SEPTA Fare Sensitivity Analysis

Using DVRPC's Regional Travel Forecasting Model

SEPTEMBER 2014

DELAWARE VALLEY
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REGIONAL
PLANNING COMMISSION

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DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

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Executive Summary

The Delaware Valley Regional Planning Commission (DVRPC) relies heavily on its travel forecasting model to analyze regional travel and air quality impacts. With so much riding on our analysis, we as an agency realize the importance of producing good and believable forecasts.

We are also aware of how the technology underpinning our analysis is constantly evolving, and are committed to making sure that our analytical tools remain “state-of-the-practice.” DVRPC has adopted a long-range approach to model improvements in an effort to balance the competing needs of being able to use the model on a daily basis for ongoing project work, while simultaneously ensuring that the agency keeps pace with state-of-the-art modeling practice.

The model improvement planning process began in 2008 with an internal dialogue among DVRPC’s planners and engineers to identify both short- and long-term modeling needs. The agency went through a disciplined process to identify the types of analyses and studies that it expects to conduct over the next 10 to 15 years. Among the highest priority needs identified was the analysis of multi-modal alternatives studies, the analysis of New Starts transit projects, and improved transit operations modeling capability.

Based on these recommendations, DVRPC considered its highest short-term priority to be improving the network representation and revising the mode choice element of the model. Several improvements were made in 2010 and 2011 in an effort to develop an improved regional travel forecasting model – Travel Improvement Model 2.1 (TIM 2.1). From the transit modeling perspective, these included the collection of new transit count data, the implementation of a nested choice model, and the development of a new and more accurate representation of the transit network.

This project is a continuation of these efforts. It specifically addresses the need for greater sensitivity with respect to pricing alternatives. For example, what happens to ridership if the Southeastern Pennsylvania Transportation Authority’s (SEPTA) fares increase by 5 percent? Through a series of tests, this project evaluated the model’s ability to accurately reflect the impact that changes in fares have on transit ridership. The results of these tests show that at an aggregate level, the model is able to correctly predict the direction of change in ridership: e.g., whether ridership will increase or decrease as a result of a fare change. In terms of magnitude of change, the model has a tendency to consistently underestimate the impact that a fare change will have on bus ridership. The model is a little more inconsistent with respect to estimating the magnitude of change in Regional Rail ridership. In some cases the model underestimates the change, while in other cases the model overestimates the change.

Despite these tendencies, we believe the model can be used in its current state to estimate the impact that fare changes will have on total ridership, or bus and rail ridership. As with any modeling tool, knowing the model biases allows the user to adjust (post-process) the model’s output accordingly.

This project provided valuable insight into how the model works, and identified both strengths and weaknesses. The weaknesses are things that warrant further attention. DVRPC’s engineers and planners will conduct additional tests, work to diagnose and correct these issues, and improve the TIM 2.1 model for assessing future fare increases and different fare structures for proposed transit projects, as well as assisting in the planning of SEPTA’s fare media modernization program.

CHAPTER 1:

Introduction

Background

In 2010–2011 DVRPC developed a new travel forecasting model to predict travel behavior in the region, which encompasses the following nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. The TIM 2.1 model features several key improvements. These include an improved representation of the transit network using the General Transit Feed Specification (GTFS) data provided by transit providers. New software advances also permitted a much more precise representation of the transit system than was previously possible, including fare information.

The TIM 2.1 model was validated to ensure that it could accurately represent travel patterns at the regional level. For example, model outputs were compared to transit line boarding and alighting data from the region-wide transit counts that were conducted in 2010 and work flow data from the Census Bureau’s American Community Survey. However, the model validation process rarely includes tests to see how well regional models such as TIM 2.1 respond to changing conditions. In particular, how well does the model do at estimating a change to key inputs, such as transit fares?

This project is designed to specifically address this issue. Given the increasing need to be able to model multi-modal projects, and pricing alternatives, this project was created to assess TIM 2.1’s sensitivity to fare changes. It tested the ability of TIM 2.1 to accurately predict changes to transit fare policies at SEPTA, one of the major transit operators in the DVRPC region.

Chapter 2 provides a brief review of recent empirical studies that analyzed the actual effect that fare changes had on ridership at several major transit systems in the United States, Australia, and the United Kingdom. These studies also identify several other factors, such as gas prices, which have a significant impact on ridership. The primary measure used in these types of studies is the economic concept of elasticity of demand.

Chapter 3 presents the underlying data and assumptions that were used in this study. Data on recent fare changes in the Philadelphia metro area, as well as data on changes to several of the other significant factors identified in Chapter 2, is displayed. This background data is presented in an attempt to weigh the impact that these different factors had on ridership, and to try to separate out the amount of the change in ridership that is attributable to fare changes from the amount that is attributable to these other factors.

Chapter 4 discusses the development of the 2010 base version of the model, and presents the validation results. The total daily ridership as estimated by the model was compared to actual count data provided by SEPTA.

In Chapter 5, the model was used to analyze the impact that various fare change scenarios have on ridership. These scenarios include both hypothetical and “real-world” situations. For the hypothetical scenarios, fares in the model were changed in an arbitrary way (across-the-board increase for instance), and then the resulting change in ridership as estimated by the model was compared to the expected change, based on the empirical studies cited in Chapter 2. The real-world scenarios involved actual recent fare changes as implemented by SEPTA. In these cases, the same exact fare change was entered into the model, and then the resulting ridership change as estimated by the model was compared to the actual observed change in ridership as reported by SEPTA. In addition to these empirical tests and backcasting exercise, a set of forecasting scenarios were simulated to analyze the impact of the New Payment Technology (NPT) and associated fare changes as planned by SEPTA in the future horizon.

Based on the results of these tests, the last chapter (Chapter 6) provides an overall evaluation of TIM 2.1's ability to reproduce the impacts of fare increases, and identifies improvements that could increase the model's sensitivity.

CHAPTER 2:

Literature Review

Many studies have been done that tried to identify the factors that have the biggest impact on transit ridership. This is one of the major questions that a transit agency or regional planning agency is concerned with. Much of the literature has focused on the impact that a change in the price of a transit fare has on ridership. However, other factors have also been analyzed, such as how a change in the price of a gallon of gas may result in auto users switching to public transit.

The concept of *elasticity of demand* is frequently used to describe this phenomenon. In simple terms, price elasticity is the percentage change in the demand for some good or service that results from a 1 percent change in its price, while holding everything else constant.

This chapter presents the results of several empirical studies using data from the United States, Australia, and Europe.

Transit Fares

The relationship between transit fare and transit ridership can be described using the concept of price elasticity of demand. In economics, elasticity of demand is a quantitative measure of demand response to price, service, and certain other changes and differences which influence demand. Price elasticity of transit is the percentage change in transit ridership in response to a 1 percent change in transit fare price.

A commonly used rule of thumb (i.e., the Simpson–Curtin rule) for aggregate ridership in response to fare change is that an overall fare increase of 10 percent will result in ridership loss of 3.3 percent (i.e., fare elasticity = –0.33). Throughout the United States and Europe, the most commonly observed range of aggregate fare elasticity values is from –0.1 to −0.6 (Webster and Bly, 1980). The average of aggregate fare elasticities for U.S. cities, excluding those with heavy rail transit (HRT), is about −0.4, and the average is less for those with HRT. Table 1 shows the fare elasticities (calculated using mid-point arc elasticity) from previous studies summarized in the *Transit Cooperative Research Program (TCRP) Report 95* (McCollom and Pratt, 2004). Overall, the effect of fare changes on HRT is more resilient, or less elastic, than bus.

Table 1: Bus and Heavy Rail Transit (HRT) Fare Elasticities

City	Period	Bus	HRT
Chicago	1981–1986	−0.43	−0.18
London	1971–1990	−0.35	−0.17
New York	1948–1977	−0.32	−0.16
New York	1970–1995	−0.20 to −0.30	−0.10 to −0.15
New York	1995	−0.36	−0.15
Paris	1971	−0.20	−0.12
San Francisco	1984–1986	—	−0.31

Source: McCollom and Pratt, 2004.

A study of bus and subway riders in New York City (Hickey, 2005) analyzed the results of nine historical fare increases that occurred between January 1972 and November 1995 (Table 2). The average subway point elasticity during this 24-year period is −0.09, and the average bus point elasticity is −0.37. However, the data does not account for changes in ridership that may be attributable to changes in employment level in New York City between 1972 and 1995.

Table 2: Historical Fare Change and Point Elasticity—New York City

Date of Fare Change	Change in Fare	Subway		Bus	
		Change in Ridership	Point Elasticity	Change in Ridership	Point Elasticity
January 1972	17%	−4%	−0.24	−6%	−0.38
September 1975	43%	−5%	−0.12	−17%	−0.40
June 1980	20%	−3%	−0.13	−5%	−0.26
July 1981	25%	−3%	−0.11	−11%	−0.42
January 1984	20%	−1%	−0.07	−7%	−0.35
January 1986	11%	1%	0.12	−3%	−0.30
January 1990	15%	−4%	−0.29	−6%	−0.37
January 1992	9%	0%	−0.04	−4%	−0.41
November 1995	20%	1%	0.04	−8%	−0.41
Average	20%	−2%	−0.09	−7%	−0.37

Source: Hickey, 2005.

Pham and Linsalata (1991) focused on the effect that fare changes have on bus ridership. They used data from 52 transit systems across the United States. Presented in Table 3 are the fare elasticities estimated by the size of the urban area and time of day. The data shows that fare elasticities are lower in larger cities than smaller ones, and during peak hours where a larger portion of trips are commute trips to and from work. This suggests that although a fare increase may not cause a transit rider to change how they travel to work, it could cause a person to find an alternative form of travel (auto, bicycle, or walking), or choose not to travel with non-essential trip purposes (i.e., shopping) made during off-peak hours.

Table 3: Bus Service Fare Elasticity Estimates

Time of Day	Large Cities (> 1 Million)	Smaller Cities (< 1 Million)
Average for All Hours	−0.36	−0.43
Peak Hour Average	−0.23	−0.23
Off-Peak Average	−0.42	−0.42
Peak Hours	−0.18	−0.27
Off-Peak	−0.39	−0.46

Source: Pham and Linsalata, 1991.

A similar study on fare elasticities using data from the United Kingdom (Balcombe et al., 2004) concluded that bus fare elasticities average −0.40 in the short run (less than a year), −0.56 in the medium run, and −1.0 in the long run (several years). By time of day, bus fare elasticities average −0.24 during peak travel times and −0.51 during the off-peak. For rail trips, the fare elasticities are −0.30 in the short run and −0.60 in the long run.

A study from Australia (Hensher, 1997) used data from the City of Newcastle to analyze how a change in the price of one type of transit, such as bus, impacts the use of a substitute or alternative travel mode, such as rail or auto. This is referred to as *cross-elasticity*. As shown in Table 4, a 1 percent increase in the price of a single bus ticket is estimated to result in a 0.357 percent reduction in the sale of single bus tickets, a 0.067 percent increase in the sale of single rail tickets, and a 0.116 percent increase in auto trips.

Table 4: Direct and Cross-Share Elasticities between Train and Bus

Ticket Increase ↓/ Response →	Train, Single Fare	Train, 10 Fares	Train, Pass	Bus, Single Fare	Bus, 10 Fares	Bus, Pass	Auto
Train, Single Fare	−0.218	0.001	0.001	0.057	0.005	0.005	0.196
Train, 10 Fares	0.001	−0.093	0.001	0.001	0.001	0.006	0.092
Train, Pass	0.001	0.001	−0.196	0.001	0.012	0.001	0.335
Bus, Single Fare	0.067	0.001	0.001	−0.357	0.001	0.001	0.116
Bus, 10 Fares	0.020	0.004	0.002	0.001	−0.160	0.001	0.121
Bus, Pass	0.007	0.036	0.001	0.001	0.001	−0.098	0.020
Auto	0.053	0.042	0.003	0.066	0.016	0.003	−0.197

Source: Hensher, 1997.

The relatively wide range of observed elasticities suggests a need for explanatory factors to describe rider response (ridership changes) to fare changes. Potential factors may include alternative transit mode, direction and size of fare change, time of day (peak versus off-peak), population, congestion level, parking cost of the service area, and concurrent changes in service provision.

Population, Employment, and Transit Service

In addition to the fare price of bus and rail transit, several other factors have also been shown to have a significant impact on transit ridership. Kain and Liu (1999) analyzed the impacts due to external and internal factors. They describe external factors as being largely exogenous to the transit system and its managers, such as service area population and employment. Internal factors, on the other hand, are those over which transit managers exercise some degree of control, such as fares and service levels.

Their study used bus passenger data from Houston and bus and light rail passenger data from San Diego. Both systems experienced unusually large increases in transit ridership during a period when most other peer transit systems were experiencing sharp declines.

Shown in Table 5, the data indicates that increases in population, employment, and the level of service provided all have a positive impact on ridership, whereas an increase in fare has a negative impact as expected. In terms of magnitude, population and service level have approximately twice as much impact on transit ridership as fare price.

Table 5: Factors Affecting Transit Ridership

Factor	Elasticity
Central City Population	0.61
Regional Employment	0.25
Service Level (Transit Vehicle Miles)	0.71
Fare Price	−0.32

Source: Kain and Liu, 1999.

Gas Prices

Another factor that has an impact on transit ridership is the cost of operating a private vehicle: in particular, the price of a gallon of gas. From studies conducted in Europe (TRACE, 1999), a 1 percent increase in the price of gas resulted in a 0.16 percent increase in transit ridership in the short run, and a 0.12 percent increase in the long run. The declining elasticity value in the long run was attributed to motorists purchasing more fuel-efficient vehicles when gas prices increase.

A study done by Ozbay and Yanmaz-Tuzel in 2010 also analyzed the impact that gas prices have on transit ridership. They observed a lag of several months between the time of a change in gas prices and a change in ridership, and concluded that travelers tend to consider trends in gas prices before making long-term decisions about switching from auto to public transit, or vice versa.

Their study also estimated the elasticity of transit demand with respect to gas price for different trip purposes shown in Table 6. They found the highest percentage change in ridership resulting from a 1 percent increase in the price of gas was for work trips, and the lowest percentage change was for holiday trips. This makes intuitive sense. A person driving to and from work five days a week, week in and week out, is probably going to be much more aware of, and sensitive to, the price of gas than someone who only drives during the one or two weeks during the year when they are on vacation. Also, in many cases, the person going to work will have a bus or train that they can switch to, whereas the person on vacation may not.

