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POSTAL RATE AND FEE CHANGES
PURSUANT TO PUBLIC LAW 108-18

Docket No. R2005-1

DIRECT TESTIMONY
OF
A. THOMAS BOZZO
ON BEHALF OF THE
UNITED STATES POSTAL SERVICE

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Autobiographical Sketch

My name is A. Thomas Bozzo. I am a Vice President with Christensen Associates, which is an economic research and consulting firm located in Madison, Wisconsin. My education includes a B.A. in economics and English from the University of Delaware, and a Ph.D. in economics from the University of Maryland-College Park. My major fields were econometrics and economic history, and I also completed advanced coursework in industrial organization. While a graduate student, I was the teaching assistant for the graduate Econometrics sequence at Maryland. In the 1995-1996 academic year, I taught undergraduate microeconomics and statistics at Maryland, and monetary economics at the University of Delaware. I joined Christensen Associates as an Economist in June 1996, was promoted to Senior Economist in January 1997, and to my present position in January 2003.

Much of my work at Christensen Associates has dealt with theoretical and statistical issues related to Postal Service cost methods, particularly for mail processing. In Docket No. R2001-1, I gave direct testimony on mail processing volume-variability factors (USPS-T-14). In Docket No. R2000-1, I gave direct and rebuttal testimony on econometric estimates of volume-variability factors for mail processing labor costs (USPS-T-15 and USPS-RT-6) and rebuttal testimony on the Postal Service's estimates of costs by weight increment (USPS-RT-18). In Docket No. R97–1, I worked in support of the testimonies of witnesses Degen (USPS–T–12 and USPS–RT–6) and Christensen (USPS–RT–7). Other postal projects have included econometric productivity modeling for Postal Service field units, analysis of In-Office Cost System data, estimation of standard errors of Cost and Revenue Analysis (CRA) inputs for the Data Quality Study, and surveys of Remote Barcode System and rural delivery volumes. I have also worked on telecommunications costing issues and on various litigation support projects.

Purpose and Scope of Testimony

My testimony is an element of the Postal Service's volume-variable cost analysis for mail processing labor. The purpose of this testimony is to present the econometric estimates of volume-variability factors used in the Postal Service's Base Year (BY) 2004 Cost and Revenue Analysis (CRA) for a group of "Function 1" mail processing labor cost pools representing letter, flat, bundle, and parcel sorting operations at facilities that report data to the Management Operating Data System (MODS). According to witness Van-Ty-Smith, the labor costs associated with those cost pools total $4.76 billion for BY 2004.

The results presented in this testimony update results previously presented in my direct testimony from Docket No. R2000-1, USPS-T-15, and from Docket No. R2001-1, USPS-T-14. The principal features of the updated analysis are the incorporation of a more recent data set from MODS and other sources through FY 2004, and the implementation of econometric methods to address errors-in-variables/simultaneity issues raised by the Commission in past Opinions and by Prof. Mark Roberts in an OCA-sponsored paper from 2002. Other minor changes to the Postal Service's Docket No. R2001-1 methodology are detailed below.

I sponsor Library Reference LR–K–56, which contains background material for the econometric analysis reported in this testimony. LR–K–56 has three main parts: (1) descriptions of the computer programs used to estimate the recommended volume-variability factors; (2) descriptions of the computer programs and processing procedures used to assemble the data set used in the estimation procedures; and (3) a description of the methods used to develop MODS productivity data for use in several cost models. The accompanying LR-K-56 CD-ROM contains electronic versions of the econometric computer programs, econometric input data, and full econometric output.

My BY 2004 variabilities are used by witness Van-Ty-Smith (USPS-T-11) to compute volume-variable costs by cost pool for the Postal Service CRA. I provide witnesses Miller (USPS-T-19 and T-20), Abdirahman (USPS-T-21), and Hatcher (USPS-T-22) with MODS productivity data described in Section III of LR-K-56.

I. Introduction

I.A. Overview and Review of Research Through Docket No. R2001-1

This testimony presents econometric estimates of volume variability factors ("variabilities") for a collection of mail processing labor cost pools representing sorting operations at MODS plants, with $4.76 billion in total costs. Variabilities are essential inputs into the measurement of marginal (i.e., unit volume-variable) cost and incremental cost for postal products. See LR-K-1, App. H and App. I. The recommended variabilities for use in the BY 2004 CRA are presented in Table 1, below.

Table 1. BY 2004 recommended variabilities (USPS version)

Cost pool	Variability Factor
BCS/	0.90
BCS/DBCS	0.85
OCR/	0.78
FSM/*	1.01
FSM/1000	0.73
AFSM100*	1.03
SPBS	0.77
Manual flats	0.90
Manual letters	0.87
Manual parcels	0.78
Manual Priority	0.76
Cancellation	0.46
Composite	0.83

* Note: Witness Van-Ty-Smith (USPS-T-11) uses 1.00. See Section IV, below, for discussion and additional results.

A cost pool's volume-variability factor ("variability") is, in economic terms, the elasticity of cost with respect to volume, or the (relative) percentage change in cost that would result from a given percentage change in volume, holding other factors equal. So, if the volume-variability factor for a cost pool is *v*, and volume increases by *X* percent, then the resulting percentage increase in costs for that cost pool would be by *vX* percent. In practice, it is desirable to measure the variability of cost with respect to operation-specific—and thus analytically more useful—"cost drivers" or "outputs," and then to relate the outputs to subclasses of mail via "distribution keys." My testimony addresses the first step of the two-step "volume-variability/distribution key" method; witness Van-Ty-Smith (USPS-T-11) addresses the In-Office Cost System (IOCS)-based distribution key step.

Economic theory does not determine specific values for variabilities *a priori*, so variability measurement is an empirical matter. Economic production theory implies that costs are non-decreasing in output, which implies only that variabilities should be positive. A rare point of agreement in Docket No. R2000-1 was that economic theory does not require the mail processing variabilities to be 100 percent. See Docket No. R2000-1, Tr. 27/12989 (UPS witness Neels); Tr. 27/13212-3 (OCA witness Smith). However, as witness McCrery (USPS-T-29) notes, it is very difficult to operationally justify variabilities greater than 100 percent.[1]

The Commission's cost methodology treats nearly 100 percent of these costs as volume-variable under volume-variability assumptions for clerk and mail handler mail processing labor costs that date to Docket No. R71-1.[2] Since the BY 1996 cost presentation in Docket No. R97-1, the Postal Service's CRA has incorporated econometric variability estimates for a subset of the mail processing cost pools.

Prior to Docket No. R97-1, the 100 percent variability assumption was controversial because of the absence of empirical evidence on the actual degree of volume-variability for clerk and mail handler costs. The 100 percent variability assumption for mail processing and distribution activities had been justified prior

[1] As Dr. Neels observed in R2000-1, it is possible for the costs of specific mail processing activities to increase proportionally faster than volumes over narrow volume ranges, and much less than proportionally over larger volume ranges. The former effect should not dominate the data at the level of aggregation employed in the variability analysis, though if it did, the estimation procedure should capture it.

[2] Several mail processing activities measured in IOCS are assumed to be non-volume-variable in the "100 percent variability" method. However, the costs associated with the non-volume-variable activities are small relative to total costs in the operations analyzed here.

to Docket No. R97-1 by a qualitative analysis of mail processing cost causation.[3] It states, in essence, that because distribution workloads ("handling at each work center") vary with volume (to an unspecified degree), mail processing and distribution costs are therefore 100 percent volume-variable. The 100 percent variability assumption was originally adopted in Docket No. R71-1 not because it was shown to be correct empirically, but rather because no other party had presented a viable alternative. See Docket No. R2000-1, USPS-T-15 at 6-9.

The central problem with an assumed level of variability is that the uncontroversial assertion of a *positive* relationship between mail volumes and mail processing costs does not imply any *specific degree* of volume-variability. The 100 percent variability story can neither be ruled out nor established *a priori.*[4] Statements about the relationship between processing and distribution workloads and costs are quantitatively testable, though. For the cost pools under study here, MODS measures the "handlings at each work center" and the associated labor input. If true, the 100 percent variability assumption must manifest itself in the Postal Service's operating data.

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[3] The story supporting the 100 percent variability analysis was last presented in Docket No. R97-1, USPS-LR-H-1. That document described the development of the FY 1996 CRA, the last Postal Service CRA to employ the full 100 percent variability assumption in mail processing. Prior to Docket No. R71-1, Postal Service economists had conducted limited econometric time-series analysis of clerk and mail handler costs and volumes that led them to reject empirical variability analysis for Cost Segment 3.

[4] While a specific variability factor cannot be reliably estimated for any given mail processing operation without employing statistical methods, it is possible to develop a qualitative impression – for example, by observing the proportion of total staffing time devoted to non-volume variable tasks such as set-up and take-down, waiting time, etc. See Docket No. R2001-1, USPS-T-14 at 7.

I.B. Research Since Docket No. R2001-1

In the Docket No. R97-1 and Docket No. R2000-1 rate cases, the Commission rejected the Postal Service's variability estimates, citing a variety of economic and econometric methodology issues. (Docket No. R2001-1, USPS-T-14 at 4-6.) The settlement of Docket No. R2001-1 left the mail processing variability controversy unresolved. In May 2002, the Office of the Consumer Advocate released a paper, "An Empirical Model of Labor Demand for Mail Sorting Operations," by Prof. Mark Roberts reporting the results of OCA-sponsored mail processing variability research and subsequently held a public seminar given by Prof. Roberts.[5]

Prof. Roberts makes a number of useful contributions that should help resolve the Commission's core concerns regarding the adoption of econometric mail processing variabilities. First, he derives an economic cost model that can feasibly be estimated with the Postal Service's data (Roberts, op. cit. at 5-8). This represents a significant departure from UPS witness Dr. Kevin Neels's argument in Docket No. R2000-1 that the intricacies of mail processing operations precluded reliable cost modeling (Docket No. R2000-1, Tr. 27/12843-12844). Additionally, Prof. Roberts offers a solution for what has arguably been the central econometric controversy: the potential inconsistency of variability estimates from least squares regression due to measurement error and simultaneity in MODS output measures. (Measurement error and simultaneity are mathematically equivalent in their effects on the least squares regression

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[5] The paper, supporting materials, and audio of the seminar are available on the internet at http://www.prc.gov/OCA/OCApapers.htm (March 1, 2005).

model. I simply use the term “measurement error” below.) Prof. Roberts introduced an “instrumental variables” estimation approach that can, under suitable conditions, yield consistent parameter estimates in the presence of measurement error (Roberts, op. cit. at 51-57).

While Prof. Roberts’s work has significantly influenced the modeling of manual operations, significant portions of the Postal Service’s previous modeling efforts remain intact, not least because they are consistent with Prof. Roberts’s general approach. Economic labor demand modeling remains an appropriate theoretical framework for the mail processing labor variability analysis. I will show below that the specifications of the Postal Service’s models are consistent with the essential features of Prof. Roberts’s framework. Prof. Bradley’s key methodological choice—the use of panel data estimation techniques at the cost pool level—is valid. Many finer details of Prof. Bradley’s analysis remain defensible. Indeed, in its Docket No. R2000-1 Opinion rejecting the Postal Service’s variability analysis, the issue was not that the Postal Service’s mail processing variability modeling effort was not self-consistent (PRC Op. R2000-1, Vol. 2, App. F at 45, 52), but rather the Commission’s objections to many of the assumptions underlying the system.

