Postal Rate Commission
Submitted 4/8/2005 10:57 am
Filing ID: 43414
Accepted 4/8/2005

USPS-T-31

BEFORE THE
POSTAL RATE COMMISSION
WASHINGTON DC 20268-0001

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

TESTIMONY OF
MICHAEL D. BRADLEY
ON BEHALF OF
UNITED STATES POSTAL SERVICE

TABLE OF CONTENTS

AUTOBIOGRAPHICAL SKETCH……i

PURPOSE AND SCOPE……...iii

ASSOCIATED LIBRARY REFERENCES……...iv

I. NEW DATA SYSTEMS SUPPORT THE CALCULATION OF AN AMTRAK VARIABILITY. 1

- A. A Brief Description of Amtrak Operations..... 3
- B. The Amtrak Visibility and Footage Datasets 5
- C. Estimating the Variability of Capacity with Respect to Volume..... ……5
- D. Estimating the Variability of Cost With Respect to Capacity. 9
- E. Estimated Effect of the Proposed Change in Methodology 14

II. CALCULATING VARIABILITY UNDER DECLINING BLOCK RATES……. 15

III. CORRECTING THE WINDOW SERVICE COST ALGORITHM 19

- A. Distributing Waiting Time to All Window Services..... 19
- B. Appropriately Distributing Waiting Time to Products 20
- C. The Analytical Basis for Window Service Costs 21
- D. Estimating the Effects of the Corrections 35

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 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 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

My testimony has three purposes. First I present new variabilities for Amtrak transportation for the purpose of highlighting the use of “Visibility” data to estimate the relationship between capacity and volume. Second, I provide the analytical basis for calculating a volume variability under declining block rates. Third, I present the analytical basis for calculating volume variable costs for window service.

The part of my testimony dealing with Amtrak variabilities is used by Witness Meehan (USPS-T-9), the part of my testimony dealing with volume variability under declining block rates is used by Witness Nash (USPS-T-17), and the part of my testimony dealing with the analytics of calculating window service costs is used by Witness Meehan (USPS-T-9).

ASSOCIATED LIBRARY REFERENCES

I am sponsoring the following Library References which are associated with this testimony:

USPS LR-K-116: Constructing the Data Set for Econometric Analysis of Amtrak Transportation

This library reference contains the raw data and the printed and electronic versions of program used to create the analysis data set used in the econometric analysis presented in this testimony.

USPS LR-K-41: Econometric Analysis of Amtrak Transportation

This library reference contains the analysis data set and the printed and electronic versions of the programs used to perform the econometric analysis of Amtrak transportation.

I. NEW DATA SYSTEMS SUPPORT THE CALCULATION OF AN AMTRAK VARIABILITY.

In the past, the Postal Service proposed and the Commission accepted the assumption that the volume variability of Amtrak transportation is 100 percent. The Commission made clear, however, that it was accepting this assumption, not because it believed it was correct, but because it did not have any record evidence to find the correct variability:[1]

> Having considered the contract, including the provision for minimum space, we believe that the variability used in former proceedings and in this case probably overstates the actual attributable level. However, we do not have a convincing analysis for passenger rail. The record does not provide sufficient information for us to trace the actual effect of the minimum, or the other contract provisions, in the relationship between volume changes and costs. We are accepting the Postal Service's proposal for use in this case. Nevertheless, because of the significant effect these costs have on a class of mail, we believe the Postal Service should undertake a variability study of these costs.

Until recently, the Postal Service was hindered in its ability to undertake such a study because of a lack of data linking volumes, capacities, and costs. The assumption of 100 percent volume variability in transportation actually embodies two assumptions: a 100 percent variability of cost with transportation capacity and a 100 percent variability of transportation capacity with respect to volume. Measuring the volume variability of Amtrak thus requires considering both component variabilities.

---

[1] See, PRC Op., Docket No. R90-1, Vol. 1, at III-175.

Since the last rate case, the Postal Service pursued an effort to track, measure, and better utilize Amtrak transportation. It is my understanding that the Postal Service and Amtrak bargained for real time exchange of data. As a result, Amtrak was required to share any volume data collected by its internal system. The Amtrak data includes the number of containers transported by origin, transfer point, and destination for each of its transportation legs. The Postal Service then augmented the Amtrak data with a data collection effort of its own. That subsequent data collection effort was the initial phase of the visibility data collection program.

A side benefit of this effort is the creation of a data set that allows one to investigate the Amtrak variability. In particular, the “Visibility” dataset, described in a later section, includes measures of the contracted footage, the actual footage, and the pallets and OTRs transported for each leg of Amtrak. These data support the estimation of the variability between changes in volume and the response in capacity. Another dataset, known as the “Footage Summary” provides information on the cost and distance of each Amtrak movement. These data, when combined with the Visibility data, support estimation of the variability between cost and capacity.

Subsequent to collecting this data, Amtrak decided not to renew the contract with the Postal Service. That would seem to vitiate a variability analysis for that transportation. Nevertheless, the exercise has value for the Commission.

As mentioned above, purchased highway transportation has been modeled in a two step approach, including both variabilities of cost with respect

to capacity and capacity with respect to volume. The former variability has been estimated after extensive analysis in several dockets: R84-1, R87-1, R97-1, R2000-1. The latter variability has just been assumed to be 100 percent.

