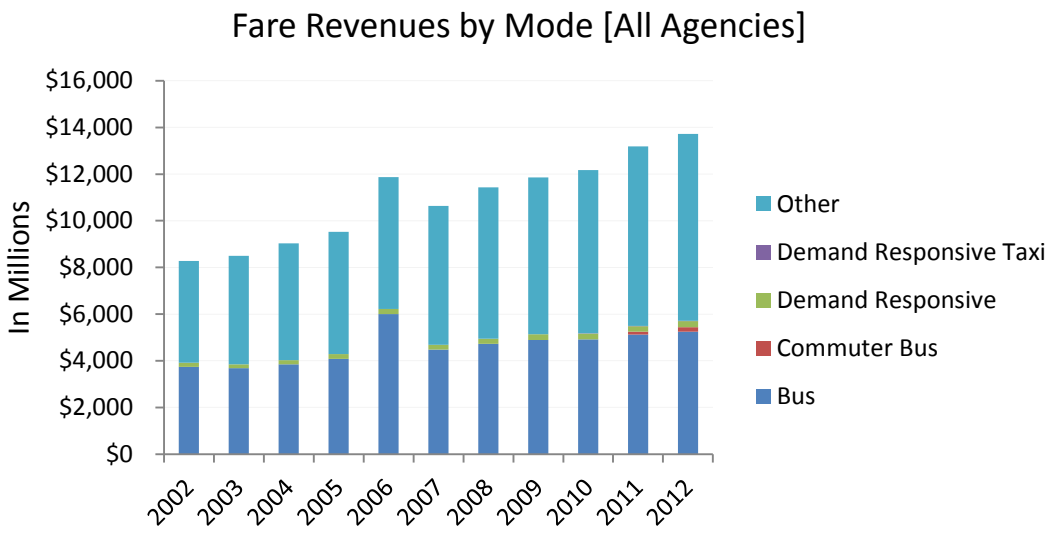

Figure 11: Fare Revenues from All Agencies and All Modes

Figure 12 shows that LADOT earned fares totaling $11,508,693 while spending $79,120,233 on transit in 2012 indicating that 14.5% of the cost of transit was covered by fare revenue. Differences in scale and expenditures on capital have a tremendous impact on how self-sufficient a transit system is. The dramatic difference in percentage of operations funded by passengers could be caused by a range of factors.

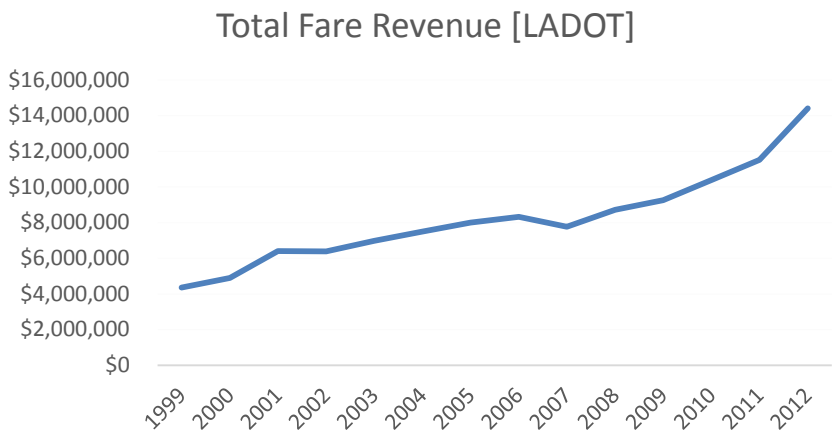

Figure 12: Total Fare Revenue Earned by LADOT

As I proceed in the analysis of transit services, I just want to make mention of the rider's choice, across modes of transportation, and in some cases bus systems. The LADOT DASH service has a one-way fare of $0.50, which is less than the MTA's $1.50 per trip. The MTA operates nearly 200 routes and 2,000 vehicles compared to LADOT's 47 routes and 450 vehicles. The effect of this heavily subsidized fare should draw more passengers. Additionally, LADOT's demand responsive service recovers an even smaller percentage of its cost, which will be discussed later.

The overall financial picture for transit services is continuously evolving with technology and culture. Lyft, a private transit network company whose service could be considered 'demand responsive,' received $250,000,000 after a series of venture funding. Lyft and Uber together, both mobile-applications enabled transit network companies, along with other ride share initiatives are challenging traditional taxi providers and single occupancy behavior. At the state level, the $80,000,000,000 high speed rail project that would connect all major urban areas of California would have unpredictable long term consequences on the population distribution of California. Globally, the shipping and airline industries continue to innovate technologies and strategies that are only sometimes

applied to the transportation problems of the average person. This section aims to contextualize the cost of operating transportation infrastructure in the broader transportation network and make it applicable to drivers, public transit users, and bicyclists.

Service Supply

Vehicle Revenue Miles

The term Vehicle Revenue Miles (VRM) indicates the number of miles a vehicle, a bus for example, travels while in service with the expectation of carrying fare paying passengers. This is a key measure of service supplied as it indicates how much access potential riders have to transit service. VRM does not include miles driven from/to storage or maintenance, which can impact the overall cost function of operating transit vehicles. It is difficult to measure the cost of operating a vehicle per mile as that depends on a range of factors that include road conditions and fuel efficiency of the vehicle. The total amount of Vehicle Revenue Miles provided by a transit agency cannot, by itself, indicate if the agency has a few routes traveling long distances, many routes circulating the same small area, or a combination of route characteristics. VRM serves as one indicator to the overall level of transit service provided by a given agency or route.

In Figure 11 the total amount of vehicle revenue miles across all transit agencies in the United States is broken down by mode of transportation. Again, bus service accounts for more than any other single mode of transportation and more than half of total public transit revenue miles from 2002 to 2008. Demand responsive accounts for an increasing percentage of total vehicle revenue miles going from 15.3% in 2002 to 19.1%

in 2012 at the national level. However, the demand responsive service provided by LADOT has been in decline as seen in figure 12.

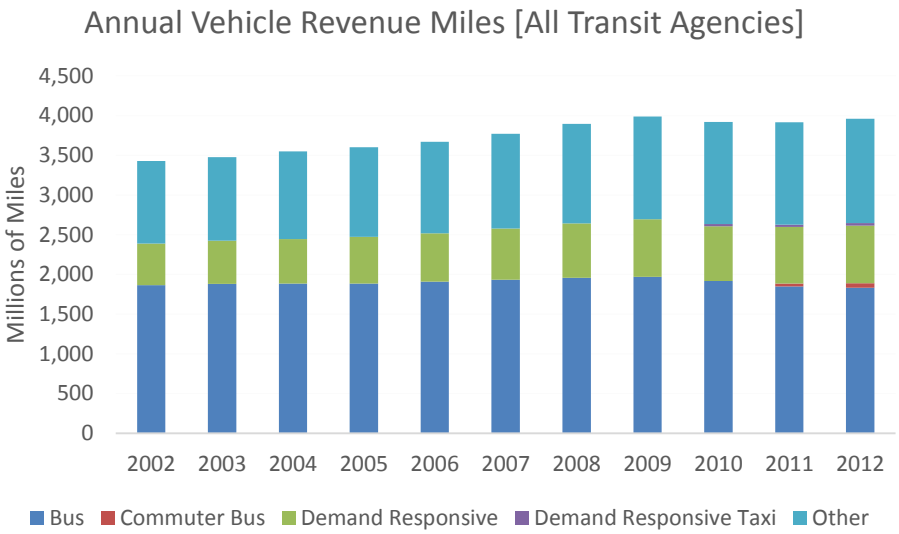

Figure 13: Total Annual Vehicle Revenue Miles across All Agencies

In Figure 14 we see that the LADOT has actually seen a dramatic decrease in annual vehicle revenue miles from 2010 to 2012. The annual vehicle revenue miles from 2010 to 2012 decreased from 10,858,364 miles to 8,045,380 representing a 25.9% drop in service. Demand responsive service has seen the greatest reduction of service going from a peak of 4,722,199 miles in 2003 to a total of 1,357,168 in 2012 (for demand response and demand response taxi), a service cut of almost 60%. Operating expenses also decline precipitously, but at a rate of about 30%. The reason for the decline in funding for LADOT's transit service was anticipated as a result of decreased revenue from Proposition A. The projected deficit was approximately $23 million for the 2010-2011 Fiscal Year. This decrease in funds was also the precursor to the 2010 Line-by-Line transit analysis the recommended the reduction of some lines along with the complete discontinuation of several LADOT routes.

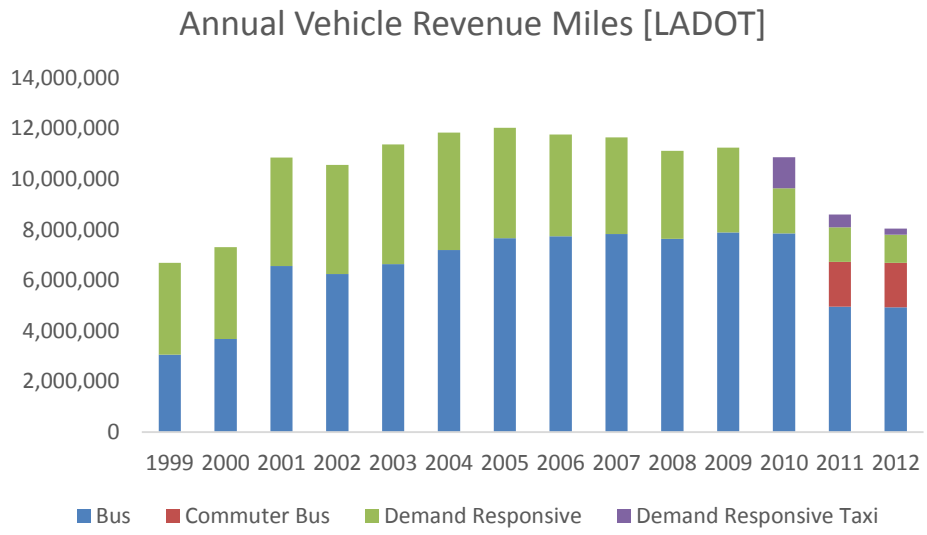

Figure 14: Annual Vehicle Revenue Miles Provided by LADOT

The spike in the spending on capital expenditures should not affect the amount of spending on operating expenses as much of the capital funds come from federal sources that are not used for operating expenses. The decrease in annual vehicle revenue miles provided by LADOT over the last two years is a question for further research.