The Commission’s core concern of the effect of measurement error on the variabilities can be addressed by adopting an instrumental variables (IV) estimation approach for manual operations, based in part upon the method advanced in Prof. Roberts’s 2002 paper. The resulting manual variabilities are higher than the comparable BY 2000 results from non-IV translog models. In the updated analysis, most but not all variabilities differ significantly from 100 percent at the cost pool level, ultimately providing mixed evidence for the 100 percent variability hypothesis at that level. As in previous presentations, though, variabilities for the studied cost pools collectively are substantially less than 100 percent. The 83% composite variability for the studied operations considerably exceeds the BY 2000 composite of 71%.

II. The Postal Service's Volume-Variability Methods for BY 2004 Mail Processing Labor Costs

II.A. Economic Theory Issues

II.A.1. Economic cost theory underlying the analysis

The volume-variability analysis for mail processing labor cost pools is grounded in economic cost minimization theory.[6] In the basic formulation of the cost minimization problem, the firm chooses the quantities of "variable" inputs that produce a given level of output at minimum cost—subject to the firm's production function, the available amounts of "quasi-fixed" inputs, and any other relevant factors that may serve as constraints (and hence explain costs).[7] That is, the labor demands generally have the form:

$$L_i = f(Q_i, w_i, K_i; X_i)\,, \qquad (1)$$

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[6] As I discussed in my Docket No. R2000-1 testimony, however, neither my analysis nor Dr. Bradley's strictly requires the assumption that the Postal Service's plans and procedures are cost minimizing. A generalized non-minimum cost function would lead to substantially the same approach. Docket No. R2000-1, USPS-T-15 at 32-34.

[7] This describes the "short run" cost minimization problem. The "long run" analysis is the case in which there are no quasi-fixed inputs.

where Q_i is the output, w_i is the price of labor, K_i is the quasi-fixed input(s) (i.e., capital), and X_i represents other controls and cost-causing factors. The use of the term "quasi-fixed"—as opposed to simply "fixed"—indicates that the quasi-fixed inputs need not be constant over time. Rather, the quasi-fixed inputs are merely those inputs that are taken as given when the quantities of the variable inputs are chosen.

The resulting cost function is a function of the level of output, the price(s) of the variable input(s), the quantities of the quasi-fixed inputs (if any), and the other factors that explain costs. Associated with the cost function is a set of derived factor demand functions that depend on the same set of variables, from which the output elasticities (i.e., variabilities) $\partial \ln L_i / \partial \ln Q_i$ can be derived. For mail processing labor variabilities, the utility of employing the factor demand function approach, as opposed to directly estimating the cost function, is that the quantity of labor demanded (workhours) by cost pool is readily observable whereas labor cost is not available at the cost pool level.[8]

II.A.2. The Postal Service's models are consistent with the key elements of Prof. Roberts's economic framework

Prof. Roberts employed an econometric approach broadly similar to the one I used to derive the labor demand equations in my previous Postal Service testimony (USPS-T-15, R2000-1; USPS-T-14, R2001-1). Prof. Roberts derived his labor demand equations for letter and flat sorting operations from a theoretical production model in which the "outputs" consist of sorted mail

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[8] Significant additional complications would arise in imputing total cost (labor and non-labor) by cost pool.

volumes by shape and labor and capital are the main inputs.[9] Several major points of correspondence to my previous testimony are notable. First, Prof. Roberts's model is "short-run" in the sense of treating the capital equipment used in mail processing as quasi-fixed. Second, Prof. Roberts also relied on quarterly MODS data to estimate his model, and found them to be of acceptable quality when coupled with an appropriate econometric estimation technique. Finally, Prof. Roberts used facility fixed effects to control for unobserved, time-invariant facility characteristics. While Prof. Roberts does not include delivery network measures as control variables, production theory does not rule them out, and their inclusion is an empirical matter.

II.A.3. Prof. Roberts, like the Postal Service, treats mail processing capital as quasi-fixed

The Postal Service's mail processing variability model, in using capital variables as controls, treats capital as a "quasi-fixed" factor. OCA witness Dr. Smith contended that labor and capital were endogenously determined, and thus that the Postal Service's approach was in error (Docket No. R2000-1, Tr. 27/13167-13168, Tr. 46-E/22366-22367). Dr. Smith also offered vigorous if conclusory arguments that only "long-run" variability models were appropriate. I countered that longer-term capital input decisions necessarily precede the staffing decisions they eventually affect (see Docket No. R2000-1, Tr. 46-

[9] See Roberts, op. cit. at 5-8, for his derivation of a labor cost function for mail processing and the demand functions for mail processing labor in letter, flat and parcel sorting operations.

E/22185-6). Thus, to whatever extent capital and labor are “endogenous” over lengthy time horizons, they are not determined simultaneously. Prof. Roberts, contrary to Dr. Smith, treats mail processing capital as quasi-fixed controls in a “short-run” specification, and thus should extinguish this controversy.[10]

As I noted in Docket No. R2001-1, there is no conflict between the treatment of mail processing capital as quasi-fixed in the “short run” and the CRA assumption that mail processing capital costs are volume-variable (to some degree) over the rate cycle. There is no dispute that over longer periods such as the “rate cycle,” capital input is both variable (in the sense of being non-constant) and volume-variable to some degree.[11] However, the long-run variability of capital costs does not imply that capital cannot be quasi-fixed in the short run. To the contrary, the general economic scheme is that inputs that are quasi-fixed in the short run may vary over the “longer run,” and vice-versa.[12] The treatment of capital as quasi-fixed for a postal quarter simply recognizes that plant management cannot freely obtain or dispose of capital in such a short time period. It does not require capital to be constant over the rate cycle. Accordingly, the Commission erred in characterizing such econometric models as assuming that “the capital equipment found in… mail processing plants is fixed for the duration of the rate cycle” (PRC Op. R2000-1, Vol. 2, App. F at 26).

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[10] I presented the relationship between the short-run and long-run variabilities in Docket No. R2001-1, USPS-T-14 at 13.

[11] In Docket No. R2000-1, I presented the economic rationale for treating mail processing capital costs as volume-variable to the same degree as the corresponding labor costs in the absence of a formal capital variability analysis (Docket No. R2000-1, USPS-T-15 at 39-41).

[12] See, e.g., Hal R. Varian, *Microeconomic Analysis, Third Edition*, New York: Norton, 1992, pp. 2-3.

The models make no such assumption, as Prof. Greene recognized (Docket No. R2000-1, Tr. 46-E/22063-4). Thus, the Commission should not be concerned that the labor variability modeling conflicts with the determination of volume-variable capital costs (see PRC Op., R2000-1, Vol. 2, App. F at 26; 48).

II.A.4. TPF is superior to FHP as a measure of distribution operation output

While the basic economic cost theory structure of Prof. Roberts's model is sound, he errs in his choice of MODS First Handling Pieces (FHP) by shape to represent mail processing "output."

FHP measures the unique pieces that are sorted in the plant's piece distribution operations. FHP are counted only once in the plant, en route to being staged for the first piece sorting operation the mail will undergo, usually by weighing the mail and applying a conversion factor to the net weight. Secondary and tertiary handlings within an office do not count for FHP purposes, so an operation in which every piece was previously sorted in an upstream operation would have zero FHP.[13]

The total piece handling (TPH) and pieces fed (TPF) used in the Postal Service's analysis measure the amount of sorting work performed. TPH is the number of pieces processed successfully, so TPH = TPF – rejected pieces. TPF and TPH are conceptually superior as measures of sorting output and, from an engineering perspective, have a closer causal relationship with operation-level workhours than FHP. Lastly, since TPF and TPH in automated and mechanized

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[13] This is true of the subsequent passes of multi-pass sorting operations, such as DPS operations.

operations are based upon machine counts, they are less susceptible to measurement error problems than FHP, which is derived mainly from conversions of weight into piece counts. For all of these reasons, the Postal Service's analysis appropriately continues to employ MODS TPF and TPH data to represent "outputs" or "cost drivers" for sorting operations.

FHP's main conceptual flaw is its incompleteness as a measure of sorting output. (See also Docket No. R2000-1, USPS-T-15 at 50-53.) An increment to the FHP count implies that a plant has increased its sorting output, but the converse is not generally true.[14] FHP's inadequacy as a measure of sorting output can be seen in the following respects. First, increases in the depth of sort to which mail is finalized will (other things equal) increase TPF and TPH, but not FHP. Major examples include the letter delivery point sequencing program, implemented over Prof. Roberts's original sample period, and in-plant automated secondary flats processing, which I understand from conversation with witness McCrery's staff, has greatly increased in recent years due to AFSM deployment. The plant will have employed more resources to produce an improved output of more finely sorted pieces, without recognition from the FHP count. Second, increases in mailer worksharing activities will, in general, substitute for Postal Service TPF and TPH handlings, but not necessarily for FHP. Compared to an otherwise identical 3-digit presort piece, for instance, a 5-digit presort piece will avoid the incoming primary TPF and TPH, but not the incoming FHP count. The mailer's worksharing effort has reduced the needed Postal Service effort without

[14] Likewise, a decrease in FHP would imply decreased output, but not generally the converse.

being recognized in FHP. Prof. Roberts ignores these defects in selecting FHP as his output measure.

From an engineering perspective, too, workhours are directly linked to TPF rather than FHP. Most notably, machine runtime is a function of TPF (or TPH for manual operations):

Runtime $\equiv$ *TPF / Throughput rate.*[15]

The workhours associated with an operation's runtime, likewise, is

Run Hours $\equiv$ *Staffing Index*[16] *x TPF / Throughput rate.*

Insofar as each piece fed must be brought to and dispatched from the operation, related container handlings (including handlings to send mail back through the operation for subsequent sorting passes) will also be proportional to TPF, as will "overhead" not-handling time that is driven by the handling workhours. Handling-mail time and associated overheads account for the vast bulk of workhours in sorting operations, so there is little in the way of causal avenues for workload measures other than TPF to enter the relationship between hours and mail processing "outputs." Again, Prof. Roberts substantially ignores these considerations in preferring FHP.

In addition to theoretical considerations favoring TPF and TPH over FHP, Prof. Bradley and I have previously stressed the econometric benefits of machine-counted TPF and TPH for automated operations. While not entirely error-free, machine-counted volumes are inherently free from the FHP measurement error caused by the conversion of mail weight into estimated piece

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[15] Note that linear functions are not constant-elasticity functions.