The Postal Service has recently launched an effort to collect Visibility data for highway transportation. A beta test for highway was conducted in New England at the end of CY02. The basic approach in the Visibility data collection is track containers of mail as they move through the transportation network. This is done through recording a series of nested barcodes. For example, rolling stock and trailers will all be assigned a unique barcode. Trays and sacks will have new labels that contain unique barcodes. By scanning the barcode at each origin, interim facility such as HASPS, and destination, the movement of the containers can be tracked through the transportation system.

This effort raises the possibility of collecting data to investigate the assumption of 100 percent variability between capacity and volume for purchased highway transportation. To that end, the current exercise for Amtrak transportation can explore the feasibility of such an analysis and perhaps provides some insights into how a purchased highway analysis should proceed.

A. A Brief Description of Amtrak Operations

The Amtrak Network was used by the Postal Service to transport mail as an alternative to air transportation and highway transportation. The Postal Service moved mail over Amtrak's existing network. Transportation movements are defined by "legs" along a train's route. For example, consider a train that

runs from Washington, DC. to Boston. In this example, the train has four individual legs, with containers of mail getting off and on at each stop. The pattern of container movements could look like:

Leg Origin	Leg Destination	Pallets	OTRs	Contracted Footage	Actual Footage
Washington	Philadelphia	45	15	90	137
Philadelphia	New York	24	2	90	57
New York	New Haven	5	1	30	13
New Haven	Boston	6	2	30	18

Although it primarily tendered containers of mail for loading onto rail cars, it occasionally provided full “RoadRailers”of mail. RoadRailers are specially modified highway trailers that are attached directly to a set of train wheels that allow it to be connected to another car in a train.

The Postal Service and Amtrak entered into contract agreements with two year durations. The contract specified minimums on each identified leg. As the example above shows, sometimes the actual footage used exceeded the minimum and sometimes it was less than the minimum. When the actual footage was less than the minimum, the Postal Service paid for the minimum.

Minimums were used to reduce the overall cost of Amtrak service even though that means the Postal Service purchased excess capacity on some days. Suppose, for example, the Postal Service has 45 feet of volume most days on a leg and then 60 feet on occasional days. Under the Amtrak contract, it could cost less to purchase the 60 feet of capacity on an every day basis rather than to

purchase 45 feet of capacity on an every day basis and then purchase exceptional service on the heavy volume days. In this situation, although the network appears to be underutilized, it is a lower cost solution. However, it does raise the likelihood that capacity would rise less quickly than volume.

B. The Amtrak Visibility and Footage Summary Datasets.

The Amtrak Visibility data was generated by scans taken by Amtrak at each rail location. Amtrak scanned the containers of mail loaded onto and unloaded from the train car as well as leg origin and leg destination. The process started at the loading station; the Postal Service placed a “license plate” on the container (pallet, rolling-stock) for use as an identifier. Once Amtrak had the mail volume it scanned the volume into their system. If a transfer happened during the trip, Amtrak scanned into their system as needed. Once the mail was at its destination Amtrak performed a destination scan.

The footage summary data set is the actual contract payment amounts the USPS paid Amtrak for transportation of mail volume. In includes information on the contracted footage, the actual footage and the cost for each Amtrak leg.

C. Estimating the Variability of Capacity With Respect to Volume.

The variability of the capacity –volume relationship measures how transportation capacity (measured by linear feet of a rail car) changes as volume changes (measured by the number of containers needing transportation). With

respect to Amtrak, there are two measurement issues to be addressed before the model is specified.

First the Postal Service contracts for a minimum amount of linear feet on each Amtrak train. When sufficient volume to fill the minimum is tendered, then all of the minimum footage is used. If more than enough volume to fill the minimum is tendered, then the Postal Service purchases additional space. Finally, even if very little volume is tendered, the Postal Service still pays for the minimum footage. This means that the actual footage used is defined by:

$$\begin{matrix} Actual \\ Footage \end{matrix} = \max\left\{\begin{matrix} Contracted \\ Footage \end{matrix}, \begin{matrix} Utilized \\ Footage \end{matrix}\right\}$$

Second, there are two types of containers in which mail is given to Amtrak, rolling stock (OTRs) and pallets. In measuring the response of capacity to changes in volume, the specification should take into account changes in both types of containers. On any given trip or leg, either one or both of the containers may be present.

A flexible functional form is appropriate for estimating this variability as no prior knowledge provides restrictions useful for specifying a form. However, in many instances one or the other type of container will not be transported. This aspect of the data reduces the utility of the traditional translog form and a generalized quadratic will be used in its place. The econometric equation used to estimate the capacity – volume variability is given by:

$$\text{Actual Footage}_{it} = \delta_0 + \delta_1 OTR_{it} + \delta_2 OTR_{it}^2 + \delta_3 Pallet_{it} + \delta_4 Pallet_{it}^2 + \delta_5 OTR_{it} * Pallet_{it} + \varepsilon_{it}$$

The visibility data is collected by train leg. That is, the Postal Service has measurements of the containers and actual footage used on each individual origin and destination pair within each train routing. Thus, the above equation can be estimated on a “leg” basis or on a “train” basis.

These results show that the variability of capacity with respect to volume is materially less than one. Assuming that both pallets and OTRs respond proportionately to increases in volume the capacity variability is estimated to be 63.7 percent at the leg day level and 73.2 percent at the train day level.