Vehicle Revenue Hours

The term Vehicle Revenue Hours (VRH) indicates how many hours a vehicle travels while in service expecting to carry fare paying passengers. Like VRM, VRH is a key measure of service supplied, but is obviously different as different route characteristics such as traffic, number of stops, and number of passengers affects how many miles are traveled per Vehicle Revenue Hour. Vehicle Revenue Hours is more important in my analysis because contracts for bus services regularly negotiate payments by VRH. The number of dollars a public agency pays a private company to operate a bus per hour will serve as a major component to comparing services across agencies and through time.

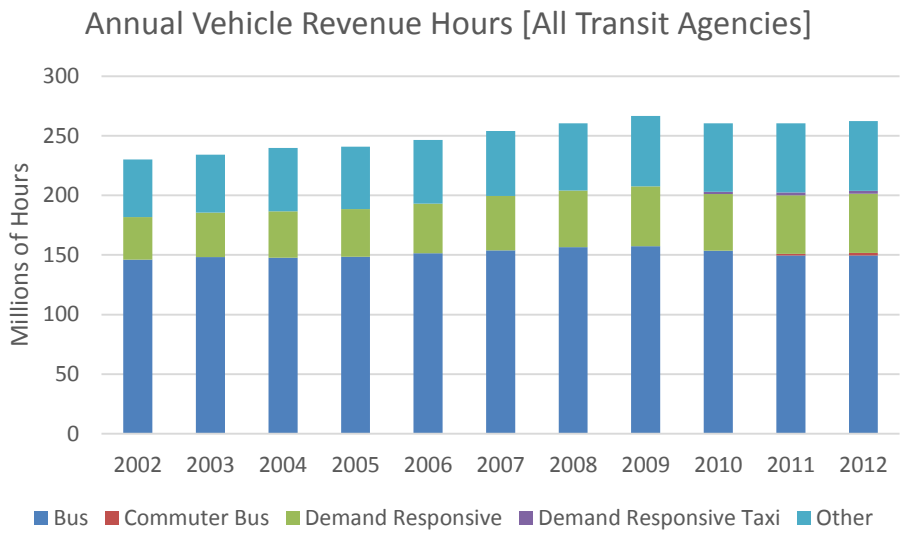

Figure 15: Annual Vehicle Revenue Hours for All Transit Agencies

The trends in vehicle revenue hours tend to parallel vehicle revenue miles, but variations indicate differences in miles traveled per hour by transit vehicles. In Figure 13 we see that the annual vehicle revenue hours for all transit agencies across the country. In Figure 14 we see annual vehicle revenue hours provided by LADOT.

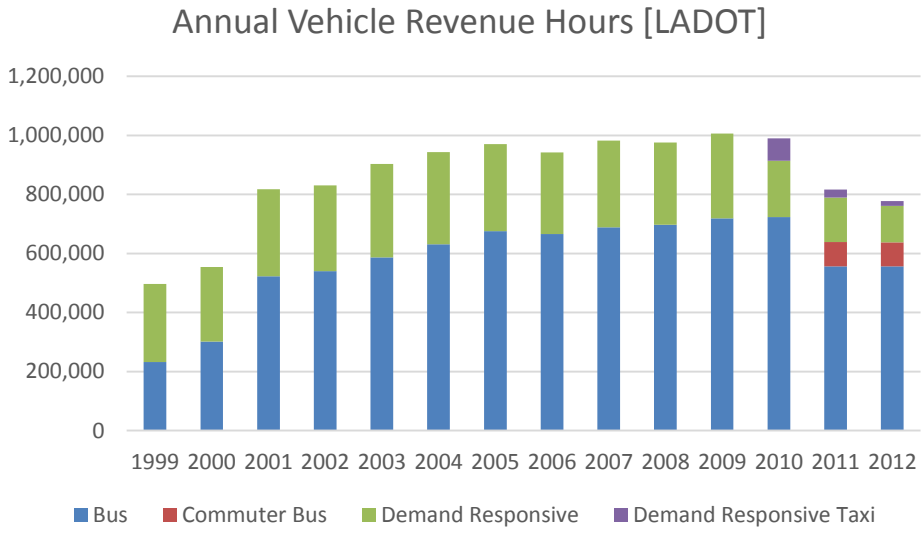

Figure 16: Annual Vehicle Revenue Hours Provided by LADOT

Again, the dramatic decline in service supply in 2011 is due to a decrease in the funding from Proposition A. Details of the sales tax and how money is allocated would provide more information on the reduction of funding, and would be an important part of a broader research unanswered research question on the source and fluctuations of funds and the effect that variability has on transit operations.

Vehicles Available for Maximum Service, Vehicles Operated in Maximum Service, and Average Fleet Age

Vehicles available for maximum service and vehicles operated in maximum service are straightforward measurements of the fleet size of a given transit agency. Maximum service for most transit agencies, including LADOT, comes during morning and evening rush hours. The number of vehicles operated in maximum service allows for a basic understanding and comparison of the size of transit agencies. These are also considered a measurement of service supplied. The average fleet age is another piece of data that the NTD collects that does not have particular relevance on my study other than the fact that the cost of operating transit service is affected by the purchasing of vehicles and their maintenance.

Service Consumption

Annual Passenger Miles

Annual Passenger Miles (APM) indicates how many total miles all passengers combined traveled on transit vehicles. This is a measure of service consumption that helps us understand the distance a passenger travels on a given route. Passenger miles traveled becomes particularly interesting when supplementing ridership numbers because this informs us on long distance commuters. Passenger miles are often measured by a

short-term count where surveyors keep track of where passengers get on and off a transit vehicle. Without high technology sensors or software, APM is not the most reliable statistic. The NTD's data on APM is not easily accessible, but in Figure 15 we can see the APM for LADOT by transportation mode. Even though the vast majority of trips are made on bus – commuter-bus, once introduced as a separate category in 2011, clearly shows that people utilizing that mode of transportation are traveling long distances. On the other hand, demand response service provides marginal usage as demonstrated by passenger miles, mostly because demand response vehicles often carry only one passenger at a time.

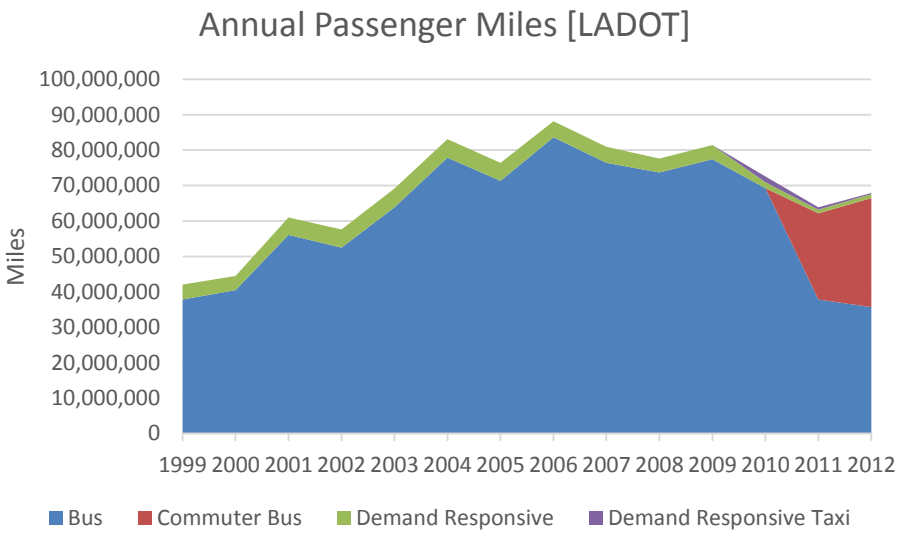

Figure 17: Annual Passenger Miles Serviced by LADOT

Unlinked Trips

Unlinked Passenger Trip (UPT) is a basic measure of service consumption as the term indicates how many individual trips, passengers utilize. This term can be measured annually, monthly, or based on the day of the week. The average number of 'unlinked trips per weekday' are usually conveyed as a measurement, while average unlinked trips

per Saturday, and per Sunday often deserve separate recognition because of varying trends, service supply, and service consumption. Basically, 'unlinked trip' indicates how many people were moved from A to B.

Figure 18 shows the total number of unlinked trips on all modes of transportation across the United States. There were over 10,000,000,000 trips made aboard public transportation in 2012. The breakdown of these 10 billion trips is worth a massive amount of research, but again, the major mode of public transportation utilized by the American people is bus service. Over 5 billion trips were made on bus almost every year from 2002 to 2012. How many people used public transit and how often they used it are major questions that this research does not address.