[16] The staffing index is the number of employees assigned per machine run-hour.

counts. I noted in my Docket No. R2001-1 testimony that analysis of TPH and FHP data performed by UPS witness Dr. Neels in Docket No. R2000-1 demonstrated the high reliability of machine-counted TPH data. (Docket No. R2001-1, USPS-T-14 at 29-31.) In using FHP to characterize sorting operation output, Prof. Roberts exacerbates the errors-in-variables problem his analysis subsequently purports to solve.

Prof. Roberts's stated preference for FHP is based largely on the claim that TPF and TPH are choice variables under the control of plant managers, and thus may be econometrically "endogenous." According to Prof. Roberts, the manager observes the volume of mail pieces of a particular shape entering a plant and directs the flows of this mail to the various mail sorting operations suitable for this shape of mail on the basis of available labor and other factors, which in turn problematizes the close connection between operations and operation-specific output measures.[17]

Prof. Roberts's account is not consistent with the organization of sorting operations, and thus greatly overstates the role of management discretion in directing mailflows among the operations. The allocation of piece sorting is determined first and foremost by the given characteristics of the mail pieces as

[17] "While the volume of FHP letters, flats, and parcels is exogenous to the plant, how to allocate this across automated and manual operations is a choice variable for the plant. The plant manager chooses the mix of labor inputs to use given the volume of letters, flats, and parcels that arrive at the plant to be sorted. Measures of 'output' that are *specific to a sorting operation*, such as the number of FHP letters allocated to manual sorting or the number of letters fed into a barcode sorting machine, are not an exogenous measure of the output of an operation. Rather, they are a reflection of the manager's decision on how best to utilize the capital inputs available and how to allocate the labor across the different sorting operations." Roberts, op. cit. at 10.

they are presented to the Postal Service, particularly physical characteristics such as machinability and the presence or absence of mailer-applied barcodes. The very large volumes of mail processed at the Postal Service's mail processing plants and the need to avoid downstream operational bottlenecks—e.g., as machinable mail diverted to manual operations cannot readily be inducted back into automated operations—requires processing to depend on pre-determined operational plans. Indeed, during a plant tour that Prof. Roberts and I attended in May 2002, operations staff at the Harrisburg, PA P&DC told Prof. Roberts that the flows of mail to sorting operations were based upon the characteristics of the incoming mail. Curiously, Prof. Roberts fails to observe that, since the endogeneity and measurement error issues are manifestations of a common underlying econometric problem, the IV estimation approach addresses both to the extent they are present. I discuss this further in Section IV.C.7, below.

II.A.5. The Postal Service's methodology correctly applies the "distribution key" approach to volume-variable cost estimation

The Commission claimed that Dr. Neels's R2000-1 analysis of the relationship between total pieces fed (TPF)[18] and first handling pieces (FHP) casts "serious doubt" on the validity of the Postal Service's application of the distribution key method, which embodies what has been termed the "proportionality assumption" (PRC Op., R2000-1, Vol. 2, App. F at 62-63). In Docket No. R2000-1, I noted that the "proportionality assumption" represented a

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[18] For manual operations, the total pieces handled (TPH) variable is equivalent to TPF. For additional discussion of MODS workload measures, see Docket No. R2000-1, USPS-T-15 at 50-53.

mathematical approximation between unit volume-variable cost and marginal cost, which is exact under special circumstances, and thus involved no bias. I further testified that, because failure of the proportionality "assumption" represented only an approximation error, Dr. Neels had been correct to observe, in Docket No. R97-1, that there was no obvious direction of bias (Docket No. R2000-1, USPS-T-15 at 53-55). Since the Commission has expressed doubt that deviations from the "proportionality assumption" represent an approximation error, I show the basis for my previous claim below.[19]

In Docket No. R2000-1, Dr. Neels presented an adjustment to the variabilities[20] in which he econometrically estimated elasticities of TPF with respect to FHP using a "reverse regression" procedure, and employed the FHP elasticities as multiplicative adjustment factors for the variabilities (Docket No. R2000-1, Tr. 27/12832, 12902-3). Prof. Greene and I demonstrated that the econometric component of Dr. Neels's analysis was fatally flawed. Prof. Greene showed that the "reverse regression" procedure employed by Dr. Neels was intrinsically biased, independent of the measurement error problem that Dr. Neels's procedure purported to address (Docket No. R2000-1, Tr. 46-E/22068-71).[21] I showed that Dr. Neels's reverse regression elasticities were, additionally,

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[19] Some of these results may be found in Appendix H of USPS-LR-K-1, and in the Docket No. R97-1 rebuttal testimony of Dr. Christensen, USPS-RT-7.

[20] Dr. Neels applied the adjustment to both the Postal Service's recommended variabilities and Dr. Neels's alternative "shapes-level" variabilities.

[21] It should be noted that Dr. Neels did not testify that the reverse regression procedure produced unbiased estimates or otherwise constituted a statistically appropriate technique.

misspecified in that they could not be derived from the "direct" relationship between TPF and FHP (Docket No. R2000-1, Tr. 46-E/22165-8).[22]

I also noted that Dr. Neels's adjustment inappropriately equated FHP, a MODS workload measure, with RPW volume. Thus, it was incomplete in that it omitted a term—neglected by both Dr. Neels and the Commission in its analysis—relating FHP and RPW volume. The omitted term is required to produce meaningful volume-variable cost estimates (Docket No. R2000-1, Tr. 46-E/22162).

The mathematics of volume-variable costs and the distribution key method demonstrate that Dr. Neels's FHP adjustment is irrelevant. The effect of the omitted term relating FHP and RPW volume, needed to correctly apply Dr. Neels's FHP adjustment, is to cancel out Dr. Neels's FHP elasticity adjustment to a first approximation. Since the FHP adjustment is unnecessary, it is also unnecessary to attempt to remedy the econometric flaws of Dr. Neels's "reverse regression" analysis of the relationship between TPF and FHP.

The volume-variable cost of subclass *j* in cost pool *i* is defined as the product of the marginal cost of subclass *j* in cost pool *i* and the RPW volume of subclass *j*:

$$VVC_{i,j} \equiv MC_{i,j} V_j \,, \tag{2}$$

where

$$MC_{i,j} = \partial C_i \big/ \partial V_j \,. \tag{3}$$

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[22] That is, since $TPF = f(FHP)$, the elasticity $\partial \ln TPF / \partial \ln FHP = \partial \ln f(FHP) / \partial \ln FHP$ is a function of FHP, whereas Dr. Neels's reverse regression elasticities are functions of TPF.

Because of the limited availability of time series data on volumes, directly estimating marginal costs using equation (3) is not feasible.[23] However, with some elementary calculus, the problem can be decomposed into feasible components. Since data on the intermediate outputs ("cost drivers") are available, the usual decomposition of marginal cost is given by equation (4):

$$\partial C_i \big/ \partial V_j = \partial C_i \big/ \partial D_i \cdot \partial D_i \big/ \partial V_j \ , \tag{4}$$

which shows that the marginal cost can be rewritten as the product of the marginal cost of the intermediate output and the marginal contribution of RPW volume to the intermediate output. Equation (4) can be rewritten in terms of elasticities as follows:

$$\partial C_i \big/ \partial V_j = (C_i \big/ D_i \cdot \varepsilon_i) \cdot (D_i \big/ V_j \cdot \delta_{ij}) = C_i \varepsilon_i \delta_{ij} / V_j \ , \tag{5}$$

where $\varepsilon_i = \partial \ln C_i / \partial \ln D_i$ is the elasticity of cost with respect to the cost driver in cost pool *i* (i.e., the variability for cost pool *i*), and δ_{ij} is the elasticity of the cost driver with respect to RPW volume. Substituting equation (5) into (2) gives:

$$\Rightarrow VVC_{i,j} = C_i \varepsilon_i \delta_{ij} . \tag{6}$$

Equation (6) is the "constructed marginal cost" formula from Appendix H of LR-J-1.

Implementing equation (6) to measure volume-variable costs is generally not feasible either, as the RPW volume time series are inadequate to estimate the function relating RPW volumes to the cost driver and thus δ_{ij}. Accordingly, the Postal Service approximates the elasticities δ_{ij} with "distribution key shares"

[23] The implicit cost function generally would have many more parameters than there are observations given the number of CRA subclasses. Of course, all the usual difficulties of reliably estimating multivariate regressions from pure time series data would also be present.

$d_{ij} = D_{i,j} / D_i$, representing the proportions of the cost driver by subclass. The substitution of the distribution key for the elasticity δ_{ij} leads to the "distribution key method" for computing volume-variable cost, which approximates marginal cost:

$$VVC_{i,j} = C_i \varepsilon_i d_{ij} \cong MC_{i,j} \cdot V_j \,. \qquad (7)$$

The distribution key formula can be shown to be equivalent to the constructed marginal cost formula when the function relating the RPW volumes to the cost driver, $D_i = g_i(V_1, ...V_N)$, is linear in volumes, in which case both equalities in (7) would be exact.[24] This is the essence of the so-called "proportionality assumption." The "assumption," however, is more appropriately termed a first-order approximation, as one can always write:

$$g_i(V_1,...,V_N) = \sum_{j=1}^{N} \alpha_{i,j} V_j + O(V^2) \qquad (8)$$ [25]

or

$$g_i(V_1,...,V_N) \cong \sum_{j=1}^{N} \alpha_{i,j} V_j \qquad (9)$$

to a first approximation. The interpretation of the parameters a_j is units of the cost driver (TPF) per RPW piece. The approximate elasticity from equation (9) is:

$$\delta_{ij} = \partial \ln g_i(V_1,...,V_N) / \partial V_j \cong \alpha_{ij} V_j \Big/ \sum_{j=1}^{N} \alpha_{ij} V_j = D_{i,j} / D_i \,. \qquad (10)$$

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[24] To see this, note that the higher order terms in equation (8) would be identically zero with $g_i(V_1,...V_N)$ linear, so the approximations in equations (9) and (10) would hold exactly.

[25] The term $O(V^2)$ denotes the sum of terms involving squares and higher-order terms in $V = V_1, \ldots, V_N$. In the Taylor series approximation, the parameters a_j are chosen so that the higher-order terms sum to zero when evaluated at the actual volumes $V^* = V_1^*, \ldots, V_N^*$: $O(V^2)\big|_{V=V^*} = 0$.

Equation (10) establishes that the distribution key method produces unit volume-variable costs that constitute a first approximation to marginal costs. Note that FHP need not be invoked in the derivation.

To introduce Dr. Neels's FHP adjustment term, the elasticity of TPF with respect to FHP (say, $\phi_i = \partial \ln D_i / \partial \ln F_i$), it is necessary to further decompose the term $\partial D_i / \partial V_j$ from equation (4), which leads to:

$$\partial C_i \big/ \partial V_j = \partial C_i \big/ \partial D_i \cdot \partial D_i \big/ \partial F_i \cdot \partial F_i \big/ \partial V_j \ , \tag{4'}$$

or in elasticity terms:

$$\partial C_i \big/ \partial V_j = (C_i \big/ D_i \cdot \varepsilon_i) \cdot (D_i \big/ F_i \cdot \phi_i) \cdot (F_i \big/ V_j \cdot \eta_{ij}) = C_i \varepsilon_i \phi_i \eta_{ij} / V_j \tag{5'}$$

$$\Rightarrow VVC_{ij} = C_i \varepsilon_i \phi_i \eta_{ij} \ , \tag{6'}$$

where the additional term η_{ij} is the elasticity of FHP with respect to RPW volume.