Table 6: Elasticity of Transit Demand with Respect to Gas Price for Different Trip Purposes

Trip Purpose	Elasticity
Work	0.220
School	0.121
Leisure	0.045
Shopping	0.031
Holiday	0.016

Source: Ozbay and Yanmaz-Tuzel, 2010.

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CHAPTER 3:

Data and Assumptions

The literature review in Chapter 2 documented the economic theory underlying the concept of price elasticity of demand. That chapter also identified various factors, in addition to fare changes, that have an impact on ridership. One of the key underlying assumptions of the economic principle of elasticity of demand is that, in theory, the price of the good in question (e.g., transit fare) is allowed to vary while everything else is held constant (*ceteris paribus*).

This chapter reviews recent data for several of the factors identified in Chapter 2 as having a significant impact on ridership. It shows how, in reality, many of these factors varied considerably during the time period when SEPTA made its most recent fare changes. This makes it difficult to separate out how much of the change in ridership is attributable to the fare change, and how much is due to other factors. It also makes it difficult to calculate the actual price elasticity of demand as observed in the Philadelphia metro area. Finally, it produces some very contradictory results, as in ridership increasing after a fare hike, when the literature (and common sense) indicates that it should decrease.

SEPTA Fares and Fare Policy

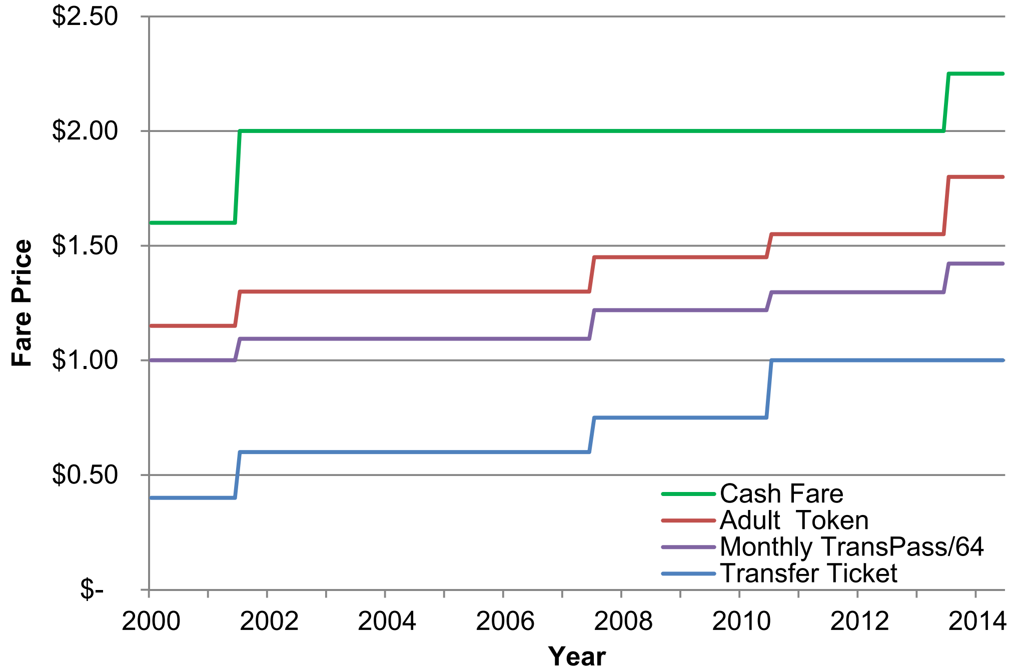
Detailed information on SEPTA's fares and fare policy are contained in its Fare Tariff.[1] The tariff identifies all of the different fare media and prices that passengers can use to pay for a trip. For example, upon boarding, bus passengers currently have the option of paying cash ($2.25), or using fare media purchased in advance like a token ($1.80), Weekly TransPass ($24.00), or a One-Day Convenience Pass ($8.00), to name a few.

Two recent bills passed by the Pennsylvania General Assembly have dramatically improved SEPTA's ability to raise fares and generate needed revenue. Act 44 was passed in 2007 and established the Public Transportation Trust Fund, which restructured public transit funding in Pennsylvania. Act 89 was passed in 2013 and provides long-term, dedicated funding for public transit as well as for roads, bridges and multi-modal transportation. The net effect of this legislation is that SEPTA is now able to raise fares on a regular basis (every 36 months or 3 years) to keep pace with inflation and maintain a state of good repair.

The most recent SEPTA fare changes occurred in July 2001, 2007, 2010, and 2013. Figure 1 shows the fare price history from 2000 to 2014 for four commonly used fare media type: cash, token, transfer ticket, and Monthly TransPass (for which, for comparison, the price was divided by 64 to present the equivalent cost per ride). For an extended period after 2001, SEPTA did not increase its fares until 2007. In July 2007, SEPTA increased the token price by 12 percent, the transfer price by 25 percent, and the Monthly TransPass price by 11 percent. In July 2010, SEPTA increased the token price by 7 percent, the transfer price by 33 percent, and the Monthly TransPass price by 6 percent. In July 2013, fare zones were eliminated for most bus routes, the number of Regional Rail fare zones was reduced from seven to six, and the cash fare was increased for the first time since 2001 from $2.00 to $2.25 along with increases of other fare media. Overall, these fare increases were relatively small and have barely kept pace with inflation since 2001.

[1] See the Operating Tariffs sections on the SEPTA website: www.septa.org/reports/. Also, the most up-to-date Fare Guide: www.septa.org/fares/new/2013%20Fare%20Brochure.pdf.

Figure 1: SEPTA Fare Price History (2000–2014)



Source: SEPTA, 2014.

Currently, SEPTA is in the midst of replacing its current fare collection process with a new "smart" system, NPT, which will work seamlessly across the entire SEPTA network. It will enable fare payment on all their buses, trolleys, subways, Regional Rail lines, and Customized Community Transportation (CCT) vehicles, as well as SEPTA parking facilities.

The new fare collection system will offer riders the same variety of payment choices with better convenience in purchase and usage. When the new system launches, the choices will include cash and refillable cards. Ultimately it will incorporate smartphones and other contactless methods or devices. The NPT project is divided into three phases, expected to be completed by 2015:

1) design, testing, and manufacturing;

2) transit installation (bus, trolley, and subway); and

3) Regional Rail installation.

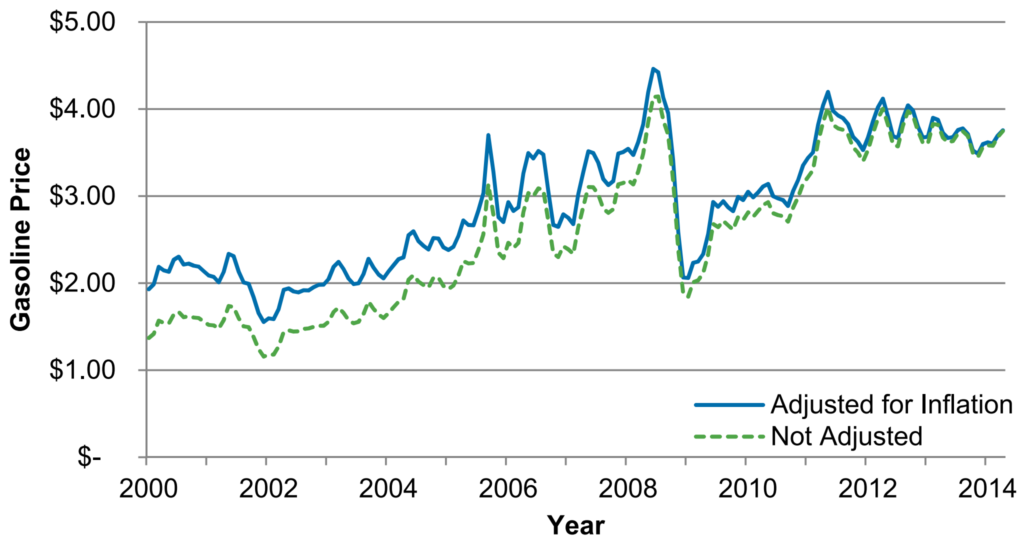
To ease the transition, SEPTA is preparing the most far-reaching public information and education campaign in its history. This includes the creation of an infographic[2] to help SEPTA riders, the public, community leaders, and visitors to better understand the scope and timing of the effort.

[2] SEPTA, "New Payment Technologies Project Details," www.septa.org/fares/npt/project-details.html.

Gas Prices

Retail gas prices throughout the entire United States and in the Philadelphia metro area dropped sharply in 2008 as a result of the Great Recession, which lasted from December 2007 to June 2009. By 2011, prices had rebounded to pre-recession levels. As shown in Figure 2, the rebound in gas prices between 2009 and 2011 coincided with the time period after the July 2010 fare change. This increase in gas prices undoubtedly contributed to the ridership increase that was observed in 2011.

Figure 2: Retail Gas Price Change—Central Atlantic Region (2000–2014)



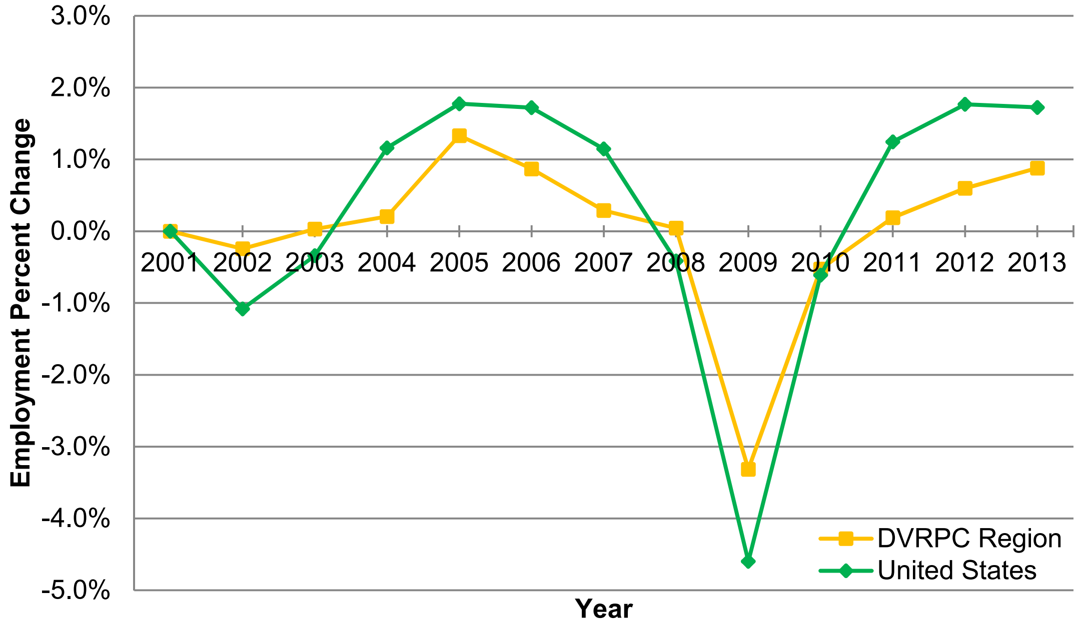
Source: U.S. Energy Information Administration, 2014.

> As gas prices keep going up, SEPTA ridership is on the rise. "It's a lot cheaper to get on the train than to drive." SEPTA ridership is up 4 percent from July to March compared to the year before. That's 10.1 million more trips made on SEPTA buses, trains, and trolleys. This week, the price of a gallon of gas went up 8 cents to an average of $3.80 in the Philadelphia five-county region. That's changing the way people get where they need to go.
>
> —Excerpt from April 15, 2011, SEPTA press release, www.abc13.com/archive/8075800/.

Employment

Between 2000 and 2013, the number of employees in Greater Philadelphia remained relatively stable, despite suffering one of the worst recessions since the Great Depression of the 1930s. Overall regional employment increased by approximately 3 percent over this time period, higher than the national gain of 0.9 percent. However, at the height of the Great Recession, between 2008 and 2009, the region's employment declined by over 3 percent. Figure 3 shows the annual change in employment for the region and United States.

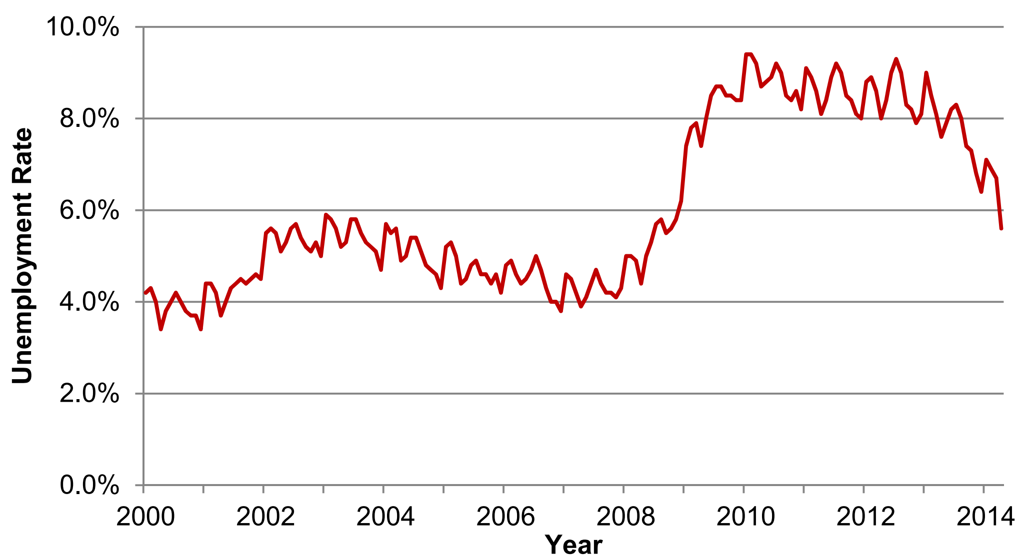
Figure 3: Percentage Annual Change in Employment (2000–2013)



Source: U.S. Department of Labor, Bureau of Labor Statistics, 2014.

The unemployment rate in the Philadelphia–Camden–Wilmington Metropolitan Statistical Area (MSA) shown in Figure 4 was 4.1 percent just before the start of the recession in November 2007 and rose to 9.4 percent in January 2010. It remained relatively constant between 2010 and early 2013 but has decreased since the second half of 2013. As of April 2014, unemployment has fallen to 5.6 percent.[3]

Figure 4: Unemployment Rate Change—Philadelphia–Camden–Wilmington MSA (2000–2014)



Source: U.S. Department of Labor, Bureau of Labor Statistics, 2014.

[3] Bureau of Labor Statistics, "Economic News Release, Civilian Labor Force and Unemployment by State and Metropolitan Area," www.bls.gov/news.release/metro.t01.htm.

