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USPS-T-16

BEFORE THE
POSTAL RATE COMMISSION
WASHINGTON DC 20268-0001

POSTAL RATE AND FEE CHANGES, 2001	Docket No. 2001-1

TESTIMONY OF
MICHAEL D. BRADLEY
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 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 over fifteen 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. Finally, 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.

Beside my work with the U.S. Postal Service, I have served as a 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 the Postal Service's approach to measuring city carrier street time cost in this docket and explain the reason behind that choice. The Postal Service is essentially adopting the Commission's "established" model of city carrier street time costs as described by the Commission in Docket No. R2000-1. It does so in a spirit of cooperation and because the Commission has made clear that it believes the established model makes the best use of the existing data.

My second purpose is to identify and discuss the key methodological principles that Commission has articulated as desirable in a study of city carrier street time costs. I identified those properties through a review of Commission opinions on city carrier street time costing in the last nine rate cases. The purpose of this analysis is to draw lessons that can guide future city carrier street time cost analyses. To that end, I then evaluate the established model in light of the methodological properties.

Finally, I present a method of calculating incremental load time costs in the context of the Commission's established model.

I. THE POSTAL SERVICE METHOD OF CALCULATING CITY CARRIER VOLUME VARIABLE STREET TIME COSTS.

The Postal Service shares the Commission's general goal of attributing street time costs to products using the most accurate methods available and relying upon all reliable linkages.[1] Based upon this shared goal, and in a spirit of cooperation in trying to solve a difficult costing problem, the Postal Service essentially adopts the Commission's methodology for calculating city carrier street time in this docket. The only difference between the two methods is that the Postal Service uses single subclass costs as incremental access costs rather than volume variable access costs. In previous dockets, the Commission's own expert witness, intervenor witnesses, and Postal Service witnesses have all recognized that single subclass costs are incremental costs:[2]

> Professor Sowell's approach first attributes the full costs of single subclass stops to the mail classes responsible for those stops, as had the Commission previously in this proceeding. He attributes single subclass stop costs on the ground that they are incremental costs for each of those subclasses, and therefore reliably measure causation

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1 In fact, in Docket No. R2000-1, the proposed Postal Service methodology attributed materially more cost to products than the Commission's established methodology.

2 See, PRC Op., Docket No. R90-1 Remand, at 31.

and:[3]

> There is a consensus among the remand witnesses that single subclass stop costs are "incremental" to the subclass involved, i.e., the consequence of providing the subclass of service as a whole.

Given the general agreement on this point, and given that the Postal Service now calculates incremental costs, it seems appropriate to include these single subclass costs in incremental costs when such costs are being calculated. However, this inclusion leaves the Postal Service without a measure of volume variable or marginal access costs. It is widely recognized that single subclass costs are not a marginal concept and are not part of volume variable cost. For this reason the Postal Service calculates volume variable costs cost in addition to single subclass costs.

The Postal Service adopts the Commission's methodology for calculating city carrier street time costs because the Commission has made clear that it believes the established model makes the best use of the existing data, not because the Postal Service believes that the methodology is necessarily error free. As the Commission stated in Docket No. R2000-1:[4]

> The Commission does not take the position that the analytical framework or the empirical analysis adopted in this Opinion represent perfection.

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3 Id. at 35.

4 See, PRC Op., Docket No. R2000-1, Vol. 1, at 168.

Rather than re-litigate old differences, the Postal Service believes that it is more productive to go forward and to construct future costing analyses that are consistent with the following articulated Commission methodological preferences in city carrier street time costing. To that end, I reviewed the Commission's Opinions in the last nine dockets in an attempt to extract a set of methodological properties that the Commission has articulated as appropriate for city carrier street time analyses. In the next section, I identify and describe those properties. I then investigate the established methodology to ascertain its consistency with those properties.

II. THE COMMISSION'S PREFERRED METHODLOGICAL PROPERTIES FOR A CITY CARRIER STREET TIME COSTING ANALYSIS

There have been many changes to the methods for calculating city carrier street time costs in the past and there are likely to be additional changes in the future. Because there have been many changes, some of which have been surrounded by considerable controversy, it can be difficult to discern the Commission's methodological preferences for the city carrier street time costing methodology from any one Opinion. In contrast, a concurrent review of previous Commission opinions allows one to identify, by analyzing the Commission's words and actions, the properties of city carrier street time methods that the Commission appears to prefer in forming its costing algorithms. These properties should guide future analyses of city carrier street time costs. In this section, I list and discuss those properties with the aim of reducing controversy, establishing common ground between the Commission and the Postal Service in the area of city carrier costing, and guiding future Postal Service studies.

A. Timeliness of the Data

On several occasions, the Commission has revealed its desire to have timely data on carrier operations. Because carrier operations change and the mail stream that carriers deliver changes, actual volume variable costs may change through time. If so, more recent data would better reflect those actual costs than historical data.

The Commission has expressed its view on the timeliness of the data by both applauding the Postal Service for providing new data and castigating the Postal Service when it felt that new data were required. An example of the former is given by:[5]

> We are pleased to note that the Service's R80-1 filing has responded in several areas. First and foremost, the Service has presented the results of the Carrier Cost Study (CCS) to estimate the functional proportions of carrier street activities on residential and mixed routes

An example of the less positive message is given by:[6]

> It has been difficult, however, to translate this progress into more accurate attributable costs, because the basic data on which city delivery carrier cost attribution must rely come largely from obsolete

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[5] See, PRC Op., Docket No. R80-1, Vol. 2, App J., CS VI & VII at 70.

