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POSTAL RATE AND FEE CHANGES PURSUANT TO PUBLIC LAW 108-18	Docket No. R2005-1

TESTIMONY OF
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ON BEHALF OF
UNITED STATES POSTAL SERVICE

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AUTOBIOGRAPHCIAL SKETCH

My name is Michael D. Bradley and I am Professor of Economics at George Washington University. I have been teaching economics there since 1982 and I have published many articles using both economic theory and econometrics. Postal economics is one of my major areas of research and my work on postal economics has been cited by researchers around the world. I have presented my research at professional conferences and I have given invited lectures at both universities and government agencies.

Beyond my academic work, I have extensive experience investigating real-world economic problems, as I have served as a consultant to financial and manufacturing corporations, trade associations, and government agencies.

I received a B.S. in economics with honors from the University of Delaware and as an undergraduate was awarded both Phi Beta Kappa, Phi Kappa Phi and Omicron Delta Epsilon for academic achievement in the field of economics. I earned a Ph.D. in economics from the University of North Carolina and as a graduate student I was an Alumni Graduate Fellow. While being a professor, I have won both academic and nonacademic awards including the Richard D. Irwin Distinguished Paper Award, the American Gear Manufacturers ADEC Award, a Banneker Award and the Tractenberg Prize.

I have been studying postal economics for nearly twenty years, and I have participated in many Postal Rate Commission proceedings. In Docket No. R84-1, I helped in the preparation of testimony about purchased transportation and in

Docket No. R87-1, I testified on behalf of the Postal Service concerning the costs of purchased transportation. In Docket No. R90-1, I presented rebuttal testimony in the area of city carrier load time costs. In the Docket No. R90-1 remand, I presented testimony concerning the methods of city carrier costing.

I returned to transportation costing in Docket No. MC91-3. There, I presented testimony on the existence of a distance taper in postal transportation costs. In Docket No. R94-1, I presented both direct and rebuttal testimony on an econometric model of city carrier access costs. More recently, in Docket R97-1, I presented three pieces of testimony. I presented both direct and rebuttal testimony in the area of mail processing costs. I also presented direct testimony on the costs of purchased highway transportation. In Docket No. R2000-1, I again presented three pieces of testimony. I presented direct testimony on the theory and methods of calculating incremental cost and I presented direct and rebuttal testimony on the econometric estimation of purchased highway transportation variabilities. Finally, in Docket No. 2001-1, I presented testimony on city carrier costs.

Beside my work with the U.S. Postal Service, I have served as an expert on postal economics to postal administrations in North America, Europe, and Asia. For example, I currently serve as External Methodology Advisor to Canada Post.

PURPOSE AND SCOPE

The purpose of my testimony is to introduce the Postal Service's new study of street time costs, the City Carrier Street Time Study (CCSTS). I provide the motivation for the study, explain its goals and then provide an overview of its structure. The balance of my testimony discusses estimating variabilities for the cost pool and constructing distribution keys for volume variable costs.

The variabilities and distribution keys described in my testimony are used by Witness Meehan (USPS-T-9). The development of the data used in this analysis is described by Witness Stevens (USPS-T-15).

ASSOCIATED LIBRARY REFERENCES

I am sponsoring the following Library Reference which is associated with this testimony:

USPS LR-K-81:

This library reference contains the computer programs and data used to estimate the econometric models presented in this testimony.

I. MOTIVATION FOR A NEW STUDY OF CITY CARRIER STREET TIME

In this case the Postal Service is presenting a new, comprehensive study of city carrier street time costs entited the City Carrier Street Time Study (CCSTS). I provided a public briefing on this study in December 2003 at the Postal Rate Commission.

This study is timely and important and was funded by the Postal Service for two reasons: (1) much of the data underlying the established methodology is dated and (2) some important drawbacks in the established methodology have been identified by the Commission and others. In this section, I present and explain these concerns with the established methodology. Note, however, that the new City Carrier Street Time Study presents both more recent data and attempts to correct the identified deficiencies.

A. The Data Underlying the Established Model are Dated.

Much of the data supporting the development of the established city carrier street time cost analysis have become dated. A number of different special data collection efforts underlie that costing structure. They include:

> <u>Street Time Sampling Study</u>
> This is a "beeper" study that provides the cost pools for the current analysis. This study was first presented in Docket No. R87-1. The data for this study were collected in 1986.[1] This means the current established method is reflecting the structure of street time activities in 1986. As Witness Lewis (USPS-T-30) indicates, carrier street operations have

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[1] <u>See</u>, PRC Op., Docket No. R87-1, Vol. 1, at 221

changed materially since then and accurate costing requires data that reflect current operations.

Curbline Access Test/Foot Access Test

This is a study of carrier delivery speed in which carriers repeatedly walked a section of their route under differing assumptions about the level of coverage. This study produces the "split factors" for various route types, the proportion of running time which is access time as opposed to route time. This study was last presented in Docket No. R90-1. The data for this study were collected in 1989.[2]

Load Time Variability Study

This study provides the data used to estimate how time loading mail at the stop varies with volume. It measured loading time and volume at a given set of stops. This study was first presented in Docket No. R87-1. The data for this study were collected in 1985.[3]

This record clearly shows that the data from these special studies are dated and more recent data would be preferable.

B. There Are Important Drawbacks, Identified By the Commission and Others, To the Established Methodology

The vintage of the data used in the established methodology is sufficient justification to undertake a new study, but there also are important drawbacks with the established methodology itself. . These drawbacks have been articulated by the Commission and others who have reviewed the city carrier street time costing structure. They can be organized into three groupings: imprecise cost estimation, a fragmented approach, and internal inconsistency,

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[2] See, PRC Op., Docket No. R90-1, Vol. 1, at III-18.

[3] See, PRC Op., Docket No. R87-1, Vol. 1, at 230.

1. The Established Methodology Suffers from Difficulties in Cost Estimation.

Much time and effort has been invested by both Postal Service and Commission analysts in an effort to best use the existing data to find accurate city carrier street time costs. Nevertheless, there are continuing concerns about the precision of the estimated costs. These concerns arise from the existence of large standard errors for the volume variable costs, an imprecision which comes from the large standard errors of the underlying estimated coefficients in the special studies:[4]

> The UVVC estimates from these cost pools have the largest cv's of all the pools examined in the simulation study. The cv's ranged from 20 and 60 percent across the sub-classes

and [5]

> In City Carrier cost pools, the sampling errors in the estimates from the special studies are the largest source of uncertainty in the UVVC estimates.

Volume variable costs calculated in the established methodology depend upon estimated parameters from a variety of special studies like LTV, CAT/FAT, and STS. These studies have two main weaknesses. First, they are complex, time consuming, and expensive. Resource constraints limit their sample sizes. These relatively small samples, in turn, contribute to the relative high variances

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[4] See, A.T. Kearney, "Technical Report #3: Simulation Analysis Of Data Quality Issues," Data Quality Study, April 16, 1999 at 59.

[5] Id. at 12.

of the estimates and the resulting imprecision in the volume variable cost calculations.

Second, the studies were not particularly well designed to collect data that support the statistical and econometric models required by the cost structure.[6]

> The econometric use of data contained in these carrier related data collection systems has been controversial since they were developed by the Postal Service and accepted by the Commission in Docket No. R84-1. The controversies seem to reflect the difficulty of conducting good, generally accepted, econometric analysis on the data collected.

The unusual nature of the data makes it difficult to follow standard econometric practice and the established methodology thus relies upon some questionable econometric procedures. Although the Commission has wrestled with different aspects of econometric practice in many dockets, this does not ensure that the established model could not include some imperfections in econometric practice.

Even a cursory review of two models, CAT/FAT and LTV, suggests that this is the case. First, consider the CAT/FAT analysis. The established econometric model requires the estimation of over 250 parameters when there are only 384 observations in the data set. This in and of itself is a suspect approach. Moreover, the specified model actually contains more parameters that

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[6] See, A.T. Kearney "Technical Report #1: Economic Analysis of Data Quality Issues," Data Quality Study, April 16, 1999 at 45.

can be estimated by the data and the attempt at estimation led to a non-invertible, singular regression matrix. While the canned statistical procedure eliminated a sufficient number of model parameters to permit estimation of a version of the original equation, it issued dire warnings about the results:[7]

> The above estimates represent only one of many possible solutions to the normal equations. Estimates followed by the letter B are biased and do not estimate the parameter.

By my count, there are over 100 biased coefficients in the established model. These factors suggest that the CAT/FAT analysis does not follow accepted econometric practice.[8]

In Docket No. R2000-1, the Postal Service attempted to remedy these deficiencies by imposing some additional restrictions on the model. The Commission rejected these restrictions, apparently feeling that the cure was worse than the disease. It did, at least implicitly, recognize that there may be a problem with the established econometric equation:[9]

> Although the restrictions on the established model proposed by the Postal Service are rejected by the data, it might be worthwhile in the future to investigate whether less drastic restrictions could be imposed on

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[7] See, Docket R90-1 PRC LIB REF 10, "Analysis of City Carrier Street Runtime Variability," at Tab 1B (the pages are unnumbered).

[8] In addition, the CAT/FAT study has been criticized for being artificial and not reflecting actual carrier operations. See, PRC Op., Docket No. R90-1, Vol. 1, at III-19.