1

Regression of Capacity on Volume

By Leg Day

Variable	Coefficient	t-statistic
Intercept	29.7170	80.19
OTRs	2.1655	60.63
OTRs^2	-0.0069	-15.59
Pallets	1.5778	75.59
Pallets^2	-0.0030	-24.08
Pallets*OTRs	0.0019	3.66
# of Observations		21208
R^2		0.7065

Variablities Calculated from the Equation

	Mean Value	Variability
OTRs	11.96	31.96%
Pallets	16.03	31.74%

By Train Day

Variable	Coefficient	t-statistic
Intercept	59.7095	37.76
OTRs	2.2392	36.97
OTRs^2	-0.0025	-9.13
Pallets	1.8946	56.63
Pallets^2	-0.0015	-17.74
Pallets*OTRs	0.0014	4.30
# of Observations		8044
R^2		0.7654

Variablities Calculated from the Equation

	Mean Value	Variability
OTRs	31.54	38.85%
Pallets	42.27	34.35%

D. Estimating the Variability of Cost With Respect to Capacity.

The other part of the overall variability calculation is the variability of cost with respect to capacity. Estimation of this variability does not break new methodological ground, as it has already been estimated for purchased highway transportation, freight rail transportation, and passenger air transportation.

A logical place to start the specification is to simply extend the previous variability analysis which measures how quickly linear feet of Amtrak capacity vary with volume. Such an extension would suggest that the cost variability should measure the relationship between cost and linear feet. Transportation cost has a second dimension, however, and that is distance. Cost rises with changes in both cubic capacity and distance. For purposes of measuring the variability of transportation cost, both dimensions have been used in forming the transportation capacity measure. Accordingly, the measure of transportation capacity used in the variability regressions for Amtrak will be linear foot-miles.

A translog specification for a one variable model is simply the log term and the log term squared.

$$\ln(\text{Cost}) = \beta_0 + \beta_1 \ln(\text{FTMiles}) + \beta_2 \ln(\text{FTMiles})^2$$

The results of estimating this equation are presented in the following table. Note that the regression has been mean centered so that the coefficient on the first

order term is the estimated elasticity. This regression can also be estimated by leg day and train day. Both results are presented in the table.

Regression of Cost On Capacity

By Leg Day

Variable	**Coefficient**	**t-statistic**
Intercept	6.4610	1426.19
Ln(Foot Miles)	0.7760	191.45
Ln(Foot Miles)^2	0.0843	50.27
# of Observations		20871
R^2		0.6924

By Train Day

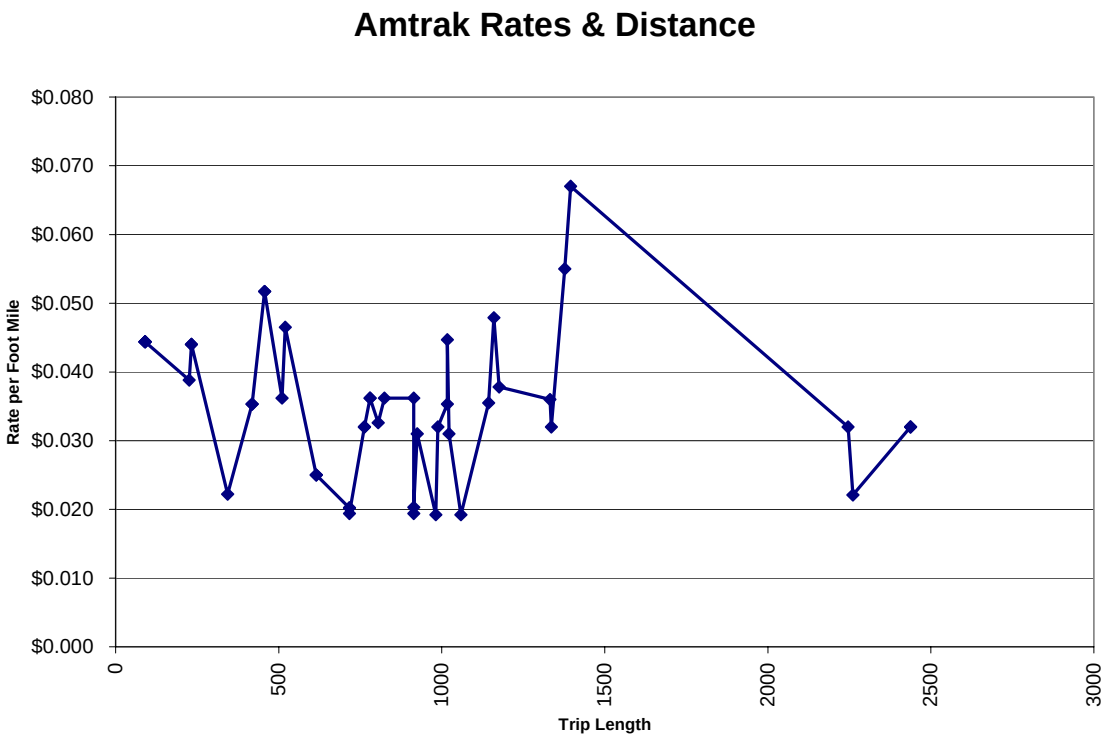
Variable	**Coefficient**	**t-statistic**
Intercept	7.5851	1112.96
Ln(Foot Miles)	0.4777	69.85
Ln(Foot Miles)^2	-0.0118	-5.14
# of Observations		7943
R^2		0.6842

In purchased highway transportation, the model specification is more complicated because a variable is included to control for the "distance taper."[2] In the purchased highway data set, each observation is an annual contract and the capacity variable is cubic foot miles which includes truck capacity, frequency of trips, and route miles. Because the Postal Service has great flexibility in constructing its highway network, it can specify contracts along all three of these

[2] See, PRC Op., Docket No. R87-1, Vol. 1, at 311.

dimensions and can adjust all three margins when volume changes. Moreover, because the cost per mile of highway transportation falls sharply with miles driven, it is important to account for the distance taper in that mode.