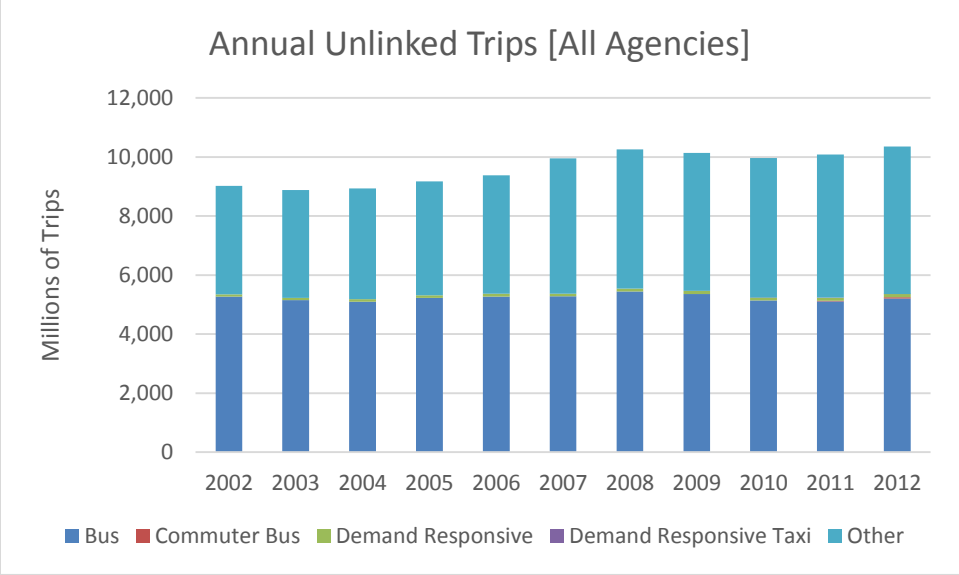

Figure 18: Total Unlinked Trips across All U.S. Transit Agencies

Even though national trends have increased over the last three years, the number of trips by LADOT has decreased along with operating expenses, annual revenue miles, and annual revenue hours. The reduction in funds, as discussed previously, is due to a decrease in Proposition A sales tax revenue. This decrease in funds has had major

impacts on the LADOT and will be addressed specifically later in this section. Figure 19 shows the total number of unlinked trips by LADOT. Well over 90% of all trips provided by LADOT happen on the DASH Routes.

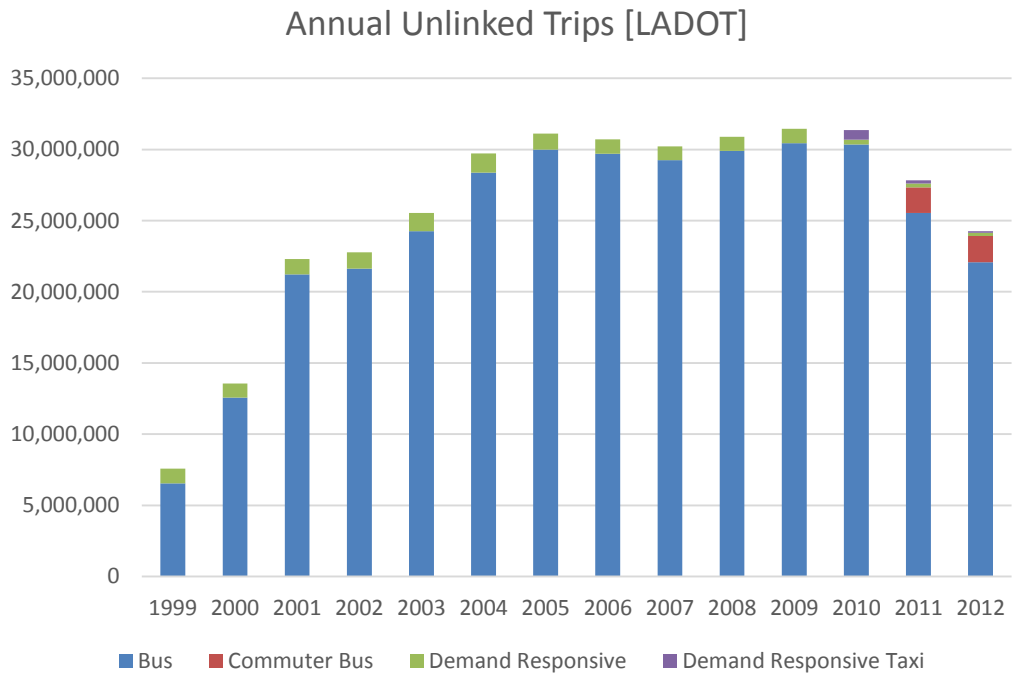

Figure 19: Annual Unlinked Trips by LADOT

Comparing figures 15 and 17 clearly shows that commuter-bus passengers are, as expected, traveling longer distances by a significant amount. This difference in utilization rate also creates interesting comparisons when considering the associated costs of each of these services. This is where a combination of the cost per unlinked trip and cost per passenger mile can be developed to evaluate the bus and commuter-bus systems respectively. This will be investigated under Performance Measures in this section.

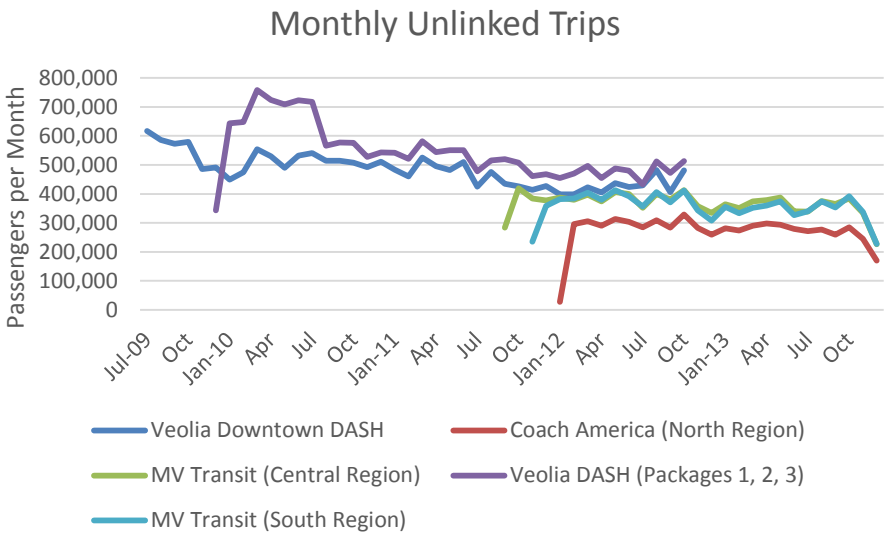

Figure 20: Trips provided by different transit companies within LADOT

Figure 20 breaks down the unlinked trips provided by LADOT categorized by contract. Each of these contracts has been voted on by the Los Angeles City Council. This is a gap in the literature that this study is shedding light on through an empirical analysis of LADOT. The literature on privately operated versus publicly operated is deep, but here, I am going to look at the differences between individual transportation contracts. Interestingly, Veolia has two different contracts to operate different transportation services for the City, as does MV Transit. Coach America has only one contract, but operates a bulk of the Commuter Express routes. Continuing through the Data and Results section, bus service, among other modes of transportation, is simply evaluated by the number of people that use the service. Additionally, analysis on an individual route's time and cost (the Northridge DASH) will be briefly compared to other modes of transportation along the same route.

Incidents and Patron Fatalities

The number of accidents and deaths while in transit is important on many levels, and the NTD was collecting that information in 1999, but stopped including it in its Transit Profile starting in 2002. There is some research indicating that new drivers have higher accident rates and that private transportation companies have higher turnover, largely due to lower pay and benefits. The 'characteristics of bus drivers' is not a major part of my research, but it could provide a different angle to approach the operations of LADOT. Incidents and patron fatalities could have dramatic effects on the budget of a transit agency, but riding a bus is exponentially safer than driving in a private automobile. The broader societal benefits of a clean, fast, safe, and cheap public transportation system may be unlocked if we can transition away from single occupancy gasoline vehicles.

Performance Measures

Throughout the collection, manipulation, and presentation of the technical data, it is obvious that one statistic cannot give a proper understanding of a transportation service. By combining and creating functions out of multiple variables, a better understanding of the transit service and its characteristics can be understood. In this sub-section, the combination and comparison of different variables that produce performance measures is expanded upon. Many of these terms are used extensively by the National Transit Database allowing us to easily compare complicated data between LADOT and the average of all transit agencies. These performance measures have become fundamental terminology to transit evaluation, especially when comparing transit services across broad categories, modes, and geographies.

Operating Expense per Vehicle Revenue Mile and Operating Expense per Vehicle Revenue Hour (Service Efficiency)

Measuring the amount of service provided per dollar spent is done through a function of operating-expense (OE) and vehicle-revenue-miles (VRM) or vehicle-revenue-hours (VRH). As the descriptions of Vehicle Revenue Mile and Vehicle Revenue Hour aim to convey, these two measures of service supply are different but supplementary. While Operating Expense per Vehicle Revenue Mile (OE/VRM) indicates how much money is spent to provide transit service per mile, it varies from mode to mode and route to route. It is less costly, over thousands of miles, to operate a bus on a Bus Rapid Transitway than on Grade D or F streets as the City of Los Angeles has many miles of. In figure 20, we can see that the average operating cost for one bus mile was $10.30. We can also see the decrease in cost to operate commuter-bus service, but the data is limited. This chart does not include many other modes of transportation such as heavy rail which cost $10.90 per mile. Even though there is only a slight difference in operating cost between bus and rail, the amount of capital needed to build a rail system is prohibitive to most transit agencies. Figure 20 also shows that operating commuter-bus service costs less per mile than a local bus; this could be for a range of factors that would include fuel and maintenance. The operation cost of demand responsive vehicles has increased steadily to over $4 per VRM in 2012, while the number of demand responsive vehicles operated by public transit agencies has ranged between 25,000 and 30,000 for the last 5 years. Compared to the AAA's assessment that a large sedan traveling 20,000 miles would cost $0.635 per mile, we see a lot of room for competition between existing services and new ones like Lyft and Uber.

