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Docket No. R97-1

DIRECT TESTIMONY
OF
THOMAS E. THRESS
ON BEHALF OF
UNITED STATES POSTAL SERVICE

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DIRECT TESTIMONY
OF
THOMAS E. THRESS

AUTOBIOGRAPHICAL SKETCH

My name is Thomas E. Thress. I am a Vice-President at RCF Economic and Financial Consulting, Inc., where I have been employed since 1992. As Vice President at RCF, I have major responsibilities in RCF's forecasting, econometric, and quantitative analysis activities. I had primary responsibility for the econometric analysis underlying Dr. George Tolley's volume forecasting testimony in Docket Nos. R94-1, MC95-1, and MC96-2. I was responsible for the development of the share equation methodology used by Dr. Tolley in MC95-1 and MC96-2, as well as the classification shift matrix construction used in Dr. Tolley's volume forecasting testimony in MC95-1 and MC96-2 to shift mail into the new categories proposed under classification reform.

I completed my Master's Degree in Economics in 1992 at the University of Chicago. I received a B.A. in Economics and a B.S. in Mathematics from Valparaiso University in 1990. I appeared as a rebuttal witness for the Postal Service in Docket No. MC95-1, and submitted written testimony for the Postal Service in Docket No. MC97-2.

PURPOSE AND SCOPE OF TESTIMONY

The purpose of this testimony is to model the demand for mail volume and to provide forecasts of the worksharing categories of First-Class and Standard A mail. The demand equations developed in this testimony provide demand elasticity estimates which are used by Dr. George Tolley in making volume forecasts in support of this case (USPS-T-6).

I. Introduction

A. General Outline of Testimony

In this testimony, demand equations are modeled for mail, which provide demand elasticities and share forecasts which are used by Dr. Tolley in making volume forecasts, as described in USPS-T-6. This work builds upon a foundation of Dr. Tolley's work in earlier rate cases, including Docket Nos. R94-1, MC95-1, and MC96-2. In addition, Dr. Tolley continued to play an integral role in the development of the results presented here.

Demand equations for the categories of mail forecasted by Dr. Tolley are presented and discussed in section II below. The general econometric methodology used in modeling these demand equations is outlined in section III below. Shares of the presortation and automation rate categories of First-Class and Standard A mail are forecasted in section IV of my testimony below.

B. Demand Equation Estimation

The basic approach to modeling demand equations taken here is to model mail volume as a function of explanatory variables suggested by economic theory. A separate demand equation is generally modeled for each subclass of mail, except for First-Class letters, where separate equations are modeled for workshared and single-piece mail, First-Class cards, where separate equations are modeled for postal and private cards, and for Standard bulk nonprofit mail, where a single equation is modeled for Nonprofit and Nonprofit Enhanced Carrier Route mail. The coefficients estimated from these equations are used as an input in the Postal Service's forecasting model to forecast future mail volumes for each subclass of mail. Volume forecasts are performed by Dr. George Tolley in USPS-T-6.

The final demand equations are presented in section II below on a class-by-class basis. First-Class Mail is discussed in section II.B.; Periodical Mail is discussed in section II.C.; Standard bulk mail is discussed in section II.D.; Standard non-bulk mail is discussed in section II.E.; finally, other mail categories and special services are presented and discussed in section II.F. The econometric methodology used to develop these demand equations is outlined in section III below.

C. Share Equation Estimation

The shares of First-Class and Standard A mail that have taken advantage of Postal Service presort and automation discounts were modeled as a function of the level of the discounts offered by the Postal Service as well as the costs to mailers of doing the work necessary to receive these discounts. The methodology for modeling worksharing shares in this way was originally presented in Dr. Tolley's testimony in MC95-1 (USPS-T-16). This methodology is developed in section IV.A. of this testimony below.

Information on the distribution of mailers' user costs historically is forecasted and combined with information on Postal Service discounts to forecast the use of Postal Service worksharing categories of First-Class and Standard A mail. The econometric analysis of historical worksharing usage is described in section IV.B. of my testimony below. This information in then used to project the shares of these categories of mail in the forecast period in section IV.C. below. Forecasted shares, both before- and after-rates, are presented in section IV.D. at the conclusion of my testimony.

Three workpapers accompany my testimony. Workpaper 1 presents the data used in my work as well as full econometric results for the demand equations and share equations presented in my testimony. Workpaper 2 documents the calculation of permanent income elasticities from the Household Diary Study. Finally, Workpaper 3 presents intermediate econometric results leading to my ultimate choice of the demand equations presented in section II of my testimony.

II. Demand Equation Estimation

A. General Overview

1. General Approach to Demand Equation Estimation

The economic demand for a product can be defined as "the quantity of an economic good that will be bought at a given price at a particular time" (A Dictionary of Economics, by Harold S. Sloan & Arnold J. Zurcher, 1959). A demand equation relates the quantity demanded of a particular good to factors which affect this quantity. That is, a demand equation takes the general form,

$$Q_t = f(Y_t, P_t, \ldots) \qquad \text{(II.1)}$$

where Q_t is the quantity of the particular good consumed at time t, f(.) indicates that Q_t is a function of the variables within the parentheses, Y_t refers to income of consumers in the particular market at time t, P_t is the price of the good at time t, and the ... is included to reflect the fact that factors other than income and price may affect demand for the product being modeled. The factors affecting the demand of a product, as well as the magnitude of the impact of these factors, may be expected to differ across consumers and across products. Within the context of the Postal Service, therefore, a separate demand equation along the lines of equation (II.1) ought to be specified for each unique product provided by the Postal Service and/or for each specific group of users of a particular Postal product.

2. Division of Mail for Estimation Purposes

The demand for mail is not limited to a single demand based upon a single purpose. Rather, mail demand is expected to differ across mailers, due, at least in part, to differences in the purpose of the mail. Mail serves a purpose in many economic markets, in the sense that it satisfies a number of unique roles and purposes. For example, mail can be used for personal correspondence, for bill-sending and bill-paying, for advertising, for delivery of newspapers and magazines, and for delivery of other types of goods.

Mail can be divided into four broad categories, based on the purpose of the mail:

(i) Correspondence & Transactions

(ii) Periodicals

(iii) Direct Mail Advertising

and (iv) Delivery Services

Correspondence & Transactions mail is mail sent for the purpose of establishing or maintaining a relationship. This mail may be sent between households (e.g., letters, greeting cards), between households and nonhouseholds (e.g., orders, bills, bill-payments, financial statements), or between nonhouseholds (e.g., invoices, bill-payments). For the purposes of my testimony, Correspondence & Transactions are equated to First-Class Mail. Not all First-Class Mail would properly be considered Correspondence & Transactions based on this breakdown of mail. For example, there is a significant amount of direct mail advertising that is sent First-Class. Data limitations effectively prevent us from separating out this portion of First-Class Mail, however. Hence, this mail is combined with the rest of First-Class Mail. The distinctions made within First-Class Mail and the final demand equations associated with this type of mail are developed and presented in section B. below.

Periodicals are magazines, newspapers, journals, and newsletters sent on a periodic basis through the mail. This corresponds to the Postal Service's Periodical class. As with Correspondence & Transactions mail and First-Class Mail, the correspondence between the Periodical mail market and the Periodical mail class may not be exact. For purposes of estimating demand equations, given the data limitations imposed by the RPW system, however, this distinction is useful and sufficient. The distinctions within Periodical Mail and the final demand equations associated with this type of mail are developed and presented in section C. below.

Direct mail advertising is mail sent by businesses or other organizations for the purpose of advertising goods or services. Over 90 percent of Standard bulk mail (mail formerly classified as third-class bulk regular and third-class bulk nonprofit mail) falls within this category. As noted above, some portion of First-Class Mail is also direct mail advertising. It is difficult, if not impossible, however, to develop a useable time series of First-Class advertising mail volume given available data sources. Hence, this category of mail is included with the rest of First-Class Mail for modeling purposes. Standard bulk mail volume is modeled in section D. below using a model of direct mail advertising.