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

> special studies that no longer conform to current delivery operations or the current state of analysis

It is true that the Commission rejected the timely Engineering Study (ES) data in Docket No. R2000-1 in favor of vintage data, but that most likely reflects the unique circumstances in that case and not a change in approach. In previous opinions the Commission clearly indicated its desire for timely data because changes in carrier operation and the mix of mail could cause changes in attributable costs.[7]

> These new studies sometimes reflect changed conditions. For example, the provision of CCS IV data for FY 1982 allows us to use this information to attribute the costs of coverage related activities . . . The higher CCS IV coverage levels appear to reflect more recent phenomena, particularly the growth of saturation mailing campaigns by businesses and other institutions.

Thus, the overall methodological property of preferring timely data seems to be well established.

B. Accuracy of the Estimates

An obvious property, but not one that should be overlooked, is accuracy of the estimates. In every case, the Commission works toward trying to get the most accurate estimates available. However, this desire for accuracy may conflict with other methodological properties. An example of this conflict is illustrated by the Commission's rejection of the ES data in Docket No. R2000-1.

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[7] See, PRC Op., Docket No. R84-1, Vol. 2, Appendix J, CSVII, at 3-4

It rejected the data because it apparently had concerns about the accuracy of the volume variable cost estimates derived from that data.[8] It thus traded off its timeliness of data property against its accuracy property.

The Commission has made it clear, however, that accuracy is an important property. For example, in Docket No. R80-1, the Commission explicitly cited an update in methodology as improving the accuracy of the estimates:[9]

> Considering the improved street time methodology in this proceeding, we deem it more likely that the present results are a better reflection of reality than the R77-1 results. Measurements of carriers actually covering their routes, as opposed to measurements of carriers traversing their routes in a hypothetical manner, should yield more accurate, realistic results.

In other cases, the Commission has modified proposed analyses without rejecting them. When this occurs, it will generally accept an approach but will make changes that it believes renders the approach more accurate. This means that the Commission's established methodology is often not presented by any witness but is based upon arguments or approaches presented by witnesses.

For example, in Docket No. R90-1 four different witnesses presented alternative approaches to estimating load time variabilities.[10] The Commission did not adopt any of the four proposed approaches and did not continue to use

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[8] The Commission raised the following concerns about the ES data: (1) data collection and measurement issues, (2) sample size and selection issues and (3) compatibility issues. See, PRC Op., Docket No. R2000-1, Vol. 1, at 114-119.

[9] See PRC OP., Docket No. R80-1 App J. CX VI and VII at 77.

[10] See, PRC Op., Docket No. R90-1, Vol. 1, at III-62-64.

the previously established methodology from the earlier docket. Instead, it estimated its own load time model, after the record was closed, basing it upon an amalgam of the approaches presented to it.[11] Presumably, the Commission took this approach because it believed that its own analysis was more accurate than any of the approaches presented on the record.

The Commission's adoption of a modified approach to estimating coverage variability in Docket No. R84-1 provides another example. The Commission's modification of the approaches placed on the record was based upon its goal of improving the accuracy of the estimates, as opposed to wrestling with an underlying fundamental costing issue:[12]

> Based on this record, we find that some adjustment to the Service's coverage related variability analysis is in order. Our modifications result from weighting the data in the parameter estimation process, weighting the data in the variability determination differently than the Service, and from our treatment of high volume stops.

That is, the Commission accepted the general approach put forward by the Postal Service but modified that approach to improve its accuracy.

These examples serve to establish that the Commission believes that accuracy is an important methodological property in city carrier street time analyses.

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[11] See, PRC Op., Docket No. R90-1, Vol. 1, at III-85.

[12] See, PRC Op., Docket No. R84-1, Vol. 2, Appendix J, CSVII, at 27.

C. A System-Wide Approach

This property surfaced early in the history of city carrier street time costing but has been rearticulated in recent dockets. An early reference to the Commission's stated desire for a unified or system-wide approach to city carrier street time costing was given in Docket No. R80-1:[13]

> We are pleased to note that the Service's R80-1 filing has responded in several areas. First and foremost, the Service has presented the results of the Carrier Cost Study (CCS) to estimate the functional proportions of carrier street activities on residential and mixed routes. In addition to the comprehensive unified nature of the CCS, a positive development, this study presents a more complete identification and quantification of subfunctional activities compared to previous Postal Service filings. (Emphasis added)

A more recent example of its preference for this property was presented in Docket No R2000-1, in the Commission's discussion of load time costs:[14]

> The Commission uses an established model of load time variability that is derived from the testimony of technical witnesses in Docket No. R90-1. The basic elements of the model consist of sub-models that are used to identify and combine the components of volume-variable load time at the stop level and at the system level.

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13 See PRC OP., Docket No. R80-1 App J. CX VI and VII at 70.

14 See, PRC Op., Docket No. R2000-1, Vol. 1, at 123.

The advantages of a system-wide approach are two fold. First, volume variable costs are calculated at the system level, so a costing structure at that level facilitates accurate cost measurement. Second, a system-wide approach captures all linkages between products and cost. Under a system-wide approach, one does not have to be concerned that a linkage between a product and the cost it causes is missed.