These characteristics do not hold for Amtrak transportation. First, the routings are set by the passenger train schedules and the Postal Service cannot adjust those schedules. In addition, there is no distance taper in Amtrak transportation. This is demonstrated by the following chart which presents a cross plot of the rate per foot mile for transportation of mail on Amtrak trains with the route length of the train. This chart shows that there is no distance taper in Amtrak rates. The absence of a distance taper suggests that there is no reason to add route miles to the cost variability equation.



Nevertheless because this specification was used for calculating in purchased highway transportation, it was estimated for Amtrak. The translog specification yields:

$$\begin{aligned}\ln(Cost) &= \beta_0 + \beta_1 \ln(FTMiles) + \beta_2 \ln(FTMiles)^2 \\ &+ \beta_3 \ln(Miles) + \beta_4 \ln(Miles)^2 + \beta_5 \ln(FTMiles) * \ln(Miles)\end{aligned}$$

The results of estimating this specification are presented below. Note that coefficient on miles is positive, not negative, contradicting the existence of a distance taper**.** Thus the results without including miles are preferred.

Regression of Cost On Capacity

By Leg Day

Variable	Coefficient	t-statistic
Intercept	6.4935	1589.28
Ln(Foot Miles)	0.5057	110.41
Ln(Foot Miles)^2	0.1041	48.82
Ln(Miles)	0.4555	71.32
Ln(Miles)^2	0.0062	0.87
Ln(Footmiles)*Ln(Miles)	-0.1113	-15.2
# of Observations		20871
R^2		0.8009

By Train Day

Variable	Coefficient	t-statistic
Intercept	7.5121	1088.83
Ln(Foot Miles)	0.3786	49.72
Ln(Foot Miles)^2	0.0421	10.07
Ln(Miles)	0.3768	25.38
Ln(Miles)^2	0.0111	0.61
Ln(Footmiles)*Ln(Miles)	-0.0579	-3.52
# of Observations		7943
R^2		0.7396

E. Estimated Effect of the Proposed Change in Methodology

As mentioned above, the previous approach to Amtrak costs assumed a variability of 100 percent. The foregoing analysis shows that the actual variability is less than one. The effect of applying the new variabilities is to reduce volume variable Amtrak costs by 40 to 50 percent.

II. CALCULATING VARIABILITY UNDER DECLINING BLOCK RATES.

If transportation is purchased under declining block rates, the unit cost of the transportation would fall as more transportation was purchased to accommodate increasing volume. This means that cost will rise less quickly than the transportation purchased and the variability of these costs is less than 100 percent. As a consequence, the calculation of the variability of transportation must take the block structure into account. Moreover, because cost is incurred according to a declining step function the variability depends upon which steps are used.

These points can be made though a simple mathematical formulation and constructed numerical example. Suppose that transportation is purchased by the pound in three blocks, with each block having its own, constant, rate per pound. Hypothetically, this structure could look like:

Volume Block (Pounds)	**Block Rate**
1 to v_a	ϕ_a
(V_a+1) to v_b	ϕ_b
(V_b+1) to v_c	ϕ_c

Where: $\phi_a > \phi_b > \phi_c$.

Given this block structure, the transportation cost structure is given by:

$$C = \sum_{i=1}^{v_a} \phi_a v_i + \sum_{j=v_a+1}^{v_b} \phi_b v_j + \sum_{k=v_b+1}^{v_c} \phi_c v_k$$

With this cost equation, the marginal cost will depend upon which block is active. Specifically, the marginal cost will be equal to the rate in the last active block:

$$\frac{\partial C}{\partial v}(v) = \begin{Bmatrix} \phi_a \\ \phi_b \\ \phi_c \end{Bmatrix} \text{ as } \begin{Bmatrix} 0 < v \le v_a \\ v_a < v \le v_b \\ v_b < v \le v_c \end{Bmatrix}$$

The variability (or elasticity) is equal to the marginal cost at the current volume multiplied by the current volume divided by the total cost of providing that volume. The variability will also depend upon which block is active. The formulae for the elasticities are given by:

$$\varepsilon_{cv}(v) = \begin{cases} \dfrac{\phi_a\left(\sum_{i=1}^{v_a} v_i\right)}{\sum_{i=1}^{v_a} \phi_a v_i} & 0 < v \le v_a \\[2ex] \dfrac{\phi_b\left(\sum_{i=1}^{v_a} v_i + \sum_{j=v_a+1}^{v_b} v_j\right)}{\sum_{i=1}^{v_a} \phi_a v_i + \sum_{j=v_a+1}^{v_b} \phi_b v_j} & v_a < v \le v_b \\[2ex] \dfrac{\phi_c\left(\sum_{i=1}^{v_a} v_i + \sum_{j=v_a+1}^{v_b} v_j + \sum_{k=v_b+1}^{v_c} v_k\right)}{\sum_{i=1}^{v_a} \phi_a v_i + \sum_{j=v_a+1}^{v_b} \phi_b v_j + \sum_{k=v_b+1}^{v_c} \phi_c v_k} & v_b < v \le v_c \end{cases} \quad \text{as}$$