Delivery services refer to the use of the Postal Service to deliver goods which would not fall into one of the earlier categories (e.g., mail-order deliveries, books). This corresponds roughly to Standard non-bulk mail (single-piece mail and mail formerly labeled fourth-class mail). This type of mail is modeled and discussed in section E. below.

Other categories of mail are discussed in section F. below, including Mailgrams, Postal Penalty mail, Free-for-the-Blind mail, and special services.

3. Sources of Information used in Modeling Demand Equations

The primary source of information on mail volumes is the Postal Service's quarterly RPW reports. These data serve as the dependent variable in the demand equations developed and described in my testimony.

In general, variables which are believed to influence the demand for mail volume are introduced into an econometric equation as a quarterly time series in which an elasticity of mail volume with respect to the particular variable is estimated, using a Generalized Least Squares estimation procedure that is described more fully in section III below.

The estimation of elasticities with respect to certain variables may be problematic, however, in an isolated quarterly time series regression. Even if quarterly time series data exists on this information, additional data may be brought into the regression process, including the results of independent regression procedures. The Household Diary Study provides an alternate source for modeling the relationship of mail volume with other factors. The Household Diary Study data provides cross-sectional, rather than time series, data. For certain mail relationships (e.g., modeling the effect of income on mail volume received by consumers), cross-sectional data lends itself more easily to evaluation and estimation than does time series data. In addition, the Household Diary Study provides a means of dividing mail within a particular subclass or rate category by content, sender, or recipient, in a way that is not possible with RPW data (e.g., distinguishing First-Class advertising mail from First-Class non-advertising mail). In selective instances, information was obtained from the Household Diary Study, and was then introduced into the quarterly time series equations. This information was introduced in such a way as to continue to gather the maximum possible amount of information from the time series data themselves.

In some cases, Dr. Tolley introduces additional non-econometric information in making volume forecasts. This is a necessary and prudent thing to do, particularly when this information is not available in the form of a quarterly time series amenable to introducing into an econometric demand equation. The demand equations presented and discussed in my testimony should be viewed therefore as providing a starting point for Dr. Tolley in making volume forecasts, but should not be viewed as the end-all and the be-all in understanding mail volume behavior in the future.

B. First-Class Mail

1. General Overview

First-Class Mail is the largest class of mail delivered by the Postal Service, accounting for more than 50 percent of all mail and generating more than 55 percent of Postal Service revenue. First-Class Mail is divided into two subclasses on the basis of the shape of the mail: First-Class letters, flats, and IPPs (often referred to simply as First-Class letters); and First-Class cards. First-Class Mail is used for a variety of purposes, which can be summarized as Correspondence and Transactions.

2. Types of Mail Within First-Class Letters Subclass

The First-Class letters subclass includes a wide variety of mail sent by a wide variety of mailers for a wide variety of purposes. This mail can be divided into various substreams of mail based on several possible criteria, including the content of the mail-piece (e.g., bills, statements, advertising, and personal correspondence), the sender of the mail-piece (e.g., households versus businesses versus government), or the recipient of the mail-piece (e.g., households versus business versus government). While the above-mentioned distinctions may be useful from a theoretical standpoint, the Postal Service's quarterly volume data do not distinguish between these various types of mail. Instead, the Postal Service's volumes only distinguish between First-Class letters on the basis of postage received by the Postal Service.

a. Breakdown of First-Class Letters Volume from Household Diary Study

The Household Diary Study provides a basis for separating First-Class letters volume into broad categories on the basis of the senders and recipients of the mail, as well as the content of the mail.

The Household Diary Study divides First-Class letters between mail that is sent by households and mail that is sent by nonhouseholds (which include businesses, nonprofit organizations, and government agencies). In addition, it distinguishes between mail received by households and mail received by nonhouseholds.

Table II-1 below combines information from the Household Diary Study with Postal Service volume data to provide a broad breakdown of First-Class letters volume by sender, recipient, and content.

i. Household-to-Household First-Class Letters

Household-to-household mail was the only one of the four sender-recipient components that declined in volume from 1987 to 1995. Over that time period, household-to-household mail volume had an average annual growth rate of -1.18 percent. The volume of household-to-household mail is sufficiently small that further subdividing it by content seems somewhat impractical, although the Household Diary Study does provide some information on the content of household-to-household mail.

ii. Household-to-Nonhousehold First-Class Letters

Household-to-nonhousehold mail volume did somewhat better for the Postal Service, growing at an annual rate of 2.97 percent over this time period.

The Household Diary Study is not specifically designed to measure mail sent by households. Nevertheless, it is possible to glean some information regarding the content of mail sent by households to nonhouseholds via First-Class Mail.

Table II-1
First-Class Letters by Content

	1987	1988	1989	1990	1991	1992	1993	1994	1995	Annual Growth Rate 1987 - 1995
Household-to-Household	6,950.447	7,067.170	7,012.707	6,948.935	7,283.359	6,673.634	6,727.035	6,236.066	6,319.378	-1.18%
Household-to-Nonhousehold	9,619.419	10,825.110	13,632.703	12,530.867	12,929.373	10,174.557	12,008.591	11,092.472	12,152.650	2.97%
Nonhousehold-to-Household	30,299.382	32,983.611	34,408.756	35,832.810	37,032.189	36,945.693	37,310.207	38,158.419	41,424.443	3.99%
Bills & Statements	15,321.178	17,831.018	18,130.029	18,651.478	20,492.868	19,959.111	19,238.855	19,494.369	20,665.494	3.81%
Advertising, Invitations, & Announcements	5,601.593	6,694.709	7,460.911	8,593.910	8,633.480	8,485.186	9,284.422	10,568.020	11,782.251	9.74%
Other	9,376.611	8,457.885	8,817.816	8,587.421	7,905.841	8,501.396	8,786.930	8,096.030	8,976.698	-0.54%
Nonhousehold-to-Nonhousehold	28,436.430	28,952.016	26,448.735	28,979.717	27,672.359	31,734.265	31,535.462	34,545.355	31,631.015	1.34%
Total First-Class Letters	75,305.679	79,827.907	81,502.901	84,292.329	84,917.280	85,528.150	87,581.295	90,032.312	91,527.487	2.47%

Source: The Household Diary Study, Fiscal Years 1989 and 1990, Tables 4-36, 4-37; Fiscal Year 1992, Fiscal Year 1994, Fiscal Year 1995, Tables 4-35, 4-36
Quarterly RPW Reports, 1987 - 1995

The majority of household-to-nonhousehold First-Class letters are bill-payments, accounting for as much as 80 percent of household-to-nonhousehold mail volume. The growth in household-to-nonhousehold mail volume shown in Table II-1 suggests that the volume of bill-payments sent via First-Class letters experienced solid growth from 1987 through 1995.

According to the Household Diary Study, the chief alternative to bill-paying by mail between 1987 and 1995 was in-person bill paying. Electronic diversion, particularly electronic banking, did not appear to be a serious threat to the Postal Service through 1995 based on the Household Diary Study.

In 1987, approximately 29 percent of household-to-nonhousehold First-Class letters mail were in response to advertising. Response to advertising by mail fell dramatically between 1987 and 1995, due to an increased use of the telephone, particularly 800-numbers, to respond to advertising. By 1995, only 12 percent of household-to-nonhousehold First-Class letter mail was a response to advertising (source: 1995 Household Diary Study, Table 4-48) .

iii. Nonhousehold-to-Household First-Class Letters

Nonhousehold-to-household mail volume grew more rapidly than mail volume in general, with annual growth of 3.99 percent from 1987 through 1995.