I noted in Docket No. R2000-1 that Dr. Neels's analysis sheds no light on η_{ij} (Docket No. R2000-1, Tr. 46-E/22162). However, the results derived above imply that the additional term neglected by Dr. Neels must, to a first approximation, cancel out his FHP adjustment. This result may be shown by combining equations (6) and (6'), which gives:

$$\delta_{ij} = \phi_i \cdot \eta_{ij} \ . \tag{11}$$

The approximation result from equation (10) implies

$$d_{ij} \cong \phi_i \cdot \eta_{ij} \tag{12}$$

or

$$\eta_{ij} \cong d_{ij} / \phi_i \ . \tag{13}$$

Finally, substituting (13) into (6'), we obtain:

$$VVC_{ij} \cong C_i \varepsilon_i \phi_i d_{ij} / \phi_i = C_i \varepsilon_{ii} d_{ij} \ , \tag{14}$$

the rightmost term of which is the same as equation (7), establishing the result that properly applying FHP elasticities in the calculation of volume-variable costs would have (to a first approximation) no effect on the measured costs.

II.B. Econometric Issues

II.B.1 Correct assessment of model "robustness" does not require biased and unbiased models to produce similar results

In its Docket No. R2000-1 Opinion, the Commission stated that in evaluating econometric estimates:

> [the Commission] relies not only upon the usual statistical measures of goodness-of-fit and significance, but also upon less formal demonstrations that the estimates are robust and stable. In practice these demonstrations of robustness and stability usually take the form of comparisons of results between alternative models, data sets or estimators. (PRC Op. R2000-1, Vol. 2, Appendix F at 55)

The Commission's use of informal robustness checks to evaluate the econometric estimates is appropriate up to a point. Robustness checks are appropriate to deal with data handling and model selection decisions that are difficult to subject to formal hypothesis testing, or which would not be expected to significantly alter the results. However, there is no general expectation of robustness in econometric theory. In particular, theory dictates that the results of an econometric analysis, in general, will not be robust to misspecification of the model.[26] *In comparing a restrictive model that fails a specification test to a more*

[26] For example, discussing omitted variables bias, Schmidt notes that "it should… be clear that least squares applied to the misspecified equation will not have desirable properties" such as consistency and unbiasedness. Peter Schmidt,

general model, or comparing a biased model to an unbiased model, "non-robustness" of the results is the expected outcome. In such cases, non-robustness is appropriately interpreted as favoring the more general model, or the unbiased model.

II.B.2. The panel data fixed effects model is the appropriate econometric framework

In its Docket No. R97-1 Opinion, the Commission rejected Prof. Bradley's analysis in part because it believed that the facility-specific latent variables (i.e., "fixed effects") for which Prof. Bradley's analysis controlled were likely to be volume-variable (PRC Op., R97-1, Vol. 1 at 73, 87-88). The Commission reasserted this claim in its Docket No. R2000-1 Opinion (PRC Op., R2000-1, Vol. 2, App. F at 71). The Commission's past conclusions are inconsistent with the structure of the fixed effects model and should be reversed.

The "fixed effects" model controls for site-specific latent (unobserved) factors that do not vary over the sample period—a property which is clear from the "dummy variable" formulation of the fixed effects model. The site-specific dummy variables are, by construction, constant for all time periods in the regression sample. Therefore, the "fixed effects" can only represent factors that are *nonresponsive* to volume, or any other variable(s) that vary over the course of the sample period. In fact, the fixed effects, as the Commission recognized in Docket No. R97-1 (see PRC Op., Docket No. R97-1, Vol. 2, App. F at 41), only

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Econometrics (Marcel Dekker, 1976) at 39. The expected difference between the mis-specified model and a correctly specified model would be the amount of the bias, not zero.

control for the fixed (time-invariant) factors. Consequently, as Prof. Bradley and I have maintained, they cannot represent non-fixed, volume-driven factors.

The Commission has contended that this "would be true if the Postal Service's mail processing system was completely static." (PRC Op., R2000-1, Vol. 2, App. F at 71). However, the Commission claims that since the mail processing system is "not static," the "fixed effects will change" as the system evolves (*id*.). This should be understood as a question of the existence of the fixed effects, rather than of their volume-variability. Indeed, if mail processing operations were totally fluid over the sample period, there could in principle be no fixed effects.

The absence of fixed effects is a testable hypothesis, and it has repeatedly failed in standard tests (Docket No. R97-1, USPS-T-14 at 41-43; Docket No. R2000-1, USPS-T-15 at 122-124; Docket No. R2001-1, USPS-T-14 at 63-64; Section IV.C.1, below). This is to be expected. Factors affecting mail processing are neither totally fixed nor totally fluid. Many Postal Service operations currently occupy the same buildings, and in some cases with substantially similar configurations—at least for certain operations—as they did at the 1999 start of the sample period for the mail processing variability analysis. Cost-causing factors deriving from those characteristics are in no way the sole cost-causing factors, but they are fixed. To the extent such effects are present, failing to control for them would result in omitted variables bias. (See also Docket No. R2000-1, USPS-T-15 at 34-35.) Accordingly, Prof. Greene concluded:

> The Commission should have taken a much more favorable view [of the fixed effects model] in 1997 [*sic*], and should at this time consider the panel data, fixed effects form of econometric analysis an appropriate platform for continuing work on developing a model

for mail processing costs. (Docket No. R2000-1, Tr. 46-E/22040 [USPS-RT-7 at 5])

Prof. Roberts's analysis also eliminates much of the controversy over the use of the panel data fixed effects approach. Among opposing experts, OCA witness Dr. Smith consistently opposed the use of the fixed effects model.[27] While acknowledging the Commission's concerns regarding the model, Prof. Roberts pursued his analysis within the fixed-effects framework.

The Commission's contention that the use of a fixed effects model is problematic because the specific nature of the fixed latent variables is unknown (PRC Op., R2000-1, Vol. 2, App. F at 49) also misstates the real econometric problem. The problem—described in most treatments of panel data econometrics[28]—is not that the fixed latent variables are unknown *per se*, but rather that when latent variables are present, econometric methods that fail to control for their effects such as pooled OLS will generally be biased.[29] The advantage of the fixed effects model is precisely that it provides a means of

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[27] In his testimony on behalf of UPS, Dr. Neels at various times presented alternative analyses based on heterodox methods including cross-section regression on means (Docket No. R97-1, Tr. 28/15626-30), aggregate time series (Docket No. R2000-1, Tr. 27/12835-43), and the fixed effects model (Docket No. R2000-1, Tr. 27/12829-35), but declined to recommend any of them for adoption by the Commission.

[28] See, e.g., Cheng Hsiao, *Analysis of Panel Data,* Econometric Society Monographs No. 11, Cambridge, UK: Cambridge University Press, 1986, pp. 3-5.

[29] This statement is, of course, also true of estimation methods, such as the group means regression ("between model"), that are inherently unable to control for site-specific latent variables. See also Docket No. R2000-1, USPS-T-15 at 67-71; Docket No. R97-1, USPS-T-14 at 39-46.

resolving or reducing the magnitude of the omitted variables bias that would result if the latent variables were simply ignored.

II.B.3. The "instrumental variables" analysis proposed by Prof. Roberts addresses the measurement error problem for MODS manual piece handlings

The possibility that measurement error in MODS TPH could impart a downward bias on mail processing variability estimates, particularly for manual operations, was central to the Commission's rejection of econometric variabilities in Dockets No. R97-1 and R2000-1. Prof. Roberts notes that for all the argument over measurement error in those proceedings, little formal analysis was done to either quantify the extent of the problem or to present estimators that are robust to the presence of measurement error. Prof. Roberts then offers his most significant contribution to mail processing variability analysis, the specification of a feasible "instrumental variables" (IV) model to provide elasticity estimates that are statistically consistent in the presence of measurement error.

Prof. Roberts observed that piece handling variables excluded from the labor demand specification—other-shape FHP—were likely to have the statistical properties that would make them good "instruments" for the included piece handlings. The desired properties for an instrumental variable are correlation with the "true" regressor and independence from the observed regressor's measurement error. The independence of the measurement processes for the included and excluded MODS volumes gives Prof. Roberts good reason to believe that his FHP instruments will satisfy the latter property, though his use of "classical" IV (in which exactly one excluded instrumental variable is provided for the regressor with measurement error) precludes formal testing of the IV properties. Significantly, as Prof. Roberts notes, it does not matter for the purposes of the IV estimation that the other-shape FHP is itself imperfectly measured.

The BY2004 variability models for manual operations employ IV models using similar instruments to Prof. Roberts's models. Prof. Roberts's logic for selecting other-shape FHP as an instrument remains applicable with TPH appropriately specified as the sorting output measure (see Section II.A.4, above). In particular, TPH measurement error will be independent of other-shape FHP conversion error for the same reasons. Since the previous discussion of sorting operation output measures additionally implies little or no role for outside-operation handlings—or other volumes that do not measure sorting output—in explaining sorting workhours, it is also appears reasonable to assume that the other-shape FHP instruments are exogenous (appropriately excluded from the regression). It is possible to *test* whether the instruments are exogenous by specifying additional excluded instruments. The BY2004 variabilities extend Prof. Roberts's approach by using ODIS/RPW destinating volumes as additional instruments. An "over-identifying restrictions" test generally validates the instrument selection, see Section IV.B, below.

II.B.4. Selecting the regression sample period

The choice of regression sample period represents a tradeoff between maximizing the number of observations available for the regression, thereby minimizing the variance of the estimator (other things equal), and avoiding misspecification due to structural shifts in the underlying relationship being estimated. In practice, the underlying model need not be completely static: time-related shift factors and other control variables can allow for some structural drift over longer sample periods.

The BY2004 variabilities use a sample period from FY1999-FY2004. A primary motivation for this period is that it is relatively long—only one year (four quarters) shorter than the FY1994-FY2000 period employed in Prof. Roberts's analysis—but all manual volumes are collected under the MODS weight conversion factors implemented at the start of FY1999. That obviates the need to employ control variables solely to deal with the shift in measurement regime for the manual volumes.[30]

Using a more recent sample period also ensures that the estimates are derived from current sorting technologies to the extent possible. Obsolete technologies like LSM were substantially withdrawn at the start of the sample period, while newer technologies such as the FSM 1000 and AFSM 100 are present. In this update, there are sufficient data from AFSM 100 operations to introduce an estimated variability for the AFSM 100 cost pool.

II.B.5. Choice of functional form

The recommended estimating equations for the labor demand functions use the translog and log-linear functional forms. The log-linear form is used for the cost pools using IV estimation.

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[30] Automated TPF and TPH are derived from machine counts and thus not subject to the conversion factor change.