To see how the formulae work, consider a simple example. Suppose that transportation was purchased on a pound basis under the following conditions:

Block Volume

Minimum	Maximum	Rate
1	100	$0.80
101	200	$0.75
201	300	$0.70

Further suppose that the Postal Service tenders 250 pounds of mail. That would put it in the third block. According to the cost equation, the cost of 250 pounds would be:

C = \$0.80 (100) + \$0.75 (100) + \$0.70 (50) = \$190

According to the elasticity formula:

$$\varepsilon_{cv}(v) = \frac{\$0.70\,(100+100+50)}{\$0.80(100)+\$0.75(100)+\$0.70(50)} = \frac{175}{190} = 0.9211$$

This can be verified by computing the percentage increase in cost and percentage increase in volume associated with adding 1 more pound of mail. Adding 1 pound of mail would increase volume to 251 pounds and would increase total cost to \$190.70. The 1 pound increase is a 0.4% increase in volume. The \$0.70 increase in cost is a 0.3684% increase in cost. Using the familiar definition of variability – the percentage change in cost for a given percentage change in volume – one gets (0.0036842/0.004) = .9211.

III. CORRECTING THE WINDOW SERVICE COST ALGORITHM

In calculating base year window service volume variable costs, the Postal Service identified two computational errors in the window service spreadsheets. It then made corrections to remove the two errors. This section of my testimony presents the two corrections and also presents the implied changes in the analytical framework for calculating volume variable window service costs. For sake of comparison, I first present the analytical foundation for the previous framework and then present the revised framework including the corrections.

A. Distributing Waiting Time to All Window Services

The established methodology distributes waiting time as a "burden" in the sense that it is distributed to the products handled at the window in proportion to their costs:[3]

> Volume variable costs for time at a window waiting for a customer, uniform allowance costs and volume variable overhead costs (codes 6521, 6522, and 6523) are distributed to classes and subclasses of mail, special services and other window service activities in proportion to the costs associated with those services.

Unfortunately, a review of the spreadsheets implementing this method revealed that some products, inadvertently, were not receiving waiting time cost . This error was corrected in the spreadsheets so that all products at the window receive their proportionate waiting time costs.

---

[3] See, The United States Postal Service, "Summary Description of USPS Development of Costs By Segment and Components, Fiscal Year 2002," at 3-17.

B. Appropriately Distributing Waiting Time to Products

As mentioned above, in the established methodology, waiting time costs are assumed to vary in proportion to the time spent in other window service activities:[4]

> Information from the widow service transaction time and profile studies indicates that time spend at a window waiting for a customer is directly proportional to the time spend on other window service activities. Thus, the costs for time at a window waiting for a customer are classified as variable to the same degree as the costs for all other window service activities.

A similar treatment is accorded to window overhead time (eg. break, clock in or out, moving empty equipment):[5]

> Window service overhead time tends to vary in accord with the same amount of other window service time, and the costs for it are classified as variable to the same degree as cost for all other window service time.

The established method thus specifies two steps in the treatment of both waiting time and window overhead. First, both are distributed to products based upon the products' own accrued costs. Next, they receive the window "system" variability -- they are as variable as all other window service activities.

The implementation of this methodology was correct in the spreadsheets for window overhead as the overhead costs were first distributed to products and received the appropriate variability. Waiting time costs were not handled

---

[4] See, The United States Postal Service, "Summary Description of USPS Development of Costs By Segment and Components, Fiscal Year 2002," at 3-16.

[5] Id.

appropriately. As it turns out these costs were distributed to products based upon the product's volume variable, not accrued costs, and waiting time did not receive the appropriate system variability. This error in the computational algorithm was also corrected.

C. The Analytical Basis for Window Service Costs

In this section, I present the analytic basis for calculating window service costs. This exercise makes clear how individual cost pools are handled in the spreadsheet cost model. To ascertain the effect of the above correction on window service costs, I first present the analytics underlying the old methodology and then present the corrections. Note, that for expositional clarity, I assume that waiting time and overhead costs are distributed to all window service activities.

The old cost attribution methodology proceeded in 12 steps:

Step 1: Reading in Accrued Costs

The first step in the calculation is to read in accrued costs for window service. While costs are read in for each of the various mail products, a vector of non-mail products, stamps and other window activities, for analytical purposes we can group the costs into 5 categories:

- Cost for Mail & Special Services ($\alpha_i + \eta_i$)
- Costs for Break (B), Clocking (C), and Empty Equipment (E)
- Costs for Stamps, Cards and Metered (S_k)
- Cost for Waiting for the Customer (W)

- Costs for Other Activities (O_j)

The first group includes both acceptance costs (α_i) and non-acceptance costs (η_i). At this point they are not separated. These costs are indexed by the class, subclass, or special service that causes them to arise. The third group includes the several activities that constitute stamp, card, and metered activities. They are indexed by the activity. This last group, "Other Activities," includes "At Window Serving Customers," "Customer Related Window Activities," and "All Other Work." Because all three of these categories are treated in the same way in the algorithm, they can be combined into one. Note that this group includes handling of non-mail products like phone cards and passports. The sum of costs across all of these categories is total Accrued Cost (AC)

Step 2: Allocate Break, Clocking and Empty Equipment

The allocation formula is different for mail and special services than it is for stamps and other services. Empty Equipment is allocated to mail and special services only. Define the allocation of BCE to mail as β_i:[6]

$$\beta_i = \frac{\eta_i + \alpha_i}{\sum_i (\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j}(B + C) + \frac{\eta_i + \alpha_i}{\sum_i (\eta_i + \alpha_i)} E$$

[6] The denominator of this expression is presented in the spreadsheet by its numerical equivalent, (AC-B-C-E). The current presentation facilitates demonstrating that all BCE costs are allocated.