The largest source of First-Class letters sent by nonhouseholds to households is bills, invoices, premiums and financial statements. This mail is statutorily protected by the Private Express Statutes and is required by regulation to travel as First-Class Mail. In 1987, bills and statements sent to households accounted for approximately 20 percent of total First-Class letters volume. From 1987 to 1995, the volume of bills and statements sent by nonhouseholds to households as First-Class letters grew at an annual rate of 3.81 percent.

In 1987, 18 percent of nonhousehold-to-household mail was direct mail advertising, invitations, or announcements, which accounted for slightly more than 7 percent of total First-Class letters. This type of First-Class mail grew at an annual rate of 9.74 percent from 1987 through 1995, accounting for nearly 13 percent of total First-Class letters in 1995.

Nonhousehold-to-household mail that did not fall into either of these two categories declined slightly (4.3 percent total) between 1987 and 1995.

iv. Nonhousehold-to-Nonhousehold First-Class Letters

The final sender-recipient component of First-Class letters is nonhousehold-to-nonhousehold mail volume, which has grown at an average annual rate of 1.34 percent over the past eight years. Since the Household Diary Study surveys households, there is no information on the content of this mail volume.

b. Breakdowns of First-Class Letters Used in This Case

There is not sufficient data for a sufficiently long time period to break First-Class letters down based on content. Instead, First-Class letters can only be divided into distinct rate categories.

Looking at Table II-1, First-Class letters can be divided into two broad categories based on rates of growth from 1987 through 1995. Mail generated by households, nonhousehold-to-household mail classified as Other mail, and nonhousehold-to-nonhousehold mail grew at a combined annual rate of 1.04 percent. On the other hand, mail sent from nonhouseholds to households that is classified as either Bills &

Statements or Advertising, Invitations, & Announcements grew at a combined annual rate of 5.64 percent.

One common link between the categories Bills & Statements and Advertising, Invitations, & Announcements in Table II-1 is that both of these types of mail are generally sent in bulk. Because of the bulk nature of these types of mail, this mail is likely to have been workshared.

On the other hand, all household-generated mail as well as nonhousehold-generated mail that is sent only a few pieces at a time would generally be ineligible for Postal worksharing options. The majority of nonhousehold-generated mail that would fall into this category would be mail classified as either Other Nonhousehold-to-Household mail or Nonhousehold-to-Nonhousehold mail in Table II-1.

As an approximation therefore, the mail classified by content in Table II-1 can be broadly divided into two categories of mail: Individual Correspondence, consisting of all household-generated mail, and nonhousehold-generated mail sent a few pieces at a time; and Bulk Transactions, consisting of nonhousehold-generated mail sent in bulk (which may roughly correspond to mail characterized as Bills & Statements and Advertising, Invitations, & Announcements in Table II-1). Relating these two categories of First-Class letters to rate categories, Individual Correspondence mail may be thought of as being approximately equivalent to single-piece First-Class letters, while Bulk Transactions mail could be viewed as comparable to workshared First-Class letters.

Even abstracting from Table II-1, it seems plausible that First-Class letters sent in small, nonworkshared, mailings would be expected to exhibit similar demand characteristics, while First-Class letters sent as part of a large workshared mailing may be expected to face a different set of demand characteristics as compared with single-piece mail.

Based on an understanding of the content of mail, it therefore appears worthwhile to attempt to distinguish between single-piece and workshared First-Class letters. Within workshared First-Class letters, however, it seems unlikely that any meaningful demand differences could be distinguished between the volumes of specific worksharing categories of First-Class Mail. Thus, separate demand equations are estimated for single-piece and workshared First-Class letters.

3. Choice of Starting Date for First-Class Letters Regressions

The single-piece and workshared First-Class letters regressions are estimated over a sample period of 1983Q1 through 1996Q3. This encompasses 55 observations and spans five omnibus rate regimes.

The starting period of 1983Q1 was chosen based on experimentation with the starting period in the workshared First-Class letters equation. The first worksharing discount was introduced in 1976Q4. Hence, the earliest possible starting date for the workshared First-Class letters equation was 1977Q1.

The growth of workshared First-Class letters volume was quite rapid, and rather volatile, over the first few years in which worksharing discounts existed. In fact, the growth of workshared First-Class letters volume, due to a combination of new growth and migration from single-piece First-Class letters, was the only story regarding volume over this early time period. That is, it was impossible to disengage meaningful responses from economic activity, price changes, and even seasonality from a general upward trend.

Prior to the introduction of worksharing discounts, single-piece and "workshared" First-Class letters would have been combined into a single volume series by the Postal Service's RPW system. Further, much, if not most, of the early growth in workshared First-Class letters can best be attributed to migration from single-piece First-Class letters. Hence, the volume volatility of workshared First-Class letters over this early time period would also be expected to adversely impact the volume of single-piece First-Class letters. For this reason, it was decided that the single-piece First-Class letters regression ought to start at the same time as the workshared First-Class letters regression.

The rapid and overwhelming growth of workshared First-Class letters eased into more stable growth, which allowed for more detailed analysis of other factors underlying changes in the volume of workshared First-Class letters (e.g., seasonal patterns, price elasticities) beginning around 1979. The workshared First-Class letters equation was run starting at various times between 1977Q1 and 1985Q1. Based on a minimum mean-squared error criterion, the optimal starting period was determined to be 1983Q1. When the workshared letters equation was estimated beginning prior to 1983Q1, the equation was improved by including a logistic market penetration variable (sometimes called a z-variable). In most cases, this market penetration variable reached its ceiling by the early-to-mid 1980s, around 1983Q1. The migration of single-piece First-Class letters into workshared First-Class letters was much smoother and easier to model beginning the equation in 1983Q1, as this logistic market penetration was no longer influencing workshared letters volume.

The regressions were ended in 1996Q3 to avoid potentially confounding the results with the impact of classification reform, which was implemented in 1996Q4.

Specifically, it appeared, in analyzing First-Class letter volume, that a substantial portion of workshared First-Class letters were shifted into the single-piece category after classification reform. It further appeared that the projected effects of changes in discounts, prices, and user costs (as will be described below) did not adequately model this shifting. It is hoped that with the addition of more post-MC95 data it will become possible to econometrically explain the movement between single-piece and workshared First-Class letters as a result of classification reform. In the meantime, however, to avoid any potential adverse reaction with any other regression coefficients that may inadvertently pick up some of the effect of classification reform, the regressions were terminated ending in 1996Q3, thereby completely eliminating any potentially confounding influences due to classification reform.

4. Modeling Shifts between Single-Piece and Worksharing Letters

One of the most obvious trends evident through even casual observation of First-Class letters volumes is that the share of total First-Class letters that are workshared has grown considerably over time. For example, in 1983 21.7 percent of First-Class letters were workshared. By 1991, this share grew to 34.2 percent. By 1996, the share of First-Class letters that were workshared was 42.4 percent, an increase of nearly 100 percent in thirteen years. While some of this growth was due to differences in demand characteristics between single-piece and workshared First-Class letters and differences in changes in the prices of single-piece and workshared First-Class letters over this time period, another important reason for this phenomenon was substitution of mail from single-piece First-Class letters into workshared First-Class letters.

Any demand equations that purport to accurately model the demands for single-piece and workshared First-Class letters must therefore take into account shifts between these two categories. A mailer will choose whether or not to workshare by comparing the costs to the mailer of worksharing vis-a-vis the discount offered by the Postal Service for the worksharing.[1] Thus, shifts from single-piece into workshared First-Class letters may occur for either of two reasons: due to changes in worksharing discounts offered by the Postal Service or due to changes in the cost of worksharing borne by mailers.

a. Shifts Due to Changes in Worksharing Discounts

Shifts between single-piece and workshared First-Class letters due to changes in price are modeled through the inclusion of the worksharing First-Class letters discount in the demand equations for both single-piece and workshared First-Class letters. The discount is used here, rather than the price, to reflect the nature of the decision being made by mailers, which is whether to workshare or not, as opposed to a decision of whether to send the mail or not. The reaction of mailers to changes in worksharing discounts may not fully take effect immediately following rate changes, however. Therefore, to account for possible lagged reactions of mailers to changes in worksharing discounts, the current discount is entered along with the discount lagged one through four quarters, as with the other price variables entered into the demand equations presented here.