D. Appropriate Econometric Practice.

In each of the eight last rate cases, the Commission has addressed issues of econometric practice. During that period it has reviewed a diverse set of topics such as functional form, eliminating outliers, evaluating estimated equations, autocorrelation, heteroskedasticity, bias, and efficiency. Many times it has rejected econometric analyses because it did not feel that the analysis followed what it believed was appropriate econometric practice. In fact, the Commission has been explicit that proper econometric practice is an important methodological principle for city carrier street time studies.[15]

> The premise underlying that revision is that testing of alternatives in econometric modelling is essential to validate such models. This premise is accepted in the econometric literature. Our goal is to receive econometric research in our hearings that satisfies this standard, in order to bring objectivity and consistency of research method to our investigations of carrier street time costs. The testimony of Postal Service witness Bradley satisfies this standard. Although we disagreed with witness Bradley on some substantive issues, we hope that the parties will treat

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15 See, PRC Op., Docket No. R90-1, Vol. 1, at III-8.

> his testimony as a standard in terms of their future research procedure and documentation.

E. Internal Consistency

The current method of estimating city carrier street time costs has many different individual pieces. It relies upon the STS, the LTV, the CAT/FAT and the CCS. Understandably, the Commission is concerned that the individual pieces fit together in a consistent manner and has expressed the benefits of integrated analyses for over twenty years: [16]

> As we previously pointed out, the CCS represents an improvement in terms of a systematic, unified attempt to estimate costs for most of the street time functions occurring on residential and mixed routes. In R77-1 various nonintegrated sources were used for this purpose (e.g., LCRES, route evaluation forms, and the city delivery carrier auxiliary cost system) and residuals were used to develop costs for the particular functions at issue here.

Without internal consistency, the individual pieces could be accurately estimated in isolation, and inaccuracies could still occur in the overall volume variabilities. The methodology of calculating city carrier street time costs is improved if it is internally consistent.

The importance that the Commission places on the property of internal consistency is emphasized by its willingness to make untested assumptions in an attempt to reconcile seemingly inconsistent parts of the city carrier street time

[16] See PRC OP., Docket No. R80-1 App J. CX VI and VII at 76-77

costing system. In Docket No. R97-1, it was brought to the Commission's attention that the amount of load time calculated by the STS proportions greatly exceeded the amount of load time predicted by the LTV study. The Commission felt it was important to reconcile these differences and applied, by its own admission, an untested "proportionality" factor to generate apparent consistency between the two measures of load time:[17]

> The Commission concludes that the most reasonable inference from the indirect evidence available is that STS-based accrued load time is higher than the LTV accrued load time by a constant proportion. This inference allows STS-based accrued costs to be viewed as consistent with the elemental volume variability model and, at the same time, allows volume variable load time costs to be viewed as consistent with the proportion of load time to other street time functions found in the STS survey.

This action emphasizes the importance that the Commission puts on the methodological property of internal consistency.

III. EVALUATING THE ESTABLISHED METHODOLOGY RELATIVE TO THE METHODOLOGICAL PROPERTIES.

In this section, I compare the current established methodology with the properties the Commission has articulated, through both word and action, that it prefers in a city carrier street time costing methodology. I list each of the characteristics and provide examples of the degree to which the current methodology embodies them.

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[17] See, PRC Op., Docket No. R97-1, Vol. 1, at 185.

It is not my intention to criticize the Commission or its analysis. As the Commission has pointed out, it does not collect data and must perform its analysis on the data that the Postal Service collects.[18] In addition, the established model has evolved over a number of dockets. Nevertheless, future costing analyses can be enhanced by understanding the degree to which the current established model conforms to the methodological properties listed above.

A. Timeliness of the Data

It is quite apparent that, with the exception of the CCS data, the data used for estimating city carrier street time costs are not timely. The street proportions were first introduced in Docket No. R87-1 and it is likely that those proportions have changed, given the changes that have occurred in both the mail stream and carrier operations. In fact, one of major concerns that the Commission had with the ES database was that it produced significantly different street time proportions than the old STS.[19]

Similarly, the data used to estimate the load time variabilities was first presented in Docket No. R87-1. Although there has been ongoing econometric analysis of those data, there is justifiable concern that the established variabilities suffer from being based upon different volumes and volume mixes than are

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18 See, PRC Op., Docket No. R2000-1, Vol. 1, at 110

19 See, PRC Op., Docket No. R2000-1, Vol. 1, at 112.

prevalent today. In sum, with the exception of the CCS, the city carrier data are no longer timely.

B. Accuracy of the Estimates

Despite the efforts of the Postal Service and the Commission to find accurate costs, concerns about the accuracy of the estimated costs remain. The inaccuracy can be traced to a fundamental weakness in the established approach to city carrier attributable costs. The established cost structure depends upon estimated parameters from a variety of special studies like LTV, CAT/FAT, and STS. These studies are difficult, time consuming, and expensive. Real world resource constraints limit their sample size. At the same time, it is not clear that increases in the sample size alone would solve the accuracy problem. The studies were not particularly well designed to collect data that support the statistical and econometric models required by the cost structure.[20]

> 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.

Taken together, these two factors lead to parameter estimates that have relatively high coefficients of variation and thus low precision. This also means

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

that the subsequent estimates of attributable costs have high coefficients of variation and low precision:[21]

> 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 [22]

> 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.