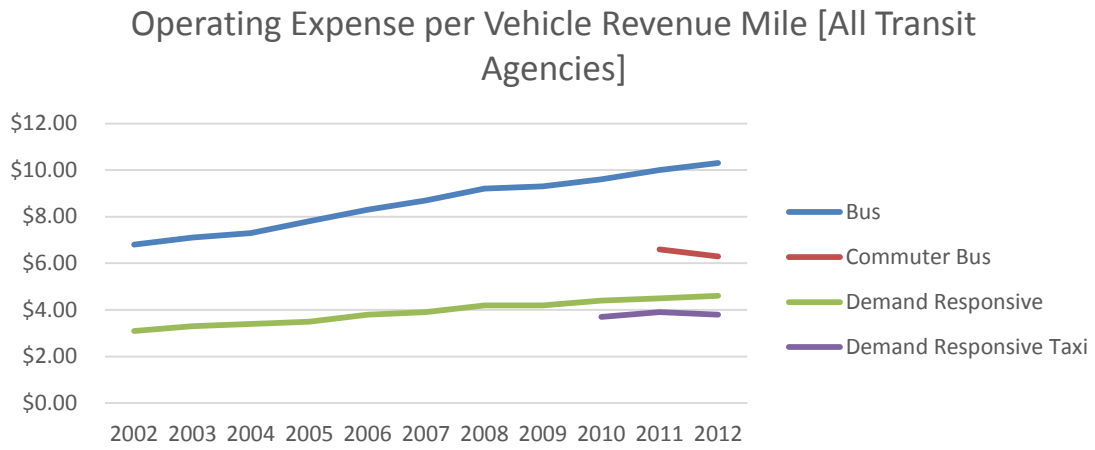

Figure 21: Operating Expense per Vehicle Revenue Mile for All Transit Agencies

On the other hand, Operating Expense per Vehicle Revenue Hour (OE/VRH) is generally the measure used in contract negotiations to determine compensation for transit services provided. We can see that the private companies at LADOT have been charging less per hour than the national average, according to the data from the NTD displayed in Figure 22. However, I get into more detail on the different cost per hour by different transit companies later in this section. The public is basically paying a private company to operate a bus route. This cost has gradually increased nationally to over $120 per hour while LADOT was able to keep costs to under $100 per hour in 2012. There are many interesting questions here including ownership of vehicles, variations in fuel costs, how routes are designed, and managing schedules all would have significant impact on the cost of operating a bus for an hour and more importantly, managing a system of bus routes to synergize and create a transportation network.

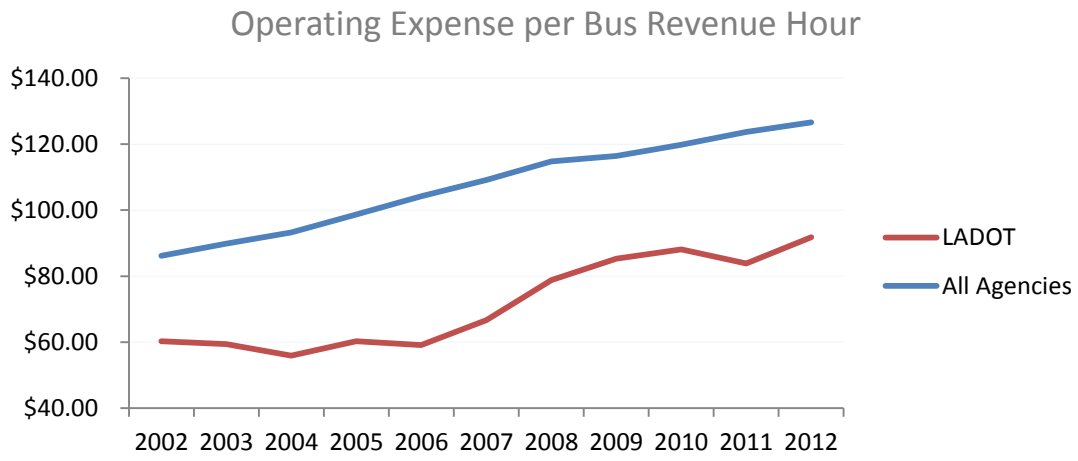

Figure 22: Cost per hour to operate a bus

Moving between an understanding of Vehicle Revenue Hours (VRH) and Vehicle Revenue Miles (VRM) requires us to note the different factors that can cause dramatic changes in the OE/VRM or OE/VRH, most obviously traffic. Conditions that would cause more travel time over the same distance or more distance in the same time are different aspects of transit service that VRM and VRH allow us quantify. Figure 22 shows the operating expense for bus service by LADOT and all transit agencies. LADOT was operating buses at 25% lower cost per mile, but starting in 2006 the cost to LADOT increased more rapidly than the cost nationwide leading to an equivalency in 2012 of cost per vehicle mile. Even though many of the least efficient routes were eliminated after the 2010 Line-by-Line analysis, the OE/VRM has increased dramatically. One possibility for the increase in OE/VRM is that along with a slight contractual increase in hourly operating expense and increased traffic, but this is another descriptive measurement that could be studied in more depth.

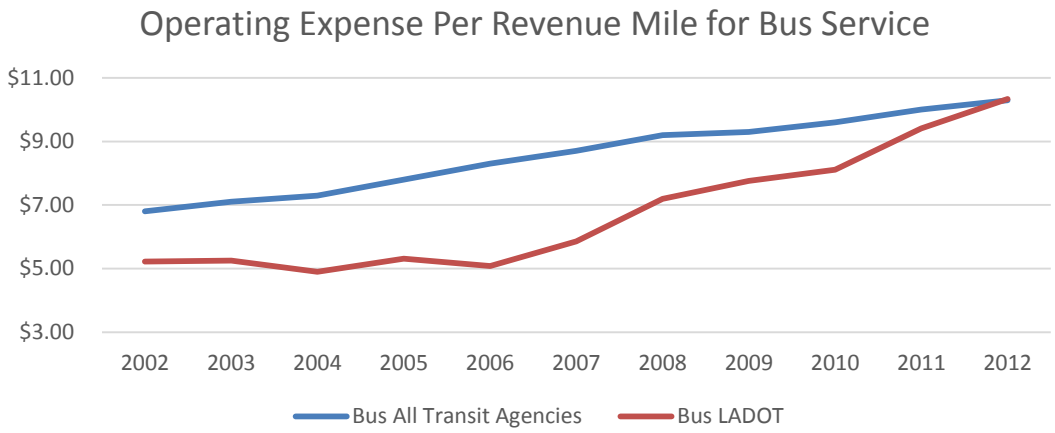

Figure 23: Comparison of Operating Expense per Mile for Bus Service

In Figure 23, cost per vehicle mile for demand responsive service is visualized. The chart shows that the cost increased more dramatically for LADOT after 2007 while the overall nationwide cost increased more gradually. The cost increases parallel increases in the cost per vehicle revenue hour as part of the negotiated contract between LADOT and MV Transit. It has been over the last 3 years that Lyft and Uber have been challenging the demand responsive transit space, but existing demand responsive transit providers have allowed their service to become more expensive while generating the same or diminishing public benefit. In Los Angeles the increased cost per mile for demand responsive services can be attributed mainly to the contract details. The cost per demand responsive mile reaches $8 for LADOT in 2012, when compared to the $0.68 cents an hour to operate a private automobile, alternative transit solutions need to be included. The expansion of the NTD to separately categorize demand responsive taxi moves in this direction.

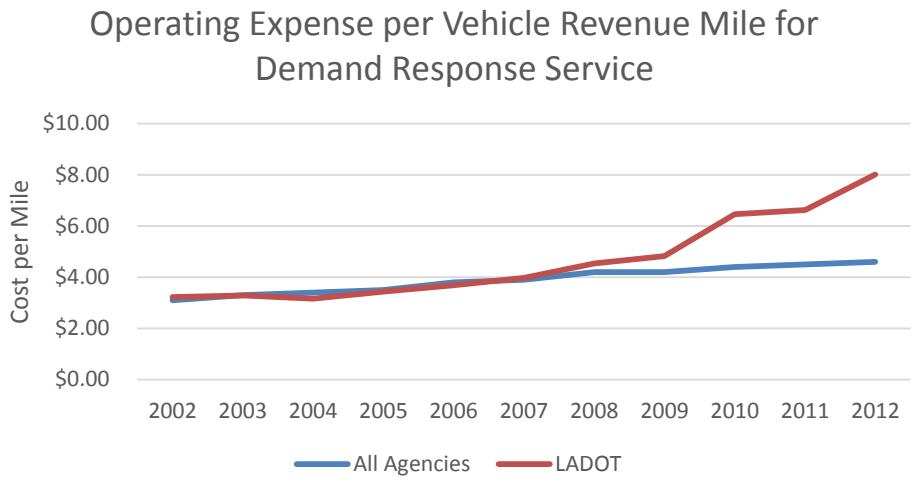

Figure 24: Comparison of Operating Expense per Mile for Demand Responsive Service

Figure 24 shows the cost to operate demand responsive service per hour. Whereas fixed-route bus service is almost always negotiated per vehicle revenue hour, demand responsive schemes are more variable. A more detailed study of the demand responsive transit services would note new contract operators, when they were officially put in charge of day-to-day service, and changes in technology. Those key factors may account for changes and variability in the cost of operating demand responsive services. In figure 25 we see the cost of operating demand responsive service nationally is $65 per hour and LADOT is paying over $75 per hour. Comparing that information to the previous figure 24, we can see estimate that LADOT's average demand-responsive-trip-speed is 10 miles per hour. Contract negotiations and payments to private companies are based on hours of service provided, but the data on travel time for riders is an often isolated field of study. In the Measuring Cost and Time per Mile subsection where the operations of the Northridge DASH are detailed, the cost per hour of operating a vehicle is further discussed.