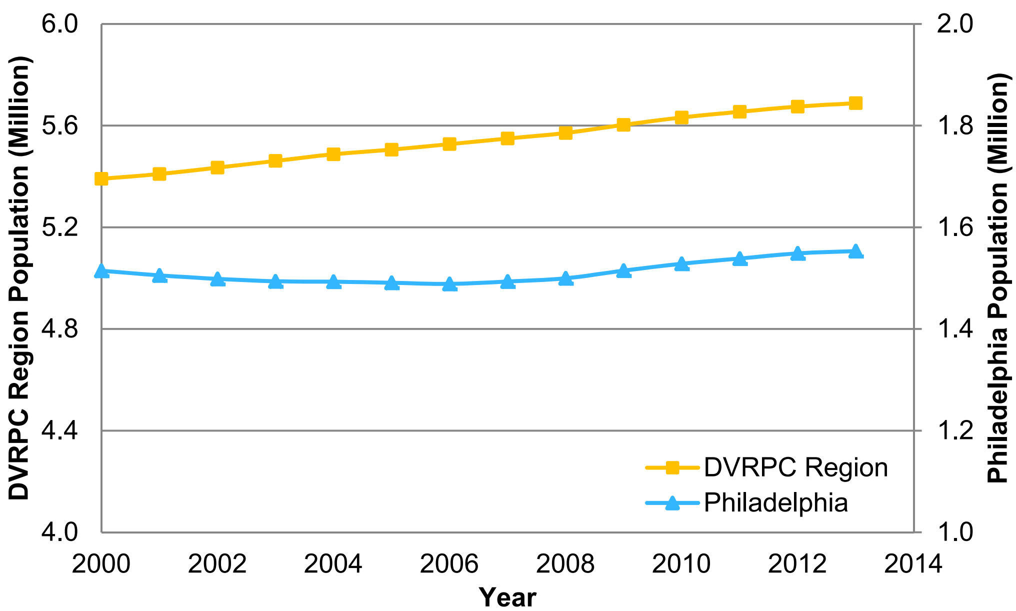
Since the beginning of the economic recovery in mid-2009, job growth in the Philadelphia metro area has been slower than in the nation as a whole. However, the region's job loss during the recession was also not as severe. The diversity of the region's economy has historically protected it from the dramatic increases and declines experienced in other less diverse economies.

As with the increase in gas prices, the prolonged period of elevated unemployment that followed the July 2010 fare change probably contributed to the increase in ridership that was observed in 2011. As people lose their jobs, or their positions become less secure, there is a tendency to look for ways to reduce expenses.

Population

For the region as a whole, the years between 2000 and 2013 can be characterized as a period of population growth, as shown in Figure 5. The nine-county DVRPC region's population increased by 5.5 percent with most of the growth continuing to occur in growing suburbs and rural areas, which realized population increases of approximately 18 percent and 13 percent, respectively. Much of the change in regional demographics during recent decades can be thought of as a doughnut, with the urban communities in the center of the region losing jobs and people, and the suburban communities surrounding the region's core gaining jobs and people. Between 2000 and 2013, the City of Philadelphia's population increased by 2.5 percent, ending a period of long-term decline.

Figure 5: Census Population (2000–2013)



Source: U.S. Census Bureau, 2014.

SEPTA Service Levels

Some commonly used metrics in the transit industry are shown in Table 7 to illustrate how the amount of service provided by SEPTA changed during the recent fare changes. These service metrics are defined below:

- *Unlinked trips* is the total number of passenger trips made, counting all passenger transfers and vehicle boarding to reach the destination.
- *Passenger miles* is the cumulative total distance ridden by all passengers.
- *Vehicle revenue miles* is the cumulative total distance travelled by all vehicles while in revenue service.
- *Revenue vehicles*, *Stations*, and *Number of bus/trolley stops* is the number of each in revenue service.
- *Fixed routes* is the number of routes that provide service on a fixed-schedule and fixed-route basis.

The data was summarized by SEPTA's fiscal year (FY), which runs from July 1 through June 30. As shown in the table, there were minimal year-to-year changes in service level, with most values varying by less than ±5 percent. One of the most recent fare changes occurred in July 2010 (between FY 2010 and FY 2011). Despite the fare increase, unlinked trips (ridership) increased by 4 percent even though the total passenger miles remained same. In terms of actual service provided by SEPTA, there was a slight decrease in vehicle revenue miles and the number of revenue vehicles in service.

Table 7: SEPTA Transit Service Levels, Annual (FY) Percentage Change

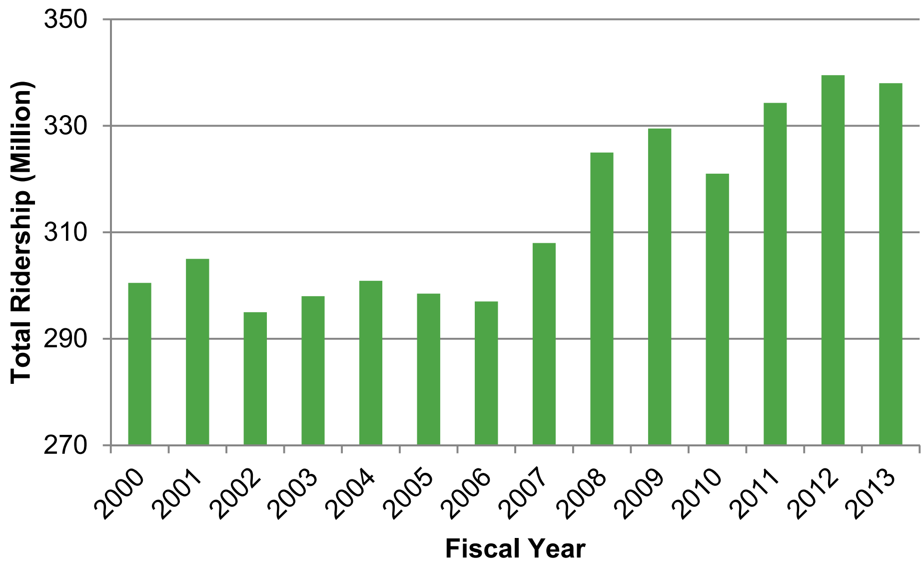
Level of Service Metric	2009–2010	2010–2011	2011–2012	2012–2013
Unlinked Trips	−3%	4%	2%	−1%
Passenger Miles	−2%	0%	6%	−2%
Vehicle Revenue Miles	0%	−8%	9%	1%
Revenue Vehicles	1%	−2%	0%	1%
Fixed Routes	0%	0%	1%	−1%
Stations	0%	0%	0%	0%
Number of Bus/Trolley Stops	NA	1%	4%	0%

Source: SEPTA, 2009–2013.

SEPTA Ridership

Figure 6 shows SEPTA's total annual ridership from FY 2000 to FY 2013. Ridership remained relatively stable from 2000 to 2006 followed by an observed increase of approximately 30 to 40 million annual rides in later years. SEPTA service has been interrupted twice in the last decade by transport union strikes. Service was suspended for seven days in 2005, and for six days in 2009. These strikes generally have short-term negative ridership impacts; thus, ridership on SEPTA would likely have been even higher if the strikes had been averted in these two instances.

Figure 6: Total SEPTA Ridership (FY 2000–FY 2013)



Source: SEPTA, 2014.

SEPTA operates with three divisions that provide service to different areas of the region. The City Transit Division (CTD) mainly serves the City of Philadelphia, the Suburban Transit Division (STD) consisting of two subdivisions (Victory and Frontier) mainly serves the suburbs, and the Regional Rail Division (RRD) provides a direct link between the city and suburban areas. Within the CTD, services are further separated into rail (subway and trolley) and bus (including trackless trolley) to provide a detailed comparison. Table 8 shows the average daily ridership change between FY 2010 and FY 2011 for all SEPTA divisions. Despite the fare increase that occurred between these two FYs, the average daily ridership across all SEPTA services increased by 3.2 percent. This ridership growth is probably a result of several factors. First, there was some amount of increased economic activity and residential development in and around Center City Philadelphia (CCP), the focal point of the regional transit system. Second, as shown earlier in Figure 2, retail gas prices in the DVRPC region increased from approximately $2.78 per gallon in July 2010 to $3.78 in July 2011. Third, the sustained high unemployment that resulted from the Great Recession has likely both hurt and helped transit ridership. Individuals have curtailed unnecessary travel, but at the same time have turned to transit as a way to save money.

Table 8: Average Daily Ridership—Before and After July 2010 Fare Change

Transit System	FY 2010 (Before)	FY 2011 (After)	Difference	Percentage Change
City Rail	407,085	418,420	11,335	2.8%
City Bus	453,301	468,355	15,054	3.3%
Victory	53,640	56,744	3,104	5.8%
Frontier	12,799	13,489	690	5.4%
Regional Rail	115,025	118,305	3,280	2.9%
Total	1,041,850	1,075,313	33,463	3.2%

Source: SEPTA, 2010 and 2011.

Following its schedule, SEPTA increased fares again in July 2013, and the ridership before and after this change is shown in Table 9. It compares the FY 2011 ridership with the average of March and April in 2014. These two months from FY 2014 were selected because it takes about six months for ridership to stabilize after a fare change (e.g., it takes a while after a fare hike for passengers to adjust, and for ridership to stabilize) and the months of January and February were unreliable due to multiple winter weather-related impacts in the region. Despite a fare increase, SEPTA ridership increased again, this time by 4.1 percent. In particular, ridership for the Victory, Frontier, and Regional Rail divisions experienced the greatest increase. During this time, gas prices had become relatively stable from year to year, not accounting for seasonal fluctuations. However, the Philadelphia metro area was still experiencing persistent high unemployment. The unemployment rate averaged 9.2 percent during FY 2011 and was at 8.0 percent in August 2013, before falling to 6.7 and 5.6 percent in March and April 2014, respectively.

Table 9: Average Daily Ridership—Before and After July 2013 Fare Change

Transit System	FY 2011 (Before)	FY 2014 / Mar.–Apr. (After)	Difference	Percentage Change
City Rail	418,420	421,957	3,537	0.8%
City Bus	468,355	495,977	27,622	5.9%
Victory	56,744	59,599	2,855	5.0%
Frontier	13,489	13,558	69	0.5%
Regional Rail	118,305	128,815	10,510	8.9%
Total	1,075,313	1,119,906	44,593	4.1%

Source: SEPTA, 2011 and 2014.

Overall, the two most recent SEPTA fare increases do not provide a “clean” or economically logical data source in order to determine local transit elasticities.

CHAPTER 4:

Fare Modeling in TIM 2.1

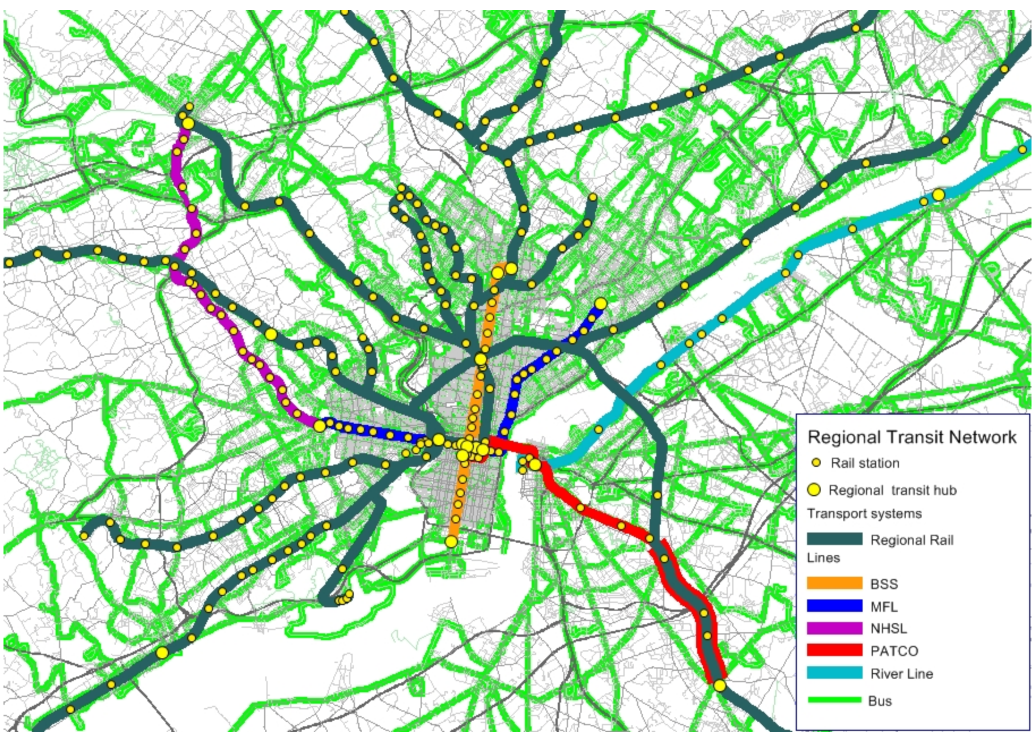
This chapter discusses how SEPTA's routes and fare system are modeled using DVRPC's TIM 2.1 travel forecasting model, and the validation of the base year model.

Transit Network

The TIM 2.1 model is a traditional four-step, trip-based travel forecasting model. Built on PTV's VISUM software platform, it includes representations of the highway and public transit systems in DVRPC's nine member counties plus an extended area of 16 counties (where a less detailed transportation network is modeled) in Pennsylvania, New Jersey, Delaware, and Maryland, immediately surrounding the DVRPC region. The highway network was built on the base of the Open Street Map and the transit network was developed by importing the GTFS data. The transit network represents operational characteristics of the regional transit system including route alignment, stop locations, service schedules, and fare information. The fare model is presented by fare systems and ticket types. Each transit operator has their own fare system(s), and a ticket type is defined for a set of lines that exhibit the same characteristics with regard to pricing. A ticket type describes how the fare is applied to a transit line or a part of its connections.

A 2010 base transit network was developed, which reflects the bus and rail routes that were in operation between July 2010 and July 2011. The transit network includes a total of 1,896 line routes and 11,917 stops and is displayed in Figure 7. The Port Authority Transit Corporation (PATCO) high speed line is displayed in red, the Broad Street Line (BSL) is displayed in orange, the Market-Frankford Line (MFL) is displayed in blue, the Norristown High Speed Line (NHSL) is displayed in purple, Regional Rail routes are displayed in dark green, and local bus routes are displayed in light green.