The principal advantages of the translog functional form were summarized quite well by the Commission itself in Docket No. R87-1 (in the context of modeling purchased transportation costs):

> [T]he translog model can be considered the source for [log-linear] models. That is, they [log-linear models] are simplified derivations from it [the translog model]… [The translog model's] flexibility permits it to follow the relationship between cost and the factors affecting costs in any pattern. That is, unlike the more simplistic models, it does not constrain the results to follow a linear or particular curvilinear arrangement, but instead follows whatever functional form the data show. (PRC Op., R87-1, Vol. 1, ¶ 3543)

In OLS estimation, it is an empirical matter whether the restrictions of simpler functional forms are warranted.[31] Accordingly, I tested the translog functional form against the simpler log-linear functional form in Docket No. R2001-1 (USPS-T-14 at 65). The test results favored the translog specification over the log-linear model.[32]

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[31] Historically, the use of simpler functional forms such as the log-linear model was primarily a matter of necessity. When Cobb and Douglas introduced their log-linear functional form in 1928, most computations were done by hand or with mechanical calculators. The computation and memory requirements of high order multivariate regressions such as those required by the use of the translog and other flexible functional forms were prohibitive prior to the widespread availability of digital (mainframe) computers. See, e.g., Ernst R. Berndt, *The Practice of Econometrics: Classic and Contemporary*, Reading, MA: Addison-Wesley, 1991, pp. 450-452.

[32] In Docket No. R2001-1, I also re-estimated a subset of the variabilities using the generalized Leontief functional form. The generalized Leontief, like the translog, provides a second-order approximation to an arbitrary functional form.The generalized Leontief functional form is $y = \sum_i \sum_j \gamma_{ij} \left(x_i x_j \right)^{1/2},\ \gamma_{ij} = \gamma_{ji}$.

See Robert G. Chambers, *Applied Production Analysis: A Dual Approach,* Cambridge, UK: Cambridge University Press, 1988, p. 181. The translog fit, as measured by R-squared, was somewhat better, and the variabilities from the generalized Leontief model were lower overall than the corresponding translog variabilities (Docket No. R2001-1, USPS-T-14, App. C).

The introduction of IV estimation methods complicates the functional form choice.[33] Selection of instrumental variables for higher-order and interaction terms of output is not a trivial matter, which presumably drove Prof. Roberts's choice of the log-linear form (Roberts, op. cit. at 74-75). However, loss of the translog form's improved approximation properties is likely to be less important than obtaining variabilities that are robust to the measurement error problem.

Since the various flexible functional forms would all be approximating the same underlying function, the Commission should not expect that use of alternative functional forms with the same approximation properties would alter the central result that mail processing labor variabilities are less than 100 percent.

II.B.6. Issues pertaining to the wage variable

In Docket No. R2000-1, the Commission criticized my wage variable as being a "plant level average" that may not be applicable to specific operations (PRC Op., R2000-1, Vol. 2, App. F at 51). The Commission's description of the wage variable as a plant level average was incorrect. The wages by Labor Distribution Code (LDC) that I used in Docket No. R2000-1 were functional averages that represent a finer level of disaggregation than the plant level:

[33] The main complication is the need to have at least one excluded instrumental variable for each regressor suspected of containing measurement error. Whereas the log-linear model for a manual operation contains a single output variable with measurement error, and therefore requires a minimum of one excluded instrument for identification, the translog version of the model adds to that a squared output term and terms interacting output with each of the other regressors, thus greatly expanding the required number of IVs.

> [M]ost of the important differences in compensation at the cost pool level (due to skill levels, pay grades, etc.) are related to the type of technology (manual, mechanized, or automated) and therefore are present in the LDC-level data. Thus, the LDC wage is a reasonable estimate of the cost pool-specific wage. (Docket No. R2000-1, USPS-T-15 at 92).

Table 2 shows the relationship between LDCs and cost pools, and the LDC wages associated with each cost pool for which I provide an estimated variability.

Table 2. Relationship between LDCs and cost pools

LDC (Wage variable)	LDC Description	Cost Pools included in LDC	Variabilities using LDC wage
11 (WLDC11)	Automated letter distribution	BCS/ BCS/DBCS OCR	BCS/ BCS/DBCS OCR
12 (WLDC12)	Mechanized distribution—flats	FSM/ FSM/1000 AFSM 100	FSM/ FSM/1000 AFSM 100
13 (WLDC13)	Mechanized distribution—other than letters and flats	SPBS (Priority and Other) Mecparc 1SackS_m	SPBS
14 (WLDC14)	Manual distribution	MANF MANL MANP Manual Priority	MANF MANL MANP Manual Priority
17 (WLDC17)	Allied labor	1CANCEL Platform, Opening Units, Other Allied Labor[34]	1CANCEL

[34] See LR-K-55, Section I.

The Commission also contended that since the LDC wage is calculated "by dividing wages by work hours," I employ a wage rate "that is correlated with the error in work hours, [the] dependent variable" (PRC Op., R2000-1, Vol. 2., App. F at 52) and therefore may contribute to simultaneity bias. The Commission's analysis is incorrect. First, the wage calculation actually divides LDC *dollars* by LDC work hours. Second, the Commission's analysis neglects the important detail that the LDC dollars are, implicitly, the product of LDC work hours and the LDC average wage rate. Therefore, work hours are present in both the numerator and denominator of the ratio and the division cancels out work hours, eliminating the source of simultaneity bias.

Prof. Roberts implicitly agrees that the wage variable is not econometrically problematic, since he did not treat wages as endogenous variables in his mail processing models. He did, however, argue that the conceptually correct wage variable was the relative wage between the operation and its manual or automated alternative(s) (Roberts, op. cit. at 12-13). Prof. Roberts's point is reasonable, and the BY 2004 models use a wage variable defined as the ratio of the applicable automated or mechanized LDC wage to the manual LDC wage.

II.B.7. The Commission's interpretation of the capital elasticities in Docket No. R2000-1 was incorrect

The models I recommended in Docket No. R2000-1 yielded elasticities of cost pool workhours with respect to the facility capital index (capital elasticities) that were small, positive, and mostly statistically significant (Docket No. R2000-1, USPS-T-15 at 119-120). The Commission, interpreting these results as "capital productivities," argued that the capital elasticities implied massive waste of inputs. The Commission illustrated its claim with an example purporting to show how my models would predict an increase in labor costs, rather than labor savings, from deployment of the AFSM 100 (PRC Op., R2000-1, Vol. 2, App. F at 34-36). Consequently, the Commission viewed the capital elasticities as "plainly wrong," "incompatible with basic production theory," and evidence that the accompanying variabilities were "fatally flawed" (*id*. at 54-55).

The Commission's specific criticisms are mooted to some extent by the fact that the current results show capital elasticities that are still small but now mostly statistically insignificant and/or negative in sign (see Section IV.C.5, below). Nevertheless, the Commission's contention that the capital elasticities are nonsensical if they are positive is not correct. The Commission's analysis neglected the major source of cost savings from equipment deployment. The cost savings derive not from the deployment of the equipment *per se*, but rather from the transfer of processing output (i.e., TPF or TPH) from operations with lower labor productivity to higher-productivity operations that such deployments permit. The capital elasticities indicate the effect on labor costs of increasing capital input *holding other things equal.* Significantly, TPF is among the "other things" held equal. The *ceteris paribus* effect of adding capital, which is measured by the capital elasticities, could be to increase costs slightly as, for instance, mailflows must be coordinated across more equipment. In this light, small positive capital elasticities need not be surprising, and do not imply that inputs are being "wasted" as long as the coordination-type costs are offset by the labor savings from shifting processing to the higher productivity operations. See also witness Kingsley's testimony, Docket No. R2001-1, USPS-T-39 at 17-18.

To capture the full cost impact of an equipment deployment, it is necessary to determine the effect of the transfer of TPF across operations. The Commission made no effort to quantify the savings that would result from employing an expanded automation capacity, and therefore, its analysis was incomplete. The omission is significant, since when the capital elasticities are small, their effect on labor costs will be dwarfed by the effect of the shift of processing to higher-productivity operations.

The faulty conclusion drawn from the Commission's incomplete analysis can be readily shown using the AFSM example. The AFSM deployment, though representing a substantial national investment, would only increase the capital input for a mail processing plant modestly.[35] For the purpose of discussion, assume the increase in facility capital input is 10 percent. The capital elasticities from Docket No. R2000-1 implied that labor costs for the cost pools I studied would increase by $25 million,[36] other things equal. This is the labor (cost) increase to which the Commission refers. However, other things would *not* be equal, since the purpose of the AFSM deployment is to shift processing from older, less productive FSMs to the much higher productivity AFSM operations.

The Commission's analysis completely ignored the labor savings from shifting processing from the older FSMs to the AFSMs. The omission is

[35] Most plants included in the first phase deployment were only scheduled to receive one AFSM machine.

[36] To obtain this figure, I multiplied the FY 1998 cost pool dollars by the capital elasticities from pages 119-120 of USPS-T-15, summed the results, and multiplied by 0.1 (the 10 percent increase in facility capital).

significant because AFSM productivity is much higher than that of the older FSMs. Thus, the productivity data in Section III of LR-K-56 and LR-J-56 show that BY 2004 AFSM operations perform over 50% more piece handlings than BY 2000 FSM 881 operations with less than half the workhours. (This represents a marked improvement even after labor in flat prep operations is considered.) Far from indicating that the AFSM investment would be wasted, the econometric models—correctly interpreted—predict a substantial labor cost savings.

In general, the Postal Service's mail processing capital investments (and the related capital inputs) mainly bring about mail processing labor savings not by making existing operations more productive on the margin (or reducing costs other things equal), but rather by creating the capacity to shift workload (piece handlings) from lower productivity operations to higher productivity operations.

III. Changes to Variability Estimation Methods for Mail Processing Labor Since R2001-1

III.A. Variabilities for AFSM 100 and Cancellation Cost Pools Added, LSM Discontinued

The set of mail processing cost pools covered by the variability analysis must be adjusted to maintain consistency with the sorting technologies in use. Since BY 2000, the AFSM 100 has replaced the FSM 881 as the primary flat sorting operation. With sufficient data from AFSM 100 operations now available, the AFSM 100 operation is incorporated in the econometric analysis. The FSM 881 operation remains in the analysis, though its cost pool no longer represents a significant share of the costs covered by econometric variabilities. I understand that the last FSM 881 was withdrawn from service in mid-2004, so there will be no future need for the FSM 881 variability.

In Docket No. R2001-1, I remarked upon preliminary analysis suggesting that the Cancellation and Meter Prep cost pools, which had been combined in BY 1996 and BY 1998, should be disaggregated (Docket No. R2001-1, USPS-T-14 at 9). That work had not been completed in time for inclusion in BY 2000. The BY 2004 CRA includes an econometric variability for the Cancellation pool (1CANCEL). I recommend using the IV estimation methodology for Cancellation. While most cancellations are performed on AFCS equipment, and thus cancellations are predominantly machine-counted, there is also considerable cost in non-AFCS cancellation operations. The non-AFCS volumes are subject to conversion error, and thus allowing for measurement error in the cancellation output is appropriate. I do not recommend an econometric variability for the Meter Prep operation (1MTRPREP).