Only break and clocking costs are allocated to stamps (β_k), waiting time (β_W), and other services (β_j):

$$\beta_k = \frac{S_k}{\sum_i(\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j}(B + C)$$

$$\beta_W = \frac{W}{\sum_i(\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j}(B + C)$$

$$\beta_j = \frac{S_j}{\sum_i(\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j}(B + C)$$

Inspection of these equations shows that:

$$\sum_i \beta_i + \beta_W + \sum_k \beta_k + \sum_j \beta_j = B + C + E$$

Thus, all BCE costs are allocated. One further analysis of this step will facilitate the presentation in later steps. We can rearrange the formulas for the β terms to isolate the initial accrued costs. For example, for mail products:

$$\beta_i = (\eta_i + \alpha_i)\left[\frac{(B + C)}{\sum_i(\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j} + \frac{E}{\sum_i(\eta_i + \alpha_i)}\right]$$

and for stamp sales:

$$\beta_k = S_k \frac{(B + C)}{\sum_i(\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j}$$

We can thus rewrite the BCE expressions as:

$$\beta_i = (\eta_i + \alpha_i)\rho$$

$$\beta_k = S_k \delta$$

$$\beta_W = W\delta$$

$$\beta_j = O_j \delta$$

$$\rho = \delta + \varepsilon$$

where:

$$\delta = \frac{(B + C)}{\sum_i (\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j}$$

$$\varepsilon = \frac{E}{\sum_i (\eta_i + \alpha_i)}$$

Step 3: Identify Acceptance Costs for Mail

As mentioned above, the initial accrued costs include both acceptance and non-acceptance. Because, acceptance costs are multiplied by a variability of 56.3 percent while non-acceptance costs have 100 percent variability, the two must be separated for application of the variabilities. This separation is done at this point in the algorithm as acceptance costs are allocated to the various mail products and special services. Note that these acceptance costs are a subset of the initial accrued costs.

Step 4: Allocate Break, Clocking, and Empty Equipment Costs to Acceptance

Acceptance costs are inflated for BCE costs by multiplying the allocated acceptance cost by the ratio of the mail product's BCE costs to its initial accrued cost:

$$\alpha_i \frac{\beta_i}{\eta_i + \alpha_i} \ .$$

This can be expressed in a convenient manner by using the alternative definition of allocated BCE costs given in Step 2:

$$\alpha_i \frac{\beta_i}{\eta_i + \alpha_i} = \alpha_i \frac{(\eta_i + \alpha_i)\rho}{\eta_i + \alpha_i} = \alpha_i \rho.$$

Step 5: Calculate the Acceptance or Activity Subtotal

For mail products, this step amounts to combining the BCE costs with the acceptance costs:

$$\alpha_i + \alpha_i \frac{\beta_i}{\eta_i + \alpha} = \left(1 + \frac{\beta_i}{\eta_i + \alpha}\right)\alpha_i = \alpha_i(1+\rho).$$

For stamps and other activities, this step involves combining the initial accrued costs with the allocated breaking and clocking costs:

$$O_j + \beta_j = O_j(1+\delta)$$

$$S_k + \beta_k = S_k(1+\delta)$$

Step 6: Find the Volume Variable Acceptance or Activity Costs

The acceptance and activity costs are multiplied by the relevant volume variability to determine the volume variable acceptance or activity costs. No variability is multiplied by the other activity costs. For mail:

$$\theta_i\left(1+\frac{\beta_i}{\eta_i+\alpha_i}\right)\alpha_i \quad = \quad \theta_i\alpha_i(1+\rho)$$

For stamps:

$$\theta_k\ S_k \ + \ \beta_k \quad = \quad \theta_k S_k(1+\delta)\,.$$

Step 7: Find the "Non-Acceptance" Volume Variable Costs

This step is only for mail and special services and involves subtracting the combined acceptance costs from the sum of the initial accrued cost and the allocated BCE costs:

$$\eta_i+\alpha_i \ + \ \beta_i \ - \left(1+\frac{\beta_i}{\eta_i+\alpha_i}\right)\alpha_i \quad .$$

Substituting the alternative definitions listed above yields:

$$(\eta_i+\alpha_i)(1+\rho) \quad - \quad \left(1+\frac{(\eta_i+\alpha_i)\rho}{\eta_i+\alpha_i}\right)\alpha_i\,.$$

Which simplifies to:

$$\eta_i(1+\rho)$$

Step 8: Combine the Acceptance and Non-Acceptance Volume Variable Costs

The results from the previous two steps are combined in this step. For stamps and other activities, the "combination" is the acceptance or activity costs. For mail, the total volume variable cost (to this point) is given as:

$$\theta_i\left(1+\frac{\beta_i}{\eta_i+\alpha_i}\right)\alpha_i \;+\; \eta_i + \;\; \alpha_i \;+\; \beta_i \;-\; \left(1+\frac{\beta_i}{\eta_i+\alpha_i}\right)\alpha_i$$

Using the alternative representations derived above, this can be simplified to:

$$(\eta_i+\theta_i\alpha_i)(1+\rho).$$

Step 9: Allocate the Stamp Costs.