Figure 7: TIM 2.1 Transit Network



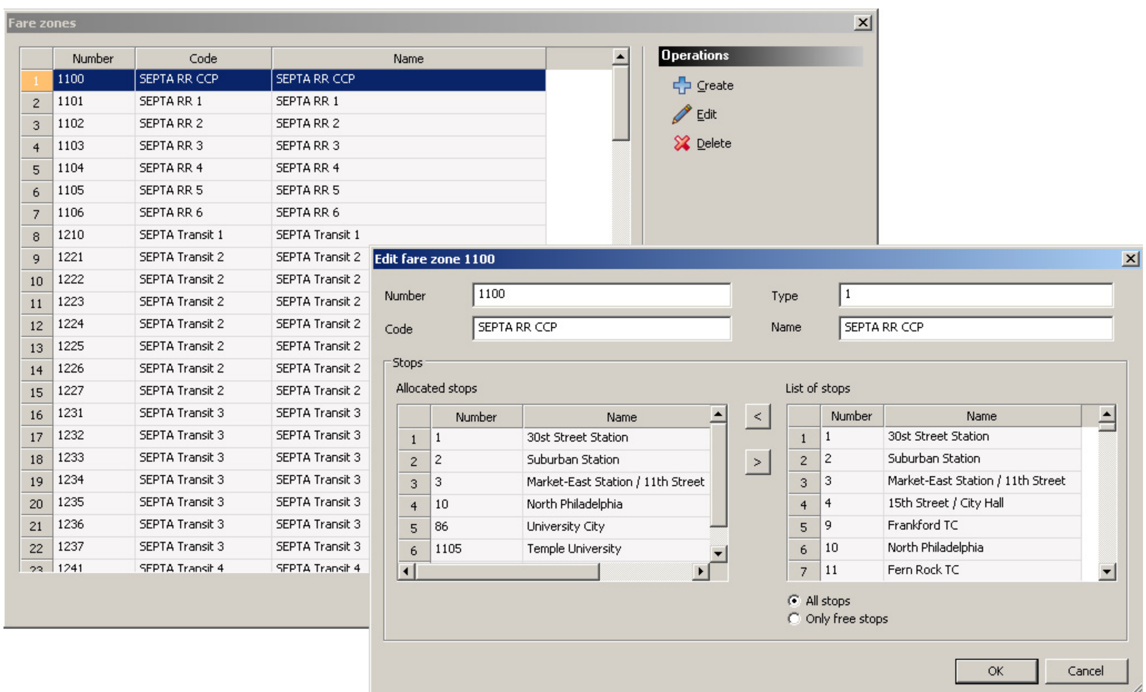
Source: DVRPC, 2014.

The schedules or timetables that were in effect in 2010 were entered for each route. The model is able to keep track of the amount of time it takes a passenger to walk to a bus stop or drive to a Park and Ride lot, the amount of time spent waiting at the bus stop for the bus to arrive (headway), the amount of time that it takes for the bus to travel from the stop where the passenger boarded to the stop where they get off, and the amount of time it takes from the alighting location to the destination. The next four sections will provide details on how the fare model was developed and configured in the TIM 2.1 model in VISUM.

Fare Zones

To replicate the fare structure used by SEPTA, the "fare zone" concept is used in the TIM 2.1 model. All transit stops in the model are assigned to a fare zone that comprises a set of stops. Most stops are a member in one fare zone, but stops can be assigned to multiple fare zones as necessary. For example, 30th Street Station is a member in five fare zones (i.e., SEPTA's Regional Rail CCP zone, SEPTA's Transit zone 1, New Jersey Transit [NJT] Acela Philadelphia zone, Amtrak zone 10, and Bieber Bus zone 6). Figure 8 shows some of the fare zones defined in TIM 2.1 and an example of stops allocated to the "SEPTA RR CCP" fare zone. In TIM 2.1, there are a total of 143 fare zones.

Figure 8: Fare Zones Configuration



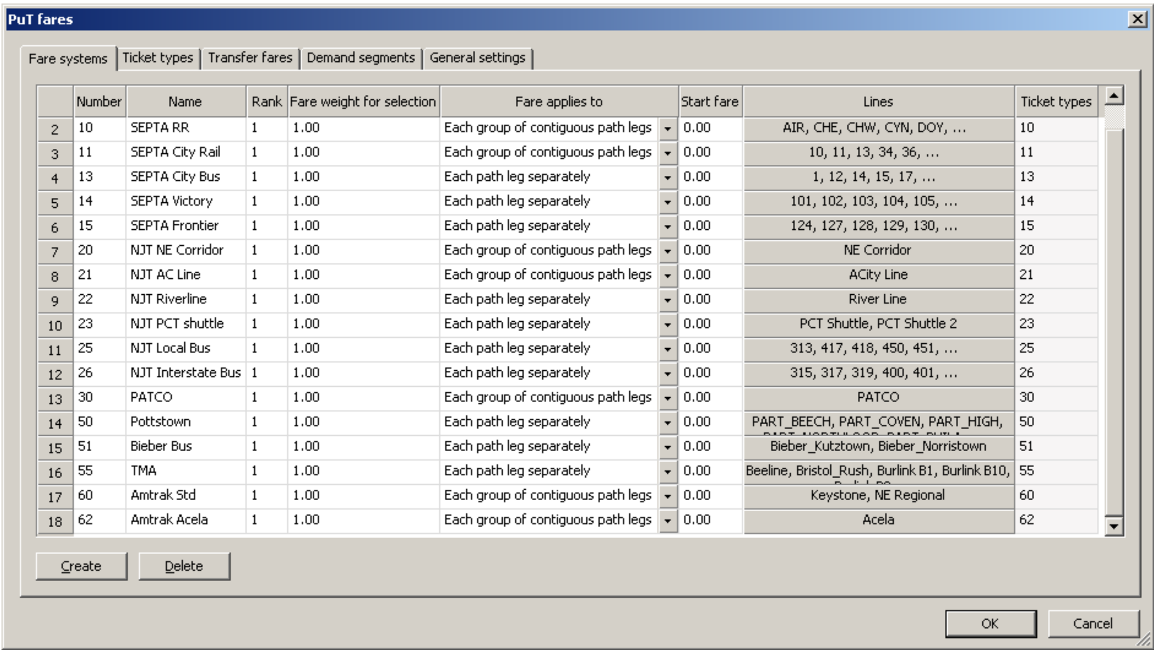
Source: DVRPC, 2014.

The advantage of using fare zones is that, other than stops, there is no need to define fare-related information on links, line routes, time profiles, and vehicle journeys. So during network coding, the fare model will not be affected by changes to nodes, links, routes, and schedules.

Fare Systems and Ticket Types

A “fare system” is a group of transit lines that obeys the same pricing scheme. A total of 17 fare systems are defined in TIM 2.1 based on prices charged by the transit operators for different services, as shown in Figure 9. Each fare system’s ticket type and associated transit lines are assigned here.

Figure 9: Fare Systems Configuration



	Number	Name	Rank	Fare weight for selection	Fare applies to	Start fare	Lines	Ticket types
2	10	SEPTA RR	1	1.00	Each group of contiguous path legs	0.00	AIR, CHE, CHW, CYN, DOY, ...	10
3	11	SEPTA City Rail	1	1.00	Each group of contiguous path legs	0.00	10, 11, 13, 34, 36, ...	11
4	13	SEPTA City Bus	1	1.00	Each path leg separately	0.00	1, 12, 14, 15, 17, ...	13
5	14	SEPTA Victory	1	1.00	Each path leg separately	0.00	101, 102, 103, 104, 105, ...	14
6	15	SEPTA Frontier	1	1.00	Each path leg separately	0.00	124, 127, 128, 129, 130, ...	15
7	20	NJT NE Corridor	1	1.00	Each group of contiguous path legs	0.00	NE Corridor	20
8	21	NJT AC Line	1	1.00	Each group of contiguous path legs	0.00	ACity Line	21
9	22	NJT Riverline	1	1.00	Each path leg separately	0.00	River Line	22
10	23	NJT PCT shuttle	1	1.00	Each path leg separately	0.00	PCT Shuttle, PCT Shuttle 2	23
11	25	NJT Local Bus	1	1.00	Each path leg separately	0.00	313, 417, 418, 450, 451, ...	25
12	26	NJT Interstate Bus	1	1.00	Each path leg separately	0.00	315, 317, 319, 400, 401, ...	26
13	30	PATCO	1	1.00	Each group of contiguous path legs	0.00	PATCO	30
14	50	Pottstown	1	1.00	Each path leg separately	0.00	PART_BEECH, PART_COVEN, PART_HIGH,	50
15	51	Bieber Bus	1	1.00	Each path leg separately	0.00	Bieber_Kutztown, Bieber_Norristown	51
16	55	TMA	1	1.00	Each path leg separately	0.00	Beeline, Bristol_Rush, Burlink B1, Burlink B10,	55
17	60	Amtrak Std	1	1.00	Each group of contiguous path legs	0.00	Keystone, NE Regional	60
18	62	Amtrak Acela	1	1.00	Each group of contiguous path legs	0.00	Acela	62

Source: DVRPC, 2014.

In the DVRPC region, the three major transit operators are SEPTA, NJT, and PATCO. Five fare systems are defined for SEPTA, including one for the RRD, two for the CTD, and two for the STD. The following provides an overview of SEPTA’s fare systems in TIM 2.1:

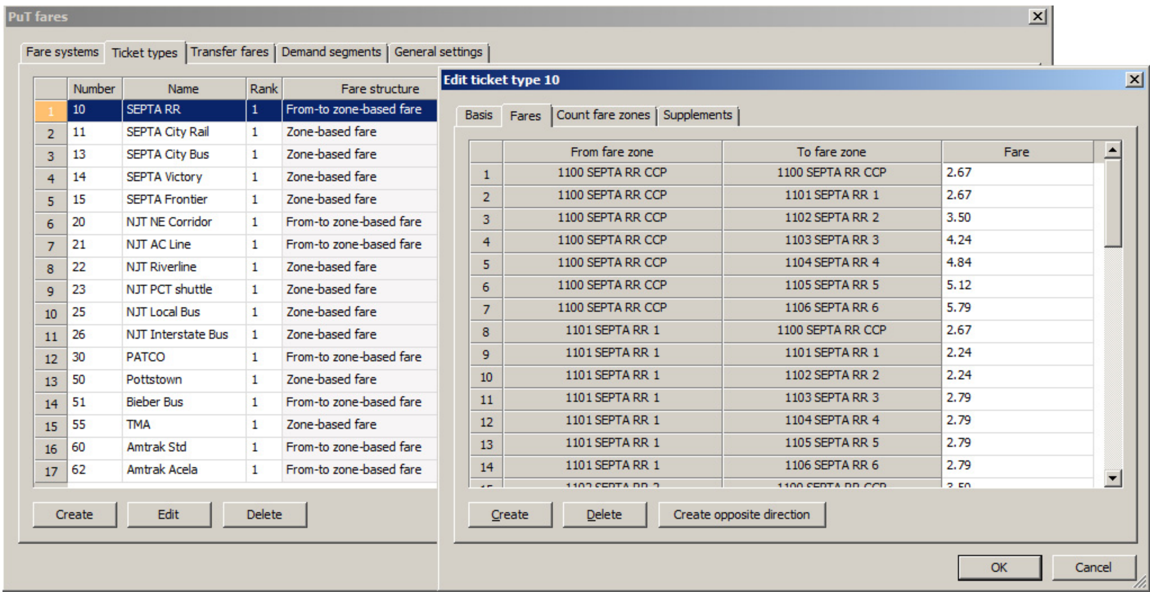
- The RRD is modeled as its own fare system because of the very different fare rules and pricing. Regional Rail uses a “from–to zone-based” fare structure wherein the fare is calculated based on the origin fare zone and destination fare zone. Figure 10 shows the fare inputs to the “from–to zone-based” ticket type. Fares are applied to “each group of contiguous path legs” where a ticket can be used for several successive path legs for a trip. This option is selected since most Regional Rail passengers use TrailPasses, which allow for free travel on successive legs of the journey (path legs) within the fare system.

- The “City Bus” fare system for the CTD includes all city buses, bus substitutions, trolley route 15, and all trackless trolley lines under this division. A “zone-based” fare structure is used wherein the fare is calculated based on the number of zones traversed. Figure 11 shows the fare inputs to the “zone-based” ticket type. Fares are applied to “each path leg separately” since a ticket must be purchased for each single path leg.

- The “City Rail” fare system for the CTD includes the two subway/elevated lines (MFL and BSL) and trolley routes 10, 11, 13, 34, and 36. These seven lines are coded in their own fare system to allow for free transfer between these lines at 30th Street, 13th Street, and 15th Street (City Hall) stations. It also adopts a “zone-based” fare structure, and fares are applied to “each group of contiguous path legs” to allow for the free transfer.

- For the STD, two fare systems are defined, one for each subdivision. The Victory Division includes all Victory buses, trolley routes 101 and 102, and the NHSL. These lines operate from the 69th Street Transportation Center in Upper Darby Township. The Frontier Division includes all Frontier services, which are buses that only operate from the Garage in Plymouth Township. A “zone-based” fare structure is used for both subdivisions.