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[1] The basic theory here is equivalent to the theory underlying my share equations, which are discussed in section IV below and are used to divide First-Class and Standard A mail into worksharing categories. The exact implementation of this methodology differs somewhat here, however, in order to integrate the concept of worksharing decisions with the notion that the demand characteristics associated with single-piece and workshared First-Class letters are fundamentally different.

The total volume leaving single-piece First-Class letters due to changes in worksharing discounts should be exactly equal to the volume entering workshared First-Class letters. Mathematically, this is a restriction that

$$(\partial V_{sp}/\partial d_{ws}) = -(\partial V_{ws}/\partial d_{ws}) \qquad \text{(II.2)}$$

where V_{sp} is the volume of single-piece First-Class letters, V_{ws} is the volume of workshared First-Class letters, and d_{ws} is the worksharing discount. Given the functional form used in this case,

$$(\partial V_{sp}/\partial d_{ws}) = \beta_{sp}\bullet(V_{sp}/d_{ws}) \qquad \text{(II.3)}$$

$$(\partial V_{ws}/\partial d_{ws}) = \beta_{ws}\bullet(V_{ws}/d_{ws})$$

where β_{sp} is the elasticity with respect to the worksharing discount in the single-piece letters equation and β_{ws} is the elasticity with respect to the worksharing discount in the worksharing letters equation.

Combining these results, and canceling out the d_{ws} from both sides of the equation, we get that

$$\beta_{sp} = -\beta_{ws}\bullet(V_{ws}/V_{sp}) \qquad \text{(II.4)}$$

This restriction was imposed on the single-piece First-Class letters equation. The value of β_{ws} was freely estimated rather than the value of β_{sp} because the worksharing discount, as expected, had a larger and more significant impact on worksharing First-Class letters than on single-piece letters. The value of (V_{ws}/V_{sp}) was calculated using the last four quarters of the regression period (1995Q4 - 1996Q3), and was equal to 0.742.

b. Shifts Due to Changes in the Cost of Worksharing

The cost to mailers of worksharing has been generally declining over time since the introduction of worksharing discounts. Three effects are principally at work leading to this result. First, there are initial learning costs associated with worksharing, such as understanding Postal requirements and developing proper mailing procedures. These costs will decline over time as mailers become more familiar with worksharing in general. Second, the costs to mailers of worksharing include large fixed costs to buy equipment and adjust mailing practices to facilitate worksharing. Once these fixed costs have been sunk, however, the marginal cost of continuing to workshare is relatively low. Hence, the average cost of worksharing will decline over time as these fixed costs are spread over a greater volume of mail. Finally, the declining cost of new technology works to lower worksharing costs. For example, the cost of new automation equipment is significantly less expensive than it was five years ago.

Shifts from single-piece into workshared First-Class letters due to declining user costs over time are modeled through the inclusion of logarithmic time trends in the demand equations for single-piece and workshared First-Class letters. Logarithmic time trends were found to perform better than linear or exponential time trends.

A simple logarithmic time trend in the workshared First-Class letters equation generates a constant percentage increase in the volume of workshared First-Class letters over time due to declining user costs. This constant percentage increase is of an ever-growing base, however, so that the actual volume increase implied by the time trend, expressed as a number of pieces of mail, is increasing over time. To capture this within the single-piece First-Class letters equation, the logarithmic time trend is also entered into the single-piece equation squared. The time trend squared has a negative coefficient, so that an increasing percentage of single-piece First-Class letters are migrating out of single-piece First-Class letters over time. In this way, migration out of single-piece First-Class letters is approximately equivalent to the migration into workshared First-Class letters over time without the need to resort to any artificial constraints to that effect.

5. Relationship of First-Class Letters with other Subclasses of Mail

a. Cross-Price Relationship with First-Class Cards

A cross-price with respect to private First-Class cards was included in the First-Class letters equations to acknowledge possible substitution between First-Class cards and First-Class letters. In the present instance, the cross-price elasticity obtained from the demand equation for private First-Class cards appeared more reasonable than the freely estimated cross-price elasticities in the First-Class letters regressions. Therefore, the Slutsky-Schultz equation was applied to the cross-price elasticity from the private First-Class cards regression, and the result was entered as a stochastic constraint in the First-Class letters regressions. See section III.B. below for the derivation of the Slutsky-Schultz relationship and a more detailed discussion of its application to First-Class letters and cards.

b. Relationship of First-Class Letters to Standard Mail

To the extent that consumers respond to direct mail advertising in the form of orders for products, bills, bill-payments, and receipts, Standard bulk mail volume would be expected to generate First-Class letters volume. Hence, in this respect, First-Class letters have a complementary relationship with Standard bulk mail. On the other hand, First-Class and Standard mail provide alternate means of delivering direct mail advertising. In this regard, therefore, First-Class and Standard mail act as substitutes.

Cross-volume variables with respect to Standard bulk regular and nonprofit mail are included in the demand specification for single-piece First-Class letters to model the complementary effect of Standard bulk mail volume on First-Class letters volume. A cross-price variable with respect to Standard Regular mail is also included in the demand equations for both single-piece and workshared First-Class letters to reflect the substitutability of these mail categories with Standard Regular mail.

i. Cross volumes

Because Standard mail is both a substitute and a complement for First-Class letters volume, it is problematic to attempt to freely estimate cross-volume and cross-price effects within the First-Class letters equations, since the variables used to measure these effects, Standard bulk mail volume and Standard bulk prices, are inevitably correlated. In addition, introducing the volume of one category of mail into the demand equation for another Postal volume may lead to endogeneity problems, since the volume of Standard bulk mail is likely to be highly correlated with First-Class letters residuals. This will be true for two reasons. First, there may well be common variables similarly affecting both of these categories of mail, some of which may be omitted from the First-Class letters equation. Second, the RPW sampling system ties mail volumes together in such a way as to lead to potential correlation in data changes across mail categories, even if these mail categories were completely independent of one another. Given these constraints, it should not be surprising to find that the freely estimated elasticities of single-piece letters with respect to Standard bulk regular and nonprofit mail are not estimated reliably from quarterly time series data. In fact, the cross volume elasticities with respect to Standard bulk regular and nonprofit mail in the single-piece First-Class letters equation (t-statistics in parentheses) were estimated econometrically to be equal to -0.040 (-0.484) and -0.227 (-2.781), respectively. Since advertising mail is expected to have a positive effect on First-Class letters volume, both of these results are counter to expectations. These results demonstrate the necessity of bringing additional information into the estimation process in this case.

The estimated cross-volume elasticity can be expressed theoretically as:

$$\text{Elasticity} = \frac{\text{(Response Rate)} \bullet \text{(Total Standard bulk mail volume)}}{\text{(Total First-Class letters volume)}} \qquad \text{(II.5)}$$

where the Response Rate refers to the rate of First-Class letters sent in response to Standard bulk mail received.

Equation (II.5) assumes that the response to Standard bulk mail volume is a single First-Class letter. A single piece of Standard bulk mail may generate multiple First-Class letters, however. For example, a single response to a piece of Standard mail may generate a bill for the product ordered in the initial response, a bill-payment, and possibly even a receipt for the product.