[9] See, PRC Op., Docket No. R97-1, Vol. 1, at 167

the established model, and parameter estimates made more precise, without introducing bias.

The established LTV model is also suspect when it comes to econometric practice. In Docket No. R90-1, the established econometric analysis used a technique called "stepwise regression" to estimate the elemental load time equation. Although included in many statistical software packages, stepwise regression is not part of acceptable econometric practice. In fact, one such statistical program includes a listing of problems caused by stepwise regression. These problems include:[10]

1. Stepwise regression yields R-squared values that are badly biased upward.

2. The F-tests associated with the included coefficients do not have the F- distribution.

3. The estimated confidence intervals are falsely narrow.

4. Stepwise regression gives biased regression coefficients.

The combination of small data sets and irregular data forcing irregular econometric methods strongly argues for a fresh approach to estimating the parameters needed for calculating volume variable carrier street time costs.

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[10] See, "What Are Some of the Problems with Stepwise Regression," STATA FAQs, www.stata.com/support/faqs/stat/stepwise.html.

This fact was discussed in the Data Quality Study, which recommended such a course:[11]

> *Do difficulties associated with generating accurate and precise estimates of product delivery marginal, incremental, and attributable costs indicate the need to identify new ways of estimating city carrier product costs?*
>
> The current methodology involves complex algebraic formulae to integrate the results of numerous sampling studies and/or econometric analysis. The combination of these stochastic variables requires that each study be performed with precision and accuracy. The cost of employing the same data collection methodology at a reasonable level of precision needs to be examined carefully before any updating of the current data is undertaken.

2. The Established Method is a Fragmented Approach

The established methodology constructs city carrier street time cost in a fragmented approach. Carrier street time is analyzed through a series of special studies, on data taken at different times, under different measurement systems. To calculate volume variable city carrier street time, the Postal Service must rely upon, jointly, the results of the Street Time Sampling Study, the Load Time Variability Study, the Curbline Access Test/Foot Access Test study and the Access Variability Study. Most of these individual studies look at only a single, limited aspect of carrier street activity.

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[11] See, A.T. Kearney "Technical Report #1: Economic Analysis of Data Quality Issues," Data Quality Study, April 16, 1999 at 48.

The Street Time Sampling Study attempted to identify time proportions for a carrier's total street time, but the other studies looked at only small, perhaps arbitrary, sections of carrier time. While this fragmented approach had the advantage of producing an understanding, at a micro level, of carrier street activities, it has several drawbacks as a method of cost estimation.

Perhaps the most important drawback is that the fragmented approach fails to capture the "big picture" in the sense of measuring the system-wide response in city carrier street time to changes in volume. Two examples highlight this drawback. First, the Load Time Variability study focused on how load time varied at individual stops. In this micro approach, stops that were receiving mail were identified and then the load time at those stops was measured. A serious weakness with this approach is that it cannot measure the increase in load time that occurs when mail is delivered to stops that were previously uncovered (not receiving mail). In other words, if mail volume rises, the Load Time Variability study accounts only for the additional load time cost that occurs at stops that were already getting mail and ignores the additional load time cost associated with loading mail at stops that previously were not getting mail.

To attempt to remedy this deficiency the Commission was forced to construct an artificial measure called "Coverage Related Load Time," a clever but unusual amalgam of the Load Time and Access Time studies that brings with it a host of additional assumptions and concerns.

Another example of the fragmented approach's inability to capture the big picture is its focus on individual stops and sections of routes. The special studies that support developing the costs do not account for the fact that the Postal Service's primary mechanism for adjusting street time to sustained increases or decreases in volume is though adjusting the route structure. City carrier operations structure routes so that they can be completed in a regular carrier day. If workload gets too larger or too small, the route is "evaluated," a process in which the workload is adjusted back to a standard day. Thus, when there is a sustained increase or decrease in volume, the resulting change in hours shows up through the route adjustment process, not a sustained increase or decrease in hours spent on the existing routes. The established methodology does not capture this important response and thus may understate the responsiveness of city carrier time to changes in volume.

Another serious drawback of the fragmented approach is its artificial division of a fluid, ongoing delivery process. This division can lead to measurement difficulties and internal inconsistencies. For example, one of the divisions is between "access time" (the time the carrier takes to approach the stop) and "load time" (the time the carrier spends at the stop). While conceptually clear, this distinction is not recognized by Postal Service operations personnel and can be difficult to measure accurately. If a carrier slows along his or her walk to the mailbox to prepare the mail for loading, should that additional time be included in "access time" or "load time?" If it is load time, how can it be measured?

Perhaps this difficulty is why the Street Time Sampling study and the Load Time Variability study provide very different estimates of the total amount of "load time" in the city carrier delivery system. This type of inconsistency is symptomatic of a fragmented approach.

Another measurement difficulty that arises in the fragmented approach involves the Curbline Access Test/Foot Access Test (CAT/FAT) study. This study attempts to measure the "split factor," the proportion of carrier "running time" that is devoted to accessing stops, as opposed to simply traversing the route. In reality, these two types of time are blended as the carrier efficiently covers the route.[12] The CAT/FAT study attempts to measure the increase in time associated with visiting more stops under the assumption that route time is fixed and does not increase. Thus, the CAT/FAT study asked carriers to walk portions of their routes under various assumptions about the percentage of stops getting mail, from 60 percent to 90 percent. The difficulty with this micro analysis is that it cannot be done in "real time." During actual delivery, carriers cannot be asked to repeatedly walk the sections of the route, sometimes delivering all of the mail and sometimes delivering only some. Thus, the CAT/FAT study did not reflect actual route activity, did not match actual coverage ratios, and carriers did not carry any mail. The artificial nature of the study leads to doubts about the accuracy of the collected data.

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[12] For example, on a park and loop route the carrier will often walk directly from house to house without returning to the street. This walking time is a combination of "access" and "route" time.

In addition to issues with accuracy, the fragmented approach may cause the micro studies to be limited in what they measure. One of the limitations of the Load Time Variability Study -- its inability to account for load time a previously uncovered stops -- has already been discussed above. Another example is given by the Access Time Study which measures how quickly possible stops become actual stops as volume rises. Because this study focuses solely on how rapidly additional stops occur, and not the actual time associated with those stops, it cannot account for special accesses like parcel retraces or accountables that could require two accesses to a single stop or could cause customer contact.

II. GOALS OF THE NEW CITY CARRIER STREET TIME STUDY

Because of the difficulties associated with the previous analyses, the Postal Service decided to pursue a new study of city carrier street time. One of the advantages of a new study is that it provides the opportunity to articulate the goals of the study before it is begun. The main goals are to produce accurate measurements of volume variable street time cost per class and subclass and to build a cost structure that provides reliable costs through time. However, the chances of achieving these main goals are improved by first identifying the tasks required to meet those goals. The study can be structured so as to focus on accomplishing those tasks. This section outlines the three broad tasks of the new City Carrier Street Time Study and then discusses how the study construction fosters accomplishing the tasks.

A. Tailor the Analysis to Commission Methods and Requirements

Although the new study must replace the established methodology, it does not have to be in conflict to with established Commission methods and requirements. The new study should meet the following requirements:

- It should be a system-wide approach. That is, it should attempt to include all links from volume to cost.

- The new study should draw data in accordance with good statistical practice. The data should accurately represent the city carrier national delivery network.

- The new study should reflect current operational reality in its analytical structure and data collection efforts.

B. Increase The Precision Of The Analysis.

One of the major drawbacks of the old approach was the high variance of the estimated volume variable costs. The new study should collect data and design models with goals of estimating volume variable costs with a lower variance. It can do so in the following ways:

- The study should draw a sufficiently large sample so as to permit good econometric analysis and reduce the variance of the parameter estimates.

- The model structure should be designed to be consistent with the underlying cost generation process. This increases the likelihood of accurate estimates.

- The data collection effort should be structured so as to provide variables consistent with acceptable econometric methods.

C. Construct The Study In Such A Way So As To Permit And Encourage Regular Updates.

Another major drawback of the old approach was difficulty in performing updates. Because the special studies were individually complex and expensive, an overall update was extremely difficult and expensive. This precluded updates being done on a timely basis. There are two ways that the new study can avoid that drawback:

- The new study should avoid unnecessary complexity and prohibitive cost.
- To the extent possible, the new study should be consistent with ongoing USPS city carrier data collection efforts. This increases the likelihood of using operational data in future updates.

D. Efforts in the New Study to Achieve these Goals

The previous sections outline three tasks that should be accomplished in City Carrier Street Time Study to increase the probability that it will meet its two major goals. Table 1 details the efforts actually made in the study to accomplish those tasks.

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Table 1

Task: Tailor the Analysis to Commission Methods and Requirements

Steps Required	Efforts to Complete Steps
Employ a system wide approach. Attempt to include all links from volume to cost.	(1) Include all carrier street time activities in both the analysis and data collection effort. (2) Perform analysis at the ZIP CODE level to embody the route adjustment mechanism.
Draw data in accordance with good statistical practice. Represent the city carrier national delivery network.	(1) Draw a national stratified random sample following a formal statistical design. (see Testimony of John Kelly, USPS-T-X)
Reflect current operational reality in analytical structure and data collection eforst	(1) Consult with Postal Service experts to define street activities appropriately. (2) Measure real time carrier activities in data collection effort. (3) Collect volume measures consistent with operational view of volume. (4) Estimate variabilities at the ZIP CODE level.