Witness Van-Ty-Smith (USPS-T-11) does not report any costs for the LSM operation in BY 2004, and that operation has been dropped from the analysis.

III.B. Limited Information Maximum Likelihood Estimation for Manual Sorting and Cancellation Operations

I employ instrumental variables (IV) estimation methods for the manual sorting and Cancellation operations to provide variability estimates for those cost pools that are robust to the presence of measurement error (and/or simultaneity). However, in addition to model specification issues discussed in Section II, above, my estimation approach differs from Prof. Roberts's IV implementation in two main ways: the use of additional variables as instruments, and the use of the

"Limited Information Maximum Likelihood" (LIML) estimator[37] instead of two-stage least squares (2SLS). The LIML models replace the translog/fixed-effects models employed in BY 2000 for manual and Cancellation operations. The estimating equations are detailed in Section IV, below.

The use of additional instruments to estimate an "over-identified" model, as opposed to the exactly identified model used by Prof. Roberts, allows testing of the appropriateness of the selection of instruments by way of an "over-identifying restrictions" test.[38] Over-identifying restriction tests are designed to reject the null hypothesis if the restrictions that exclude the instruments from the model fail. Rejecting the over-identifying restrictions suggests that the instruments may not be exogenous and thus that the IV model does not produce consistent estimates. The LIML over-identifying restrictions test indicates that the instrument selection is acceptable; see Section IV.B.

The LIML and 2SLS estimators have identical asymptotic distributions (i.e., as the sample size tends to infinity), though studies have shown LIML to have a smaller small-sample bias than 2SLS under some circumstances, particularly when the instruments are "weak"—i.e., they have a low correlation with the true regressor.[39] Prof. Roberts's results suggest that the FHP instruments are not particularly weak,[40] though I still prefer the LIML estimator.

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[37] See, e.g., Takeshi Amemiya, *Advanced Econometrics* (Harvard University Press, 1985) at 234-239.

[38] See, e.g., Judge et al., *The Theory and Practice of Econometrics*, Second Edition (Wiley, 1985) at 614-616.

[39] See, e.g., D. Staiger and J.H. Stock, "Instrumental Variables Regression with Weak Instruments," *Econometrica* 65 (May 1997) at 557-586.

[40] In the canonical "weak instrument" cases, the sample correlations between the excluded instruments and the associated regressors are nearly zero.

Note that in exactly identified models such as Prof. Roberts's, LIML and 2SLS are equivalent.

III.C. More Recent Time Period for the Regression Samples; Accommodation of FY 2004 Data Frequency Changes

The maximum regression sample period extends from postal FY (PFY) 1999 PQ1 to PFY 2004 PQ 4.[41] This period is as long as was used in the BY 2000 variabilities, and only four quarterly observations shorter than that used by Prof. Roberts. It also eliminates the need to control for the FY 1999 MODS weight conversion factor change, which affects FHP and manual TPH counts.

Alternative results from the one-year-shorter subsamples (FY 1999-FY 2003 and FY 2000-FY 2004) are presented in Appendix B. The shorter subsamples yield composite variabilities (82%, 85%) quite close to the full sample's 83%. Standard errors of the cost pool level estimates are higher—markedly so for some IV estimates—and thus I prefer the lower variance estimates from the full sample period.

Note that the variability models use PFY 2004 according to the *old* postal calendar for FY 2004, rather than the new PFY aligned with the federal government fiscal year. Data handling procedures for variables no longer available by accounting period are described in LR-K-56, Section II. The considerably greater effort that would be involved in attempting to recast historical data from MODS and other sources to the new calendar was the

[41] FY 1999 observations are excluded from the regression samples of the translog models because one or more of the lagged TPF observations for an FY 1999 quarter would be from the excluded FY 1998 data. However, FY 1999 TPF data enter the regressions as lags to FY 2000 observations.

primary factor in keeping the variability analysis on the old calendar. I would not expect the time period shift between the old and new PFYs to materially affect the measured variabilities.

Once sufficient data are available under the new postal calendar, I would anticipate recasting some pre-FY 2004 data to the new calendar in order to restore the alignment between the variability data set and the postal calendar.

III.D. Use of Capital Indexes for Equipment Groups

Prof. Roberts's model implies that the capital variable(s) used in the models should be sorting operation specific, in contrast to the facility-level capital variable I employed in BY 2000. The Postal Service's BY 2004 models use a capital quantity index for letter sorting equipment types (QIAHE) in letter operations, and an index for flat and bundle sorting operations (QIMHE) for flat sorting and SPBS operations. Preliminary letter operation results using this approach had been presented in Docket No. R2001-1.

III.E. Treatment of Cost Pools Without Econometric Variabilities

While the econometric models cover a large absolute amount of costs, it remains necessary to determine variabilities for mail processing cost pools outside the econometric analysis using appropriate assumptions. In BY 1998, variabilities using the Commission's 100 percent variability assumption were adopted for cost pools without econometric variabilities. Docket No. R2000-1, USPS-T-15 at 132-133. The Postal Service continued this approach for BY 2000 in Docket No. R2001-1. I recommended the approach mainly in the view that the "disqualifying defects" noted by the Commission in Docket No. R97-1 could not be overcome by updating Dr. Bradley's allied labor proxy models or assumptions for other cost pools, which I judged to favor the Commission's status quo. Id.

For BY 2004, I recommend that witness Van-Ty-Smith apply the 83 percent cost weighted average of the econometric variabilities to mail processing cost pools not covered by the econometric analysis. In my opinion, using the average econometric variability yields a more consistent set of mail processing variabilities than the previous hybrid of econometric sorting operation variabilities and the 100 percent variability assumption elsewhere.

Applying the composite variability is justifiable on several grounds. First, the activities (e.g., set-up and take-down time at scheme changes) identified by witness McCrery and his predecessors as having relatively fixed costs with respect to marginal volume changes are present in operations not covered by the econometric models. Judging by the relative composition of IOCS handling and not-handling tallies in the operations, the low-variability activities are likely to be present to the same or greater extent as in the econometric cost pools. This consideration alone will make the 100 percent variability assumption overstate the true variability for most operations. Second, a number of BMC and post office operations have direct analogues within the set of cost pools covered by the econometric variabilities, as Dr. Bradley observed in Docket No. R97-1, whereby estimates for similar operations may provide superior estimates to the 100 percent assumption. This was briefly discussed by Postal Service witness Moden in Docket No. R97-1 (Docket No. R97-1, USPS-T-4 at 22). Third, for allied labor and general support operations, it is possible to view cost causation as following a “piggyback” model, in which the costs in support operations are viewed as driven by—and thus volume-variable to the same degree as—the “direct” operations.

IV. Principal Results of the Volume-Variability Analysis for Mail Processing Labor Costs

The mail processing volume-variability analysis uses two distinct estimating equations. First, the automated and mechanized operations—BCS (non-DBCS), DBCS, FSM 881, FSM/1000, AFSM 100, OCR, and SPBS—employ the following estimating equation (15):

$$\begin{aligned}
\ln HRS_{int} = &\sum\nolimits_{k=1}^{N} \beta_{1k} SITE_k \\
&+(\alpha_1 + \gamma_1 L + \gamma_2 L^2 + \gamma_3 L^3 + \gamma_4 L^4) \ln TPF_{int} \\
&+(\alpha_{11} + \gamma_{11} L + \gamma_{22} L^2 + \gamma_{33} L^3 + \gamma_{44} L^4)(\ln TPF_{int})^2 \\
&+\alpha_2 \ln CAP_{int} + \alpha_{22} (\ln CAP_{int})^2 + \alpha_3 \ln DEL_{nt} + \alpha_{22} (\ln DEL_{nt})^2 \\
&+\alpha_4 \ln WAGE_{int} + \alpha_{22} (\ln WAGE_{int})^2 + \alpha_5 TREND_t + \alpha_{55} TREND_t^2 \\
&+\alpha_{12} \ln TPF_{int} \ln CAP_{int} + \alpha_{13} \ln TPF_{int} \ln DEL_{nt} + \alpha_{14} \ln TPF_{int} \ln WAGE_{int} \\
&+\alpha_{15} \ln TPF_{int} \cdot TREND_t \\
&+\alpha_{23} \ln CAP_{int} \ln DEL_{nt} + \alpha_{24} \ln CAP_{int} \ln WAGE_{int} + \alpha_{25} \ln CAP_{int} \cdot TREND_t \\
&+\alpha_{34} \ln DEL_{nt} \ln WAGE_{int} + \alpha_{35} \ln DEL_{nt} \cdot TREND_t \\
&+\alpha_{45} \ln WAGE_{int} \cdot TREND_t \\
&+\beta_2 QTR2_t + \beta_3 QTR3_t + \beta_4 QTR4_t \\
&+\varepsilon_{int} \qquad (15)
\end{aligned}$$

where the subscripts *i, n* and *t* refer to the cost pool, site, and time period, respectively; *L* denotes the lag operator.[42] The variables are:

TPF: Total Pieces Fed for cost pool *i*, site *n*, and time *t*,

CAP: Capital input index for cost pool *i*,[43] site *n*, and time *t*,

DEL: Possible deliveries (sum of city, rural, highway contract, and P. O. box) for site *n*, and time *t*,

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[42] The lag operator is defined such that $L^s x_t = x_{t-s}$.

[43] The index is QIAHE for letter operations, QIMHE for flat and SPBS operations.

WAGE: Relative wage for the LDC associated with cost pool *i* (see Table 1, above), versus the LDC 14 wage, for site *n*, and time *t*,

TREND: Time trend, set to 1 for Postal Quarter (PQ) 1, FY 1993, incremented linearly by PQ for time *t*,

SITE*X*: Dummy variable, equals 1 if for observations of site *X*, zero otherwise; used to implement fixed effects model,[44] and

QTR*X*: Dummy variable, equals 1 if time *t* corresponds to PQ *X*, zero otherwise.[45]

No *a priori* constraints are placed on the coefficients. Among other things, this allows the effects of facility-level variables to vary by operation.

As in previous implementations of the translog model, the regression error ε_{int} is allowed to exhibit first-order serial correlation. As was the case in BY 1998 and BY 2000, the generalized least squares procedure used to implement this is a version of the "Baltagi-Li" autocorrelation adjustment (see Docket No. R97–1, USPS–T–14, at 50) modified to accommodate breaks in sites' regression samples. The standard errors for the translog model are computed using a heteroskedasticity-consistent covariance matrix for the regression coefficients.

Second, the specification for the cost pools using IV estimation—manual flats, manual letters, manual parcels, manual Priority Mail, and cancellation is log-linear, like Prof. Roberts's models. The log-linear model omits higher-order and interaction terms involving TPH, capital, deliveries, the relative wage, and the time trend. It adds year dummy variables to control for a more general

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[44] Dummy variables for all sites are included in the regression, so the overall constant term is omitted to avoid multicollinearity.