Response rates were calculated from Household Diary Study data for 1987 and 1988. These response rates gave the following elasticities:

TABLE II-2
Number of Responses Generated

		One	Two
Standard Bulk Regular	1988	0.0110	0.0236
	1987	0.0121	0.0242
Standard Bulk Nonprofit	1988	0.0035	NA
	1987	0.0036	NA

When the second piece of First-Class letter mail generated by the initial piece of Standard bulk regular mail was taken into account, the calculated elasticity doubled. In order to take into account the effect of an arbitrary number of pieces of First-Class Mail generated by the initial piece of Standard bulk mail, a conservative estimate of 2½ pieces of mail generated per response was used. This could correspond, for example, to one piece of mail to place an order, followed by an additional 1½ pieces of mail corresponding to either a bill and bill-payment (2 pieces), or a bill, bill-payment, and receipt (3 pieces), or even multiple bills and bill-payments (e.g., a response to a credit card solicitation which may generate 24 pieces of mail per year). It was assumed that the difference in the elasticity between the first and second pieces would be proportional to the difference between the second and the extra half of a piece of mail. Using this method gives an estimate of the cross-volume elasticity with respect to Standard regular volume for 1987 and 1988 of:

$$\begin{aligned} 0.0242 + 0.5\bullet(0.0242 - 0.0121) &= 0.0303 \\ 0.0236 + 0.5\bullet(0.0236 - 0.0110) &= 0.0299 \end{aligned} \qquad \text{(II.6)}$$

These numbers were then rounded to 0.030. For Standard bulk nonprofit, 2½ pieces of First-Class mail were also assumed to be generated by each response. It was also assumed that the change in elasticity associated with each additional piece of First-Class Mail would be proportional to the change in elasticity associated with Standard bulk regular mail. This yielded an estimated elasticity of 0.010 with respect to Standard bulk nonprofit mail.

These elasticities were only incorporated into the demand equation for single-piece First-Class letters, since the majority of responses would be expected to be sent in this way (e.g., initial responses, bill-payments, and receipts). The elasticities of 0.030 and 0.010 were scaled up proportionally to correspond only to single-piece First-Class letters. This scaling was done by multiplying the elasticities by the ratio of total First-

Class letters to single-piece First-Class letters. The scaled-up elasticities equal 0.040 and 0.013, respectively.

ii. Cross-Price with Standard Bulk Regular

(a) Theory

Some First-Class letter mail is direct mail advertising and could alternatively have been sent as Standard bulk regular mail. A cross-price with respect to Standard bulk regular mail was included in the First-Class letters demand equations to attempt to model this possible substitution between First-Class letters and Standard bulk regular mail.

(b) Calculation of Cross-Price Elasticity

According to the 1991 Household Diary Study, 4.9 percent of First-Class letters were classified as advertising-only. (1991 Household Diary Study, Table 4-33, p. IV-86). Thus, as a reasonable estimate, approximately 4.9 percent of First-Class letters would be expected to be substitutable with Standard bulk regular mail.

Making some assumptions, it is possible to use the Household Diary Study to estimate an expected cross-price elasticity between First-Class letters and Standard bulk regular mail. The following assumptions were used:

- The own-price elasticity of advertising-only letters is -0.500, approximately equal to the own-price elasticity of Standard bulk regular mail

- Advertising mail shifts between comparable presort categories: i.e.. noncarrier-route presort letters substitute with Standard Regular mail and carrier-route presort letters substitute with Standard Enhanced Carrier Route mail

- The maximum reasonable shift of advertising mail is a shift of total postage costs

According to the 1991 Household Diary Study, 3.1 percent of nonpresort letters were advertising-only, 7.9 percent of 3/5-digit presort letters were advertising-only, and 13.6 percent of carrier-route presort letters were advertising-only (1991 Household Diary Study, Table 4-36, p. IV-95). This yields the following data:

TABLE II-3
ADVERTISING-ONLY COMPONENT OF FIRST-CLASS LETTERS

	Volume (millions of pieces)	Revenue (millions of dollars)	Revenue per Piece
Nonpresort letters	1,702.978	$597.133	$0.35064
3/5-digit presort	2,342.324	$615.773	$0.26289
Noncarrier-route presort	4,045.302	$1,212.906	$0.29983
Carrier-route presort	381.113	$91.429	$0.23990
Total	4,426.415	$1,304.335	$0.29467

Source: 1991 Household Diary Study and 1993 RPW reports

Table II-4 presents the volume, revenue, and revenue per piece for non-carrier-route presort and carrier-route presort Standard bulk regular mail in 1993.

TABLE II-4
STANDARD BULK REGULAR VOLUME AND REVENUE BY PRESORT CATEGORY

	Volume (millions of pieces)	Revenue (millions of dollars)	Revenue per Piece
Non-Carrier-Route Presort	25,614.157	$4,644.729	$0.18133
Carrier-Route Presort	27,712.465	$3,658.651	$0.13202
Total	53,326.622	$8,303.380	$0.15571

Source: 1993 RPW reports

Combining the data in Tables II-3 and II-4, cross-price elasticities between mail categories of First-Class letters and Standard bulk regular can be generated as follows.

A one percent rise in the price of noncarrier-route presort letters leads to a loss of noncarrier-route letters revenue of

$$(4045.302)\bullet(0.005)\bullet(\$0.29983) = \$6.065 \qquad \text{(II.7)}$$

Assuming that this shifts entirely into non-carrier-route Standard bulk regular mail, this leads to an increase in non-carrier-route Standard bulk regular volume of

$$(\$6.065) / (\$0.18133) = 33.444 \qquad \text{(II.8)}$$

yielding a cross-price elasticity for non-carrier-route Standard bulk regular mail with respect to noncarrier-route presort First-Class letters of

$$100 \bullet (33.445) / (25614.157) = 0.130 \qquad \text{(II.9)}$$

A one percent rise in the price of carrier-route presort letters leads to a loss of carrier-route presort letters revenue equal to

$$(381.113)\bullet(0.005)\bullet(\$0.23990) = \$0.457 \qquad \text{(II.10)}$$

Assuming that this revenue shifts entirely into carrier-route presort Standard bulk regular mail, this leads to an increase in carrier-route Standard bulk regular mail volume of

$$(\$0.457) / (\$0.13202) = 3.463 \qquad \text{(II.11)}$$

yielding a cross-price elasticity for carrier-route Standard bulk regular mail with respect to carrier-route presort First-Class letters of

$$100 \bullet (3.463) / (27712.465) = 0.0125 \qquad \text{(II.12)}$$

The estimated cross-price elasticity between carrier-route First-Class and Standard mail is virtually non-existent, and can thus be disregarded. Hence, Standard Regular mail is estimated to have a cross-price elasticity with respect to First-Class letters[2]

[2] For simplicity, the price of total First-Class letters was used in this equation, including carrier-route letters. Carrier-route letters represent fewer than five percent of total First-Class letters.

equal to 0.130. The cross-price elasticities of single-piece and workshared First-Class letters with respect to Standard Regular mail were calculated from this result using the Slutsky-Schultz equality condition, and were calculated to be equal to 0.019 and 0.035, respectively.

6. Single-Piece First-Class Letters

The demand equation for single-piece First-Class letters models single-piece First-Class letters volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory Income (lagged three quarters to reflect a lagged reaction of single-piece First-Class mailers to changing economic conditions)
- The volumes of Standard bulk regular mail (lagged one quarter) and Standard bulk nonprofit mail, with elasticities constrained to values of 0.040 and 0.013, respectively, as derived above
- Logarithmic time trend and logarithmic time trend squared to reflect increasing attractiveness of worksharing First-Class options
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
  [Coefficient constrained to a value of 0.024 based on analysis of government use of single-piece First-Class letters from 1988Q1 through 1992Q4, as described in section III.A.4.b. below.]
- Current and four lags of the average worksharing discount for First-Class letters, with the sum of the coefficients constrained from the worksharing First-Class letters equation as described above
- Current and four lags of the price of private single-piece First-Class cards, with the sum of the coefficients stochastically constrained from the private First-Class cards equation using Slutsky-Schultz equality constraint
- Current and four lags of the price of Standard regular mail, with the sum of the coefficients constrained from the Household Diary Study as described above
- Current and four lags of the price of single-piece First-Class letters

Elasticities are listed in Table II-5.