Stamp costs (including stamps, cards, meters, etc.) are allocated to mail products on relative RPW volumes.

$$\sigma_i \;=\; \sum_k (S_k+\beta_k)\theta_k\frac{v_i}{V}.$$

Note that the algorithm sums across the k activities within stamp costs. The equation above can be simplified to:

$$\sigma_i \;=\; (1+\delta)\theta_k v_i S_k$$

Step 10: Calculate the Subtotal Costs

Costs are combined at this step. For mail products, this requires adding the acceptance volume variable costs, the non-acceptance volume variable costs

and the stamp costs. For other activities the algorithm brings forward the initial accrued and BC costs.

$$ST_i = \eta_i + \alpha_i + \beta_i - (\theta_i - 1)\left(1 + \frac{\beta_i}{\eta_i + \alpha_i}\right)\alpha_i + \sigma_i$$

$$ST_j = O_j + \beta_j .$$

In the analytical framework, these subtotals can be expressed as:

$$ST_i = (\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k$$

$$ST_j = (1+\delta)O_j$$

Step 11: Allocate Waiting Time To Mail and Other Activities

Waiting time is allocated to mail and other activities based upon their proportion of total "Subtotal" costs as calculated in Step 10.

For mail, waiting time is given by:

$$\frac{(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k}{\sum_i [(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k] + \sum_j O_j (1+\delta)} W$$

Waiting time for other activities is given by:

$$\frac{O_j (1+\delta)}{\sum_i [(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k] + \sum_j O_j (1+\delta)} W$$

These formulations are particularly awkward. They can be simplified by defining:

$$\omega = \frac{W}{\sum_i [(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k] + \sum_j O_j (1+\delta)}.$$

One can then define the waiting costs for mail and other activities as:

$$\left[(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k\right]\omega$$

$$[O_j (1+\delta)]\omega$$

Step 12: Calculate Total Attributed Window Costs.

Attributed window service costs amount to the sum of subtotal cost and waiting time costs. This can be simplified to:

$$TWC_i = \left[(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k\right](1+\omega)$$

$$TWC_j = [O_j (1+\delta)](1+\omega)$$

I now present the corrected methodology in which waiting time is appropriately allocated to products based upon their accrued cost and then, through the allocation process, receives the overall window variability. Much of the methodology is the same as before, so I will focus only on the differences.

Step 1: Reading in Accrued Costs

Most of this step is the same as in the old methodology. The only difference is that an additional breakout of cost groups is required. One subset

of “Other Activities” is not related to products at the window and should not receive a waiting time treatment. This group must be separately identified from the rest of the category. This group is called “All Other Work” and the elements of this group will be identified as AO_n.

Step 2: Allocate Break, Clocking and Empty Equipment

There are two differences in this step. First, the formulas for allocating BCE costs must be modified to recognize the additional breakout of accrued cost. For example the formula for mail and special services is given by:

$$\beta_i = \frac{\eta_i + \alpha_i}{\sum_i (\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j + \sum_n AO_n}(B + C) + \frac{\eta_i + \alpha_i}{\sum_i (\eta_i + \alpha_i)} E$$

In addition, the allocation of BC costs to all other activities must be made explicit. In the old methodology, this was included in the other activities allocation. There is no change in the allocation of costs, just a separate breakout:

$$\beta_n = \frac{AO_n}{\sum_i (\eta_i + \alpha_i) + W + \sum_k S_k + \sum_j O_j + \sum_n AO_n}(B + C).$$

Step 3: Allocate Waiting Time.

It is in this step that that the correction is put into place. Waiting time is allocated to mail and special services, stamp activities and other activities at this

point. The allocation of waiting time is based upon the relative cost for each activity compared to the total cost for mail, stamps, and other activities:

$$\omega_i = \frac{\eta_i + \alpha_i}{\sum_i (\eta_i + \alpha_i) + \sum_k S_k + \sum_j O_j} W$$

$$\omega_k = \frac{S_k}{\sum_i (\eta_i + \alpha_i) + \sum_k S_k + \sum_j O_j} W$$

$$\omega_j = \frac{O_j}{\sum_i (\eta_i + \alpha_i) + \sum_k S_k + \sum_j O_j} W$$

Note that the allocation of waiting time does <u>not</u> depend upon the allocation of BCE time to products. That is, although the allocation of waiting time to activities comes after the allocation of BCE costs to activities in the spreadsheets, it need not. It could come before and the same outcome would obtain.

As with the old methodology, one can simplify the formulas by recognizing that the waiting time allocations are based upon the same ratio for each of the three types of activities. Defining that ratio as:

$$\lambda = \frac{W}{\sum_i (\eta_i + \alpha_i) + \sum_k S_k + \sum_j O_j},$$

allows us to simplify the waiting time allocations as:

$$\omega_i = (\eta_i + \alpha_i)\lambda$$

$$\omega_k = S_k \lambda$$

$$\omega_j = O_j \lambda.$$

Step 4: Identify Acceptance Costs for Mail

This step is identical to step 3 in the old methodology.

Step 5: Allocate Break, Clocking, and Empty Equipment Costs to Acceptance

This step is identical to step 4 in the old methodology.