Task : Increase the Precision of the Analysis.

Steps Required	Efforts to Complete Steps
Draw sufficiently large sample to permit good econometric analysis.	(1) Attempt to collect data on all routes in 150 Zip Codes. (2) Include 3,400 routes for up to a 2 week period. (3) Collect over 1,500 Zip-Code day and 35,000 route day observations. (4) Performa a beta test to gauge response rates and variances.
Design a model structure consistent with the underlying cost generation process	(1) Review previous Postal Service, Commission, and academic studies of carrier activities (2) Consult with Postal Serivce experts who understand the management of carrier activities. (3) Form time pools consistent with operational practice.
Structure the data collection effort so as to provide variables consistent the acceptable econometric methods.	(1) Review previous carrier econometric studies for strenghts and weaknesses. (2) Do a beta test (3) Collect "real time" data and volumes. (4) Coordinate data collection and modelling efforts.

Task: Construct the Study in Such a Way so as to Permit and Encourage Regular Updates

Steps Required	Efforts to Complete Steps
Avoid unecessary complexity and prohibitive cost.	(1) Avoid artifical special studies and relfect current operations (2) Collect data through carriers self scanning activities during actual street delivery, (3) Set activity defintions consistent with actuall delivery operations.
Be consistent with ongoing USPS city carrier data collection efforts.	(1) Have carriers use same scanner used for other iniatives (2) Collect volume data in a format consistet with DOIS system.

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III. AN OVERVIEW OF THE CITY CARRIER STREET TIME STUDY

The City Carrier Street Time Study (CCSTS) measures volume variable cost for classes and subclasses four steps. First, it identifies and measures the amount of street time spent in the various activities performed by city carriers. In other words it forms “time pools” for street activities. Next, it measures the volume collected and delivered by city carriers. Third, it estimates how the time spent in the various activities changes in response to changes in volumes. That is, it estimates the volume variabilities for the various time pools. Finally, the volume variable costs are distributed to classes and subclasses.

In this section of my testimony I describe each of these steps and indicate how it contributes to measuring volume variable costs.

A. Formation of the Time Pools for Street Activities

The first step in measuring volume variable costs is the formation of the time pools for street activities. This step is described in detail in the testimony of Postal Service Witness Stevens, USPS-T-15, but an overview is provided here.

The time pools are the proportions of time spent by carriers in the various activities on the street. These proportions were measured by having carriers identify their activity times as they worked through the street time portion of the day. Specifically, carriers were provided a set of bar codes representing the beginning and end of each of the activities. During the study, carriers were asked to use the scanners that they already carry for other purposes to record

their activities. All time on the street was captured and scans were taken sequentially throughout the day.

Street time activity lends itself to this type of study as carrier actions are divided into broad identifiable groups. Thus, in forming city carrier street time pools, a set of activities were defined that are well known to both carriers and delivery supervisors. The time pools reflect the street time portion of the carrier's day and cover all time from when the carrier clocks to the street through when the carrier clocks off the street.

Consultation with Postal Service delivery experts both at headquarters and in the field provided the initial bases for defining the activity scans. Experience with a beta test, which showed that carriers could successfully self scan, refined the activity scan definitions. In general, scan definition -- and thus time pool formation -- is guided by four main characteristics of city carrier delivery.

First, delivery is done in identifiable sections, each of which has a dominant delivery technology.[13] A section represents a geographical subset of the route that is characterized by steady collection and delivery. Sections are relatively large subsets of the route, are well known to carriers, and are used by

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[13] The "delivery" activity involves delivery mail to customers' receptacles and collecting mail from the customers' receptacles. More formally it should be called "collection and delivery." However, this phrasing is awkward and collection at customers' mail receptacles will be subsumed in the term "delivery." Note that this is just terminology; collection costs are measured separately. Also note that this covers only collection at delivery points and does not include collection of mail from street letter boxes.

supervisors in managing street delivery. To give a sense of the size of a section, a typical route may have 2 to 4 sections.

The delivery technologies that define sections are: (1) Curbline, in which the carrier drives from box to box and does not leave the vehicle except for special circumstances, (2) Park & Loop/Foot, in which the carrier makes delivery on foot and refreshes his or her bag at a vehicle or relay box, (3) Dismount, in which the carrier drives from delivery to delivery but exits the vehicle at virtually every delivery, (4) NDCBU, in which the carrier puts the mail up into a neighborhood delivery and collection box, (5) VIM, in which the carrier delivers the mail “vertically” in a tall building, and (6) Central/Apartment, in which the carrier puts the mail up in a mail room or box section.

The second important characteristic of city carrier delivery is that accountables and “large” parcels cause retraces and customer contact. These actions generate a material amount of additional time for these pieces and should be captured separately. Note that “large” parcels are defined as those that cannot be loaded in the receptacle with other mail and cause the carrier to make an additional delivery effort. For example, a large parcel on a curbline route would not fit into the customer’s mailbox and would cause the carrier to leave the vehicle and approach the residence or business.

The third characteristic is that “access time” and “load time” are not easily separated activities. Under the fragmented approach followed in previous rate cases, the Postal Service broke the delivery activity into three sub-portions: the time spent traversing the route (route time), the time spent approaching the stop

(access time), and the time spent at the stop (load time). While these were useful distinctions for learning about the mechanics of delivery on a route, they caused several measurement difficulties. As mentioned above, these distinctions are not known to delivery supervisors, carriers, and operations planners. This makes it hard to measure with real time carrier data.[14] In addition, it is difficult to measure the separate parts accurately because carriers often "finger" and otherwise prepare mail on the way to the stop. This clearly affects the amount of time spent at the stop. It is also difficult to precisely separate access from route time.

The last characteristic guiding time pool formation is the fact that carriers have a set of non-delivery activities that occur at specific locations on their routes. These include things like serving relay boxes, mail preparation, and collection at street letter boxes.

B. Measuring Volume

Volume data were collected to permit measurement of the responsiveness in city carrier street time to sustained changes in volume. [15] Volume measurements were taken in the same Zip Codes on the same days that scan

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[14] Even in the previous approach access time was not actually observed. Instead, it was inferred through the use of "split factors" derived from the CAT/FAT study. This study did not use actual carrier activities as its basis.

[15] The details of the volume data collection effort are contained in Library Reference LR-K-80.

data were collected. As with the scan data collection effort, the goal was to collect all volume data for the Zip Code on the day of the test.

Volume data were collected by shape. This approach has four advantages. First, previous work has shown that shape is an important cost driver of volume variable cost. Second, this is how operations personnel measure volume for management purposes. For example, carrier workload is calculated in terms of volume per shape. Delivery supervisors are responsible for collecting volume data during the study so a volume measure with which they are familiar will increase the accuracy of the volume collection effort. Third, the DOIS system collects volume by shape. Linking to the DOIS system means that volumes will be readily available for future updates, reducing their cost. Fourth, the CCS data collection effort, which collects volume data by class and subclass, also collects volume by shape. Collecting volume by shape in this study facilitates the use of the CCS data for constructing distribution keys.

C. Estimating the Variabilities for the Time Pools

There are six time pools for which variabilities are required. For each time pool, the variability measures the percentage change in time with respect to a percentage change in volume. Each of the six time pools is described in this section along with an explanation of the basis for its variability.

C.1. Delivery on Route Sections

This time pool captures the primary activity on the street.[16] It includes traversing the route within the section, approaching the deliveries, loading mail into and collecting mail from the customers' receptacles. The variability for this time pool is estimated with an econometric model of delivery time. Note that it was not feasible to measure volumes by individual route section but only by route. As a result, separate econometric models cannot be estimated for each of the different delivery technologies and only a single delivery time variability can be derived. This is an interesting topic for future research.

In terms of comparison with the previous approach, the delivery on route sections time pool contains the time that was classified as access time, load time and a portion of route time in the previous cost structure. There is some fixed route time involved in traversing the route sections and this is included in the time pool. Its fixity will work into the estimated variability.

C.2. Travel To/From the Route

This time pool contains the time the carrier takes going from the delivery unit to the first street action of the day plus the time from the last street action to the carrier's return to the delivery unit. Its variability is derived from the "burden" method under the assumption that this travel time is a function of the number of

[16] In the balance of the testimony, this time will be referred to a "regular" delivery time so as to distinguish it from parcel/accountable delivery time which is described in section C.6. below.

routes and routes are variable with respect to volume in the same proportion as total street time. Travel to and from the route thus receives the average variability for the other activities in street time. This is the same approach to variability as is taken in the established methodology. This time was separately identified in the old cost structure but was included in the street support pool.

C.3. Network Travel Time

This time pool contains the time required to traverse the network portion of the route. It is the time it takes to get from one route section to another or from one delivery activity to another. For example, on a motorized route, it would include the time it takes to drive from the end of a mounted/curbline section to a foot/loop section. Alternatively, it could be the time it takes to drive from a collection box to the next mounted/curbline section. Network travel time can be walking or driving. This time was classified as route time in the established methodology and was assume to be fixed. Here, like there, it is treated as a fixed time and has zero variability.