Figure 10: Ticket Type: From–To Zone-Based Fare Structure—Regional Rail



PuT fares

Fare systems | Ticket types | Transfer fares | Demand segments | General settings

	Number	Name	Rank	Fare structure
1	10	SEPTA RR	1	From-to zone-based fare
2	11	SEPTA City Rail	1	Zone-based fare
3	13	SEPTA City Bus	1	Zone-based fare
4	14	SEPTA Victory	1	Zone-based fare
5	15	SEPTA Frontier	1	Zone-based fare
6	20	NJT NE Corridor	1	From-to zone-based fare
7	21	NJT AC Line	1	From-to zone-based fare
8	22	NJT Riverline	1	Zone-based fare
9	23	NJT PCT shuttle	1	Zone-based fare
10	25	NJT Local Bus	1	Zone-based fare
11	26	NJT Interstate Bus	1	Zone-based fare
12	30	PATCO	1	From-to zone-based fare
13	50	Pottstown	1	Zone-based fare
14	51	Bieber Bus	1	From-to zone-based fare
15	55	TMA	1	Zone-based fare
16	60	Amtrak Std	1	From-to zone-based fare
17	62	Amtrak Acela	1	From-to zone-based fare

Create | Edit | Delete

Edit ticket type 10

Basis | Fares | Count fare zones | Supplements

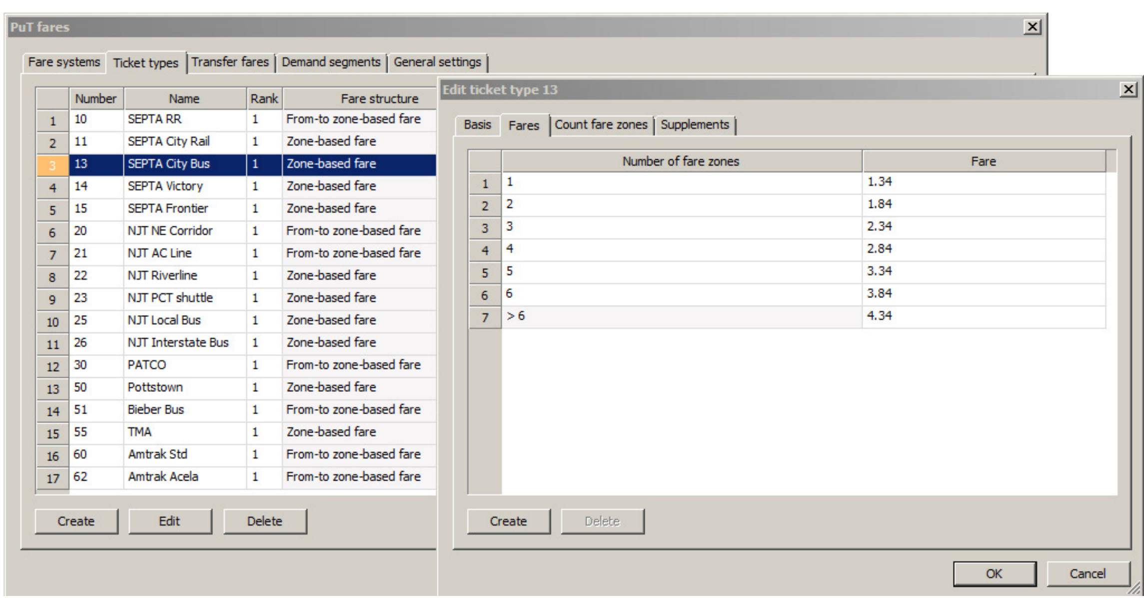
	From fare zone	To fare zone	Fare
1	1100 SEPTA RR CCP	1100 SEPTA RR CCP	2.67
2	1100 SEPTA RR CCP	1101 SEPTA RR 1	2.67
3	1100 SEPTA RR CCP	1102 SEPTA RR 2	3.50
4	1100 SEPTA RR CCP	1103 SEPTA RR 3	4.24
5	1100 SEPTA RR CCP	1104 SEPTA RR 4	4.84
6	1100 SEPTA RR CCP	1105 SEPTA RR 5	5.12
7	1100 SEPTA RR CCP	1106 SEPTA RR 6	5.79
8	1101 SEPTA RR 1	1100 SEPTA RR CCP	2.67
9	1101 SEPTA RR 1	1101 SEPTA RR 1	2.24
10	1101 SEPTA RR 1	1102 SEPTA RR 2	2.24
11	1101 SEPTA RR 1	1103 SEPTA RR 3	2.79
12	1101 SEPTA RR 1	1104 SEPTA RR 4	2.79
13	1101 SEPTA RR 1	1105 SEPTA RR 5	2.79
14	1101 SEPTA RR 1	1106 SEPTA RR 6	2.79

Create | Delete | Create opposite direction

OK | Cancel

Source: DVRPC, 2014.

Figure 11: Ticket Type: Zone-Based Fare Structure—City Bus



PuT fares

Fare systems | Ticket types | Transfer fares | Demand segments | General settings

	Number	Name	Rank	Fare structure
1	10	SEPTA RR	1	From-to zone-based fare
2	11	SEPTA City Rail	1	Zone-based fare
3	13	SEPTA City Bus	1	Zone-based fare
4	14	SEPTA Victory	1	Zone-based fare
5	15	SEPTA Frontier	1	Zone-based fare
6	20	NJT NE Corridor	1	From-to zone-based fare
7	21	NJT AC Line	1	From-to zone-based fare
8	22	NJT Riverline	1	Zone-based fare
9	23	NJT PCT shuttle	1	Zone-based fare
10	25	NJT Local Bus	1	Zone-based fare
11	26	NJT Interstate Bus	1	Zone-based fare
12	30	PATCO	1	From-to zone-based fare
13	50	Pottstown	1	Zone-based fare
14	51	Bieber Bus	1	From-to zone-based fare
15	55	TMA	1	Zone-based fare
16	60	Amtrak Std	1	From-to zone-based fare
17	62	Amtrak Acela	1	From-to zone-based fare

Create | Edit | Delete

Edit ticket type 13

Basis | Fares | Count fare zones | Supplements

	Number of fare zones	Fare
1	1	1.34
2	2	1.84
3	3	2.34
4	4	2.84
5	5	3.34
6	6	3.84
7	>6	4.34

Create | Delete

OK | Cancel

Source: DVRPC, 2014.

Average Fares

For each fare system, an average base fare was calculated for its associated ticket type. In reality, SEPTA offers a wide array of fare options, which includes but is not limited to cash fare, tokens, weekly passes, monthly passes, zonal fees, and transfer tickets, depending on whether passengers are using the local or regional service and the number of traversed fare zones. In order to represent SEPTA's complex fare mixture, a weighted average fare was calculated based on the most commonly used fare media types. Table 10 shows the different fare media types considered and the average base fare calculation for the City Bus, which accounts for 99 percent of the total passengers who ride on this fare system. Average base fares were calculated the same way for City Rail, Victory, and Frontier fare systems.

Table 10: Average Base Fare Calculation (2010)—SEPTA City Bus

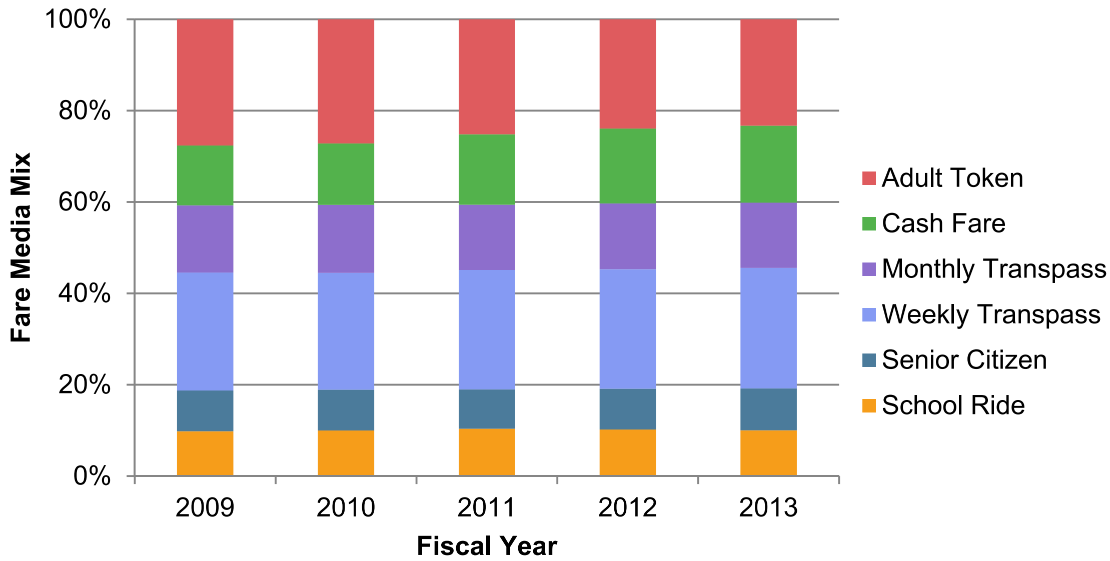
Fare Media	Fare Cost	Rides per Fare Media	Per-Ride Fare	Weight by Riders	Weighted Fare
Adult Token	$1.55	1	$1.55	18.34%	$0.28
Cash Fare	$2.00	1	$2.00	15.43%	$0.31
Monthly TransPass	$83.00	64	$1.30	14.17%	$0.18
Weekly TransPass	$22.00	17	$1.30	26.60%	$0.34
Senior Citizen	$1.00	1	$0.00	11.63%	$0.00
School Ride	$15.36*	9	$1.77	11.67%	$0.21
Day Pass	$7.00	7	$1.00	0.67%	$0.01
Handicap Fare	$1.00	1	$1.00	0.95%	$0.01
Free Ride	$0.00	1	$0.00	0.55%	$0.00
Average	—	—	—	—	$1.34

**weighted average of school token and weekly School Passes*

Source: DVRPC, 2014.

In Table 10, the weights used for calculating the average fare are based on the ridership split among these fare media types. For each fare system, the fare mix in terms of ridership remained approximately the same from year to year, including the occurrence of a fare change. Figure 12 summarizes the fare mix data for SEPTA's CTD from FY 2009 through FY 2013. At the same time, the number of rides per fare media (Monthly/Weekly TransPass and School Ride) was calculated based on the revenue of pass, cost of pass, and number of rides recorded. Since the calculated value was found to be approximately the same from FY 2009 to FY 2013, an average was taken and used to calculate the per-ride fare. Additionally, the Day Pass in reality allows up to eight rides per pass; since not everyone reaches this limit, it was assumed to be seven for the calculation in Table 10.

Figure 12: SEPTA City Transit Division Fare Mix (FY 2009–FY 2013)



Source: SEPTA, 2014.

For Regional Rail, average fares were calculated based on a different set of commonly used fare media types and weights as shown in Table 11, which represent the fare type choice of 95 percent of passengers. An average fare was calculated for each zone-pair in the system since it operates on a from–to zone-based fare structure. Table 11 shows how the average Regional Rail fare between zone CCP and zone 1 was calculated.

Table 11: Average Base Fare Calculation (2010)—SEPTA Regional Rail, CCP/1

Fare Media	Fare Cost	Rides per Fare Media	Per-Ride Fare	Weight by Riders	Weighted Fare
Monthly Pass*	$91.00	40.5	$2.22	56.41%	$1.27
Weekly TrailPass	$24.25	9.5	$2.43	12.93%	$0.33
Ten Trip	$35.50	10	$3.55	6.55%	$0.23
One-Way Pre-Paid	$4.00	1	$4.00	11.04%	$0.44
One-Way On-Board	$4.00	1	$4.00	8.94%	$0.36
Seniors	$1.00	1	$1.00	4.12%	$0.04
Average Fare	—	—	—	—	$2.67

**Monthly TrailPass, Intermediate Monthly Pass, or Monthly Cross County Pass depending on zone-pair*
Source: DVRPC, 2014.

The average fare for other zone-pairs was calculated similarly in concurrence with selecting the best out of three monthly pass options available (in terms of cost). These options include the standard Monthly TrailPass for trips beginning or ending in CCP, the Intermediate Monthly Pass for trips up to two zones outside CCP, and the Monthly Cross County Pass for trips three or more zones outside CCP. Table 12 shows the resultant matrix of average fares for all Regional Rail zone-pairs.

Table 12: Average Fare Matrix (2010)—SEPTA Regional Rail

From↓ / To→ Fare Zone	CCP	1	2	3	4	5	6
CCP	$2.67	$2.67	$3.50	$4.24	$4.84	$5.12	$5.79
1	$2.67	$2.24	$2.24	$2.79	$2.79	$2.79	$2.79
2	$3.50	$2.24	$2.24	$2.24	$2.79	$2.79	$2.79
3	$4.24	$2.79	$2.24	$2.24	$2.24	$2.79	$2.79
4	$4.84	$2.79	$2.79	$2.24	$2.24	$2.24	$2.79
5	$5.12	$2.79	$2.79	$2.79	$2.24	$2.24	$2.24
6	$5.79	$2.79	$2.79	$2.79	$2.79	$2.24	$2.24

Note: CCP = Center City Philadelphia. Source: DVRPC, 2014.

In addition to the base fares, which are applied to the first leg of a transit path, average transfer fares (discounts) can be calculated the same way and applied for each transfer, where a new ticket has to be bought for the following leg(s). Table 13 shows different fare media types considered in calculating the average transfer fare for the City Bus. In this table, only the transfer ticket has a fare cost greater than $0.00 because transfers are essentially “free” for other fare media.

Table 13: Average Transfer Fare Calculation (2010)—SEPTA City Bus

Fare Media	Fare Cost	Ride Per Fare Media	Per-Ride Fare	Weight by Riders	Weighted Fare
Adult Token/Cash Transfer Ticket	$1.00	1	$1.00	19.94%	$0.20
Monthly TransPass	$0.00	26	$0.00	16.58%	$0.00
Weekly TransPass	$0.00	7	$0.00	32.26%	$0.00
TransPass Flash	$0.00	7 to 26	$0.00	0.00%	$0.00
Senior Citizen	$0.00	1	$0.00	12.98%	$0.00
School Ride	$0.00	5	$0.00	18.24%	$0.00
Average Fare	—	—	—	—	$0.20

Source: DVRPC, 2014.

For each SEPTA fare system modeled in TIM 2.1, the average base and transfer fares are summarized in Table 14. For comparison purposes, Regional Rail fares are shown as simplified averages; inputs into the model are in matrix format (Table 12).

Table 14: Average Base and Transfer Fares by Fare Systems

Fare System	Average Fare
City Rail—Base	$1.45
City Rail—Transfer	$0.17
City Bus—Base	$1.34
City Bus—Transfer	$0.20
Victory—Base	$1.50
Victory—Transfer	$0.42
Frontier—Base	$1.59
Frontier—Transfer	$0.40
Regional Rail—All Zones	$2.99
Regional Rail—To/From CCP	$4.12

Note: Values are rounded to the nearest tenth; CCP = Center City Philadelphia. Source: DVRPC, 2014.

In order to present the accurate cost to passengers in VISUM, transfer fares are inputted as price discounts (negative vales) when boarding a line in one fare system from a line in another fare system. Table 15 provides an example of the calculated transfer discounts between selected SEPTA fare systems. A full table between all SEPTA fare systems is provided in the Appendix.

Table 15: Transfer Discount between Selected Fare Systems

From↓ / To→ Fare System	Regional Rail	City Rail	City Bus
Regional Rail	$0.00	−$1.19	−$1.19
City Rail	−$1.19	$0.00	−$1.15
City Bus	−$1.19	−$1.28	−$1.15

Source: DVRPC, 2014.