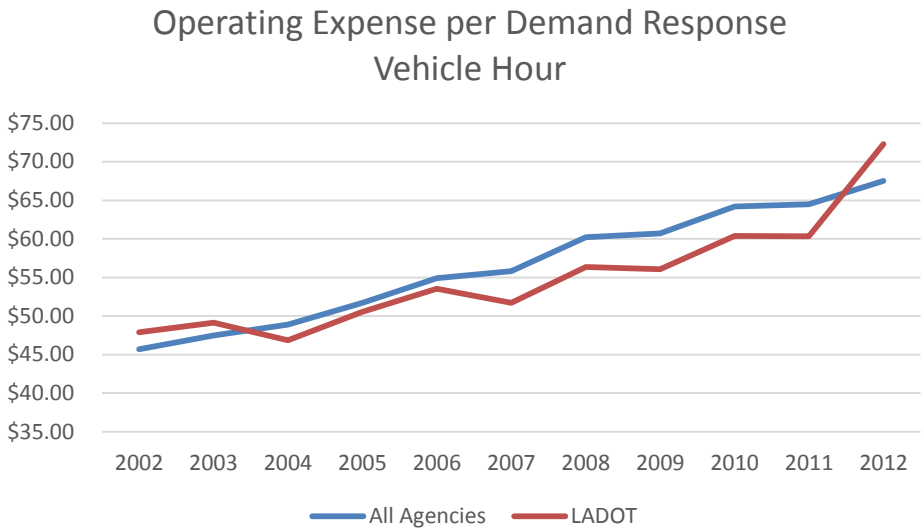

Figure 25: Operating Expense per Hour for Demand Response Service

Operating Expense per Passenger Mile and Operating Expense per Unlinked Passenger Trip (Cost Effectiveness)

The amount of service used, and at what cost, is what Operating Expense per Passenger Mile (OE/PM) and Operating Expense per Unlinked Passenger Trip (OE/UPT) convey. Operating Expense per Passenger Mile (OE/PM) measures the cost to move a person per mile, which can show the efficiency of long distance transportation as a vehicle may not pick up new passengers, but is still being utilized while in service. Operating Expense per Unlinked Passenger Trip (OE/UPT) conveys how much it costs to get a person from an origin to a destination if distance isn't considered. These are crucial measurements and useful for comparing one transit provider's effectiveness to another.

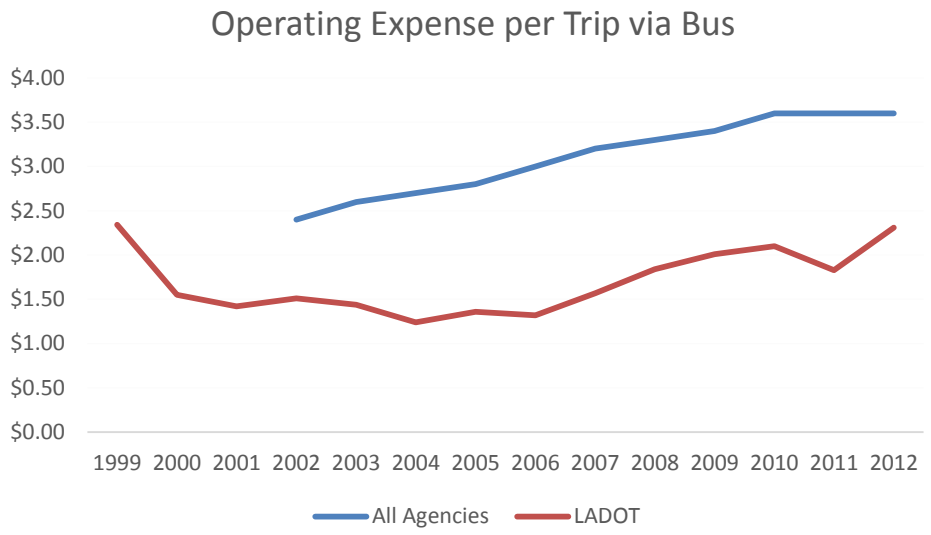

Figure 26: Operating Expense per Unlinked Passenger Trip via Bus

Figure 26 shows the cost per unlinked passenger trip via bus. Here, again, there are many factors that play into the trends that lead us to a national cost per trip average of $3.60 while Los Angeles can claim to spend $2.31 per trip. Operating expenses for LADOT is what the public agency pays to private companies after fare revenue is deducted from the original invoice for transit service. This causes a distortion in the cost and value of the transit service as the public's monetary contribution is not considered by the transit agency. In figure 27 we see that the cost per trip for demand responsive service is nearly 10 times more costly than a trip on the bus. From 2009 to 2012 the cost per trip on LADOT's demand responsive transit service increased from $16.09 to $41.32, a 56.8% increase. This also coincides with the creation of the demand responsive taxi category, which may have some responsibility for the drastic increase in cost. Regardless, if the demand responsive taxi was keeping the overall cost of the service down, it is now exposed that demand responsive service is costing the City $41.32 to move one person. When we combine the information on LADOT's cost per trip (figure 27) and trips per

mile (figure 30), we can further understand that each $41.32 trip through demand responsive service is on average, a 3 mile trip.

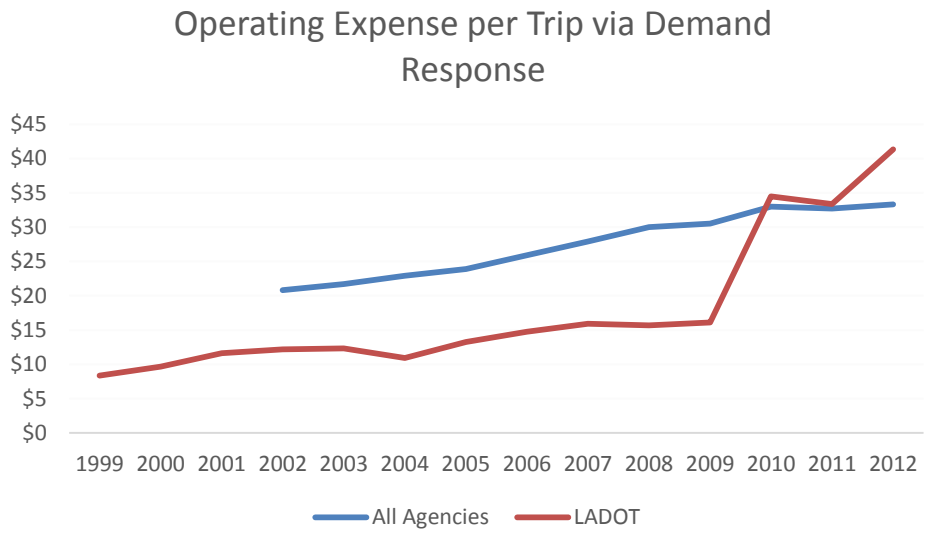

Figure 27: Operating Expense per Unlinked Passenger Trip via Demand Response

Furthermore, we can analyze information on cost per trip by individual contract. The differences in cost and other transit efficiency performance measures between LADOT and the average of all transit agencies is due to innumerable different factors, a major one being the contract that governs service. To further illustrate this point, Figure 28 shows the 5 different contracts that are used to govern the operations of LADOT's 34 DASH routes, 13 Commuter Express, and the demand responsive services under Cityride (MV Transit Central). The figure details how much LADOT is paying the operator of each contract for each trip provided. The contract with Coach America, which consistently has the highest cost per trip, includes the Commuter Express routes. As discussed earlier, the Commuter Express routes pick up fewer passengers, but take their riders to further destinations. Similarities, trends, and spikes in the cost per trip across contracts might lead to assessments of individual private companies. Many of the major

private transit providers have contracts with dozens of major American and global cities. We can see at LADOT MV Transit and Veolia Transportation each have 2 different contracts that include different routes and have noticeably different cost per trip patterns.