[45] QTR1 is omitted to avoid multicollinearity.

pattern of time-related demand shifts than a linear time trend would allow. It also includes, for the letter and flat operations, a set of dummy variables to control for the plant's mix of automation technology, a feature also acquired from Prof. Roberts's models. The estimation procedure does not adjust for serially correlated errors. The estimated function is given by equation (16):

$$\begin{aligned}\ln HRS_{int} = & \textstyle\sum_{k=1}^{N} \beta_{1k} SITEk_n \\ & + \alpha_1 \ln TPH_{int} + \alpha_2 \ln CAP_{int} + \alpha_3 \ln DEL_{nt} \\ & + \alpha_4 \ln WAGE_{int} + \alpha_5 TREND_t \\ & + \beta_2 QTR2_t + \beta_3 QTR3_t + \beta_4 QTR4_t \\ & + \delta' YEAR + \gamma' TECH \\ & + \varepsilon_{int}. \end{aligned} \qquad (16)$$

with the additional variables:

YEAR: a set of dummy variables indicating the fiscal years;

TECH: a set of dummy variables indicating the presence of automation operations, omitted in the manual parcel and Priority models;

δ, γ: parameter vectors associated with YEAR and TECH.

IV.A. Summary Statistics for the Regression Samples

Table 3. Summary of effect of sample selection rules on sample size

Cost Pool	Non-missing	Threshold	Productivity	Minimum Obs
BCS	6183	5869 (95%)	5576 (90%)	5449 (88%)
BCS/DBCS	7380	7356 (99%)	7293 (99%)	7275 (99%)
OCR	6610	6581 (99%)	6459 (98%)	6427 (97%)
FSM	3615	3564 (99%)	3497 (97%)	3420 (95%)
FSM/1000	4961	4953 (99%)	4750 (96%)	4622 (93%)
AFSM100	3176	3168 (99%)	3125 (98%)	3093 (97%)
SPBS	4803	4787 (99%)	4765 (99%)	4761 (99%)
MANF	7315	6412 (88%)	6157 (84%)	6141 (84%)
MANL	7380	7352 (99%)	7253 (98%)	7252 (98%)
Cancellation	7210	7152 (99%)	7023 (97%)	7022 (97%)
MANP	5626	5423 (96%)	4233 (75%)	4176 (74%)
Manual Priority	5692	5407 (95%)	4765 (84%)	4718 (83%)

Percentages are of non-missing observations.

Descriptions of the threshold, productivity, and minimum observation screens used to select the final sample I used to estimate my models were given in my previous testimony (Docket No. R2000-1, USPS-T-15 at 107-115; Docket No. R2001-1, USPS-T-14 at 41-42, 53-54).

Table 4. Selected summary statistics for regression samples

Cost Pool	Median Hours	Median TPF (000)	Median LDC wage ($/hr)	Median productivity (TPF/hr), before screening
BCS/	4012	28202	30.50	7570
BCS/DBCS	16405	138523	30.41	8486
OCR	3767	23631	30.52	6367
FSM/	10947	7286	29.41	659
FSM/1000	8228	4479	31.72	552
AFSM100	14131	27653	34.53	2012
SPBS	12843	3639	32.06	279
MANF*	4748	2215	29.62	456
MANL*	16241	9611	29.71	601
1CANCEL*	4856	19020	27.55	3932
MANP*	1433	391	29.73	344
Manual Priority*	3169	801	29.51	297

* Operations using TPH.

IV.B. Recommended Volume-Variability Factors and Other Econometric Results

Principal econometric results for my recommended models are presented in Tables 5, 6, and 7, below. I produced the results with TSP version 4.5 econometric software, running on a Dell PowerEdge computer with 8 GB RAM, running the Red Hat Linux Advanced Server operating system. The econometric code is also compatible with PC versions of TSP. The TSP programs, along with the complete output files, are included in LR-K-56.

For two cost pools, FSM 881 and AFSM 100, the estimated variability exceeds 100 percent, though the difference between 100 percent is less than one standard error. It is my understanding that witness Van-Ty-Smith has used 100 percent variability for those cost pools rather than the point estimate, apparently to avoid possible downstream difficulties from the result that volume-variable costs exceed the total costs for those pools. Given that the differences between the point estimates are both small (1 and 3 percentage points) and statistically insignificant, witness Van-Ty-Smith's usage is acceptable. Absent other considerations, though, as a general matter the use of the point estimates is preferable, as the point estimates represent the most probable value of the true elasticities.

Table 5. Principal results for automated letter sorting operations, translog-FE method

Cost Pool	BCS/	BCS/ DBCS	OCR
Output Elasticity or Volume-Variability Factor	0.90 (0.05)	0.85 (0.07)	0.78 (0.06)
Wage Elasticity	-0.20 (0.13)	-0.29 (0.04)	-0.25 (0.08)
Deliveries Elasticity	0.14 (0.32)	0.14 (0.10)	-0.19 (0.36)
Capital Elasticity	-0.08 (0.12)	0.01 (0.04)	-0.02 (0.08)
Auto-correlation coefficient	.68	.69	.68
Adjusted R-squared	.82	.93	.84
N observations	3954	5651	4921

Translog-FE elasticities evaluated using arithmetic mean method.
Heteroskedasticity-consistent standard errors in parentheses.

Table 6. Principal results for automated flat and parcel sorting operations, translog-FE method

Cost Pool	FSM/	FSM/1000	AFSM100	SPBS
Output Elasticity or Volume-Variability Factor	1.01 (0.04)	0.73 (0.03)	1.03 (0.09)	0.77 (0.06)
Wage Elasticity	-0.24 (0.15)	-0.12 (0.06)	-0.42 (0.06)	-0.62 (0.07)
Deliveries Elasticity	0.12 (0.18)	-0.11 (0.19)	0.28 (0.42)	-0.16 (0.18)
Capital Elasticity	0.01 (0.05)	-0.03 (0.03)	-0.03 (0.03)	-0.04 (0.02)
Auto-correlation coefficient	.49	.66	.52	.71
Adjusted R-squared	.96	.86	.96	.91
N observations	2113	3483	1966	3679

Heteroskedasticity-consistent standard errors in parentheses.

Table 7. Principal results for operations using IV estimation method

Cost Pool	Manual Letters	Manual Flats	Manual Parcels	Manual Priority	Cancellation
Output Elasticity or Volume-Variability Factor	0.87 (0.07)	0.90 (0.13)	0.78 (0.18)	0.76 (0.08)	0.46 (0.07)
Wage Elasticity	0.27 (0.03)	-0.04 (0.03)	-0.33 (0.27)	-0.86 (0.21)	-0.21 (0.11)
Deliveries Elasticity	-0.11 (0.03)	-0.06 (0.08)	0.67 (0.09)	-0.12 (0.09)	0.14 (0.08)
Capital Elasticity	-0.01 (0.01)	0.02 (0.01)	-0.01 (0.04)	0.09 (0.03)	-0.05 (0.02)
Adjusted R-squared	.97	.95	.84	.91	.94
N observations	7250	6139	4176	4718	7022

Table 8. Over-identification test statistics for IV regressions.

Cost pool	F-statistic	*P*-value	Reject over-identifying restrictions?
Manual flats	0.8	0.36	N
Manual letters	1.3	0.25	N
Manual parcels	1.6	0.20	N
Manual Priority	0.6	0.53	N
Cancellation	3.8	0.05	Borderline

IV.C. Discussion of Results

IV.C.1. Specification tests validate use of the fixed effects model

The recommendation of results from the fixed effects model is not merely an *a priori* preference, but rather is consistent with specification tests that decisively reject the simpler “pooled” model (with a common intercept for all sites) in favor of the fixed effects specification. Consistent with the results of similar tests in Docket No. R97-1, Docket No. R2000-1, and Docket No. R2001-1, the tests of the fixed effects specification versus the pooled model strongly favor fixed effects. Tables 9 and 10, below, present the test statistics and p-values.

Table 9. F-statistics for tests of fixed effects versus pooled OLS specifications, translog-FE methods

Cost pool	F-statistic	*P*-value	Reject pooled OLS?
BCS/	3.7	<.00005	Y
BCS/DBCS	6.4	<.00005	Y
OCR	4.7	<.00005	Y
FSM/	4.9	<.00005	Y
FSM/1000	5.9	<.00005	Y
AFSM100	3.1	<.00005	Y
SPBS	8.1	<.00005	Y

Table 10. Chi-square statistics for tests of fixed effects versus pooled IV specifications, IV methods.

Cost pool	Chi-square statistic	*P*-value	Reject pooled IV?
MANF	5317.7	<.00005	Y
MANL	9421.5	<.00005	Y
Cancellation	14980.3	<.00005	Y
MANP	5393.5	<.00005	Y
Manual Priority	3159.6	<.00005	Y

In response to the specification issues raised in Docket No. R2000-1 (Docket No. R2001-1, USPS-T-14 at 27), I also tested the translog specification against the simpler log-linear specification for the models where I recommend the translog estimating equation. The log-linear functional form is obtained from the translog by restricting the coefficients on second-order and interaction terms to zero. I used a Wald test statistic for a set of zero restrictions on linear regression coefficients. In every case, the more restrictive log-linear specification is rejected in favor of the translog. The test results are presented in Table 11, below. While similar results for the cost pools using the IV/log-linear model might be expected, based on results from Docket No. R2001-1 (USPS-T-14 at 65), the potential specification issue is relatively minor, since the higher-order terms in the translog function serve to determine the approximation properties of the models.

Table 11. Wald tests of translog versus log-linear functional forms.

Cost pool	Chi-square statistic	*P*-value	Reject log-linear?
BCS/	53.0	.00005	Y
BCS/DBCS	42.0	.00175	Y
FSM/	60.7	<.00005	Y
FSM/1000	197.9	<.00005	Y
AFSM100	88.1	<.00005	Y
OCR	32.5	.02765	Y
SPBS	79.8	<.00005	Y

IV.C.2. Comparison to Docket No. R2001-1 econometric variabilities

The recommended econometric variabilities for BY 2004 and BY 2000 (Docket No. R2001-1) are compared in Table 12, below. The BY 2000 variabilities are 12 percentage points lower, overall, than the recommended BY 2004 variabilities. This mainly reflects two factors: essentially 100 percent estimated variability for the new AFSM 100 operation, and higher variabilities for manual operations from the IV models. The high AFSM 100 variability, and the similarly high result for the outgoing FSM 881 operation, appear to be consequences of the rapid ramp-up of AFSM 100 operations and the offsetting removal of the FSM 881s. That is, the Postal Service is adding (or removing) entire operations with the shift of flat processing volumes from the FSM 881 to the AFSM 100. This is not typical of volume changes on the margin for established operations, which will not normally result in the introduction of new equipment or scheme runs. Variabilities for operations that have seen less pronounced operational changes, including the letter automation operations and FSM 1000, have been quite stable since BY 2000.