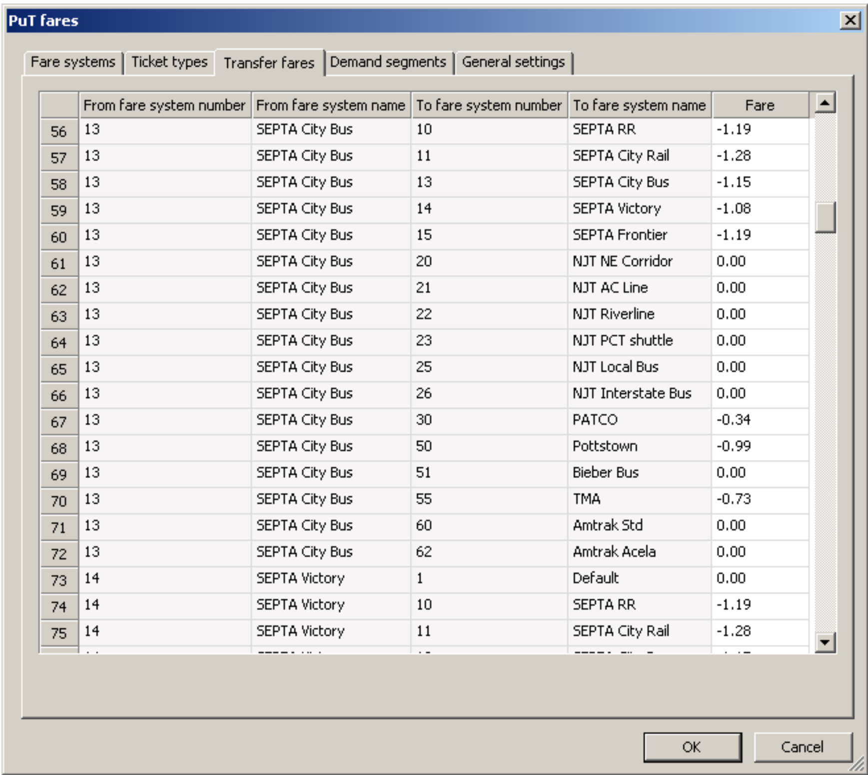
The following explains how these transfer discounts were calculated:

- A value of $0.00 means that the model will not apply a discount for a transfer between those two fare systems: Regional Rail to Regional Rail, and City Rail to City Rail. A discount is already built into the model when the fare option “each group of contiguous path legs” was selected during the fare system setup, which allows for free transfer on any successive leg of a trip within the same fare system.
- An assumption is made that frequent Regional Rail passengers without a TrailPass will not own a TransPass since it is economically unreasonable to own a TransPass and still make frequent Regional Rail trips. Therefore, passengers who do not own a TrailPass and make transfers to and from other SEPTA lines will be paying with a token or cash for the second leg (assuming other ticket types contribute insignificantly). Since 69 percent of Regional Rail trips are made with TrailPasses (Table 11), the transfer discount between Regional Rail and other SEPTA fare systems (City Rail and City Bus) will be 69 percent of the weighted average of token and cash fare ($1.72). As a result, the transfer discount is $1.19.

- The discount between all other SEPTA fare system pairs is calculated as the average base fare minus the average transfer fare. For example, the discount transfer to the City Bus is $1.34 – $0.20 = $1.15 (rounded).

The transfer discounts are calculated between all fare systems and inputted in VISUM (Figure 13).

Figure 13: Transfer Fare Discount Inputs in VISUM



PuT fares

Fare systems | Ticket types | Transfer fares | Demand segments | General settings

	From fare system number	From fare system name	To fare system number	To fare system name	Fare
56	13	SEPTA City Bus	10	SEPTA RR	-1.19
57	13	SEPTA City Bus	11	SEPTA City Rail	-1.28
58	13	SEPTA City Bus	13	SEPTA City Bus	-1.15
59	13	SEPTA City Bus	14	SEPTA Victory	-1.08
60	13	SEPTA City Bus	15	SEPTA Frontier	-1.19
61	13	SEPTA City Bus	20	NJT NE Corridor	0.00
62	13	SEPTA City Bus	21	NJT AC Line	0.00
63	13	SEPTA City Bus	22	NJT Riverline	0.00
64	13	SEPTA City Bus	23	NJT PCT shuttle	0.00
65	13	SEPTA City Bus	25	NJT Local Bus	0.00
66	13	SEPTA City Bus	26	NJT Interstate Bus	0.00
67	13	SEPTA City Bus	30	PATCO	-0.34
68	13	SEPTA City Bus	50	Pottstown	-0.99
69	13	SEPTA City Bus	51	Bieber Bus	0.00
70	13	SEPTA City Bus	55	TMA	-0.73
71	13	SEPTA City Bus	60	Amtrak Std	0.00
72	13	SEPTA City Bus	62	Amtrak Acela	0.00
73	14	SEPTA Victory	1	Default	0.00
74	14	SEPTA Victory	10	SEPTA RR	-1.19
75	14	SEPTA Victory	11	SEPTA City Rail	-1.28

OK | Cancel

Source: DVRPC, 2014.

As a check, the fare inputs calculated from this approach were compared to SEPTA's average fares. It is important to note the difference in calculation methodology between SEPTA and the regional model. SEPTA does not calculate a weighted average fare based on its fare structure but reports this average cost based on the total revenue and ridership per division. Additionally, the reported average fares count for both base and transfers rides, so they may be more comparable to per-ride cost in the model. Therefore, for comparison purposes, the average base and transfer fares were combined using data from an on-board transit survey conducted by DVRPC in 2011 (Table 16). The survey provides data on the percentage of passengers that were able to travel from origin and to destination using a single bus or train, and those that made transfers during the trip.

Table 16: 2011 Transfer Percentages—On-Board Travel Survey

Number of Transfers	Number of Trip Legs	City Rail	City Bus	Victory	Frontier
0	1	36%	31%	24%	36%
1	2	54%	46%	51%	38%
2	3	9%	20%	21%	20%
3+	4+	1%	3%	4%	6%

Source: DVRPC, 2011.

Using these percentages, an average fare per leg was estimated. Using City Bus as an example, the average fare for passengers who make one transfer is calculated by adding the average base fare to the average transfer fare (from Table 14); the average fare for that trip is $1.34 + $0.20 = $1.54 and the average fare per leg is $0.77. Table 17 compares the estimated average fares applied in the TIM 2.1 model versus the average fares reported by SEPTA.

Table 17: 2010 Average Fare per Leg by Fare Systems

Number of Transfers	Number of Trip Legs	City Rail	City Bus	Victory	Frontier	Regional Rail
0	1	$1.45	$1.34	$1.50	$1.59	—
1	2	$0.81	$0.77	$0.96	$1.00	
2	3	$0.60	$0.58	$0.78	$0.80	
3+	4+	$0.49	$0.49	$0.69	$0.70	
TIM 2.1 Average	—	$1.02	$0.90	$1.04	$1.15	$2.99
SEPTA Average	—	$0.99	$0.99	$1.24	$1.35	$3.82

Source: SEPTA, 2011; and DVRPC, 2014.

Overall, the TIM 2.1 inputs and SEPTA averages are comparable. The small differences are attributable to limitations in the way the model is currently configured or set up, and the difference in method of calculation. For example, while SEPTA has established an average that applies across the entire CTD, the model was configured in such a way that fares for bus are treated separately from fares for rail. Additionally, the model's average fare does not include zonal fees in its calculation. This fee incurs an additional charge for zones traversed and inputs separately in the model. This difference is especially noticeable for average fares calculated for the Victory and Frontier divisions. For Regional Rail, these two values are not directly comparable – the TIM 2.1 average listed in Table 17 is the average fare of all zone pairs (i.e., the arithmetic mean of Table 12), whereas SEPTA's is the total RRD revenue divided by ridership.

Base Year (2010) Model Validation

For the purposes of this project, the designated base year is 2010. The base year model includes the zonal demographical and employment data of 2010, the GTFS data of 2010, and the average fares that were in effect in July 2010. The model outputs were compared to the SEPTA FY 2011 ridership counts.

Once the transit routes, schedules, and average fares had been entered into TIM 2.1, the model was run to see how close its estimate of transit ridership comes to actual passenger count data. Several adjustments were made to the TIM 2.1 model during the validation process to bring it closer to the count data:

- Corrections to certain routes were made to make sure they truly reflect what was on the ground in 2010. For example, adjusting either the route the bus takes (the sequence of nodes and links) or its schedule so that the travel time on a given route between a selected origin–destination pair as calculated by the model was within an acceptable amount of deviation from the actual travel time.
- Corrections to the fare zones for certain routes were made to make sure that the fare on a specific route between a selected origin–destination pair as calculated by the model matches the actual fare that a passenger would have paid.
- Additional refinements were made to the average fare used in the model. For example, the average base fare for SEPTA's suburban bus (Victory and Frontier) passengers was adjusted to reflect transfers between suburban bus and Regional Rail.
- Adjustments were made to the coefficients for in-vehicle travel time for the bus and Regional Rail modes in the utility equations used in the mode choice step.

After these adjustments, the model's estimate of 2010 daily ridership for SEPTA, PATCO, and NJT services is shown in Table 18 and compared to counts. The variation for City Rail, Victory, and Frontier are relatively high for SEPTA. Overall, the improved base year model is within 1 percent of total for SEPTA and the region across all three transit providers.

Table 18: 2010 Base Year Model Validation

Transit System	SEPTA FY 2011 Count	Model	Difference	Percentage Difference
SEPTA City Rail	418,420	367,471	−50,949	−12.2%
SEPTA City Bus	468,355	508,701	40,346	8.6%
SEPTA Victory	56,744	65,022	8,278	14.6%
SEPTA Frontier	13,489	20,732	7,243	53.7%
SEPTA Regional Rail	118,305	113,947	−4,358	−3.7%
SEPTA Total	1,075,313	1,075,873	560	0.1%
PATCO Total	35,686	37,000	1,314	3.7%
NJT Total	83,402	73,739	−9,663	−11.6%
Region-Wide Total	1,194,401	1,186,612	−7,789	−0.7%

Note: PATCO = Port Authority Transit Corporation; NJT = New Jersey Transit. Source: DVRPC, 2014.

CHAPTER 5:

Scenarios Analyzed

This chapter presents the results of five sensitivity tests. Two of these scenarios (Scenarios 3 and 4) were theoretical or hypothetical exercises that involved raising the fare of a target mode by a specified percentage in the model, while holding everything else constant (*ceteris paribus*). The model was run, and then the price elasticity of demand for the target mode as estimated by the model was calculated and compared to values from the empirical studies presented in Chapter 2.

Two of the scenarios (Scenarios 1 and 2) involved more rigorous tests of the model, where the *ceteris paribus* assumption was suspended. In these cases, the transit fares in the model were increased to match an actual observed fare change implemented by SEPTA. The model was run, and then the resulting change in ridership as estimated by the model was compared to the actual observed change in ridership. The important distinction with these tests is that while everything else was held constant in the model, this was not the case in the "real" world. In reality there were several other factors (rising gas prices, high unemployment), in addition to the fare change that were influencing ridership.

The average fares presented and inputted into VISUM for all scenarios account for inflation adjusted to the 2010 base year of the model. In addition, the target year's zonal data is updated to the closest year that DVRPC has available, which includes 2010, 2013, 2015, and 2020.

Scenario 1: Backcast and Validation—July 2010 Fare Change

This scenario analyzes the impact of the July 2010 fare change at the start of FY 2011. It compares the change in ridership as estimated by the model to the actual observed change in ridership from SEPTA's count data. In July 2010, SEPTA increased its token price by 7 percent, the transfer ticket price by 33 percent, the TransPass price by 6 percent, and the TrailPass price by 5 to 10 percent depending on fare zone. Table 19 shows how this fare change was approximated with the average fares in the model. The 2009 average fares were inflated to the 2010 values (in order to retain the value of time assumptions and utility coefficients used in the 2010 base year model) for the 2009 scenario run. The inflation rate was about 3 percent from 2009 to 2010. In regions serviced by Frontier and Victory transit where passengers often conduct transfers with a transfer ticket, the 33 percent increase is visibly reflected in the average transfer fare increase. In comparison, the CTD transfer fares are more resilient because the majority of transfer passengers in the city use School Passes and TransPasses.

Table 19: Average Fares—Before and After July 2010 Fare Change

Fare System	Before Fare Change (2009 Scenario)	After Fare Change (2010 Base)	Percentage Change
City Rail—Base	$1.40	$1.45	4%
City Rail—Transfer	$0.16	$0.17	6%
City Bus—Base	$1.30	$1.34	3%
City Bus—Transfer	$0.19	$0.20	5%
Victory—Base	$1.45	$1.50	3%
Victory—Transfer	$0.32	$0.42	31%
Frontier—Base	$1.56	$1.59	2%
Frontier—Transfer	$0.30	$0.40	33%
Regional Rail—All Zones	$2.90	$2.99	3%
Regional Rail—To/From CCP	$3.99	$4.12	3%

Note: CCP = Center City Philadelphia. Source: DVRPC, 2014.

Table 8 in Chapter 3 shows the actual observed ridership change before and after this fare increase. According to SEPTA's counts, there was actually a 3.2 percent increase in ridership across all of SEPTA's bus and rail services. As discussed in Chapter 3, there were other factors besides the fare change that may contribute to the observed ridership change. In this case, the change of gas prices may be more significant. The price of gas in the DVRPC region was increasing between July 2010 and July 2011 by approximately $1 per gallon. Taking inflation into account, this is approximately a 32 percent increase. There was also a period of sustained and relatively high unemployment (between 8.1 and 9.2 percent) in the wake of the recession. In a tight economy, with rising gas prices, many people were looking for ways to save money, and travel more cheaply. A study of travel to and from CCP between 2005 and 2010,[4] using observed count data, recorded a 0.6 percent increase in daily transit trips and a 1.9 percent decrease in auto trips.

As the model is currently configured, it does not have a specific variable to account for the impact of changes in gas prices. However, there is a term in the utility/impedance equations that can be used. In TIM 2.1, the utility equation for the auto mode for work trips is defined as follows:

*U(auto) = −0.025*IVT – 0.0625*OVT – 0.15*TOL + 0.00*DIS – 0.3333*Park_Day,* where:

- IVT is in-vehicle travel time;
- OVT is out-of-vehicle travel time;
- TOL is the cost of any tolls;
- DIS is the auto distance traveled; and
- Park_Day is the daily parking cost.

To account for gas prices that increased between 2010 and 2011, the DIS variable coefficient was changed from 0.00 to 0.0045. This essentially treats gas prices as a distance-based toll (about 3 cents per mile).

[4] Delaware Valley Regional Planning Commission, *1980–2010 Travel Trends in the Philadelphia Central Business District,* Publication Number 13053 (Philadelphia: Delaware Valley Regional Planning Commission, September 2013).