C.4. Relay Time

This time pool captures the time that a carrier spends obtaining or dropping off relay mail at a relay point. The time starts when the carrier arrives at the relay point and ends when the carrier leaves the relay point. The variability for relay time is based upon the burden method. This is the same approach to

variability as is taken in the established methodology. This time was separately identified in the old cost structure but was including in the street support pool.

C.5. Collection Time

This time pool contains the time required to sweep general and Express Mail mailboxes. The time starts when the carrier arrives at the collection box and ends when the carrier leaves the collection box. Its variability is the one developed by the Commission in Docket No. R2000-1 and thus is the same as in the established methodology.

C. 6. Parcel /Accountable Delivery

This cost pool contains the time it takes for carriers to deliver “large” parcels and accountables including the time it takes to drive to a deviation park point and the time it takes to return from a deviation park point. For the purposes of measuring cost, a “large” parcel is defined as any mail piece that will not fit in the receptacle and thus requires additional time. This matches the definition of large parcels in the volume data. A parcel that does fit into the receptacle is called a “small” parcel. The cost of delivering small parcels is included in regular delivery time. Note that not all parcel/accountable deliveries require a deviation park point. For example, a parcel or accountable delivery on a mounted-curbline section will not require another park point but will require additional time as the carrier leaves the vehicle and takes the parcel to the customer’s door. This time pool was not separately identified in the old cost

structure but was implicitly included as part of the access and load time pools. This variability is estimated with an econometric model.

Table 2
Summary of Time Pools and Variability Sources

Time Pools	Variability Source
DELIVERY ON ROUTE SECTIONS	Econometric Model
TRAVEL TO/FROM ROUTE	Burden Method
NETWORK TRAVEL	Fixed Time
RELAY	Burden Method
COLLECTION	PRC R2000-1
PARCEL/ACCOUNTABLE DELIVERY	Econometric Model

D. Distributing Volume Variable Cost to Products.

In the first step of the cost attribution process, the time pools are formed and in the third step the variabilities for each time pools are estimated[17]. Total volume variable city carrier street time costs can then be calculated using these results. First, the time proportions derived in the first step are multiplied against total *accrued* city carrier street time costs. This multiplication allocates the

[17] Recall that the second step was the collection of volume data. This was used in the estimation of the variabilities in the third step.

accrued cost to the various activities and forms the *accrued* cost pools. For example, there are accrued cost pools for collection from street letter boxes and travel to and from the route.

The *volume variable* cost for each cost pool is found through multiplying the estimated variability times the accrued cost in the pool. This process provides total volume variable cost for the pool, but not the volume variable cost by class and subclass. These product-specific volume variable costs are calculated by multiplying, for each cost pool, the volume variable costs by the relevant distribution key.

The details of distribution key formation are presented in section VI below, but the primary source of information is the Carrier Cost System (CCS) which has been used in the past. The CCS records information on both the shape and class and subclass of mail delivered on city routes.

IV. ECONOMETRIC MODELING

Before the econometric models of delivery time can be estimated, a number of pre-estimation steps must be followed. This section of my testimony reviews these key steps and explains how each was made for the both the regular delivery time equation and the parcel/accountable delivery time equation.

A. Identify the Behavior Being Modeled

The first step in the pre-estimation process is to identify and describe the behavior being modeled by the econometric equation. In the current exercise, I am trying to model the response in the city carrier delivery network in two areas: (1) how does regular delivery time respond to a sustained change in the volume of letters, flats, sequence mail, collection mail and small parcels? and (2) how does parcel/accountable delivery time respond to a sustained change in the volume of large parcels and accountables?

When volume increases on a sustained basis, both regular delivery time and parcel/accountable delivery time will increase. This means that overall street time will increase and this will increase the burden on the current network of city carriers. That is, the current carriers will be unable to perform both the office and street work required in a regular delivery day. This change in workload will lead to route evaluations, in which the current routes are restructured and additional routes will be added.[18] In this way, total street time will rise in response to the sustained increase in volume. Similarly, a sustained decrease in volume would lead to insufficient volume per route to justify a full carrier day for that route. This imbalance will also lead to a route restructuring, except in this case, individual routes will get larger and the total number of routes will fall.

The route optimization process is done at the Zip Code level. During a route evaluation, the Postal Service attempts to determine the best route

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[18] For example, as volume rises on a route, the number of delivery points falls. The constraint of the regular carrier day limits the workload on any one route.

configuration to delivery mail within each Zip Code. This important fact strongly indicates that the appropriate behavior to be modeled is the adjustment of delivery time in a Zip Code to changes in the amount of volume delivered in that Zip Code.[19] In addition, analysis of delivery time at the Zip Code has the advantage of being a system-wide analysis. It captures all responses to volume changes including route reconfiguration. Analysis at the route level, in contrast, is likely to understate the response in delivery time to changes in volume.

B. Identify the Variables to be Included in the Econometric Equation

The behavior being modeled in the regular delivery equation is the response in delivery time to a sustained change in volume in an environment in which the Postal Service is attempting to ensure timely collection and delivery of mail across a network of deliveries in the geographical area covered by a Zip Code. This translates into an equation in which delivery time is the dependent variable and mail volume, the delivery network, and the geographical dispersion of deliveries are the right-hand-side variables. In this section, I describe how those right-hand-side variables were chosen.

[19] Because of route restructuring, there is relatively little variation in delivery times and volumes across routes. This makes it infeasible to estimate the response of delivery time to volume at the route level. In equilibrium, all routes would be just large enough to be covered by a regular carrier day. If volume on a route gets too large, it is restructured down to fit approximately into the regular carrier day, and, if volume gets too small, the opposite happens.

Although a single variable for volume could be used, previous work has shown that shape is an important determinant of delivery time. Thus, mail volumes by shape will be included in the equation. The delivery network will be modeled by the delivery points in the Zip Code and, following the work of researchers at the Postal Rate Commission, a geographical variable will be included as the density of delivery, the number of deliveries per square mile.[20]

The parcel/accountable equation is modeling a similar but not identical behavior. It captures the response of parcel/accountable delivery time to changes in a specific type of volume in an environment in which carriers are already delivering other mail. As such, it does not involve standard activities such as route time, and only captures the additional time required for special accesses and customer contact. The volumes of large parcels and accountables are included, as well as the number of delivery points over which the volume is delivered. However, geographical dispersion is not an issue because city carriers are already at or near the delivery points for large parcels and

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[20] See, Cohen, Robert, Robinson, Matthew, Waller, John, and Xenakis, Spyros, "The Cost of Universal Service in the U.S. and its Impact on Competition," Proceedings of Wissenschaftliches Institut fur Kommunikationsdienste GmbH (WIK), 7th Koenisgwinter Seminar on Contestability and Barriers to Entry in Postal Markets, 2003 and Bernard, Stephane, Cohen, Robert, Robinson, Matthew, Roy, Bernard, Toledano, Joelle, Waller, John and Xenakis, Spyros, "Delivery Cost Heterogeneity and Vulnerablity to Entry," in Postal and Delivery Services: Delivering on Competition, Michael Crew and Paul Kleindorfer (eds.), Kluwer, 2002

accountables because of the collection or delivery of other mail. Thus, a density variable is not required for this equation.[21]

C. Specify a Functional Form.

The next step in preparing for estimation is choosing a functional form. If there is technological or other knowledge about the underlying cost generation process, this can be used to guide functional form selection. If not, there are advantages to selecting a flexible functional form in attempting to measure the responsiveness of cost to volume changes. Finally, one can review previous work to identify functional form selections for similar modeling efforts.

In the area of city carrier delivery, previous work has shown the quadratic functional form to be useful. It was specified by both the Postal Service and the Commission in estimating models for load time and access time. These two components make up the overwhelming majority of volume variable delivery time, so the application of a quadratic form would be appropriate for delivery time.

The quadratic functional form also has the advantage of being a flexible functional form in the sense that it plays no restrictions on the first and second order derivatives. Thus it is agnostic, *a priori,* about the absence or presence of scale or network economies that lead to variabilities being less that one hundred

[21] Parcel/Accountable delivery time generally arises because of customer contact or because the carrier must leave the vehicle to make a special access. However, it is possible that a large parcel or accountable could cause a motorized carrier to deviate from a regular parking point. This additional time is included in the dependent variable.

percent. The primary alternative flexible functional form is the translog.[22]

However, because of repeated instances in which one or more of the volume measures has a zero value a traditional translog cannot be used. The Box-Cox transformation can permit the estimation of logarithmic function but, given the previous work employing the quadratic function, it is unnecessary to introduce this nonlinear method of estimation.[23]