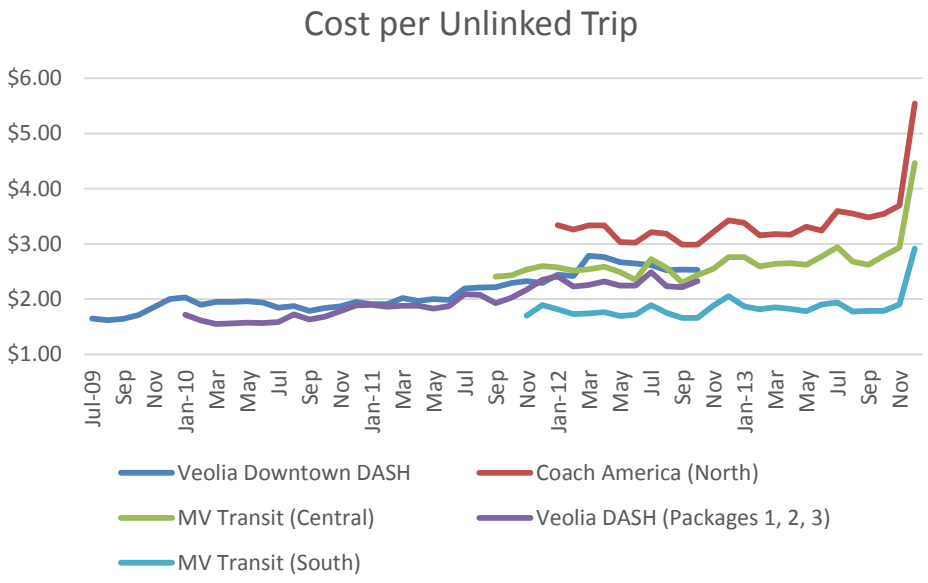

Figure 28: Cost per trip across different LADOT contracts

This subsection on cost effectiveness lacked sufficient data on OE/VRM as it is difficult to get accurate measurements on how long people ride a mode of transit for. Regardless, the information and data utilizing unlinked trips shows a broad range of factors and issues that have changed and continue to affect the cost per trip across modes of transportation. The cost per trip via demand responsive services leads to several different questions on the utility and philosophy of public transportation. As a response to the American's with Disabilities Act (1990), demand responsive transit service has become an issue of civil rights. All people should have access to transportation services, but the quality of those services has specific minimum requirement. There have been

many legal cases, including a civil rights consent decree that forced a series of actions at the Metropolitan Transit Authority, that highlight the socio-economic importance of public transportation.

Unlinked Passenger Trips per Vehicle Revenue Mile and Unlinked Passenger Trips per Vehicle Revenue Hour (Service Effectiveness)

Cost effectiveness and service effectiveness are two similar concepts that when taken together give a better understanding of the transportation network and mode choice. Both of these measures depend on unlinked trips as the primary measure for service consumption. Without considering cost, service effectiveness conveys if people are actually using the transit service provided. Unlinked Passenger Trips per Vehicle Revenue Mile (UPT/VRM) indicates the number of people that are getting on a transit vehicle for every mile that the vehicle travels. Unlinked Passenger Trips per Vehicle Revenue Hour (UPT/VRH) indicates the number of people that are getting on a transit vehicle for every hour that the vehicle travels. These terms are complementary, shedding light on different riders and routes and their behaviors and characteristics.

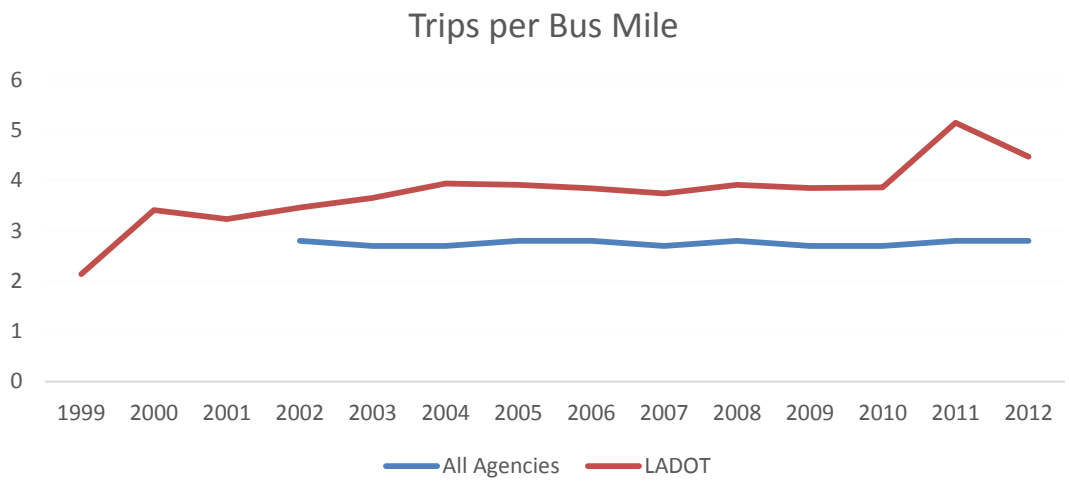

Figure 29: Passenger Trips per Bus Mile

Figure 29 displays Unlinked Passenger Trips (trips) per mile for bus services. We can see that LADOT has more people riding the bus per mile, making a substantial jump in 2011 after the most inefficient lines were eliminated. This also shows that across the country, the average transportation agency gets less than 3 riders per mile of bus service. When comparing this to standing room only routes during rush hour, this means that there must be many public transit vehicles picking up fewer than 3 passengers per mile.

Figure 30 shows the number of trips per mile for demand responsive service. The LADOT peaked at 0.3 trips per mile in 2009. That translates to the average trip being 3 miles. Nationally, across all transit agencies, there is an average of 0.1 trips per mile, meaning that the average demand responsive trip across the country is 10 miles. LADOT's relatively impressive 0.3 trips per mile dramatically decreased to under 0.2 trips per mile indicating that the average trip has increased to an average of 5 miles.

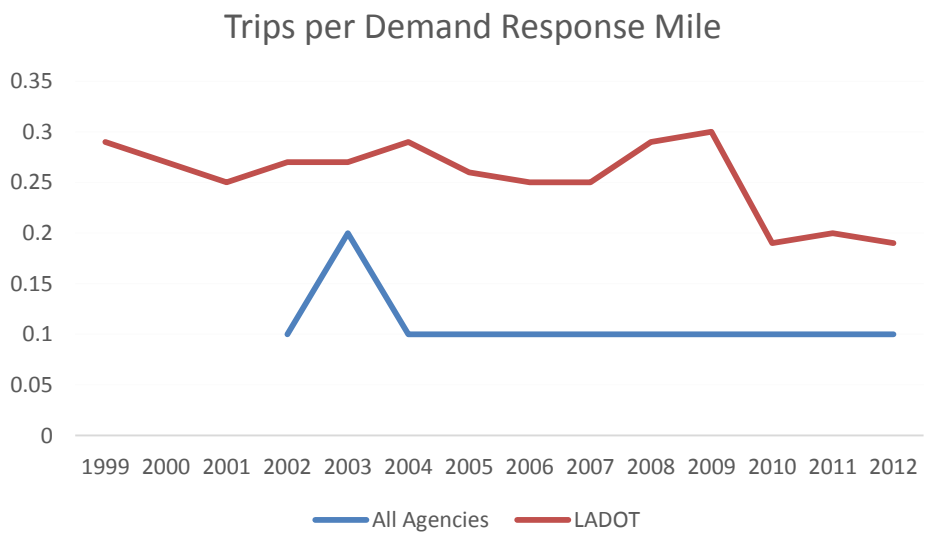

Figure 30: Passenger Trips per Demand Response Mile

The previous figures showed trips per mile of demand responsive or bus service. Figure 31 shows trips per hour of bus service. We can see that LADOT moved nearly 40 people per hour on its bus services, while the national average has stayed around 35 passengers per hour for nearly 10 years. Surprisingly, LADOT's trips per hour for bus service decreased from over 45 passengers per hour to under 40 per hour even though the commuter bus services was separated from the regular bus service. After comparing data from the National Transit Database and from LADOT's Ridership and Cost Component Summary conflict, the statistics on trips per bus hour are not the same. This is a tremendous problem when considering the fact that private companies are largely responsible for reporting data on ridership to the public transit agency. Private companies would benefit from increased ridership numbers in order to solidify their hold on transit operation contracts. The broader issue is the reliability of transit data.