Taking into account the gas price change in simulation, Table 20 shows the resulting change in ridership as estimated by the model. The model shows an increase for all of the transit systems as observed except for Regional Rail. The total overall increase in average daily ridership for all services is 1.1 percent.

Table 20: Backcast Results—Before and After July 2010 Fare Change

Transit System	SEPTA Count				Model			
	FY 2010	FY 2011	Diff.	% Diff.	2009 Scenario	2010 Base	Diff.	% Diff.
City Rail	407,085	418,420	11,335	2.8%	364,725	367,471	2,746	0.8%
City Bus	453,301	468,355	15,054	3.3%	499,236	508,701	9,465	1.9%
Victory	53,640	56,744	3,104	5.8%	64,633	65,022	389	0.6%
Frontier	12,799	13,489	690	5.4%	20,162	20,732	570	2.8%
Regional Rail	115,025	118,305	3,280	2.9%	115,906	113,947	−1,959	−1.7%
Total	1,041,850	1,075,313	33,463	3.2%	1,064,663	1,075,873	11,210	1.1%

Source: SEPTA, 2010 and 2011; and DVRPC, 2014.

Comparing the model results to the observed change in ridership, the model's predication is largely in the right direction. However, the magnitude is lower than the observed change. For example, the model's estimate of change in ridership for Victory (0.6 percent increase) is much less than what actually occurred (5.8 percent). In addition, the model predicts a 1.7 percent decrease for Regional Rail while the actual ridership went up after the fare change. This suggests that passengers on Regional Rail are less sensitive to gas price changes than other transit modes (e.g., bus). Collecting the necessary data to verify this is beyond the scope of this study.

Scenario 2: Forecast and Validation—July 2013 Fare Change

This scenario analyzes the impacts of the fare change that occurred in July 2013. During this fare change, SEPTA increased the base cash fare by 12.5 percent (from $2.00 to $2.25), the token price by 16 percent, the TransPass price by 9 percent, and the TrailPass price by 5 to 12 percent, whereas the transfer ticket price did not change. Meanwhile, SEPTA phased out its distance based fare system that involved fare zones, and designated four bus routes from the Victory and Frontier Division as "premium" that charges an additional fee of $1.50 for most passengers. Due to this change, a separate fare system was created for these premium routes in TIM 2.1 to accurately reflect the higher fare. Another fare system in TIM 2.1 was also created for the NHSL (previously part of the Victory Division) that now charges most passengers an additional fee of $0.50 regardless of zones traversed. SEPTA also reduced the number of fare zones in the Regional Rail system, which was adjusted accordingly in the TIM 2.1 network as well.

After the gas price increase between 2010 and 2011, it stabilized and remained relatively constant (not accounting for seasonal fluctuations). Therefore, for the purposes of this scenario, it is assumed that there was no change in gas prices between 2010 and 2013. However, the changes of population and employment from 2010 to 2013 were considered, although small (less than 1 percent in the DVRPC region), and updated at the zonal level for this scenario run. Table 21 summarizes the fare changes that occurred between 2010 and 2013, in terms of the average fares that are input to the model. In Table 21, the 2013 fares were deinflated to the 2010 values for the 2013 scenario run (the inflation rate was 5 percent from 2010 to 2013). Although the transfer ticket price did not decrease in reality, the average transfer fare decreased as a result of adjustments for inflation.

Table 21: Average Fares—Before and After July 2013 Fare Change

Fare System	Before Fare Change (2010 Base)	After Fare Change (2013 Scenario)	Percentage Change
City Rail—Base	$1.45	$1.55	7%
City Rail—Transfer	$0.17	$0.16	−6%
City Bus—Base	$1.34	$1.43	7%
City Bus—Transfer	$0.20	$0.19	−5%
Victory—Base	$1.50	$1.58	5%
Victory—Transfer	$0.42	$0.41	−2%
Frontier—Base	$1.59	$1.70	7%
Frontier—Transfer	$0.40	$0.38	−5%
Regional Rail—All Zones	$2.99	$3.16	6%
Regional Rail—To/From CCP	$4.12	$4.21	2%
NHSL—Base	—	$1.93	—
NHSL—Transfer	—	$0.83	—
Premium Routes—Base	—	$2.70	—
Premium Routes—Transfer	—	$1.75	—

Note: CCP = Center City Philadelphia; NHSL = Norristown High Speed Line. Source: DVRPC, 2014.

As discussed in Chapter 3, according to the counts available at the time this study was conducted (March and April 2014), there was an overall 4.1 percent increase in ridership. Table 22 shows the resulting change in ridership as estimated by the model. Again, the model predicted the ridership change in response to the fare change in the right direction, although the magnitude is slightly lower than the observed change. The ridership change may be re-evaluated when more ridership data becomes available. A relatively short period of time has elapsed since the fare change, and it may be too soon to see its actual impact.

Table 22: Forecast Results—Before and After July 2013 Fare Change

Transit System	SEPTA Count				Model			
	FY 2011	FY 2014 Mar.–Apr.	Diff.	% Diff.	2010 Base	2013 Scenario	Diff.	% Diff.
City Rail	418,420	421,956	3,536	0.8%	367,471	373,546	6,075	1.7%
City Bus	468,355	495,977	27,622	5.9%	508,701	526,318	17,617	3.5%
Victory	56,744	59,598	2,854	5.0%	65,022	66,203	1,181	1.8%
Frontier	13,489	13,558	69	0.5%	20,732	20,993	261	1.3%
Regional Rail	118,305	128,815	10,510	8.9%	113,947	112,915	−1,031	−0.9%
Total	1,075,313	1,119,905	44,592	4.1%	1,075,873	1,099,975	24,102	2.2%

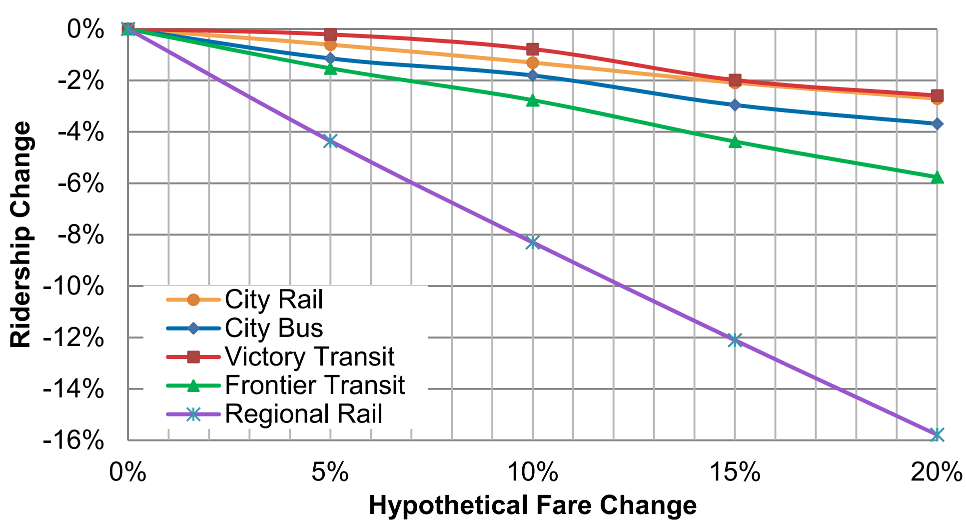
Source: SEPTA 2011 and 2014; and DVRPC, 2014.

Scenario 3: Direct Elasticity Test—Across-the-Board Fare Increase

For this scenario, the objective is to determine the elasticity and impact on ridership by imposing an across-the-board fare increase while other factors are held constant. For example, there is no change to employment levels, and no change to the cost associated with alternative modes (e.g., gas prices). The assumption is that all SEPTA average fares increase by 5, 10, 15, and 20 percent. It is important to note that fare prices can only be input into the model with two decimal places. Therefore, after rounding, the actual increase may be slightly lower or higher than the intended percentage. For instance, a $0.01 increase for City Rail transfer from $0.17 to $0.18 is actually a 5.9 percent increase instead of 5.0 percent.

Figure 14 shows the resulting ridership changes in response to the average fare changes according to the assumptions. Overall, the model responds to the fare increase in a linear fashion and the point elasticities are within the range reported in the literature except for Regional Rail.

Figure 14: Ridership Change with Across-the-Board Fare Increase



Source: DVRPC, 2014.

Table 23 shows the approximated point elasticities (or shrinkage ratios), calculated by dividing the percentage change in fare by the percentage change in ridership. Comparing the model results to the observed data presented in Chapter 2 provides some indication of how the model is performing with regard to fare sensitivity. Of all of the studies reviewed in Chapter 2, probably the closest city to Philadelphia is the study of fare changes in New York City between 1972 and 1995 shown in Table 2. The reported average subway point elasticity is −0.09, and the average bus point elasticity is −0.37. From the model results, the average point elasticity is −0.13 for City Rail, and the average point elasticity is −0.20 for City Bus. The model results are close to the observations in the literature, although the bus elasticity is slightly lower (but within the range). For the Regional Rail system, however, the model estimated higher fare elasticities than expected. According to the literature review, the elasticity of heavy rail or commuter rail is typically lower than bus. This suggests that TIM 2.1 is overly sensitive to an increase in the cost of Regional Rail fares. In other words, an increase in rail fares leads to a sharper than expected decrease in rail passengers. This may explain the unexpected Regional Rail model results observed in the first two scenarios.

Table 23: Elasticities of Across-the-Board Fare Increases

Transit System	Point Elasticity				
	Fare +5%	Fare +10%	Fare +15%	Fare +20%	Average
City Rail	−0.12	−0.13	−0.14	−0.14	−0.13
City Bus	−0.23	−0.18	−0.20	−0.18	−0.20
Victory	−0.04	−0.08	−0.13	−0.13	−0.10
Frontier	−0.31	−0.28	−0.29	−0.29	−0.29
Regional Rail	−0.87	−0.83	−0.81	−0.79	−0.82

Source: DVRPC, 2014.

Scenario 4: Cross Elasticity Tests

This scenario analyzes the impact of a fare increase for a competing mode. The average fare for SEPTA transit (bus, subway, and trolley lines) was raised by 5 percent, and then the model was run to see how this increase affected the overall ridership. The same test was then repeated to see how increasing the average fare for Regional Rail only, by 5 percent, would affect ridership.

Table 24 shows the model results in response to the 5 percent increase of transit fare: 1.4 to 2.5 percent decrease for transit, a 1.4 percent increase for Regional Rail, and an overall decrease of 1.3 percent in daily ridership was estimated. Table 4 in Chapter 2 is from an Australian study that derived cross-elasticities between bus, train, and auto. It suggests a 5 percent increase in bus single fare would result in a 1.785 percent decrease in the purchase of bus single fare tickets, and a 0.335 percent increase in rail single fare tickets. The model results are comparable to findings reported in the literature.

Table 24: Cross Elasticity—SEPTA Transit Fares +5%

Transit System	Before Increase (2010 Base)	After Increase (Transit +5%)	Difference	Percentage Difference
City Rail	367,471	361,674	−5,797	−1.6%
City Bus	508,701	501,335	−7,367	−1.4%
Victory	65,022	63,369	−1,653	−2.5%
Frontier	20,732	20,383	−349	−1.7%
Regional Rail	113,947	115,532	1,585	1.4%
Total	1,075,873	1,062,291	−13,581	−1.3%

Source: DVRPC, 2014.

The cross-elasticity test was repeated, this time holding SEPTA transit fares constant and raising the price of Regional Rail. Shown in Table 25 are the results with a 0.1 to 1.7 percent increase for transit, 5.4 percent decrease for Regional Rail, and an overall decrease of 0.1 percent in daily ridership. The literature (Table 4) suggests a 5 percent increase in the price of a single rail ticket is estimated to have a 1.09 percent decrease in the number of single rail tickets purchased, and a corresponding 0.285 percent increase in the purchase of single bus fares. Once again, the model results show that Regional Rail is too sensitive to the fare change, while the correlated ridership changes of other transit modes make sense.

Table 25: Cross Elasticity—SEPTA Regional Rail Fares +5%

Transit System	Before Increase (2010 Base)	After Increase (RR +5%)	Difference	Percentage Difference
City Rail	367,471	369,631	2,160	0.6%
City Bus	508,701	510,458	1,757	0.3%
Victory	65,022	66,134	1,112	1.7%
Frontier	20,732	20,756	24	0.1%
Regional Rail	113,947	107,807	−6,140	−5.4%
Total	1,075,873	1,074,787	−1,086	−0.1%

Source: DVRPC, 2014.

These two cross-elasticity tests seem to indicate that the model has a tendency to overestimate the impact that fare changes have on Regional Rail ridership. This is consistent with observations from the scenarios previously presented.

Scenario 5: Forecast—Impact of New Payment Technology (NPT)

This scenario analyzes the estimated impact of the introduction of NPT, which is set to be fully operational by 2015. The NPT system will replace and modernize SEPTA's current payment system of tokens, tickets, and paper transfers by providing riders with an electronic, account-based system. NPT works similarly to the national highways' "E-ZPass" system, but instead of a device, cards and contactless media will be used such as refillable fare cards, contactless credit or debit cards, and cell phones.

NPT represents an opportunity to greatly simplify SEPTA's payment system and create a uniform payment system across all of SEPTAs' services. The new system will enhance the purchase and payment experience while reducing the confusing and challenging aspects that infrequent users often experience with the current system. Furthermore, NPT will improve the collection and processing of ridership data and transit passenger flow.

Coinciding with the introduction of NPT will be a minor discount for one-way Regional Rail tickets, the phasing out of tokens as a payment option, and an increase in the cash fare from $2.25 to $2.50. These changes will most likely impact the use of token and cash passengers more so than other fare media types such as passes. Tokens and cash are predominantly used by occasional riders, who make up approximately 34 percent of SEPTA's passengers. These are passengers who may only make one or two trips per week, or the total cost falls short of the breakeven point for a Weekly or Monthly TransPass.

From the perspective of this analysis, the greatest change with NPT is that occasional riders who sign up or switch to NPT will continue to pay the reduced fare of $1.00 for transfer between SEPTA lines. On the other hand, those who do not use NPT are required to pay the full $2.50 (cash fare) for any successive leg of a trip. In other words, these riders will not receive a discount for transfer between SEPTA lines. Therefore, one of the key questions regarding the introduction of NPT is what occasional cash fare riders will do.

Given all of the above, the first scenario (5a) was run with the assumption that 95 percent of token users and 75 percent of cash users will switch to NPT, with no changes to the percentages of other fare media users. Based on these assumptions, Table 26 shows the resulting fare inputs. Overall, the base fare decreased slightly for all systems, but the transfer fare increased significantly for some divisions. That is because cash fare riders who do not switch to NPT and conduct transfers pay much more than before, from $1.00 to $2.50, as a result of the change mentioned previously.