The specification for the regular delivery equation is given by:

$$
\begin{aligned}
DT_{it} \quad = \quad & \beta_0 + \beta_1 L_{it} + \beta_{11} L_{ij}^2 + \beta_2 F_{it} + \beta_{22} F_{ij}^2 + \beta_3 S_{it} + \beta_{33} S_{ij}^2 \\
& + \beta_4 C_{it} + \beta_{44} C_{ij}^2 + \beta_5 SP_{it} + \beta_{55} SP_{ij}^2 + \beta_6 DP_i + \beta_{66} DP_i^2 \\
& + \beta_7 DN_i + \beta_{77} DN_{ij}^2 + \beta_{12} L_{it} * F_{it} + \beta_{13} L_{it} * S_{it} + \beta_{14} L_{it} * C_{it} \\
& + \beta_{15} L_{it} * SP_{it} + \beta_{16} L_{it} * DP_i + \beta_{17} L_{it} * DN_i + \beta_{23} F_{it} * S_{it} \\
& + \beta_{24} F_{it} * C_{it} + \beta_{25} F_{it} * SP_{it} + \beta_{26} F_{it} * DP_i + \beta_{27} F_{it} * DN_i \\
& + \beta_{34} S_{it} * C_{it} + \beta_{35} S_{it} * SP_{it} + \beta_{36} S_{it} * DP_i + \beta_{37} S_{it} * DN_i \\
& + \beta_{45} C_{it} * SP_{it} + \beta_{46} C_{it} * DP_i + \beta_{47} S_{it} * DN_i + \beta_{56} SP_{it} * DP_i \\
& + \beta_{57} SP_{it} * DN_i + \beta_{67} DP_i * DN_i + \varepsilon_{it}
\end{aligned}
$$

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[22] For an example of a translog model estimated for delivery, see Cazals, Catherine, Florens, Jean-Pierre, and Soteri, Soterios, "Delivery Costs for Postal Services in the UK: Some Results on Scale Economies with Panel Data," in Regulatory and Economic Challenges in the Postal and Delivery Sector, Michael Crew and Paul Kleindorfer (eds.), Kluwer, 2005. Cazals, Florens, and Soterios include aggregate volume, delivery points and the geographical area covered by delivery in their equation. Interestingly, they find an overall elasticity of delivery cost with respect to volume of 41.8 percent. The sum of the shape variabilities from the quadratic model estimated below is quite close to this result, at a value of 41.1 percent.

[23] A translog specification in total volume was estimated. The translog equation produces an overall volume variability that was below the sum of the variabilities for the quadratic model. For details, see section IV.G.8 below.

Where:

L	=	Letters
F	=	Flats
S	=	Sequenced Mail
C	=	Collection Mail
SP	=	“Small” Parcels
DP	=	Delivery Points
DN	=	Density: Delivery Points per Square Mile

The specification for the parcel/accountable delivery equation is given by:

$$\begin{aligned} PADT_{it} = \; & \beta_0 + \beta_1 LP_{it} + \beta_{11} LP^2 + \beta_2 A_{it} + \beta_{22} A^2 \\ & + \beta_3 DP_i + \beta_{33} DP^2 + \beta_{12} LP_{it} * A_{it} \\ & + \beta_{13} LP_{it} * DP_i + \beta_{13} A_{it} * DP_i + \varepsilon_{it} \end{aligned}$$

Where:

LP	=	“Large” Parcels
A	=	Accountables
DP	=	Delivery Points

D. Identify a Data Source.

The data used to estimate the econometric equations are taken primarily from the City Carrier Street Time Study. There are two main parts to the CCSTS data set, the “scan” data and the volume data. The scan data consist of captured carrier activity scans. As described above, these scans are used to form time pools for each route within each Zip Code that was sampled. The delivery time for the Zip Code is just the sum of the delivery time for the routes in the Zip

Code. The data were collected during a two-week period in the end of May and early June in 2002. Because the initial two-week period included the Memorial Day holiday, it included 11 delivery days.[24] Finally, the number of delivery points was collected for each route in each Zip Code in the study.

The other part of the CCSTS data set contains the volume data. Volumes were measured for all routes in the same Zip Codes, for the same days. As with delivery time, the total volume for the Zip Code is just the sum of the volume for the routes in the Zip Code.

The last piece of data required for the regular delivery equation is the geographic density of the delivery points. The density variable was calculated by comparing the deliveries per Zip Code with the geographical area, measured in square miles for the Zip Code. This latter piece of data was obtained from the Census Bureau.

The estimation data set thus consists of daily observations over a two week period on delivery time, volumes, and deliveries for each Zip Code in the sample, along with each Zip Code's square mileage.

[24] For logistical reasons a few Zip Codes could not complete the data collection effort during the initial to week period. Thus it is possible for a few Zip Codes to have 12 delivery days not just 11. For details see Testimony of Dennis Stevens on Behalf the United States Postal Service, USPS-T-15.

E. Choosing a Method of Estimation.

The data set collected in the City Carrier Street Time Study has both a time dimension and a cross-sectional dimension. It is thus a panel data set and such a data set allows for a variety of estimation techniques. For example, one could collapse all of the Zip Code data for each day into a single observation and attempt to estimate a time series model based upon 11 data points. This would involve the loss of a huge amount of information and would ignore all of the cross-sectional variation in the data set. Because there is more variation in volume and delivery times across Zip Codes than there is within Zip Code across days, this approach would not be sensible. Similarly, one could collapse all of the data for each Zip Code into one observation and estimate a cross sectional model. While this approach is preferred to a pure time series approach, it still destroys a tremendous amount of information and reduces the amount of data available for estimating parameters by a factor of 10.

This means that there are two standard approaches to estimating the econometric equation using panel data, a pooled model and a fixed effects model. A pooled model is appropriate when the modeler believes that the underlying cost generating process is the same for all Zip Codes and there are no important Zip-Code-specific effects that are omitted from the model. Previous work on carrier suggests that this may be the appropriate approach.[25]

Alternatively, one can estimate a fixed effects or “within” estimator because the modeler believes that there may important Zip-Code-specific effects,

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[25] See, Testimony of Michael D. Bradley on Behalf of the United States Postal Service, USPS-T-5, Docket No. R94-1 at 43.

the omission of which would bias the estimated coefficients. In the fixed effects approach, the estimation is focused on the measuring the response in delivery time to variations in volume within time for the set of Zip Codes.

Both the pooled model and the fixed effects model were estimated and both give plausible results. I am recommending the use of the estimated variabilities from the pooled model, however, because they are more in accordance with previous results and seem to comport better with operational understanding of carrier activities.

F. Econometric Results

The detailed results of the econometric estimation of the regular delivery equation and the parcel/accountable delivery equation are contained in Library Reference LR K-81. A summary of those results are presented here.

Because of the large cross sectional variation in the data, it is likely that the econometric estimates for the delivery equations suffer from heteroscedasticity. This must be accounted for in evaluating the regression and performing statistical tests. Unless the heteroscedasticity is accounted for, the estimated standard errors will overstate the true standard errors and inflate the apparent precision of the estimated. Thus, to control this problem the corrected

standard errors are derived from a heteroscedasticty-consistent variance covariance matrix.[26]

F.1. The Regular Delivery Equation

The results of estimating the regular delivery equation are presented in Table 3, which contains the coefficient estimates and the heteroscedasticity corrected standard errors.

The existence of a high R^2 statistic and many insignificant right-hand-side variables is a warning sign that multicollinearity is present in this equation. This is confirmed by the calculation of Variance Inflation Factors (VIF) and Tolerance factors for each of the right-hand-side variables.

[26] See, White, Halbert, "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticty," Econometrica, Vol. 48, 1980, pp. 817-833.

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Table 3
Econometric Estimate of the Regular Delivery Equation
Pooled Model Results

Variable	Estimated Coefficient	HC Standard Error	HC t-statistic
Intercept	-13416.00	3475.39	-3.86
Letters	1.659730	0.505106	3.29
Letters^2	0.000003	0.000005	0.62
Flats	1.778380	0.906959	1.96
Flats^2	-0.000073	0.000024	-3.01
Sequenced	1.199880	0.922299	1.30
Sequenced^2	0.000030	0.000017	1.72
Collection	2.899200	1.162812	2.49
Collection^2	0.000017	0.000013	1.28
Small Parcels	-19.992740	27.246414	-0.73
Small Parcels^2	-0.032860	0.014871	-2.21
Delivery Points	17.926200	1.465554	12.23
Delivery Points^2	-0.000557	0.000114	-4.90
Density	-22.496100	44.668306	-0.50
Desiity^2	0.136660	0.065571	2.08
Letters*Flats	-0.000040	0.000018	-2.22
Letters*Sequenced	0.000024	0.000028	0.88
Letters*Collection	0.000000	0.000032	0.01
Letters*Small Parcels	-0.000534	0.000455	-1.18
Letters*Delivery Points	0.000034	0.000048	0.71
Flats*Sequenced	-0.000046	0.000041	-1.11
Flats*Collection	0.000164	0.000056	2.92
Flats*Small Parcels	0.001150	0.001177	0.98
Flats*Delivery Points	0.000364	0.000088	4.12
Sequenced*Collection	-0.000400	0.000064	-6.22
Sequenced*Small Parcels	0.002040	0.001500	1.36
Sequenced*Delivery Points	-0.000043	0.000084	-0.51
Collection*Small Parcels	-0.003340	0.001126	-2.97
Collection*Delivery Points	0.000054	0.000117	0.46
Small Parcels*Delivery Points	0.007070	0.002631	2.69
Letters*Density	-0.001460	0.001452	-1.01
Flats*Density	-0.012160	0.003772	-3.22
Sequenced*Density	0.004880	0.004746	1.03
Collection*Density	-0.009180	0.003914	-2.35
Small Parcels*Density	-0.273990	0.115037	-2.38
Delivery Points*Density	0.008470	0.005126	1.65
# of Observations			1,545
R^2			0.8486

The Tolerance factor shows the relationship between any single right-hand-side variable and the others. It is given by

$$\text{Tolerance}(\hat{\beta}_i) \quad = \quad 1 - R_i^2$$

where R_i^2 is the R^2 statistic from the regression of the particular right-hand-side variable on the others. A low value for the Tolerance factor indicates a high degree of multicollinearity. The VIF measure the inflation in the standard errors due to multicollinearity and is the inverse of the Tolerance factor. A large value (usually above 15 to 20) for the VIF indicates serious multicollinearity. Table 4 provides the VIFs and tolerances for the right-hand-side variables in the regular delivery equation.