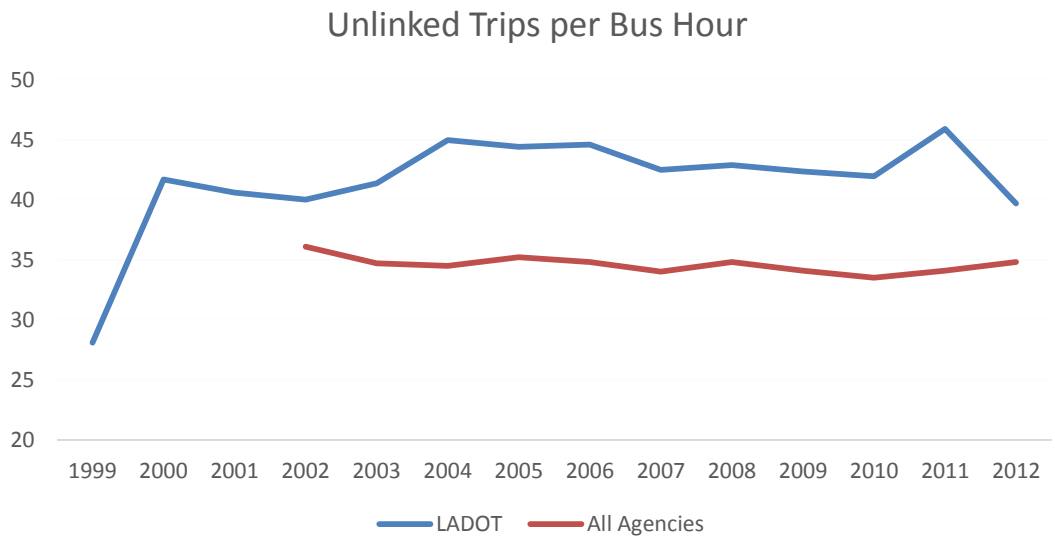

Figure 31: Unlinked Trips per Bus Hour

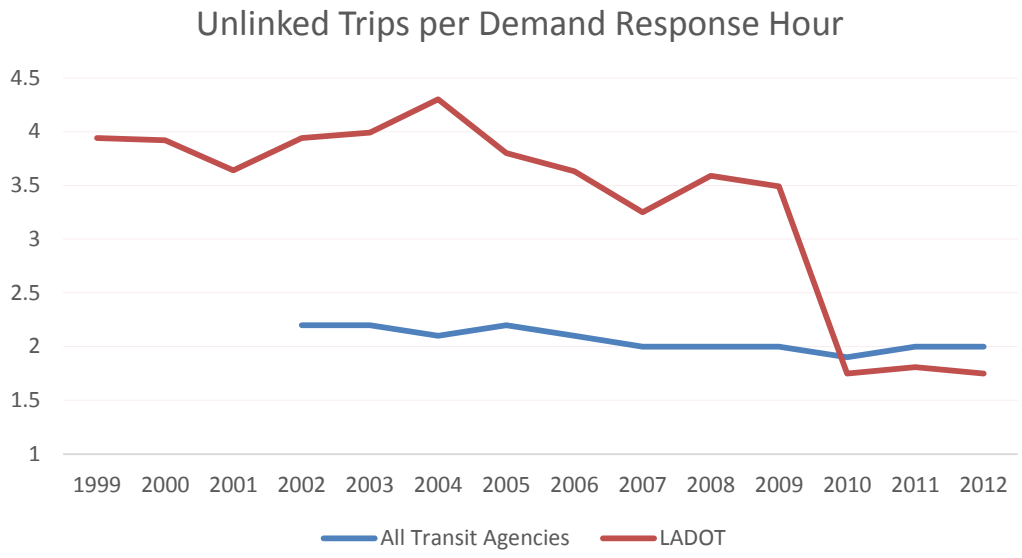

Figure 32: Unlinked Trips per Demand Response Hour

Figure 32 shows the number of trips per hour by demand responsive service. LADOT had a tremendous decline from 3.5 trips per hour in 2009 to 1.75 trips per hour in 2010. This is in part due to the separation of demand responsive taxi, but is part of the broader trend of growing inefficiency among demand responsive services in LADOT. On the other hand, the national average has stayed just around 2 trips per hour for the last 5 years.

Figure 33 shows the breakdown of trip hours by LADOT contract. Only one out of the 5 contracts averaged over 40 trips per hour while MV Transit's Central Region Contract averaged below 30 passengers per hour for 2012. These contracts include different services including commuter bus and demand responsive, which accounts for some of the variation.

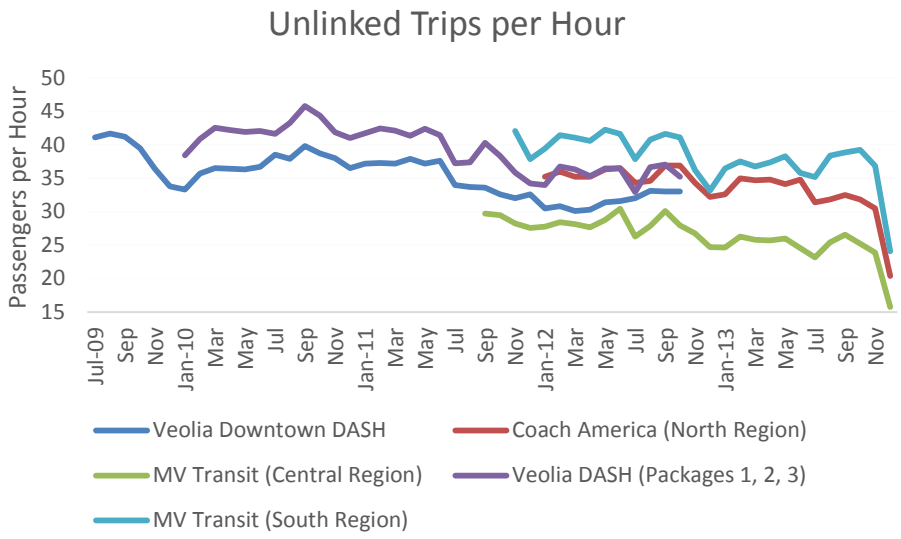

Figure 33: Trips per hour by contracted companies with LADOT

Demand responsive services, such as Cityride, are usually more costly per passenger than fixed-route bus service as demand responsive requires a more sophisticated dispatching system. The dispatch system sometimes also has to include the ability to transport wheelchair bound individuals. The current Cityride service uses medium sized vehicles capable of moving over a dozen people at a time, but as the data indicates over the last two years, Cityride moves about 2 people per hour.

The number of trips provided per hour is an important measure of public transportation service that has been shown to vary tremendously across agencies, from mode of transit to mode, and from route to route. Unfortunately, I was not able to go into the specifics of why certain routes or contracts had more riders per hour. Basic factors such as population density, key stops along the route, schedule of service, and other demographic characteristics have been shown to have major influence on ridership. Studying these factors across even 34 DASH routes would prove to be a tremendous

undertaking that the Los Angeles Department of Transportation is going to accomplish as part of their 2014-2015 Line-by-Line analysis.

Measuring Cost and Time per Mile

The previous analysis has been focused on the statistics from the perspective of the transit agency. In this subsection, I will focus on the travel time and cost of travel to the public transit patron. Looking specifically at the Northridge DASH route, I will discuss and investigate the transit experience across different modes of transportation for the rider. The cost to operate a bus and the fare to the passenger is not directly correlated, creating significant differences in how a transit agency and a rider perceive cost effectiveness. Additionally, as was discussed previously, schedule adherence and travel time for riders is not prominent in the research. In this section I will compare potential travel time across the bus, private automobile, and the bicycle. Along with travel time, I will estimate travel cost along the 8 mile Northridge DASH route by mode of transportation. The cost and time factors will be combined into one measure by attributing a cost value to travel time. Given the complicated relationship between time and currency that has spawned immense research and theory around wage labor, I will use the mean Californian income to create a unit equivalent between dollar cost and travel time. This simple calculation will allow me to compare different modes of transportation along the Northridge DASH route using the same cost unit.

The Northridge DASH takes 29.3 minutes with a standard deviation of 3.2 minutesto travel the 8 mile route. However, when calculating the amount of time it takes to utilize public transit, waiting time should be considered. The average time between buses for the Northridge DASH at the start of the route is just about 19 minutes. This

translates to an average wait time of about 9.5 minutes, which will be distributed over the 8 mile route. Technically, the rider rarely if ever goes in circles along the entire route, but for this calculation, that is the assumption utilized. In terms of currency, the few data points I have from the Performance Statistics Report (PSR) on the Northridge DASH show an hourly cost of between $90 and $120 per hour to operate the route. As mentioned earlier, private companies are often relied on to provide data to the public agency on its services. There were problems with the PSR that I discovered that will require LADOT to report the Project Manager for incomplete reports; the PSR was incomplete and information on operating costs and passenger fare revenue was not available for all routes on a monthly basis. Regardless, taking the average of $103 from the few data points available, it costs the Northridge DASH between $44.60 and $54.90 to operate the 8 mile route with the standard deviation of 3.2 minutes. That comes out to about $6.22 per mile and 3.6 minutes per mile for the average trip. However, that $6.22 per mile is the cost to LADOT, not the rider. The rider pays a one way fare of $0.50 which comes out to $0.06 per mile. And as mentioned before, the trip time of 29.3 minutes needs to have the average wait time of 9.5 minutes added which turns into a travel time of 4.9 minutes per mile. Converting the 4.9 minutes into dollars using the median income and a theoretical 40 hour work week, those 4.9 minutes are worth $1.23. Combined, the cost to the Northridge DASH rider to travel the 8 mile route is $1.29 per mile.

The private automobile at $0.68 per mile according to AAA would cost $5.44 to drive the 8 mile route of the Northridge DASH. According to Google Maps, without traffic it would take 19 minutes by car. Interestingly, the Northridge DASH often

completes its entire route in 18 or 19 minutes during its first trip at 5:30am when there is less traffic on the streets. So the measures would be $0.68 per mile and 2.4 minutes per mile by automobile. Converting the time into a dollar value, the 2.4 minutes is worth $0.60. Combined, the cost to the drive of a private automobile to travel the 8 mile route is $1.28 per mile

The bicycle costs about between $0.05 and $0.15 per mile to operate over extended uses. For this purpose, I will middle of that range. As traffic and time of day affect the travel time for the bus and the automobile, the same factors have significant impact on the travel time of the bicycle along the 8 mile route. Google Maps estimates the travel time to be 46 minutes by bicycle, but empirical results found that the route can be traveled by bicycle in 38 to 42 minutes without massive physical exertion. Regardless, we will use the conservative 46 minutes of travel time which converts to 5.8 minutes per mile. For the bicycle the measures would be $0.10 per mile and 5.8 minutes per mile. Converting the time into a dollar value, the 5.8 minutes per mile is worth $1.45. Combined, the cost to the bicyclist traveling the 8 mile route is $1.55 per mile

Using the average money income per capita to give a value to travel time has many flaws, especially when considering that parking, the variation of the utility of travel time by mode, and the fact that no one is trying to go in circles around the 8 mile route of the Northridge DASH. Regardless, by coming up with a single measure to compare different modes of transportation along a specific route, interesting implications can be further developed. According to my simple analysis, the cost of the private automobile comes out to $1.28 per mile, while the Northridge DASH comes out to $1.29 per mile, and the bicycle comes to $1.55 per mile. If an individual is making more than the average

income the cost of travel time would increase leading to the fastest mode of transportation, the automobile becoming the better option. However, if an individual has no regular income, then their time becomes less valuable making the bicycle the most efficient mode of transportation for them.