This intrinsic inaccuracy raises questions about the soundness of the general approach and suggests that any attempt at updating the studies should seriously investigate what is required to generate more accurate estimates. This fact was discussed in the Data Quality Study, which recommended such a course:[23]

> *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

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21 See, "Technical Report #3: Simulation Analysis Of Data Quality Issues," Data Quality Study, April 16, 1999 at 59.

22 Id. at 12.

23 See, "Technical Report #1: Economic Analysis of Data Quality Issues," Data Quality Study, April 16, 1999 at 48.

> 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.

C. A System-Wide Approach

The inability of the established model to be consistent with a system-wide approach is demonstrated by the established load time analysis. Both the Postal Service and the Commission use the stops-based load time data to measure elemental load time and coverage related load time. In Docket No. R2000-1, the Opinion included an analysis that attempted to demonstrate that the established stops-based model could be manipulated to produce a system-wide model. That is, a sophisticated attempt was made to show that one could go directly from the established stops-level model to a system-wide model. The effort required complex mathematical analysis and the effort alone shows the importance the Commission puts on obtaining a system-wide approach. Unfortunately, the effort was not successful, primarily because of the complexities associated with non-linear aggregation. This failure does not mean the effort had no value, however. Through this analysis, the Commission articulated its goal for achieving a system-wide approach and demonstrated the extreme difficulties associated with attempting to construct a system-wide approach from stop-level data. I now describe the analysis that attempted to bridge the gap and indicate where difficulty arose.[24]

The key formula the analytical structure that attempts to show that the total variability of load time with respect to volume combines the elemental load time variability and the residual based coverage related load variability in a single equation:[25]

$$\varepsilon_{LT} = \varepsilon_{ELT} + (1-\varepsilon_{ELT})\,\varepsilon_{S},$$

where ε_{LT} is the overall elasticity of load time with respect to volume, ε_{ELT} is the elemental load time elasticity, and ε_{S} is the actual stops or access elasticity. This equation holds in the special case that the elemental load time equation is linear but as I show below, it does not hold when the equation is nonlinear (as it actually is).

The analysis begins the derivation at the stop level with what is called the "conceptual" load time model. This model specifies that load time at a stop (L) is a function of the volume at the stop (υ) and the actual deliveries at the stop (A):

$$L = F(v, A)$$

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24 For the material discussed in the section, See, PRC Op., Docket No. R2000-1, Vol. 1, at 124-134

25 This equation has been described as the "combination equation."

However, this function is not convenient for estimation because actual deliveries are themselves a function of volume at the stop. If so, the stops-level variability is not the partial derivative of F with respect to volume. To remedy this deficiency, the analysis transforms this equation by substituting for the actual deliveries function. In general terms, this is given by:

$$A = A(v,P),$$

where P is possible deliveries at the stop.[26] Substitution yields a reduced-form equation:

$$L = L(v,P)$$

This equation has been termed the "applied" stop level load time model. Using this equation, the analysis defines the variability of load time at a stop as:

$$E_v = L_v \frac{v}{L}.$$

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[26] The analysis gets into a bit of trouble here. The equation it specifies assumes that actual deliveries are a function of υ, but υ is pieces per *actual* stop. (You can't have load time unless you have volume at the stop). In reality, actual deliveries are a function of pieces per *possible* stop. The validity of this point can be checked by examining the access equation cited on page 125 of the Opinion or by using the simple reasoning that actual stops cannot be a function of volume per actual stop, because that would require that actual stops be determined before they are determined. For now, however, we put this issue aside and continue with the mathematical analysis.

It defines L_v as marginal load time (the partial derivative of load time at a stop with respect to volume at that stop). It rearranges this expression to get volume variable load time at the stop. It is defined in two familiar ways:

$$E_v L = L_v v$$

In the parlance of city carrier costing this equation is used to calculate the elemental load time at the stop. This definition allows the bifurcation of total load time at the stop into its volume variable and non-volume variable (L_f) parts:

$$L = L_v v + L_f .$$

So far, so good. The next step is the big one. The analysis must now go from the stops-level model to the system-level model. The most direct way to do this is to simply aggregate the total stop load times across stops. However, this does not facilitate deriving a single system-wide equation, so the analysis instead defines total load time as the product of the average load time per stop and the total number of stops. It also posits the existence of an "average load time per stop" function. Moreover, it specifies this function ("H") so that average load time at a stop is a function of average volume at a stop:

$$\bar{L} S = H(\bar{v}) S .$$

It is important to note that the analysis defines $\bar{v}$ as total system volume (V) divided by total system stops (S). In contrast, the "H" function is undefined and its properties are unknown. The analysis does not describe the implicit mapping between the average volume per stop and the average load time at a stop but later attempts to approximate it with a Taylor series

The analysis then defines system-level volume variability as the elasticity of total system load time as the Commission defines it ($\bar{L}S$) with respect to total system volume (V):

$$\varepsilon_{LT} \quad = \quad \frac{\partial(\bar{L}S)}{\partial V}\frac{V}{\bar{L}S}.$$