Table 4 shows that there is a serious problem with multicollinearity in the regular delivery regression. Of the 35 right-hand-side coefficients, only 8 have a VIF less than 10 and three of those are 9.5, 9.6, and 9.9. Nearly 60 percent of the coefficients have VIFs greater than 20. Similarly, 21 of the 35 coefficients have a tolerance less than 5 percent, meaning a regression equation of that variable on the other right hand side variables has R^2 of 0.95 or higher. Upon reflection, it should not be surprising that the volume variables exhibit a high degree of multicollinearity, because a high-volume Zip Code is likely to have high value for all of the volume measures.

Table 4
Tolerances and VIF for the Full Quadratic Model

Variable	Tolerance	VIF
Letters	0.0231	43.3
Letters^2	0.0105	94.9
Flats	0.0353	28.3
Flats^2	0.0319	31.3
Sequenced	0.0759	13.2
Sequenced^2	0.2173	4.6
Collection	0.0407	24.6
Collection^2	0.1492	6.7
Small Parcels	0.0402	24.9
Small Parcels^2	0.0391	25.6
Delivery Points	0.0375	26.7
Delivery Points^2	0.0134	74.9
Density	0.0625	16.0
Desiity^2	0.1043	9.6
Letters*Flats	0.0102	98.0
Letters*Sequenced	0.0449	22.3
Letters*Collection	0.0274	36.5
Letters*Small Parcels	0.0104	96.6
Letters*Delivery Points	0.0060	165.6
Flats*Sequenced	0.1055	9.5
Flats*Collection	0.0736	13.6
Flats*Small Parcels	0.0226	44.2
Flats*Delivery Points	0.0150	66.8
Sequenced*Collection	0.1261	7.9
Sequenced*Small Parcels	0.0797	12.6
Sequenced*Delivery Points	0.0523	19.1
Collection*Small Parcels	0.0972	10.3
Collection*Delivery Points	0.0324	30.9
Small Parcels*Delivery Points	0.0108	92.3
Letters*Density	0.0497	20.1
Flats*Density	0.0888	11.3
Sequenced*Density	0.3667	2.7
Collection*Density	0.1303	7.7
Small Parcels*Density	0.1009	9.9
Delivery Points*Density	0.0491	20.4

Given that serious multicollinearity exists, the next question is what steps should be taken to control for it. The usual procedure is to drop unnecessary variables in an attempt to maintain the integrity of the regression while reducing the impact of the multicollinearity. The natural candidates here are the higher

order cross-product terms. They can be removed without causing any of the shape volumes to be dropped from the regression equation and without eliminating the quadratic nature of the equation. If these cross products can be omitted without doing violence to the estimated variabilities, the precision of the estimation can be greatly increased. The results of estimating the restricted quadratic model are given in Table 5.

Table 5
Econometric Estimate of the Regular Delivery Equation

Variable	Estimated Coefficient	HC Standard Error	HC t-statistic
Intercept	-10445.00	4050.36	-2.58
Letters	1.419120	0.322632	4.40
Letters^2	-0.0000004	0.000002	-0.18
Flats	0.7019600	0.774253	0.91
Flats^2	0.0000279	0.000017	1.66
Sequenced	0.9772400	0.542724	1.80
Sequenced^2	-0.0000217	0.000013	-1.70
Collection	4.5388900	0.642802	7.06
Collection^2	-0.0000547	0.000011	-4.77
Small Parcels	8.7914000	14.743747	0.60
Small Parcels^2	0.0010200	0.006642	0.15
Delivery Points	19.043470	1.460838	13.04
Delivery Points^2	-0.0001649	0.000058	-2.86
Density	-308.622630	37.188600	-8.30
Density^2	0.3399200	0.067366	5.05
# of Observations			1,545
R^2			0.8167

Despite the loss of many right-hand-side variables the fit of the equation is still quite good and most coefficients have their expected signs and magnitudes. A review of the VIFs and tolerances shows that the degree of multicollinearity has been greatly reduced.

The variabilities can be derived directly from the estimated coefficients according to the following formula:

$$\lambda_{DT,V_i} = \frac{\partial DT}{\partial V_i} \frac{\overline{V}_i}{DT(\overline{V})} ,$$

where $DT(\overline{V})$ is the value for delivery time at the mean values for the volumes, delivery points and density. The variabilities for regular delivery are given in Table 6 below for both the full quadratic and the restricted quadratic (without the cross products.

Table 6
Variabilities for Regular Delivery

Shape	Full Quadratic Variability	Restricted Quadratic Variability
Letters	23.60%	22.28%
Flats	11.38%	7.12%
Sequenced	0.69%	1.29%
Collection	4.70%	8.82%
Small Parcels	-1.96%	1.58%

Table 6 shows that the general pattern of variabilities is preserved from the full quadratic to the restricted quadratic with relatively large variabilities for letters and flats and relatively small variabilities for sequenced mail and parcels. In addition, the restricted quadratic has the salutary effect of eliminating the negative variability for small parcels.

In evaluating the results it is important to correctly interpret the variabilities listed in Table 6. Those values do *not* reflect the relative marginal delivery times for each shape. Recall that the regular delivery equation is a “multi-driver” equation in which there are a number of volume terms on the right-hand-side. The elasticity for a given type of volume is the change in *total* delivery time for a given percentage change in that type of volume. A particular type of mail may have a relatively high marginal delivery time, but if it has a relatively low volume, it will have a relatively low variability. Why? A 10 percent increase in a product with small volume will cause only a small increase in total delivery time, because most delivery time is caused by the high-volume products.

Consider a simple two-product example. Suppose that there are a total of 800 seconds of delivery time required to deliver the two products, called Product A and Product B. Let the marginal time for Product A be 5 seconds which is one-half the marginal time for Product B at 10 seconds. Finally, let the volume of product A be 80 pieces and the volume of Product B be 20 pieces.

We can calculate the variabilities for each product using the formula presented above. For example, for Product A:

$$\lambda_{DT,A_i} = \frac{\partial DT}{\partial V_A}\frac{\overline{V}_A}{DT(\overline{V})} = 5 * \frac{80}{800} = 50\%$$

This can also be presented in spreadsheet form:

Product	Marginal Time	Volume	Variability
A	5	80	50%
B	10	20	25%

Total Time: 800

The same calculation for Product B produces a variability of only 25 percent. In this example, the product with the low marginal time has the relatively high variability because of the amount of its volume delivered. Similarly, the letter variability is high and the small parcel variability is low in the regular delivery equation because letters are a high volume product and small parcels are a very low volume product.

F.2. The Parcel/Accountable Delivery Equation

Econometric estimates of the coefficients for the parcel/accountable delivery equation were also obtained. They are provided along with the heteroscedasticity corrected standard errors in Table 7.

Table 7
Econometric Estimate of the Parcel/Accountable Delivery Equation

Variable	Estimated Coefficient	HC Standard Error	HC t-statistic
Intercept	-629.78787	420.1233	-1.50
Large Parcels	35.57036	4.9129	7.24
Large Parcels^2	-0.00804	0.0032	-2.49
Accountables	25.24529	10.9624	2.30
Accountables^2	-0.00431	0.0330	-0.13
Delivery Points	1.54560	0.1394	11.09
Delivery Points^2	-0.00007	0.0000	-10.52
Large Parcels*Accountables	-0.17276	0.0477	-3.62
Large Parcels*Delivery Points	0.00178	0.0004	3.98
Accountables*Delivery Points	0.00980	0.0014	6.78
# of Observations			1,535
R^2			0.706

The results show an acceptable fit for the equation and most coefficients are statistically significant. In addition, the estimated coefficients display a sensible pattern with appropriate signs and magnitudes. A review of the Tolerances and Variance Inflation Factors for the parcel/accountable equations shows that only one VIF is above 20. When combined with the fact that all but one of the coefficients are statistically significant, this indicates that multicollinearity is not a serious problem for the parcel/accountable equation.

Table 8
Tolerances and VIF for the Parcel/Accountable Delivery Model

Variable	Tolerance	VIF
Large Parcels	0.08071	12.39002
Large Parcels^2	0.21799	4.58727
Accountables	0.09241	10.82076
Accountables^2	0.14321	6.98256
Delivery Points	0.07547	13.25107
Delivery Points^2	0.05385	18.57061
Large Parcels*Accountables	0.0612	16.34061
Large Parcels*Delivery Points	0.05457	18.32532
Accountables*Delivery Points	0.04571	21.87484

Finally, the variabilities for large parcels and accountables can be calculated from the estimated equation. They are presented in Table 9.

Table 9
Variabilities for Parcel/Accountable Delivery

Shape	Variability
Large Parcels	28.5%
Accountables	25.0%

G. Alternative Approaches

In this section I describe alternative econometric analysis that I performed. Although the research path directly followed the process described in the above sections, alternatives were considered along the way. For each alternative, I identify differences between the alternative and the preferred model with respect to variable definitions, equation forms or estimation results. I also discuss why the alternative is not preferred to the recommended model.