Table 12. BY 2004 recommended variabilities versus BY 2000 variabilities (USPS version)

Cost pool	R2004 USPS-T-12	R2001 USPS-T-14
BCS/	0.90	0.94
BCS/DBCS	0.85	0.87
OCR/	0.78	0.77
FSM/	1.01	0.74
FSM/1000	0.73	0.74
AFSM100	1.03	n/a
SPBS	0.77	0.66
Manual flats	0.90	0.71
Manual letters	0.87	0.58
Manual parcels	0.78	0.44
Manual Priority	0.76	0.55
Cancellation	0.46	n/a
LSM	n/a	0.90
Composite	0.83	0.71

For R2001 factors, see Docket No. R2001-1 USPS-T-14, Table 6 (p. 53).

IV.C.3. Implications for productivities

In Docket No. R2000-1, the Commission described the estimated elasticities as having the “surprising” implication that “labor costs would quickly approach zero as volume increases” (PRC Op., R2000-1, Vol. 2, App. F at 34). The variabilities do imply that marginal labor productivities are higher than average productivities for the most part, which in turn implies that average costs locally decrease with small increases in total piece handlings, other things equal.

In order for average costs to vanish, though, it would be necessary to extrapolate a constant degree of volume-variability over an infinite increase in output. Such an assumption is unwarranted for two principal reasons. First, the mail processing variabilities are not meant to be valid over all ranges of possible volume changes, but rather over volume changes of the sort that might be expected between the Base Year and Test Year. Second, such an extrapolation is inappropriate because it neglects the fact that human and machine capabilities will place nonzero floors on marginal costs. As a practical matter, I understand that the Postal Service forecasts relatively modest volume changes between BY 2004 and TY 2006.

A more reasonable alternative extrapolation, such as assuming constant marginal cost (or, equivalently, marginal productivity—the ratio of the average productivity to the volume-variability factor) need not violate the marginal cost floors. From the foregoing discussion, a more trenchant criticism would arise if the marginal productivities exceeded human or machine capabilities.

The marginal productivities are, in fact, feasible, and actually help explain some features of the average productivity data. As witness Kingsley noted in Docket No. R2001-1 (Docket No. R2001-1, USPS-T-39 at 33), sorting a letter at a case only takes 2-4 seconds, but the average time per piece in manual letters is six seconds (the median productivity in the variability data set, reported above, is 601 pieces per hour). The 87 percent variability implies that the marginal time to sort a letter manually is 5.2 seconds, still longer than witness Kingsley's observation of the required time for casing a letter-shape piece.[46]

[46] The difference may be explained by loadings of partly variable "overhead" time in the operations, which are implicit in the MODS data.

IV.C.4. Wage elasticities

Economic theory predicts that labor demand should vary inversely with the wage rate. The elasticities of workhours with respect to the relative wage variable behave largely as predicted. The wage variable is the correct sign in all operations except manual flats, where the elasticity has the wrong sign but is not (statistically) significantly different from zero. The elasticities are uniformly less than unity in absolute value. Note that the relative wage variable for manual letters is defined with the LDC 14 wage such that the expected sign of the elasticity is *positive*.

IV.C.5. Capital elasticities

In Docket No. R2000-1, the Commission found the result that the capital elasticities were (generally) small, positive, and statistically significant to be an indication that the variability models were “fatally flawed” (PRC Op. R2000-1, Appendix F at 34-36, 54-55). I explained in Section II.B.7, above, that the Commission’s conclusions were not warranted. The current results, in contrast to the results from Docket No. R2000-1, show small, often statistically insignificant, and mixed-sign capital elasticities, generally similar to results from Docket No. R2001-1. The small magnitudes of the capital elasticities are consistent with the observation that the main way in which capital affects labor input is by providing productive capacity in higher productivity (automated) operations, rather than by making specific (existing) mail processing operations more productive. The shift away from the use of facility-level capital measures has not materially changed this feature of the analysis from Docket No. R2001-1.

IV.C.6. Deliveries and network effects

The elasticities of workhours with respect to possible deliveries (“deliveries elasticities”) derived from the recommended models suggest that network effects remain difficult to accurately quantify (see also Docket No. R2001-1. USPS-T-14 at 69-70). The BY 2004 deliveries elasticities exhibit widely varying point estimates (across cost pools) in sign and magnitude, combined with relatively large standard errors. The Docket No. R2001-1 analysis indicated that the probable cause was near-multicollinearity between possible deliveries and the site-specific effects (Id.). The result that the inclusion of the site dummy variables dramatically inflated the standard errors of the deliveries elasticities is classically symptomatic of the problem. The implied high correlation between the possible deliveries and the fixed effects reinforces the argument that the fixed effects represent the effect of non-volume factors such as fixed network characteristics.

IV.C.7. Effects of instrumental variables estimation

As I noted above, the implementation of instrumental variables estimation for the manual operations increases the variabilities from the R2001-1 levels. The tables in Appendix C show the differences between translog and IV estimates both for the automated operation models, where I continue to recommend the translog specification, and for the manual operation models, where I recommend IV.

For manual operations, the effect of IV is generally consistent with a measurement error attenuation theory of the low variabilities from non-IV models.

The IV estimation method yields point estimates that are above the 95% confidence intervals for the non-IV estimates for all affected operations except cancellation. The IV point estimates are uniformly less than 100 percent, and the IV confidence intervals exclude 100 percent for the manual Priority and Cancellation cost pools. For manual letters, 100 percent variability is just inside the 95% confidence interval, but outside the 90% confidence interval. The IV estimation appears to be having the intended effect, and the results are consistent with the Postal Service's understanding of the structure of the operations.

For automated operations, I also estimated the models using the IV specification from equation 16, above. In marked contrast to the manual operations, there is no clear direction of difference between the IV and translog models: some IV estimates are markedly higher (BCS), others markedly lower (AFSM 100). Standard errors of the IV estimates are markedly larger than those of the translog estimates, such that the translog variability estimate for BCS/DBCS falls within the 95% confidence interval of the corresponding IV result. The variabilities markedly exceeding 100 percent cannot be operationally justified; for automated distribution operations, variabilities as low as the IV models produce are also difficult to square with the operational understanding of the cost pools. I conclude that the IV estimation procedure does not improve the quality of the variability estimates for automated sorting operations.

IV.C.8. Comparison with Commission methodology

The Commission's Rule 53 requires proposed cost methodology changes to discuss differences between the proposed methodology and the methodology most recently accepted by the Commission. For mail processing variability, the Commission has maintained the use of the 100 percent variability assumption, excluding from volume-variable costs only costs associated with specified IOCS activity codes assumed to represent "fixed" costs.[47] In contrast, the variabilities I recommend for use in the Postal Service's BY 2004 CRA are derived from an econometric labor demand analysis consistent with both economic cost theory and appropriate econometric practice. For some operations, the difference between the Commission's assumptions and the econometric variabilities is insignificant both practically and statistically (e.g., AFSM 100). In a few other cases, the difference is statistically insignificant but large as a practical matter. In those cases, the statistical consistency property of the econometric point estimates makes them preferable to the Commission's assumption. Elsewhere, variability estimation yields both practically and statistically significant departures from the Commission's assumptions. Overall, the estimated variability is 16 percentage points lower than Commission assumptions. See Table C-1, below, for a comparison. Witness Van-Ty-Smith provides additional comparisons including the effect of employing the sorting operation average for cost pools without econometric variabilities (see USPS-T-11, Table 5).

[47] The "fixed" costs in the Commission's methodology are small for the cost pools considered here.

Appendix A. Results Based on Alternative Sample Periods

Table A-1. Volume-variability factors from alternate sample periods.

Cost pool	Recommended FY 1999-FY 2004	FY 1999-FY 2003	FY 2000-FY 2004
BCS/	0.90 (0.05)	0.84 (0.06)	0.90 (0.05)
BCS/DBCS	0.85 (0.07)	0.89 (0.08)	0.89 (0.08)
OCR/	0.78 (0.06)	0.74 (0.07)	0.66 (0.07)
FSM/	1.01 (0.04)	0.99 (0.03)	1.01 (0.04)
FSM/1000	0.73 (0.03)	0.74 (0.03)	0.70 (0.03)
AFSM 100	1.03 (0.09)	0.87 (0.10)	1.03 (0.09)
SPBS	0.77 (0.06)	0.82 (0.07)	0.84 (0.06)
Manual flats	0.90 (0.13)	0.89 (0.15)	1.04 (0.21)
Manual letters	0.87 (0.07)	0.79 (0.06)	0.89 (0.10)
Manual parcels	0.78 (0.18)	0.84 (0.20)	0.82 (0.34)
Manual Priority	0.76 (0.08)	0.87 (0.09)	0.73 (0.09)
Cancellation	0.46 (0.07)	0.54 (0.07)	0.50 (0.07)
Composite	0.83	0.82	0.85

Appendix B. Comparison of Translog and IV Models for Automated Operations

Table B-1 Translog-fixed effects versus IV estimation, automated operations

Cost pool	Recommended Translog-FE	Instrumental variables
BCS/	0.90 (0.80,1.00)	1.66 (1.05,2.26)
BCS/DBCS	0.85 (0.71,0.98)	1.09 (0.82,1.36)
OCR/	0.78 (0.66,0.90)	0.46 (0.28,0.63)
FSM/	1.01 (0.94,1.08)	1.07 (1.00,1.13)
FSM/1000	0.73 (0.68,0.78)	0.52 (0.32,0.72)
AFSM100	1.03 (0.86,1.20)	0.59 (0.32,0.86)
SPBS	0.77 (0.66,0.88)	1.14 (0.91,1.38)

95% confidence intervals in parentheses

Table B-2. Instrumental Variables versus non-IV estimation, manual sorting and cancellation operations.

Cost pool	Instrumental variables	Translog-FE	Log linear-FE
Manual flats	0.90 (0.64,1.16)	0.75 (0.69,0.81)	0.60 (0.56,0.63)
Manual letters	0.87 (0.72,1.01)	0.40 (0.35,0.46)	0.35 (0.29,0.41)
Manual parcels	0.78 (0.43,1.14)	0.50 (0.41,0.60)	0.33 (0.28,0.37)
Manual Priority	0.76 (0.61,0.92)	0.39 (0.31,0.47)	0.48 (0.43,0.52)
Cancellation	0.46 (0.33,0.59)	0.46 (0.28,0.65)	0.45 (0.32,0.57)

95% confidence intervals in parentheses

Appendix C. Comparison of Postal Service Method to Commission Methodology, Pursuant to Rule 53

Table C-1. Comparison of Postal Service BY 2004 variabilities to Commission methodology

Cost pool	BY 2004, USPS Method	Commisison Method
BCS/	0.90	1.00
BCS/DBCS	0.85	1.00
OCR/	0.78	1.00
FSM/	1.01	0.99
FSM/1000	0.73	1.00
AFSM100	1.03	1.00
SPBS OTH	0.77	1.00
SPBSPRIO	0.77	1.00
Manual flats	0.90	1.00
Manual letters	0.87	0.99
Manual parcels	0.78	0.99
Manual Priority	0.76	0.99
Cancellation	0.46	0.97