To obtain this elasticity, one must first find the derivative of total load time with respect to volume. To do so, one must differentiate the equation that describes total load time, recognizing that $\bar{v}$ is equal to V/S(V):

$$d(\bar{L}S) \quad = \quad S\left(\frac{\partial H(\bar{v})}{\partial(\bar{v})}\frac{\partial(\bar{v})}{\partial V}\right)dV \quad + \quad H(\bar{v})\frac{\partial S}{\partial V}dV$$

or:

$$d(\bar{L}S) = S\left(\frac{\partial H\left(\frac{V}{S(V)}\right)}{\partial\left(\frac{V}{S(V)}\right)}\frac{\partial\left(\frac{V}{S(V)}\right)}{\partial V}\right)dV + H\left(\frac{V}{S(V)}\right)\frac{\partial S}{\partial V}dV$$

Before simplifying this expression, it is worth interpreting it. The expression shows that there are two ways an increase in volume can affect system load time. First, an increase in volume affects the average volume at a stop, which (according to the analysis) affects the average load time at a stop. This net effect is multiplied by the total number of stops to get the overall effect. *This is the increase in load time that takes place at existing stops.* The second term represents the effect of volume in creating additional stops. When volume rises, the number of stops rises. This adds to load time at the rate of average load time per stop (H). *This is the increase in load time at previously uncovered stops.* Note that this approach does not require knowing exactly what distribution of volume falls on the new stops.

We can simplify this expression by making use of the fact that:

$$\frac{\partial\left(\frac{V}{S(V)}\right)}{\partial V} = \frac{S(V) - \frac{\partial S}{\partial V}V}{S^2}.$$

Substitution yields the expression presented in the analysis:

$$\frac{d(\overline{L}S)}{dV} = \frac{\partial H(\overline{v})}{\partial(\overline{v})}\left(1-\frac{\partial S}{\partial V}\frac{V}{S}\right) + H(\overline{v})\frac{\partial S}{\partial V}.$$

To get the "combination equation," described above, the analysis must restate this derivative in elasticity form. It does so by multiplying the equation through by system volume and dividing through by system load time. With a little algebra and use of the fact that average volume per stop is total volume divided by total actual stops,[27] one obtains:

$$\varepsilon_{LT} = \frac{d(\overline{L}S)}{dV}\frac{V}{\overline{L}S} = \frac{\partial H(\overline{v})}{\partial \overline{v}}(1-\varepsilon_S)\frac{\overline{v}}{\overline{L}} + H(\overline{v})\frac{\varepsilon_s}{\overline{L}}.$$

It is at this point that the analysis starts to get into bit of difficulty. The above expression is defined in terms of the "H" function, the average load time function. The combination equation, in contrast, is in terms of the "L" function, the elemental load time function. Somehow, the analysis must make the transition between the two functions. When it introduced the "H" function, the analysis argued the "H" function and the "L" function were not the same. However, here the analysis essentially assumes that they are. More precisely, the analysis assumes that the elasticity of the "L" function is identical to the elasticity of the "H" function. Mathematically, this assumption is:

$$\varepsilon_{ELT} \equiv \frac{\partial L}{\partial v}\frac{v}{L} = \frac{\partial H(\bar{v})}{\partial \bar{v}}\frac{\bar{v}}{\bar{L}}.$$

If this assumption is correct, then it is just a matter of substitution and cancellation to obtain the combination equation. So, if the assumption is correct, the analysis is close to deriving a system-wide model from the stops model

In determining the validity of the combination equation and the attempt to derive a system-wide model, it is essential to investigate the validity of this assumption. We can check this assumption by calculating the two elasticities presented in the above equation, the elemental load time elasticity, and the elasticity of average load time with respect to average volume per stop, and then check to see if they are equal.

First, let's calculate the elemental load time elasticity using the established model. The load time equation is quadratic in volume.[28]

$$L = a + bv + cv^2.$$

Taking the derivative of this function with respect to volume and multiplying by V/L generates the elemental load time elasticity:

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[27] This condition is misstated in the Opinion. Presumably, it is only a typographical error. On page 130, The Opinion states that V/S = 1/υ. However, this implies that average volume per stop, υ = S/V.

[28] To ensure consistency with the analysis I follow it in suppressing the dummy variables and possible stops terms. In addition, I work in the univariate volume framework presented in the Opinion.

$$\varepsilon_{ELT} = \frac{bv + 2cv^2}{a + bv + cv^2}.$$

If the function is evaluated at mean volume per stop, as it is in the established model, the calculated elemental load time elasticity is:

$$\varepsilon_{ELT} = \frac{b\overline{v} + 2c\overline{v}^2}{a + b\overline{v} + c\overline{v}^2}.$$

I now calculate the elasticity of average load time with respect to average volume per stop. Recall that H is defined as the average load time per stop (total load time divided by the total number of stops) as a function of volume. There are established functions (the load time and access functions) that can be used to describe the total load time across the system and the total number of actual stops. One thus can write the "H" function as:

$$H = \frac{\sum_{i=1}^{N} L}{S} = \frac{\sum_{i=1}^{N} a + bv_i + cv_i^2}{(1 - e^{-\delta\frac{V}{PS}})PS},$$

where PS is system-wide possible stops. Inspection of this function shows immediately that there is not an identifiable mapping between average load time at a stop and average volume per stop. Nevertheless, we can find the derivative of H with respect to $\overline{v}$:

$$\frac{\partial H}{\partial \overline{v}} = \frac{\sum_{i=1}^{N}\left[b\frac{\partial v_i}{\partial \overline{v}} + 2cv_i\frac{\partial v_i}{\partial \overline{v}}\right](1-e^{-\delta\frac{V}{PS}})PS \quad - \quad \left(\delta\frac{S}{1-\varepsilon_s}e^{-\delta\frac{V}{PS}}\right)\sum_{i=1}^{N}\left[a+bv_i+cv_i^2\right]}{\left((1-e^{-\delta\frac{V}{PS}})PS\right)^2}$$