G.1. Fixed-Effects Estimation

An alternative approach to estimation using panel data is the fixed-effects estimator. This estimator is useful when there are location-specific omitted effects that could be influencing the estimated coefficients. The regular delivery and parcel/accountable delivery models were estimated using a fixed-effects estimator. The variabilities derived from the fixed estimation are presented in Table 10.

While the results for regular delivery appear plausible in the sense they have the correct signs and relative magnitudes, they are far lower than previous delivery variability estimates for the Postal Service and other postal administrations. The regular delivery variabilities imply that a doubling of all volumes delivered on city routes would cause only 7 percent increase in delivery time.

One possible reason for these low variabilities is the “within” nature of the fixed-effects estimator. This estimator focuses on the movement of volume and

delivery time across the observations for the individual units. If that response is muted because of inflexibility in the carrier day, then the estimated variabilities may be understated. For example, is there is a short run absorption of temporary changes in volume, that is not sustained in the long run, then the day-to-day variabilities may understate the true response to a sustained change in volume. Because of the low values for the regular delivery variabilities, the fixed effects results are not preferred to the pooled model results.

Table 10

Variabilities for Regular Delivery Fixed Effects Estimation Shape	Variability
Letters	5.39%
Flats	4.32%
Sequenced	1.47%
Collection	1.97%
Small Parcels	0.76%
Variabilities for Parcel/Accountable Delivery Fixed Effects Estimation Shape	Variability
Large Parcels	39.2%
Accountables	29.9%

G.2. Route Level Analysis.

The appropriate level of analysis is the Zip Code level as it captures the response of the Postal Service in adjusting city carrier street time to changes in volume. In addition, the process of adjusting routes suggest that a route level analysis would not be successful and measuring that response. Nevertheless, because the data were originally collected at the route level (to facilitate the data collection process) it is possible to attempt to estimate the regular delivery equation using route level data.

This regression approach uses the route day observation instead of the Zip Code day observation as the data to estimate the equation. As a result, there are many more observations and the estimated equation is based upon 30,035 observations. Despite the apparent wealth of data, the equation did not fit well, with an R^2 of only 0.0617. In addition, the estimated elasticities show virtually no relationship between the volume on the route and the delivery time on that route. As presented in Table 11 below,

Table 11
Variabilities for Regular Delivery
Estimated By Route

Shape	Variability
Letters	2.92%
Flats	-3.47%
Sequenced	1.63%
Collection	0.23%
Small Parcels	3.30%

These low variabilities reflect the fact that routes are adjusted to the standard carrier day. When a route receives too much volume, its number of delivery points is reduced. Thus, it is possible to observe routes with large and small volumes but roughly the same amount of street time. As expected, the route level is not a good place to perform a variability analysis of delivery time and this approach is not preferred to the Zip Code level analysis.

G.3. Alternative Volume Definition.

The regular delivery equation uses the traditional definitions of volume by shape: letters, flats and parcels. This approach has been widely used and is well recognized. However, an alternative approach is to disaggregate letters into two subsets: DPS letters and cased letters. This disaggregation is forward looking in the sense it anticipates a delivery environment in which virtually all letters are delivery point sequenced and residual letters are cased along with flats. The Postal Service is moving in this direction with the use of a single case for letters and flats.

To investigate this possibility, I reestimated the regular delivery equation including two letters variables, DPS letters and cased letters. The variabilities associated with this variation are presented below. The overall variability of regular delivery time is about the same (44 percent for the disaggregated letter approach as compared with 41 percent for the aggregate letter approach) with the alternative approach, but there are some shifts among the “shapes.”

Table 12
Variabilities for Regular Delivery
Alternative Letters Definition

Shape	Variability
DPS Letters	20.69%
Cased Letters	6.89%
Flats	6.60%
Sequenced	1.21%
Collection	8.55%
Parcels	0.34%

G.4. Investigating Day of Week Effects

Given that mail volume fluctuations by the day of the week a hypothesis that bears investigation is that “heavy” days are different from “light” days. This is known as the “day of week” effect and can be tested by including categorical variables in the regression, one for each day of the week.[27]

Analysis of the day of week categorical variables revealed that only one, Wednesday was significantly different from zero. The model was reestimated with this categorical variable included and the resulting variabilities are presented in the following table. These results are virtually the same as the recommended model indicating that the day of week effect is not important for estimating variabilities.

[27] Alternatively, one can include the intercept and dummies for the other 5 days.

Table 13
Variabilities for Regular Delivery
Including DOW Variables

Shape	Variability
Letters	23.87%
Flats	6.80%
Sequenced	1.02%
Collection	8.82%
Small Parcels	1.78%

G.5. Cross-Sectional Results

A cross-sectional econometric analysis requires collapsing the multiple days for each Zip Code into a single observation. This can be done either as a sum over the days or an average. This approach reduces the amount of information upon which the regression is estimated by the number of days per Zip Code. In other words, the cross-sectional regression for regular delivery is based upon 145 observations instead of 1,545. This seriously compounds the multicollinearity problem that was present in the pooled model and dramatically reduces the precision of the estimation.

The fall in precision is demonstrated by the fact that in the regular delivery equation only 2 coefficients are significantly different from zero and in the parcel/accountable equation only 4 coefficients are significantly different from zero. This compromises the reliability of the coefficients and resulting variabilities. The cross-sectional model is clearly inferior to the pooled model.

Table 14

Variabilities for Regular Delivery Cross Sectional Estimation	
Shape	Variability
Letters	32.32%
Flats	3.27%
Sequenced	-0.28%
Collection	9.29%
Small Parcels	4.26%
Variabilities for Parcel/Accountable Delivery Cross Sectional Estimation	
Shape	Variability
Large Parcels	28.5%
Accountables	27.0%

G.6. Weighted Regressions

One approach that is sometimes taken by analysts is to weight the individual observations in the regression. For example, in this analysis different Zip Codes have different number of routes. If one is concerned that the number of delivery points does not adequately control for the network effect, an alternative approach is to weight the individual observations by the number of routes in the Zip Code. In this way, the large Zip Codes take on a greater

importance in fitting the regression line than the smaller Zip Codes. The results of this approach are presented in Table 15 below.

Table 15

Variabilities for Regular Delivery Weighted Regression Weight is the of # of Routes	
Shape	Variability
Letters	25.09%
Flats	6.22%
Sequenced	0.76%
Collection	9.99%
Small Parcels	1.79%
Variabilities for Parcel/Accountable Delivery Weighted Regression Weight is the of # of Routes	
Shape	Variability
Large Parcels	22.3%
Accountables	28.0%

These results show that except for the letters variability, there is very little change in the estimated variabilities for regular delivery as a result of the weighting. This overall result indicates that the number of delivery points is successfully controlling for the delivery network across Zip Codes. The letter

variability is a bit larger in the weighted regression. However, without a strong theoretical or operational basis to increase the importance of large Zip Codes, the weighted results are not preferred to the unweighted results.

Another alternative approach is to emphasize the importance of the small Zip Codes as compared to the large Zip Codes. Rather than weighting each observation by the number of routes in the Zip Code, in this approach each route is weighted by the inverse of the number of routes in the Zip Code.[28] The results of this approach are presented in Table 16 below.

[28] Inverse weighting of this type can also be used as a mechanism to control for heteroscedasticity. If one assumes that the variance of the regression increases with cross-sectional unit size then one way to attempt to control for this is to divide each unit by a measure of size, thus potentially reducing the disparity in variances. In the city carrier street time delivery equations as possible variable for performing this type of weighting is the inverse of the number of routes. However, when the actual form of heteroskedasticity is unknown, as it is here, the preferred approach is to use White's estimator of the heteroscedasticity consistent variances as was done in the main analysis.

Table 16
Variabilities for Regular Delivery

Weighted Regression Weight is the Inverse of # of Routes	
Shape	Variability
Letters	20.03%
Flats	10.64%
Sequenced	1.09%
Collection	7.00%
Small Parcels	1.10%
Variabilities for Parcel/Accountable Delivery Weighted Regression Weight is the Inverse of # of Routes	
Shape	Variability
Large Parcels	30.7%
Accountables	25.1%

In comparison with the unweighted results, these results show a bit lower letters variability, a higher flats variability, a lower collection variability and a lower small parcel variability. However, as with the other weighting approach, there is no reason to increase the relative importance of small Zip Codes in the analysis, so these weighted results are also not preferred to the unweighted.

G.7. Including problematic Zip Codes.

As explained in Library Reference LR-K-81, the data for a small number of Zip Codes was potentially problematic because of difficulties with their reported route numbers and/or Zip Codes. These problems could cause a potential mismatch between recorded delivery times and volumes, and thus the data for these Zip Codes were omitted from the regression for the regular delivery equation. Their omission reduced the number of observations used to estimate the regression from 1,601 to 1,545.