The own-price elasticity of single-piece First-Class letters is equal to -0.189 (t-statistic of -1.684). In addition to the price of single-piece letters, single-piece First-

Class letters volume is also affected by the level of the First-Class letters worksharing discount (elasticity of -0.164) due to mailers shifting from single-piece into workshared First-Class letters. Single-piece First-Class letters also have modest positive cross-price elasticities with respect to single-piece First-Class cards and Standard regular mail. The aggregate elasticity of single-piece First-Class letters with respect to Postal prices (i.e., the impact of an across-the-board Postal rate increase on single-piece First-Class letters volume) is equal to -0.329, with a t-statistic of -2.933.

Single-piece First-Class letters have a permanent income elasticity of 0.456 (t-statistic of 19.80) versus a transitory income elasticity of 0.135 (t-statistic of 1.375).

Single-piece First-Class letters volume is adversely affected by the gradual decline in user costs associated with worksharing that has led to an increase in the proportion of mail being workshared. This is modeled by the inclusion of the time trend and time trend squared variables. The significant negative time trend squared (coefficient of -0.331, with a t-statistic of -9.039) indicates that single-piece letters volume is declining at an increasing rate due to these considerations. Over the past five years, the time trend and trend squared variables have accounted for an 11.2 percent decline in the volume of single-piece First-Class letters, while other factors would have led one to expect single-piece letters volume per adult to grow by 0.5 percent over this same time period.

The volume of single-piece First-Class letters is heaviest in October, mid-December (December 13th - 19th), and early April. Single-piece First-Class letters volume is lightest just after Christmas.

The mean-squared error associated with the single-piece First-Class letters equation is a quite favorable 0.000310. This is, however, somewhat less favorable than the regression diagnostics associated with the total First-Class letters equation in R94-1. No AR-correction is needed within this equation, however, as opposed to an AR-2 correction which was used in R94-1. A comparison of the goodness-of-fit in explaining First-Class letters volume versus R94-1 is presented below following the discussion of workshared First-Class letters for this case.

7. Workshared First-Class Letters

The demand equation for workshared First-Class letters models workshared First-Class letters volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory Income
- Logarithmic time trend reflecting increasing attractiveness of worksharing First-Class options
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the average worksharing discount for First-Class letters
- Current and four lags of the price of workshared First-Class cards, with the sum of the coefficients stochastically constrained from the private First-Class cards equation using Slutsky-Schultz equality constraint
- Current and four lags of the price of Standard regular mail, with the sum of the coefficients constrained from the Household Diary Study as described above
- Current and four lags of the price of workshared First-Class letters

Elasticities are listed in Table II-6.

The own-price elasticity of workshared First-Class letters is equal to -0.289, with a t-statistic equal to -1.683. The volume of workshared First-Class letters is positively influenced by changes in the First-Class worksharing discount, with a discount elasticity equal to 0.222 (t-statistic of 2.704). As with single-piece letters, workshared First-Class letters also have modest cross-price elasticities with respect to First-Class cards and Standard regular mail. In the aggregate, workshared First-Class letters volume is virtually unaffected by Postal rates, with an aggregate Postal price elasticity equal to -0.027 (t-statistic of -0.161).[3]

Workshared First-Class letters have a permanent income elasticity of 0.405 (t-statistic of 13.71), and a transitory income elasticity of 0.361 (t-statistic of 2.192). The permanent income elasticity of workshared First-Class letters is somewhat smaller in magnitude than was the case for single-piece letters. The transitory income elasticity of workshared letters is more than twice as large in magnitude as the transitory income elasticity of single-piece letters. This is due to differences in the originators of single-piece versus worksharing First-Class letters. Single-piece First-Class letters are generated primarily by individual consumers, who are driven principally by permanent income in making consumption decisions (see section III.A.2.b. below), whereas much worksharing First-Class letters volume is driven more directly by businesses, who might be expected to be more significantly affected by changes in transitory income in making consumption decisions.

The strongest seasons for workshared First-Class letters volume are from November 1st through January 1st, peaking after Christmas with year-end bills and statements. Workshared First-Class letters volume also observes regular quarterly peaks in March, June, and September, in addition to the year-end peak. These peaks may be explainable in part to the delivery of quarterly financial statements.

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[3] An across-the-board percentage increase in all Postal rates would also lead to an increase in the worksharing First-Class letters discount of the same percentage magnitude. If one considered, instead, an across-the-board increase in the prices of workshared First-Class letters, First-Class cards, and Standard regular mail, workshared First-Class letters volume would have a relative elasticity of -0.248. Note that this would imply an increase in the price of single-piece First-Class letters of the same *magnitude* as workshared First-Class letters, but of a *smaller* percentage.

Workshared First-Class letters volume is positively affected by generally declining user costs over time which have served to make worksharing more attractive to a larger group of mailers. The time trend included in the worksharing First-Class letters equation, which has an estimated coefficient of 0.727 and a t-statistic equal to 25.76, has accounted for a 23.9 percent increase in worksharing letters volume over the past five years.

The mean-squared error of the workshared First-Class letters equation in Table II-6 is equal to 0.000832. No AR-correction is needed in this equation, and the adjusted-R^2 is extremely impressive at 0.990.

In Docket No. R94-1, a single demand equation was modeled for all First-Class letters. This demand equation had a mean-squared error associated with it that was equal to 0.000201. Because First-Class letters are now modeled through separate equations for single-piece and workshared First-Class letters it is somewhat difficult to compare the regression diagnostics in this case with those from R94-1.

Mathematically, the R94-1 specification fit First-Class letters volume to the following specification:

$$\mathrm{Ln}(\mathrm{Vol}_{\mathrm{Letters}}) = Xb + e \qquad \text{(II.13)}$$

where $\mathrm{Vol}_{\mathrm{Letters}}$ is the volume of First-Class letters, X is a matrix of explanatory variables, and b is the vector of estimated elasticities. In this case, the mean-squared error of 0.000201 reported above is equal to (e'e)÷(degrees of freedom), or, in words, sum of squared residuals divided by degrees of freedom, where residuals are equal to the difference between total First-Class letters volume and fitted First-Class letters volume (expressed as logarithms).

For the present case, total First-Class letters volume is implicitly modeled as the sum of two unique demand equations as follows:

$$Vol_{Letters} = Vol_{Single\text{-}Piece} + Vol_{Workshared} \qquad (II.14)$$

where

$$Ln(Vol_{Single\text{-}Piece}) = X_1b_1 + e_1, \text{ and } Ln(Vol_{Workshared}) = X_2b_2 + e_2 \qquad (II.15)$$

In this case, the mean-squared errors presented in Tables II-5 and II-6 of my testimony are calculated using e_1 and e_2, respectively.

The residual e in equation (II.13) can be expressed in terms of the Volume of total letters as follows:

$$e = Ln(Vol_{Letters} \div V'_{Letters}) \qquad (II.16)$$

where $V'_{Letters}$ is the fitted value of $Vol_{Letters}$, where, in R94-1, $V'_{Letters}$ was equal to Xb from equation (II.13) above. A comparable measure of e can be derived in this case by calculating $V'_{Letters}$ to be equal to the sum of the fitted values of single-piece and workshared letters from equation (II.15) above. Once a new series of residuals is constructed in this way, a mean-squared error can then be calculated which will be generally comparable to the mean-squared error of 0.000201 for total First-Class letters cited in Docket No. R94-1.