Two points about this derivative require discussion. First, numerical calculation of this derivative requires knowledge of how an increase in average volume per stop affects the volume of mail at each stop in the system $(\partial v_i/\partial \overline{v})$. This knowledge is required by the nonlinearity of the load time function. Without such knowledge, one cannot calculate the effect on average load time, because one does not know the distribution of mail across stops and thus cannot calculate the impact on total load time. Also note that the derivative of the volume at an individual stop with respect to average volume is not the same as the derivative of volume at an individual stop with respect to total volume $(\partial v_i/\partial \overline{v} \neq \partial v_i/\partial V)$. The difference arises because average volume at a stop is a function of the number of actual stops, which is itself, a function of total volume.

Second, the $S/(1 - \varepsilon_s)$ term in the numerator comes from the fact that the actual stops equation is specified as a function of volume per possible stop, not volume per actual stop. This means that to find the derivative of the denominator with respect to average volume per actual stop, one must find the derivative of total volume with respect to average volume per actual stop $(\partial V/\partial \overline{v})$. Finding this derivative and simplifying it yields the $S/(1 - \varepsilon_s)$ term.

To find the elasticity of average load time with respect to average volume per stop, one must multiply the above derivative by the ratio of average volume per stop to average load time per stop. The stops term cancels from both the numerator and denominator of the ratio, and we end up with:

$$\varepsilon_H = \frac{\sum_{i=1}^{N}\left[b\frac{\partial v_i}{\partial \overline{v}} + 2cv_i\frac{\partial v_i}{\partial \overline{v}}\right]V}{(1-e^{-\delta\frac{V}{PS}})PS\sum_{i=1}^{N}\left[a+bv_i+cv_i^2\right]} - \frac{\delta\frac{S}{1-\varepsilon_s}e^{-\delta\frac{V}{PS}}V}{\left((1-e^{-\delta\frac{V}{PS}})PS\right)^2}.$$

The assumption about equal elasticities thus requires the following equality:

$$\frac{b\overline{v}+2c\overline{v}^2}{a+b\overline{v}+c\overline{v}^2} \overset{?}{=} \frac{\sum_{i=1}^{N}\left[b\frac{\partial v_i}{\partial \overline{v}} + 2cv_i\frac{\partial v_i}{\partial \overline{v}}\right]V}{(1-e^{-\delta\frac{V}{PS}})PS\sum_{i=1}^{N}\left[a+bv_i+cv_i^2\right]} - \frac{\delta\frac{S}{1-\varepsilon_S}e^{-\delta\frac{V}{PS}}V}{\left((1-e^{-\delta\frac{V}{PS}})PS\right)^2}$$

.

This condition does not hold unless the load time equation is linear (c=0). Because the established model is nonlinear, the analysis has not demonstrated that the system-wide model can be successfully derived from the stops-based model.

Perhaps recognizing that the mathematical structure does not hold, the Opinion presents another attempt to bridge the gap between the stop level analysis and the system-wide analysis. In this alternate approach, the assumption of equality between the H function and the elemental load time function is abandoned and replaced with a second order Taylor expansion approximation of the H function. The goal here is to show that even though the two functions are not equal, the difference between the two functions is such that it permits the assumption on the elasticities to hold. Specifically, the analysis is trying to show that the two functions differ by only a constant, so the derivatives of the two functions are the same.

To establish the approximation, the analysis envisions a continuous density function for load time per stop. (This is the analog of the calculation of the mean for a discrete data set.) This expression is given by:

$$\bar{L} = \int_{-\infty}^{\infty} L(v)\, f(v)\, dv \quad .$$

In addition, the analysis defines f(v) as "the continuous probability density function for volume per stop over the population of stops."[29] In other words, the average load time per stop is found by calculating the load time associated with any specific volume per stop and multiplying that load time by the probability of the volume per stop occurring.

Then, the analysis approximates the elemental load time function with a second order Taylor expansion. It plugs that expansion back into the average load time per stop function described above and simplifies. That yields:

$$\bar{L} = L(\bar{v}) + \frac{\partial^2 L(\bar{v})}{\partial v^2}\frac{\sigma_v^2}{2} = H(\bar{v}).$$

It then uses this expression to claim that $L(\bar{v})$ differs from $H(\bar{v})$ only by a constant and that the two functions share derivatives. While this approach is sophisticated, it, unfortunately contains two mathematical errors

First, the analysis commits the mistake of confusing the ratio of the averages with the average of the ratios. Recall that in all of the preceding analysis $\bar{v}$ was defined as the ratio of total volume to total actual stops. In fact, it made use of this property in its mathematical derivations. Now, however, it defines $\bar{v}$ as the average value of the ratio of volume per stop across all stops:

$$\bar{v} = \int_{-\infty}^{\infty} v f(v) dv.$$

These two definitions of $\bar{v}$ are not the same (and may not even be close), so the "equality" that the analysis poses is invalid. In other words, the $L(\bar{v})$ function is presenting here is not the same $L(\bar{v})$ function that it used before. The function it is presenting here specifies that load time is a function of the ratio of the averages (or totals) The analysis simply does not equate the right function to $H(\bar{v})$ and thus fails.