Table 26: 2014 Average Fares—95% of Token and 75% of Cash Riders Switch to NPT

Fare System	Before NPT (2014)	After NPT (2014)	Percentage Change
City Rail—Base	$1.55	$1.53	−1%
City Rail—Transfer	$0.16	$0.19	19%
City Bus—Base	$1.43	$1.39	−3%
City Bus—Transfer	$0.19	$0.22	16%
Victory—Base	$1.58	$1.54	−3%
Victory—Transfer	$0.41	$0.47	15%
Frontier—Base	$1.70	$1.59	−6%
Frontier—Transfer	$0.38	$0.44	16%
Regional Rail—All Zones	$3.16	$3.16	0%
Regional Rail—To/From CCP	$4.21	$4.15	−1%
NHSL—Base	$1.93	$1.90	−2%
NHSL—Transfer	$0.83	$0.88	6%
Premium Routes—Base	$2.70	$2.64	−2%
Premium Routes—Transfer	$1.75	$1.78	2%

Note: CCP = Center City Philadelphia; NHSL = Norristown High Speed Line; NPT = New Payment Technology.
Source: DVRPC, 2014.

Table 27 shows the model results. The overall total ridership remained the same under the assumptions that 95 percent of token and 75 percent of cash riders will switch to NPT. Therefore, if the percentage of riders who switch to NPT is less than the assumptions made, ridership is expected to decrease, and vice versa.

Table 27: 2014 Forecast Results—95% of Token and 75% of Cash Riders Switch to NPT

Transit System	Before NPT (2014)	After NPT (2014)	Difference	Percentage Difference
City Rail	373,546	371,911	−1,635	−0.4%
City Bus	526,318	526,881	563	0.1%
Victory	66,203	65,657	−546	−0.8%
Frontier	20,993	21,150	156	0.7%
Regional Rail	112,915	114,922	2,007	1.8%
Total	1,099,975	1,100,521	545	0.0%

Note: NPT = New Payment Technology. Source: DVRPC, 2014.

The second scenario (5b) forecasts the 2020 ridership after the introduction of NPT under three assumptions. First, factors that are known to impact ridership such as gas price, unemployment, and transit schedule changes are assumed to remain unchanged from the 2014 conditions. Second, it assumes 95 percent of token and 95 percent of cash fare riders have already made the switch to NPT by the target year 2020. The 5 percent remaining for each represents occasional riders and tourists. Third, the average fares increase to the expected price in 2020 in accordance with SEPTA's 36-month schedule: Regional Rail fares increase by 2 percent and all other SEPTA fare systems increase by 1 percent on top of annual inflation. These increases are applied twice, cumulatively in 2017 and 2020. The new average fares are shown in Table 28.

Table 28: 2020 Average Fares—95% of Token/Cash Riders Switch to NPT, 1–2% Fare Increase

Fare System	Before NPT (2014)	After NPT (2020)	Percentage Change
City Rail—Base	$1.55	$1.54	−1%
City Rail—Transfer	$0.16	$0.18	13%
City Bus—Base	$1.43	$1.40	−2%
City Bus—Transfer	$0.19	$0.21	11%
Victory—Base	$1.58	$1.54	−3%
Victory—Transfer	$0.41	$0.45	10%
Frontier—Base	$1.70	$1.57	−8%
Frontier—Transfer	$0.38	$0.42	11%
Regional Rail—All Zones	$3.16	$3.29	4%
Regional Rail—To/From CCP	$4.21	$4.32	3%
NHSL—Base	$1.93	$1.93	0%
NHSL—Transfer	$0.83	$0.87	5%
Premium Routes—Base	$2.70	$2.65	−2%
Premium Routes—Transfer	$1.75	$1.78	2%

Note: CCP = Center City Philadelphia; NHSL = Norristown High Speed Line; NPT = New Payment Technology.
Source: DVRPC, 2014.

Model results are shown in Table 29 with an overall increase in ridership of 0.1 percent. The Frontier transit system experienced a significant increase of 8.1 percent, whereas Regional Rail decreased the most by 0.8 percent. In comparison to historical annual changes in SEPTA ridership, an increase of 0.1 percent or 1,430 in daily ridership for a six-year forecast is insignificant, especially since the population of the City of Philadelphia has recently begun to increase after a prolonged period of decline.

Table 29: 2020 Forecast Results—95% of Token/Cash Riders Switch to NPT, 1–2% Fare Increase

Transit System	Before NPT (2014)	After NPT (2020)	Difference	Percentage Difference
City Rail	373,546	375,003	1,457	0.4%
City Bus	526,318	525,671	−646	−0.1%
Victory	66,203	66,063	−140	−0.2%
Frontier	20,993	22,698	1,704	8.1%
Regional Rail	112,915	111,971	−945	−0.8%
Total	1,099,975	1,101,405	1,430	0.1%

Note: NPT = New Payment Technology. Source: DVRPC, 2014.

CHAPTER 6:

Conclusions and Recommendations

Based on the tests conducted in Chapter 5, this chapter evaluates how well the TIM 2.1 model performed at capturing the impact of fare changes on ridership.

Conclusions

The real world is always complex. Many factors could affect transit ridership, not just fares and factors discussed in the literature review. Other factors may include changes in the cost of parking, the weather, the economy, safety, and the habits of aging “baby-boomers” versus millennials. This may be seen from SEPTA's ridership increase after the fare hike in July 2010. To be practical, travel forecasting models like TIM 2.1 must simplify the system and human behavior. With limited factors that are possible to be quantified and modeled, the model is inevitably limited in its modeling capacity.

The current model appears to perform well enough to be used to analyze the impact that fare changes have on ridership. It has demonstrated that the model not only responded to fare changes according to the findings in the literature review but was also able to correctly predict the direction of ridership change during two recent SEPTA fare changes. Furthermore, it is capable of forecasting ridership changes due to simultaneous changes of multiple factors, including fare, gas price, employment, and population.

In terms of the magnitude of the ridership change, the model's forecasts are close in most cases. This is especially true for changes to bus ridership. The model is very consistent but tends to underestimate in comparison to SEPTA counts. The user needs to take this into consideration and factor this into their results. Forearmed with this knowledge, the model is a valuable planning tool. For example, it is possible to post-process the model results, and essentially increase the model’s estimate of any impact by some known percentage to compensate for its tendency to underestimate impacts. This is well within standard operating procedure and accepted modeling practice.

All in all, these tests were extremely valuable from a modeling perspective and revealed several issues with the model that require additional attention, with Regional Rail being the greatest of concern. As currently configured, this system is highly sensitive to fare changes. Additional tests are required to examine and adjust the representation of Regional Rail in mode choice and transit assignment. For regional or system-wide analysis, the model is reliable although it may underestimate the impacts of a fare change. Furthermore, it may be necessary to post-process the results if ridership changes of individual lines are needed.

Recommendations

This exercise shed light on aspects of the model’s behavior that warrant further investigation, probably beyond the scope and schedule of this particular project. Based on the results of this study, we would recommend the following additional tests, analysis, and changes:

- There were several network updates to some of the smaller bus routes that we did not have time to enter into the model; for example, the shortening / extension of bus routes 79, 115, 130, etc. These are relatively small changes and are not anticipated to affect model results or conclusions in any appreciable way. The objective is simply to bring the 2010 base year model’s transit network up to date. This would help forecasting exercises in the future.
- The way Regional Rail is currently configured in the model needs another look. We believe that this is the cause of, or certainly contributing to, the model’s inconsistency with respect to estimating the

magnitude of change in rail ridership. The problem may be with the specification of their utility/impedance equations.

- The quality of data should improve once SEPTA fully implements NPT in 2015. If time and budget allow, we suggest revalidation to some future base year (after the system has stabilized) with the introduction of NPT, and then redo some of these tests.
- Given the good results and useful insights from this study, we will include a fare sensitivity test as part of the TIM 3.0's validation. TIM 3.0 is the next generation of the regional travel forecasting model. It is an activity-based model (ABM). In the ABM framework, TIM 3.0 is able to take into account the auto ownership and different value of time of an individual household, as well as individual characteristics, such as if one has a monthly transit pass or receives transportation benefits provided by employers. All the factors can be considered collectively in determining an individual's travel choice in response to changes of transit fares and other conditions.

Appendix A

Appendix A. Average Fare Calculation and Model Inputs

Average Base Fares

Table A-1: 2010 SEPTA Transit Average Base Fares

Fare Media	Fare	Per-Ride Fare	City Rail		City Bus		Victory		Frontier	
			Fare Media Weight	Weighted Fare	Fare Media Weight	Weighted Fare	Fare Media Weight	Weighted Fare	Fare Media Weight	Weighted Fare
Adult Token	$1.55	$1.55	32.94%	$0.51	18.34%	$0.28	21.72%	$0.34	21.63%	$0.34
Cash Fare	$2.00	$2.00	12.45%	$0.25	15.43%	$0.31	18.31%	$0.37	42.71%	$0.85
Monthly TransPass	$83.00	$1.30	14.49%	$0.19	14.17%	$0.18	9.21%	$0.12	3.53%	$0.05
Weekly TransPass	$22.00	$1.30	24.78%	$0.32	26.60%	$0.34	19.79%	$0.26	12.74%	$0.17
Senior Citizen	$0.00	$0.00	3.91%	$0.00	11.63%	$0.00	7.73%	$0.00	8.90%	$0.00
School Ride	$15.49	$1.78	9.37%	$0.17	11.67%	$0.21	2.83%	$0.02	0.65%	$0.01
Day Pass	$7.00	$1.00	0.64%	$0.01	0.67%	$0.01	0.00%	$0.00	0.00%	$0.00
Handicap Fare	$1.00	$1.00	1.00%	$0.01	0.95%	$0.01	1.68%	$0.02	1.94%	$0.02
Free Ride	$0.00	$0.00	0.42%	$0.00	0.55%	$0.00	0.99%	$0.00	1.28%	$0.00
Weekly TrailPass Zone 1	$24.25	$1.43	—	—	—	—	0.00%	$0.00	0.00%	$0.00
Weekly TrailPass Zone 2	$34.50	$2.03	—	—	—	—	1.68%	$0.03	0.00%	$0.00
Weekly TrailPass Zone 3	$42.00	$2.47	—	—	—	—	0.97%	$0.02	0.97%	$0.02
Weekly TrailPass Zone 4	$47.80	$2.82	—	—	—	—	0.01%	$0.00	0.01%	$0.00
Monthly TrailPass Zone 1	$91.00	$1.43	—	—	—	—	0.00%	$0.00	0.00%	$0.00
Monthly TrailPass Zone 2	$127.00	$1.99	—	—	—	—	9.54%	$0.19	0.00%	$0.00
Monthly TrailPass Zone 3	$155.00	$2.43	—	—	—	—	5.32%	$0.13	5.33%	$0.13
Monthly TrailPass Zone 4	$176.00	$2.76	—	—	—	—	0.25%	$0.01	0.32%	$0.01
Average	—	—	—	$1.45	—	$1.34	—	$1.50	—	$1.59

Source: DVRPC, 2014.

Average Transfer Fares and Discount

Table A-2: 2010 Average Transfer Fares, SEPTA Transit Fare Systems

Fare Media	Fare Cost	Per-Ride Fare	City Rail		City Bus		Victory		Frontier	
			Fare Media Weight	Weighted Fare	Fare Media Weight	Weighted Fare	Fare Media Weight	Weighted Fare	Fare Media Weight	Weighted Fare
Adult Token / Cash Transfer Ticket	$1.00	$1.00	17.27%	$0.17	19.94%	$0.20	42.09%	$0.42	40.01%	$0.40
Monthly TransPass	$0.00	$0.00	20.80%	$0.00	16.58%	$0.00	0.00%	$0.00	0.00%	$0.00
Weekly TransPass	$0.00	$0.00	35.80%	$0.00	32.26%	$0.00	0.00%	$0.00	0.00%	$0.00
TransPass Flash	$0.00	$0.00	0.92%	$0.00	0.00%	$0.00	45.52%	$0.00	48.51%	$0.00
Senior Citizen	$0.00	$0.00	5.24%	$0.00	12.98%	$0.00	7.45%	$0.00	11.49%	$0.00
School Ride	$0.00	$0.00	19.97%	$0.00	18.24%	$0.00	4.94%	$0.00	0.00%	$0.00
Average	—	—	—	$0.17	—	$0.20	—	$0.42	—	$0.40

Source: DVRPC, 2014.

Table A-3: Transfer Discounts between TIM 2.1 SEPTA Fare Systems

From↓ / To→ Fare System	Regional Rail	City Rail	City Bus	Victory	Frontier
Regional Rail	$0.00	−$1.19	−$1.19	−$1.19	−$1.19
City Rail	−$1.19	$0.00	−$1.15	−$1.08	−$1.19
City Bus	−$1.19	−$1.28	−$1.15	−$1.08	−$1.19
Victory	−$1.19	−$1.28	−$1.15	−$1.08	−$1.19
Frontier	−$1.19	−$1.28	−$1.15	−$1.08	−$1.19

Source: DVRPC, 2014.

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SEPTA Fare Sensitivity Analysis

Using DVRPC's Regional Travel Forecasting Model

Publication Number: 12083

Date Published: September 2014

Geographic Area Covered:
The Delaware Valley region comprising five counties in Pennsylvania (Bucks, Chester, Delaware, Montgomery, and Philadelphia), and four counties in New Jersey (Burlington, Camden, Gloucester, and Mercer).

Key Words:
Public Transit, Southeastern Pennsylvania Transportation Authority, SEPTA, Fare Sensitivity, Fare Change, Ridership Change, Elasticity of Demand, Travel Forecasting, Mode Choice, Backcast, Forecast, Delaware Valley Region, City of Philadelphia, Philadelphia–Camden–Wilmington Metropolitan Statistical Area

Abstract:
This study assesses the ability of the Delaware Valley Regional Planning Commission (DVRPC) regional travel forecasting model to predict the effect that fare increases have on ridership. The study analyzes five scenarios, comparing the model's results to empirical data from other similar studies and to actual observed data from recent fare changes implemented by the Southeastern Pennsylvania Transportation Authority (SEPTA). It also forecasts the projected impact that the introduction of New Payment Technology will have on ridership. This study will allow SEPTA to assess the effects of proposed fare policy changes and to plan future fare system improvements. It will also provide valuable insights into the performance of the current model. This information will be used by DVRPC's engineers and planners to improve the model—to make it more accurate to fare changes, and to enable the model to produce more accurate forecasts.

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