One additional complication needs to be introduced in calculating a mean-squared error for total First-Class letters for this case. This involves the calculation of degrees of freedom. The separate single-piece and workshared First-Class letters equations use data from 1983Q1 through 1996Q3, a total of 55 observations for both categories of mail, for a total of 110 volume observations. The single-piece letters equation relies on 28 unconstrained explanatory variables, while the workshared letters equation relies on

29 unconstrained explanatory variables. The total number of degrees of freedom for a multiple-equation system can be calculated as

$$df = T \cdot N - (P + \tfrac{1}{2} \cdot N \cdot (N+1)) \tag{II.17}$$

where T is the number of observations (55 in this case), N is the number of equations in the system (2) and P is the total number of unconstrained explanatory variables (28+29=57). Using equation (II.17), total First-Class letters are estimated with a total of 50 degrees of freedom. This compares with a total of 69 degrees of freedom in Docket No. R94-1.

The calculated mean-squared error associated with total First-Class letters in this case is equal to 0.000086. In other words, the present demand specifications represent a better than 50 percent improvement in explaining First-Class letters volume as compared with R94-1 using a simple mean-squared error criterion.

8. Total Cards

First-Class cards can be divided into two categories: stamped cards and private cards. Stamped cards, also called postal cards or government cards, are cards which are sold by the Postal Service with postage already imprinted. Postal cards represent approximately 10 percent of all First-Class cards in the Test Year (before-rates). Private cards are cards not provided by the Postal Service. Private First-Class cards may be further divided between single-piece and workshared cards, each of which represent approximately 45 percent of total First-Class cards in the Test Year (before-rates). This breakdown is comparable to the breakdown of First-Class letters used above. Separate demand equations are estimated for postal and private First-Class cards. Single-piece and workshared private First-Class cards are combined for purposes of estimating a demand equation, but are separated in making volume forecasts.

a. Stamped Cards

The demand equation for stamped cards models stamped cards volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory income
- Dummy variable reflecting a change in RPW data starting in 1993Q1, reflecting a revised methodology for reporting workshared First-Class Mail. Variable is equal to zero through 1992Q4, equal to one thereafter.
- Current and four lags of the price of postal cards

Elasticities are listed in Table II-7.

The price elasticity of postal cards is -0.168 (t-statistic of -0.281). This is comparable to the price elasticity of single-piece First-Class letters discussed above, which is to be expected. The demand for postal cards is affected by both permanent and transitory income, with income elasticities of 0.711 (t-statistic of 15.39) and 0.160 (t-statistic of 0.220) with respect to permanent and transitory income respectively.

The volume of postal cards has been somewhat unstable over time. Hence, the demand equation for postal cards is not fit nearly as reliably as the demand equations for other categories of First-Class Mail. The mean-squared error of the postal cards equation is 0.026649, with an adjusted-R^2 of 0.678.

b. Private Cards

i. Analysis of Private Cards Parallel to First-Class Letters

Private First-Class cards could be divided between single-piece and workshared First-Class cards as was done with First-Class letters above. Separate equations were investigated for single-piece and workshared First-Class cards along the lines of the First-Class letters equations described above.

The resulting equation for single-piece First-Class cards was fairly reasonable, although the cross-price elasticity with First-Class letters and own-price elasticity interacted somewhat unfavorably. If the cross-price with respect to First-Class letters was removed from the specification, however, the own-price elasticity of single-piece private First-Class cards was estimated to be equal to -0.721 (t-statistic of -1.812), with an elasticity with respect to the worksharing cards discount of -0.269 (t-statistic of -1.448). The mean-squared error of the single-piece cards equation (again, excluding the cross-price with First-Class letters) was calculated to be equal to 0.008398.

Attempts to estimate a demand equation for workshared First-Class cards proved much less fruitful, however. None of the handful of specifications for workshared First-Class cards investigated for this case yielded an own-price elasticity of the expected sign, unless the discount elasticity was constrained from the single-piece cards equation. Even in this case, the estimated own-price elasticity of workshared cards was very poorly estimated (-0.123. t-statistic of -0.129). Including no cross-price variables whatsoever (including the cards discount) yielded an own-price elasticity estimate for workshared cards of +0.228. In addition to the illogical price elasticities which arose from the workshared cards equation, the mean-squared error of the equation was quite disappointing, being in excess of 0.02 for all of the equations tested.

Ultimately, attempts to estimate separate demand equations for single-piece and workshared cards were deemed unsuccessful, and a single demand equation was estimated for private First-Class cards, as was done in Docket No. R94-1 by Dr. Tolley.

ii. Demand Equation for Total Private First-Class Cards

The use of a single demand equation for private cards provides the ability to include a considerable amount of additional data in estimating the demand equation, as compared with single-piece versus workshared equations. In particular, the demand equation was estimated over a sample period beginning in 1971Q1, more than five years prior to the introduction of any worksharing discounts by the Postal Service. In addition, because shifts between single-piece and workshared First-Class cards are irrelevant to an aggregate private First-Class cards model, it was possible to include the post-MC95 period of 1996Q4 through 1997Q2 that had to be excluded from the estimation of the First-Class letters equations.

The demand equation for private First-Class cards used in this case is nearly identical to the demand equation presented by Dr. Tolley in Docket No. R94-1. The principal difference between the two models is in the treatment of seasonality. The demand equation for First-Class private cards in this case models private First-Class cards volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Logistic Market Penetration variable (Z-Variable) to reflect the positive impact of enhanced profitability of direct mail advertising due to computerization of the early 1980s on private First-Class cards volume, as described in section III.B.5. below
- Permanent Income (as described in section III.A.2.b. below)
- Machine Dummy variable to reflect mailer adjustments to Postal Service regulations implemented in 1979Q4 restricting the mailing of First-Class cards with holes punched in them. Variable is equal to zero through 1979Q3, incrementing by 0.25 from 1979Q4 until reaching a value of one in the third quarter of 1980 (to reflect a lag in the enforcement of this particular rule), remaining at one through 1981Q3, and decreasing by 0.25 from 1981Q4 through 1982Q3, remaining at zero thereafter (reflecting mailer adaptation to this rule).
- Crossover Dummy variable reflecting the pricing of 3/5-digit presort First-Class cards less than the price of 3/5-digit presort third-class bulk regular mail

over the R87-1 rate regime (13.0¢ versus 13.2¢). Variable is equal to one from 1988Q4 through 1991Q3, zero elsewhere.

- Crossover Dummy variable interacted with a time trend beginning in 1988Q4 to reflect lagged reaction by mailers to R87-1 rate crossover
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
  [Coefficient constrained to a value of 0.006 based on analysis of government use of private First-Class cards from 1988Q1 through 1992Q4, as described in section III.A.4.b. below.]
- Current and four lags of the price of First-Class Letters
- Current and four lags of the price of private First-Class cards

Elasticities are listed in Table II-8.

The own-price elasticity of private First-Class cards was calculated to be equal to -0.944, with a t-statistic of -7.255. Private First-Class cards also have a cross-price elasticity with respect to First-Class letters equal to 0.197 (t-statistic of 1.390). Private First-Class cards have a permanent income elasticity of 0.699 (t-statistic of 15.95), while transitory income is not modeled to have any impact on private cards volume.

The private First-Class cards equation still includes a market penetration variable as was used in Docket No. R94-1 by Dr. Tolley to help to explain the growth of First-Class letters and cards as well as third-class bulk mail volumes in the early 1980s. While it would be preferable to include an economic variable that helps to explain the cause of this rapid growth, no acceptable variable of this sort has been found to work adequately in the private cards equation. The failure to include this variable in the private First-Class cards equation has a significant deleterious effect on the estimated regression diagnostics, however, so that the logistic market penetration variable was retained for this case, albeit with reservation.

The mean-squared error of the private First-Class cards equation is equal to 0.004789, which compares favorably to the value from Dr. Tolley's R94-1 private cards equation of 0.005581.