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29 See, PRC Op., R2000-1, Vol. 1 at 133.

Second, the analysis fails to recognize that both mean volume per stop, $\overline{v}$, and the variance of volume per stop, σ_v^2, are functions of total volume, V. They are not constant with respect to volume, so even if the mathematics were correct to this point, its interpretation would not be so. The $L(\overline{v})$ function clearly differs from the $H(\overline{v})$ function, but not by a constant. It differs by a volume related term and, as I showed above, the two functions do not have the same derivative.

The analysis has attempted to logically go from a stop-level model to an aggregate system-wide model. This is not an easy task when the stop-level function is nonlinear. Despite its flaws, the reflects the belief that "something" happens as one goes from the stop level analysis to the system level analysis. Analyzing what is happening at the individual stop, in this view, does not capture the whole story.

D. Appropriate Econometric Practice.

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 can be estimated by the data and the attempt at estimation led to a noninvertible, 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:[30]

> 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.

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:[31]

> 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 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

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

31 See, PRC Op., Docket No. R97-1, Vol. 1, at 167

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:[32]

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.

It is difficult to see how a model estimated with this procedure follows accepted econometric practice.

E. Internal Consistency.

The established model is built upon a series of individual special studies using different data sets collected at different points in time. If one accepts that carrier operations and the mail stream have been changing through time, internal consistency would be difficult to achieve. The Commission itself has recognized the fact that the established method contains substantial internal inconsistencies:[33]

> There is a substantial inconsistency between the base year accrued costs of the basic components of carrier

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

[33] See, PRC Op., Docket No. R97-1, Vol. 1, at 156.

> street time implied by the STS data and the base year accrued costs of the same components implied by the models that the Postal Service uses to determine attributable access, route, and load time costs in this docket.

Moreover, as the Commission pointed out in Docket R2000-1, piecemeal updates of the individual pieces may also well run into problems of consistency. The Commission was concerned in the docket that updates of the STS proportions provide by the ES database were not consistent with the elemental load time variabilities estimated on the LTV data:[34]

> Compatibility issues arise when the ES proportions are combined with LTV-based variabilities. These compatibility issues are essentially the same as the STS versus LTV compatibility issues that arose in Docket No.R97-1.

The implication of these comments is that the established model probably contains internal inconsistencies and care must be taken in updating the current studies to account for possible inconsistencies.

IV. DESIGNING CITY CARRIER STREET TIME COSTS STUDIES IN THE FUTURE

The foregoing review reveals that the established model does not really meet the methodological properties set forth by the Commission. In going forward, therefore, it is important to construct studies that do embody these properties. This would seem to require a fresh look at the city carrier street time

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[34] See, PRC Op., R2000-1, Vol. 1 at 119.

cost structure. This conclusion is not new, however. This approach was recommended by the Data Quality Study:[35]

> *Does an alternative economic model reflecting the changes in the operating environment and production regime for city carrier delivery suggest alternative cost-effective sources or data collection approaches for evaluating city carrier costs?*
>
> A fresh look at the data employed to estimate city carrier costs is appropriate. Changes in the delivery-operating environment suggest that the relationship between city carrier costs and volume may have changed. The relatively stale age of the carrier special studies demands that these studies be updated or alternative studies performed. The cost of developing new rate making specific systems/studies to meet these modeling needs has to be compared to employing existing operating data systems and improving these systems to meet regulatory requirements.

In going forward, the Postal Service should attempt to bridge the gap with the Commission in the area of carrier street time costs by following the five key methodological properties. Any new study should be designed to improve the accuracy of city carrier volume variable costs while permitting timely updates. The study should attempt to estimate system-wide costs but should be internally consistent. That is, it should use consistent definitions of activities and volumes. Finally, proper econometric practice should be applied to any data collected.

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

V. CALCULATING INCREMENTAL LOAD TIME COST IN THE ESTABLISHED LOAD TIME MODEL.

In this section, I describe the calculation of incremental load time cost within the Commission's established model. The assumptions underlying the established model have specific implications for the calculation of incremental costs, so the formula for incremental load costs should be derived explicitly. The derivation starts with the Commission's formulation of total system-wide load time as the product of the average load time per stop and the number of actual stops:

$$LT = H(\bar{v}) * AS.$$

The next step is to explicitly define the average volume at a stop and insert that formulation in the "H" function.[36]

$$LT = H\left(\frac{V_L + V_F + V_P}{AS}\right) AS.$$

To calculate incremental cost, we must calculate how costs would be different if class A were removed from the product mix. If class A were removed, we would lose class A's volume at any multiple subclass stops that were receiving it and we would lose the single subclass stops receiving only class A. Thus, the total load time when class A is not being produced can be expressed as:

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36 For notational convenience I am assuming that only letters, flats and parcels are delivered. Adding accountables complicates the notation but does not affect the basic formula.

$$LT(-A) = H\left(\frac{V_L - V_{LA} + V_F - V_{FA} + V_P - V_{PA}}{AS - SS_A}\right)(AS - SS_A).$$