To check the impact of removing these observations from the regression dataset, the regular delivery equation was reestimated with the potentially problematic Zip Codes included. Those results are presented in Table x below:

Table 17
Variabilities for Regular Delivery
Including Potentially Problematic Zip Codes

Shape	Variability
Letters	23.23%
Flats	7.90%
Sequenced	1.13%
Collection	8.52%
Small Parcels	1.88%

This table shows that omitting the potentially problematic Zip Codes had little impact on the estimated variabilities. There are sufficient data without their inclusion to successfully estimate the equations and their omission does not

cause material movements in the estimated variabilities. Thus, because of potential data problems, the preferred approach is to drop them from the regression analysis.

G.8. Estimating a Translog Specification

As discussed earlier, there are theoretical and technical reasons for estimating a quadratic econometric equation rather than a translog econometric equation. The primary technical reason is the existence of zero values for individual shape volumes across the Zip Code days. This problem does not exist for aggregate volume and a translog specification was estimated for that volume measure.

A three-variable translog was estimated in total volume (the sum of letters, flats, sequenced, collection and small parcels), delivery points, and density. The results of estimating that specification are given in Table 18 below. Because the data were mean centered before estimation of the equation, the volume variability is just the first-order coefficient on the aggregate volume term. Table 18 shows that the variability from the translog equation is 34 percent. This is below the aggregate volume variability from the quadratic equation of 41 percent but generally confirms that estimation. The quadratic equation has the substantial advantage of providing differential variabilities by shape, so it is preferred to the aggregate translog approach.

Table 18
Econometric Estimate of the Regular Delivery Equation
Translog Specification

Variable	Estimated Coefficient	Standard Error	t-statistic
Intercept	12.2337	0.0122	1002.28
ln(Volume)	0.3400	0.0245	13.89
ln(Volume)^2	0.0429	0.0294	1.46
ln(Delivery Points)	0.7020	0.0260	27.04
ln(Delivery Points)^2	0.0885	0.0385	2.30
ln(Density)	-0.0953	0.0099	-9.59
ln(Density)^2	-0.0165	0.0033	-4.99
ln(Volume)*ln(Delivery Points)	-0.0754	0.0602	-1.25
ln(Volume)*ln(Density)	-0.0289	0.0162	-1.79
ln(Density)*ln(Delivery Points)	-0.0070	0.0171	-0.41
# of Observations			1545
R^2			0.8622

V. DISTRIBUTING VOLUME VARIABLE COSTS TO CLASSES AND SUBCLASSES.

The last step in the process of calculating class-specific volume-variable cost is the distribution of volume-variable costs to products. Recall that total volume-variable cost is calculated in two steps. First, the time proportions are multiplied against total accrued city carrier street time costs. This multiplication produces the accrued cost pools. Second, the volume-variable cost for each cost pool is found by applying the estimated variability to the accrued cost in the pool.

The attribution of volume-variable costs to classes and subclasses is based upon distribution keys for each cost pool. In this section, I describe how the distribution keys are formed.

A. Regular Delivery

The largest accrued cost pool is regular delivery time. This is divided into 5 subpools, however, one for each shape delivered. There are separate volume-variable cost pools for letters, flats, sequenced mail, collection mail, and small parcels. Each separate volume-variable cost pool is formed through multiplication of the shape's volume-variability time the total accrued regular delivery cost pool. Thus, the distribution of volume-variable regular delivery cost to products requires 5 separate distribution keys.

A.1. Regular Delivery -- Letters

The letter distribution key is taken from CCS. The CCS distribution key is modified by the removal of Sequenced Letters (a subset of ECR Saturation mail), which are included in the Sequenced cost pool distribution key.

A.2. Regular Delivery -- Flats

The flat distribution key is taken from CCS. The CCS distribution key is modified by the removal of Sequenced Flats (a subset of ECR Saturation mail) which are included in the Sequenced cost pool distribution key.

A.3. Regular Delivery -- Sequenced Mail

Sequenced Mail is ECR Saturation mail that is delivered by the mailer to the delivery unit already prepared, by the mailer, in walk sequence. The carrier does not case sequenced mail, and it is delivered on the route as an additional bundle or tray. It is important to recognize that not all ECR Saturation mail is sequenced. Some ECR saturation mail is delivery-point sequenced by the Postal Service. This mail comes to the carrier unit intermingled with other delivery-point sequenced mail and is delivered as a regular letter. It is not sequenced mail from a delivery perspective and should not be included in that cost pool.

In addition, on foot and park and loop routes, (and on park and loop sections within all routes), the saturation mail may be cased because the saturation mail bundle, when combined with the other bundles, exceeds the carrier's capacity to carry bundles. This saturation mail is also delivered like a regular letter or flat and is not sequenced mail. In sum:

$$\text{Sequenced Mail} = \text{Total ECR Saturation} - \text{ECR Saturation that is DPS} - \text{ECR Saturation that is cased.}$$

Although the Carrier Cost System provides an estimate of the total ECR Saturation volume delivered, it does not separately identify how much of ECR Saturation is Sequenced Mail. That must be calculated.

The first part of the calculation is to identify the ECR Saturation that is delivery-point sequenced. Fortunately, the Carrier Cost System measures

delivery-point sequenced mail separately and an estimate of the amount of ECR Saturation mail that is DPS can be directly obtained. Next, the amount of ECR Saturation that is cased must be estimated. There is no direct measure of this quantity and it must be inferred.[29]

To estimate the amount of cased ECR Saturation mail that exists, the following three step procedure is followed. Note that the procedure is followed separately for letters and flats:

Step 1: Identify the casing hours for ECR Saturation from IOCS[30]

Step 2: Use established saturation casing productivities to estimate the number of pieces of ECR saturation cased per hour.[31] These are 41.2 pieces per minute (2,472 pieces per hour) for letters and 27.4 pieces per minute (1,644 pieces per hour) for flats.

Step 3: Divide the IOCs hours by the casing productivity to obtain an estimate of the number of pieces cased.

A.4. Regular Delivery -- Collection Mail

The collection cost pool reflects time spend collecting mail from delivery points, not street letter boxes. In FY2003, for the first time, CCS measured the mail collected by city carriers from customers. The FY2004 counts of the collection volumes are used to form the collection distribution key

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[29] During a CCS test, the sequenced mail is cased for the purpose of measuring volume per stop. Thus it is impossible to determine how much of the sequenced mail would have been cased had it not been for the test.

[30] These data come from IOCS for FY2004, In-Office Direct Labor (6.1).

[31] See, Testimony of Thomas Shipe on Behalf of the Unites States Postal Service, USPS-T-10, Docket No. R90-1.

A.5. Regular Delivery -- Small Parcels

The small parcel distribution key is taken directly from CCS.

B. Parcel/Accountable Delivery

The accrued cost pool for parcel/accountable delivery is divided into two volume-variable cost pools, one for each type of mail delivered: large parcels and accountables.

B.1 Parcel/Accountable Delivery -- Large Parcels

The large parcel distribution key is taken directly from CCS.

B.2 Parcel/Accountable Delivery -- Accountables

The accountables distribution key is taken from CCS with the exception that Delivery Confirmation volumes are removed from the distribution key. This volume is removed because Delivery Confirmation scans do not require customer contact and are included in the accountables delivery activity.

C. Travel To and From the Route.

Travel to and from route costs are “burdened” and they get the distribution of the rest of letter route street costs in delivery activities.

D. Collection at Street Letter Boxes

The distribution key for street letter boxes has not changed from the method used in previous cases.

E. Relay.

Relay costs are “burdened” and they get the distribution of the rest of letter route street costs in delivery activities.

VI. ESTIMATED EFFECT OF THE PROPOSED CHANGE IN METHODOLOGY

Because the City Carrier Street Time Study changes both the structure of the time pools and the variabilities, it is not possible to quantify solely the effect of the change in the variabilities. A higher level comparison is required, one that includes both the changes in the cost pools and the changes in the variabilities. This is presented by Witness Meehan (USPS-T-9).

However, it may be possible to get a sense of the effect of the new variabilities by doing a comparison of similar aggregate cost pools across the two methodologies. There is an approximate correspondence between the Load Time, Access Time, and Route Time cost pools in the established methodology with the Regular Delivery Time, Parcel/Accountable Delivery Time, and Network Travel Time in the proposed new methodology. While not exact, this comparison provides some insight into the changes. The comparison is presented in Table 19 below. That table shows the percentage of cost represented by the selected time pools from the two methodologies along with the estimated variabilities for each.

In the established methodology, the three cost pools account for about 83 percent of accrued city carrier street time cost and have an aggregate variability of about 30 percent. In the new methodology, the three cost pools account for a bit more, about 89 percent of cost and have a higher variability, almost 37 percent. Given this comparison, it would seem that the effect of the proposed

methodology is to somewhat raise volume variable cost though a higher aggregate variability.[32]

Table 19
Estimating the Effects of the Proposed Methodology

Established Methodology

	Percentage of Cost	Variability
Load Time	25.3%	69.5%
Access Time	27.7%	21.0%
Route Time	29.8%	4.7%
Total	**82.8%**	**29.9%**

Proposed Methodology

	Percentage of Cost	Variability
Regular Delivery	72.3%	41.1%
P/A Delivery	5.6%	53.5%
Network Travel	11.4%	0.0%
Total	**89.3%**	**36.6%**

[32] Please note that the total variability is not the sum of the three individual variabilities. Rather it is the weighted average of the three variabilities where the weights are each cost pools proportion of total accrued cost. This is identical to adding the volume variable cost for all three cost pools and dividing by the accrued cost for the same cost pools.