Step 6: Allocate Waiting Time Costs to Acceptance

Because waiting time has already been allocated to activity costs including acceptance and non-acceptance time, the identification of the acceptance portion must account for the waiting time allocation. Thus, waiting time is allocated to acceptance cost by multiplying the waiting time allocation for a particular class by the ratio of its acceptance cost to total accrued cost (excluding BCE cost):

$$\omega_i \frac{\alpha_i}{\alpha_i + \eta_i} = \frac{\lambda(\alpha_i + \eta_i)\alpha_i}{\alpha_i + \eta_i} = \lambda\alpha_i$$

Step 7: Calculate the Acceptance or Activity Subtotal

This step is similar to Step 5 in the old methodology, but the formulas are slightly different because of the allocation of waiting time. Using our simplified notation, we can express the acceptance or activity subtotals for mail, stamps, other activities and all other work, respectively as:

$$\alpha_i + \beta_i + \omega_i \quad = \quad \alpha_i(1+\rho+\lambda)$$

$$\alpha_k + \beta_k + \omega_k \quad = \quad S_k(1+\rho+\lambda)$$

$$\alpha_j + \beta_j + \omega_j \quad = \quad O_j(1+\rho+\lambda)$$

$$\alpha_n + \beta_n + \omega_n \quad = \quad AO_n(1+\rho+\lambda)$$

Step 8: Find the Volume Variable Acceptance or Activity Costs

For mail, special services, and stamps, volume variable acceptance or activity costs are calculated by multiplying the calculated acceptance or activity cost by the relevant variability:

$$\theta_i \alpha_i (1+\rho+\lambda)$$

$$\theta_k S_k (1+\rho+\lambda)$$

Step 9: Find the "Non-Acceptance" Volume Variable Costs

This step is only for mail and special services and involves subtracting the combined acceptance costs from the sum of the initial accrued cost and the allocated BCE and waiting time costs:

$$\eta_i + \alpha_i + \beta_i + \omega_i - \left(1 + \frac{\beta_i}{\eta_i + \alpha_i} + \frac{\omega_i}{\eta_i + \alpha_i}\right)\alpha_i .$$

Substituting the ratios derived above, we can simplify the expression to:

$$(\eta_i + \alpha_i)(1+\rho+\lambda) \quad - \quad \left(1 + \frac{(\eta_i + \alpha_i)(\rho+\lambda}{\eta_i + \alpha_i}\right)\alpha_i$$

or:

$$\eta_i\,(1+\rho+\lambda).$$

Step 10: Combine the Acceptance and Non-Acceptance Volume Variable Costs.

This step involves adding the results of steps 8 and 9 for mail and bringing forward stamp costs from step 8:

$$\theta_i\alpha_i(1+\rho+\lambda) \quad + \quad \eta_i\,(1+\rho+\lambda) \quad = \quad (\eta_i+\theta_i\alpha_i)(1+\rho+\lambda).$$

$$S_k\,(1+\delta+\lambda)\theta_k$$

Step 11: Allocate the Stamp Costs.

This process is assumed to be essentially the same as in the old methodology, with one exception. Here stamp costs would include waiting time:

$$\sigma_i \quad = \quad (1+\delta+\lambda)\theta_k\nu_i S_k\,.$$

Step 12: Calculate Total Attributed Window Costs.

Adding stamp costs to the subtotal for mail allows us to calculate the total attributed costs for window. In addition, for convenience the formula for other activities is presented.

$$(\eta_i+\theta_i\alpha_i)(1+\rho+\lambda) \quad + \quad (1+\delta+\lambda)\theta_k\nu_i S_k$$

$$\theta_j(1+\delta+\lambda)$$

D. Estimating the Effects of the Corrections

The first correction attributes waiting time to all products not just some. This should increase the volume variable costs of those products which were not receiving waiting time in the past and reduce the volume variable costs of those that were.

Estimating the effect of the second correction is more difficult. However, by comparing the expressions for total attributable costs under the two methods, one should be able to obtain some insight into the differences in the ways the costs are constructed. This should help to predict the effect of the correction.

Specifically for the unit cost of mail to be less after the correction, the following condition must hold true:

$$\left[(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k\right](1+\omega) \;>\; (\eta_i + \theta_i \alpha_i)(1+\rho+\lambda) \;+\; (1+\delta+\lambda)\theta_k \nu_i S_k$$

While this looks quite complex, simplifying terms produces a more intuitive condition:

$$(\eta_i + \theta_i \alpha_i + \nu_i S_k \theta_k)(1+\delta)\omega + (\eta_i + \theta_i \alpha_i)\varepsilon\omega \quad > \quad (\eta_i + \theta_i \alpha_i + \nu_i S_k \theta_k)\lambda \,.$$

Under the working assumption that the empty equipment costs are negligible (historically they have been is less than ½ of one percent), then the condition can be further simplified to:

$$(1+\delta)\omega \quad > \quad \lambda \,.$$

Recall the two formulas for the waiting time ratios:

$$\omega = \frac{W}{\sum_i [(\eta_i + \theta_i \alpha_i)(1+\rho) + (1+\delta)\nu_i S_k \theta_k] + \sum_j O_j (1+\delta)}$$

$$\lambda = \frac{W}{\sum_i (\eta_i + \alpha_i) + \sum_k S_k + \sum_j O_j}$$

Under the assumption that empty equipment time is essentially zero, then we can show that:

$$(1+\delta)\omega \approx \frac{W}{\sum_i [(\eta_i + \theta_i \alpha_i) + \nu_i S_k \theta_k] + \sum_j O_j}.$$

The inclusion of the variability in the denominator of the corrected expression insures that its denominator is smaller then the previous expression and the above condition will hold. This shows why the waiting time ratio is smaller in the new methodology: it relates waiting time to accrued costs whereas the old methodology related waiting time to volume variable cost.