Admittedly, this simple modal comparison along the route of the Northridge DASH is rudimentary and doesn't effectively account for many factors. However, this is still a valuable start to broader multi-modal evaluation, especially in context of the rest of the research that this paper presents. As the primary focus of this paper was on evaluating bus service from the perspective of a transit agency, this different approach to service evaluation in terms of cost and travel time to the rider is a dramatically different strategy to make this research applicable to developing a more effective transportation network in Los Angeles.

Summation

Transportation is crucial to economic, material, and social productivity, and along with water and electricity, is a fundamental charge of government. America's modern transportation infrastructure and the population's behavior revolves around the private automobile, nevertheless, public transportation provided by public transit agencies services millions of Americans about 10,000,000,000 times annually. The vast majority of that service is provided through fixed-route bus service that is contracted out to private companies at a rate of 18.8%. Even though there are fundamental differences between privately operated and publicly operated transit services, the differences in bus service from route to route and agency to agency cannot be wholly attributed to whether the service is privately or publicly operated.

Los Angeles Department of Transportation's transit services, which are fully privately operated, show a complicated story. When considering the differences between modes of transportation and accounting for different contracts with different private companies, the analysis becomes less clear. LADOT's bus service in key performance measures, cost per unlinked trip, trips per hour, trips per mile, and cost per vehicle hour are all better than the national transit agency average. However, LADOT's demand responsive service does not compare as favorably, especially in the last two years where the cost per trip and cost per hour have become less efficient compared to the national average. The different private companies and their separate contracts to operate these services within a transit agency have an impact, but the intrinsic geography and demographics of Los Angeles also have an impact. Differentiating between the impact of the geography and the varying private operators could be done through a comparative analysis of individual routes and other transit agencies that operate in the same geography.

Fixed-route bus service is currently the backbone of public transportation in the United States, but the cost, usage, and travel time of bus service leaves much to be desired. The demand responsive services that account for more than a quarter of all public transit vehicles are magnitudes less cost- effective and move relatively few people compared to other modes of public transportation. This combination of factors has created massive gaps in the transportation network that can be looked at as opportunities for innovative transit services that utilize information technology to distribute transit resources more efficiently.

CONCLUSIONS AND RECOMMENDATION

The transportation network of Los Angeles is similar to most other major urban metropolises in the United States in that the private automobile is the primary mode of travel and that public transit agencies rely heavily on fixed-route bus services to provide transportation to the general population. This study did not cover the usage of the private automobile, but instead focused on the 112,060 public transit vehicles across the nation, 39,466 (35.2%) of which are privately operated, and the 450 vehicles operated under the Los Angeles Department of Transportation (LADOT).

Out of the 112,060 public transit vehicles operated by transit agencies across the United States in 2012, 51,090 were buses, out of which 18.8% (9,591) were operated by private transportation companies. All 450 vehicles operated by the LADOT are privately operated. The results comparing the privately operated buses of the LADOT and the national average showed that LADOT had a lower cost per trip, lower cost per vehicle hour, more trips per mile, and more trips per hour. This indicates that LADOT's bus services are objectively better than the national average. The results of the privately operated demand responsive services showed LADOT to be more expensive per trip, but did move more people per hour, and more people per mile.

These results did not give a conclusive answer to if the privately operated services of LADOT were better or worse than publicly operated transit services. Even though the bus service of LADOT was measurably better than the national average, further analysis conducted on the individual contracts entered into by LADOT that govern the different transit services convey a complicated picture. The different contracts and different private companies had dramatically different descriptive statistics of their services, but this study

was not able to go deep into the reasons why the different private companies has such different costs per trip and trips per hour. However, differences in geography, demographics, and route characteristics were briefly discussed and correlated to the differences in performance measures by the different private contractors. The results did clearly point to the fact that different transit services, regardless of operator – private or public, are dramatically affected by unique route and mode characteristics.

With the tremendous amount of information presented on one specific public transit agency, a few modes of transportation, and in a limited geography – this section will now put this research into the context of Southern California's transportation-network. The History and Background section of this paper attempted to interconnect the concepts of transportation, democracy, economy, and behavior. After extensively discussing different personal financial interests along with the consolidation, competition, and public takeover of transit infrastructure in Los Angeles during the first half of the 20th century, the reader was introduced to how the automobile became the primary mode of transportation. Even though this research was not able to delve deep into the evolution of the automobile and its effect on public transit usage, in order to address the broader transportation network, the automobile and its benefits are considered.

The research and data presented highlights the wide range of cost per trip by different mode of transportation. Nationally, the cost per trip by bus, commuter bus, demand responsive, and demand responsive taxi was $3.60, $8.10, $33.30, and $22.60 per trip respectively in 2012. Furthermore, even within a single mode of transportation, the cost per trip can vary tremendously as demonstrated by LADOT's Fairfax DASH and the Downtown E DASH, which cost $5.83 and $2.02 per trip respectively in July 2013.

This wide range of cost per trip has many causes including geography, demographics, and schedules. The wide range of cost per trip can actually be an opportunity for an innovative transit network company that targets a specific institution and its population.

This potential opportunity for a transit company can be further expanded if the transit service offered could account for travel time and cater to a given institution's schedule. The following subsections build on this opportunity by targeting the population of California State University Northridge (CSUN). The specific characteristics of the institution and of the staff, faculty, administration, and students of CSUN make it an ideal target for a multi-modal transportation network company.

The Multi-Modal Transportation Network

Moving to current transportation infrastructure, private entities are again entering the transportation-network by providing services. Many of these new transit services, such as Lyft and Uber, utilize information technology to accurately map and connect people to their destinations, sometimes putting these private companies in competition with existing transit providers. Lyft and Uber are basically demand responsive transit services capitalizing on technology, similar to the Jitney of 1914-1915 at the forefront of the widespread acceptance of the automobile. However, instead of severely limiting the use of entrepreneurial demand responsive endeavors like the Los Angeles City Council of 1915, the California Public Utilities Commission of 2013 produced a new legal framework to regulate these private transit companies. "The CPUC created the category of Transportation Network Company (TNC) to apply to companies that provide prearranged transportation services for compensation using an online-enabled application (app) or platform to connect passengers with drivers using their personal vehicles"

(California Public Utilities Commission, 2013). Even with the tremendous financial success of these new transit providers, the vast majority of people still travel via private automobile or a time inefficient fixed-route bus system.

Even though this research has focused on fixed-route bus service in Los Angeles, it provides a valuable and useful foundation for determining the cost to move a person from A to B in Los Angeles. The travel time research presented on LADOT's Northridge DASH, in the Data and Results section, has multiple purposes. The specific information on the Northridge DASH allows for a deeper analysis of transportation issues facing a specific community. California State University Northridge (CSUN) is at the heart of Northridge and is the destination of over 4,000,000 annual trips. CSUN's Institute for Sustainability published a detailed and extensive report on campus commuter behavior in 2010. Without getting into too many details of the report, it confirms many of the typical conceptions of a commuter college campus – 74% of faculty, staff, and students commute to campus via single occupancy vehicle (CSUN Institute for Sustainability, 2010).

Going back to the multi-modal approach and looking at the entire transportation network, currently, less than 2% of CSUN's student body regularly bicycles to and from campus. However, that number is likely to increase exponentially as proper infrastructure is built, services become more streamlined, and the overall cost of bicycling continues to decrease in comparison to the private automobile. In fact, in the commuter behavior report from CSUN's Institute for Sustainability, over 40% of students surveyed said they would be willing to bicycle to campus if conditions improved.

Seizing on the combination of knowledge around the cost of fixed-route bus service, travel time comparisons across modes of transit, and the continuing evolution of

transportation behavior, this paper recommends a demand adaptive bicycle sharing transportation network company that services the students, staff, faculty, and administration of California State University Northridge. By targeting a specific population with a fixed destination and a regular schedule, the cost per trip can be dramatically reduced by a transport network company that can facilitate active transportation through information technology and adaptive infrastructure.

Route by Route Organization of a Transportation Network

This research shows the great variability between routes of transit even those in the same geography, using the same mode of transportation, and operated by the same organization. The transportation infrastructure of Los Angeles has been built individual route by route and road by individual road. Different routes can be individually deconstructed, evaluated, and reformulated to account for and cater to a specific population of individuals to increase efficiency and utility. The vehicles utilized, the schedule, and even the exact destination & origin can vary according to demand. Creating individual routes that connect existing transportation infrastructure utilizing multiple modes of transportation is a scalable solution that can shift transportation behavior.

The bicycle is an underutilized mode of transportation, but with proper infrastructure, support, and a profitable model based on fare revenue – a shift in transportation behavior is possible. By combining the new legislation on transportation network companies that utilize mobile applications and applying the regulations to a mobile bike-share infrastructure, a series of demand adaptive routes that serve California State University Northridge could be a scalable transportation solution. The individual characteristics of CSUN, a large commuter campus of relatively low income young

people, make it a prime candidate for innovative transit options that can move people away from an environmentally crippling and economically costly dependence on the private automobile.

The transportation network of the United States, and specifically Los Angles, has been focused on the private automobile, while the public transportation infrastructure is built around fixed-route bus service. The current public transportation system provides a necessary and crucial service to millions of people across the United States that has evolved and adapted as new technologies have become available, populations have migrated, and behavior has changed. The future transportation network will continue to evolve, hopefully towards efficiency and equity.

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