The incremental load time cost for class A is just the difference between the two:

$$IC(A) = H\left(\frac{V_L + V_F + V_P}{AS}\right)AS - H\left(\frac{V_L - V_{LA} + V_F - V_{FA} + V_P - V_{PA}}{AS - SS_A}\right)(AS - SS_A)$$

To make this formula operational, we must consider how we will approximate the H function, average time at stop. Elsewhere when we calculate incremental cost, we use the constant elasticity function. Following the same approach here, total system-wide load time can be expressed as:

$$LT = \left[\alpha\left(\frac{V_L}{AS}\right)^{\varepsilon_L}\left(\frac{V_F}{AS}\right)^{\varepsilon_F}\left(\frac{V_P}{AS}\right)^{\varepsilon_P}\right] * AS.$$

Using this formulation, we can write the incremental load time cost for class A as:

$$IC(A) = \left[\alpha\left(\frac{V_L}{AS}\right)^{\varepsilon_L}\left(\frac{V_F}{AS}\right)^{\varepsilon_F}\left(\frac{V_P}{AS}\right)^{\varepsilon_P}\right] * AS - \left[\alpha\left(\frac{V_L - V_{LA}}{AS - SS_A}\right)^{\varepsilon_L}\left(\frac{V_F - V_{FA}}{AS - SS_A}\right)^{\varepsilon_F}\left(\frac{V_P - V_{PA}}{AS - SS_A}\right)^{\varepsilon_P}\right] * (AS - SS_A)$$

But this is not a very operational equation. It requires explicit counting of the number of actual and single subclass stops in a given year and it does not appear to be based upon accrued load time in an explicit way. Because volume variable cost is based upon accrued load time, it would be useful in incremental cost could also explicitly based upon it.

We can make this expression more operational by recognizing that we can decompose actual stops into the single subclass stops for class A (SS_A) and the rest of the stops ($AS - SS_A$). Using this decomposition, we can rewrite the incremental cost in a convenient way:

$$IC(A) = \left[\alpha\left(\frac{V_L}{AS}\right)^{\varepsilon_L}\left(\frac{V_F}{AS}\right)^{\varepsilon_F}\left(\frac{V_P}{AS}\right)^{\varepsilon_P}\right] * SS_A$$

$$+ \left\{ \begin{array}{l} \left[\alpha\left(\frac{V_L}{AS}\right)^{\varepsilon_L}\left(\frac{V_F}{AS}\right)^{\varepsilon_F}\left(\frac{V_P}{AS}\right)^{\varepsilon_P}\right] \\ -\left[\alpha\left(\frac{V_L - V_{LA}}{AS - SS_A}\right)^{\varepsilon_L}\left(\frac{V_F - V_{FA}}{AS - SS_A}\right)^{\varepsilon_F}\left(\frac{V_P - V_{PA}}{AS - SS_A}\right)^{\varepsilon_P}\right] \end{array} \right\} (AS - SS_A)$$

Now let's examine the two right-hand-side terms. In the first term after the equals sign, the expression in the square brackets is just the H function. The first right-hand-side term can thus be written as:

$$\left[\alpha\left(\frac{V_L}{AS}\right)^{\varepsilon_L}\left(\frac{V_F}{AS}\right)^{\varepsilon_F}\left(\frac{V_P}{AS}\right)^{\varepsilon_P}\right] * SS_A = H * SS_A.$$

But, H is just equal to LT / AS so we can rewrite the expression as:

$$H*SS_A \quad = \quad LT*\frac{SS_A}{AS}.$$

The first term can be expressed as class A's single subclass ratio time accrued load time. The second term is more complicated because of the presence of changes in both the numerator and the denominator of the constant elasticity expression when class A is removed from the product vector. However, with a little algebra, this second term can be rewritten as:

$$\left[\alpha\left(\frac{V_L}{AS}\right)^{\varepsilon_L}\left(\frac{V_F}{AS}\right)^{\varepsilon_F}\left(\frac{V_P}{AS}\right)^{\varepsilon_P}\right]\left[1-\left(\frac{1-\theta_{LA}}{1-\rho_A}\right)^{\varepsilon_L}\left(\frac{1-\theta_{FA}}{1-\rho_A}\right)^{\varepsilon_F}\left(\frac{1-\theta_{PA}}{1-\rho_A}\right)^{\varepsilon_P}\right](AS-SS_A)$$

where θ_{LA} is class A's proportion of letters, θ_{FA} is class A's proportion of flats, θ_{PA} is class A's proportion of parcels and ρ_A is class A's single subclass ratio. This term now starts with the H function which is just LT / AS, so it can be rewritten as:

$$LT\left[1-\left(\frac{1-\theta_{LA}}{1-\rho_A}\right)^{\varepsilon_L}\left(\frac{1-\theta_{FA}}{1-\rho_A}\right)^{\varepsilon_F}\left(\frac{1-\theta_{PA}}{1-\rho_A}\right)^{\varepsilon_P}\right](1-\rho_A).$$

This allows us to write incremental costs more simply as:

$$IC(A) \quad = \quad LT\left\{\frac{SS_A}{AS}+\left[1-\left(\frac{1-\theta_{LA}}{1-\rho_A}\right)^{\varepsilon_L}\left(\frac{1-\theta_{FA}}{1-\rho_A}\right)^{\varepsilon_F}\left(\frac{1-\theta_{PA}}{1-\rho_A}\right)^{\varepsilon_P}\right](1-\rho_A)\right\}$$