TABLE II-5
SINGLE-PIECE FIRST-CLASS LETTERS

	Coefficient	T-statistic
First-Class Single-Piece Letters price -- SUM	-0.189	-1.684
current	-0.106	-1.774
lag 1	-0.061	-1.668
lag 2	-0.022	-0.617
lag 3	-0.001	-0.018
First-Class Single-Piece Cards price -- SUM	0.005	1.065
current	0.001	0.116
lag 1	0.001	0.406
lag 2	0.002	0.271
lag 3	0.001	0.202
Standard Regular price -- SUM	0.019	---
current	0.004	0.346
lag 1	0.005	1.424
lag 2	0.006	0.877
lag 3	0.004	0.590
Worksharing First-Class Letters Discount -- SUM	-0.164	---
current	-0.112	-1.645
lag 1	-0.030	-0.454
lag 2	-0.018	-0.307
lag 3	-0.004	-0.070
Permanent Income	0.456	19.80
Transitory Income (lag 3)	0.135	1.375
Standard bulk regular volume (lag 1)	0.040	---
Standard bulk nonprofit volume	0.013	---
Declining Worksharing User Costs:		
Time Trend	2.371	8.256
Time Trend Squared	-0.331	-9.039
Dummy for use of Government-Distributed Volume	0.024	---
Seasonal coefficients:		
September	-0.389	-1.275
October	0.361	0.921
Nov. 1 - Dec. 12	-0.218	-0.601
Dec. 13 - 19	0.280	0.759
Dec. 20 - 24	-0.241	-0.801
Dec. 25 - Jan. 1	-1.012	-1.290
Jan 2 - Feb. 28	0.131	1.057
March	-0.303	-1.022
April 1 - 15	0.564	0.857
April 16 - May	-0.200	-0.778
June	-0.121	-0.350

REGRESSION DIAGNOSTICS :

AR coefficients	None
Mean Square Error	0.000310
Degrees of Freedom	27
Adjusted-R^2	0.943

TABLE II-6
WORKSHARED FIRST-CLASS LETTERS

	Coefficient	T-statistic
Worksharing First-Class Letters price – SUM	-0.289	-1.683
current	-0.068	-0.619
lag 1	-0.079	-1.325
lag 2	-0.078	-1.262
lag 3	-0.064	-1.138
Worksharing First-Class Cards price – SUM	0.006	0.939
current	0.003	0.249
lag 1	0.002	0.439
lag 2	0.001	0.112
lag 3	0.000	0.000
Standard Regular price – SUM	0.035	---
current	0.019	0.828
lag 1	0.011	1.460
lag 2	0.004	0.325
lag 3	0.000	0.002
Worksharing First-Class Letters Discount – SUM	0.222	2.704
current	0.084	0.782
lag 1	0.068	1.010
lag 2	0.060	0.894
lag 3	0.009	0.130
Permanent Income	0.405	13.71
Transitory Income	0.361	2.192
Declining Worksharing User Costs:		
Time Trend	0.727	25.76
Dummy for use of Government-Distributed Volume	0.026	1.382
Seasonal coefficients:		
September	0.506	1.049
October	-0.153	-0.430
Nov. 1 - Dec. 15	0.738	1.495
Dec. 16 - 21	0.517	0.895
Dec. 22 - 24	-0.595	-1.133
Dec. 25 - Jan. 1	2.804	2.002
Jan 2 - Feb. 28	0.156	0.777
March	0.724	1.533
April 1 - 15	-0.402	-0.371
April 16 - May	0.367	0.867
June	0.794	1.460

REGRESSION DIAGNOSTICS :

AR coefficients	None
Mean Square Error	0.000832
Degrees of Freedom	26
Adjusted-R^2	0.990

TABLE II-7
FIRST-CLASS STAMPED CARDS

	Coefficient	T-statistic
First-Class postal cards price – SUM	-0.168	-0.281
current	-0.101	-0.415
lag 1	-0.052	-0.288
lag 2	-0.015	-0.119
lag 3	-0.000	-0.000
Permanent Income	0.711	15.39
Transitory Income	0.160	0.220
Dummy for Mailing-Statement Adjustment to Data	-0.176	-1.339
Seasonal coefficients:		
September	0.931	1.595
October	-0.544	-1.415
Nov. 1 - Dec. 10	0.841	2.334
Dec. 11 - 12	3.280	1.552
Dec. 13 - 24	-0.178	-0.335
Dec. 25 - Jan. 1	-0.430	-0.516
Jan 2 - Feb. 28	0.295	1.746
March - June	0.214	1.266

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.520
AR-2 coefficient	0.282
Mean Square Error	0.026649
Degrees of Freedom	89
Adjusted-R^2	0.678

TABLE II-8
FIRST-CLASS PRIVATE CARDS

	Coefficient	T-statistic
First-Class private cards price -- SUM	-0.944	-7.255
current	-0.315	-2.130
lag 1	-0.273	-2.826
lag 2	-0.180	-1.766
lag 3	-0.176	-1.827
First-Class letters price -- SUM	0.197	1.390
current	0.038	0.318
lag 1	0.056	1.010
lag 2	0.065	1.064
lag 3	0.037	0.629
Permanent Income	0.699	15.95
Machine dummy variable	-0.122	-4.870
Crossover dummy	0.049	1.220
Crossover trend	0.008	1.578
Parameters used in calculating Z-variable:		
Param1	0.379	6.822
Param2	241.8	0.475
Param3	0.135	2.566
Dummy for use of Government-Distributed Volume	0.006	---
Seasonal coefficients:		
September	0.000	---
October	0.945	3.199
Nov. 1 - Dec. 17	-0.555	-3.443
Dec. 18 - Jan. 1	0.879	2.732
Jan 2 - Feb. 28	-0.030	-0.512
Mar. 1 - Apr. 15	0.157	0.865
April 16 - May	-0.161	-1.648
June	0.182	0.830

REGRESSION DIAGNOSTICS :

AR-1 coefficient	-0.029
AR-2 coefficient	-0.207
Mean Square Error	0.004789
Degrees of Freedom	82
Adjusted-R^2	0.938

C. Periodical Mail

1. General Overview

The demand for Periodical mail is a derived demand, which is derived from the demand of consumers for magazines and newspapers. Those factors which influence the demand for newspapers and magazines would therefore be expected to be the principal drivers of the demand for Periodical mail.

The factors which would be expected to influence the demand for newspapers and magazines are drawn from basic micro-economic theory. These factors include permanent and transitory income (see section III.A.2.b for an overview of the theoretical underpinnings of permanent and transitory income), the price of newspapers and magazines, and the demand for goods which may serve as substitutes for newspapers and magazines.

The price of newspapers and magazines is divided into two components for the purposes of modeling demand equations for Periodical mail. The first component is the price of postage paid by publishers (and paid, implicitly by consumers through subscription rates). In addition to affecting the price of newspapers and magazines by being incorporated into subscription rates, the price charged by the Postal Service will also affect the demand for Periodical mail directly by affecting publishers' decisions over how to deliver their periodicals. For example, relatively few newspapers are delivered through the mail. This is due, in part, to the existence of inexpensive alternate delivery systems (e.g., paper boys).

The second component of the price of newspapers and magazines considered in this analysis is the price of paper, modeled by the Bureau of Labor Statistics' wholesale price of pulp, paper, and allied products. This index is used in the Periodical mail equations to track the non-Postal price of periodicals. This component of the price of periodicals will only affect the demand for Periodical mail indirectly insofar as it is incorporated into subscription prices.

The principal substitute for newspapers and magazines that is considered in this analysis is television. Over the past twenty-five years, the variety of television available has undergone a dramatic change with the arrival and market penetration of cable television. Real cable television expenditures per adult increased nine-fold from 1971 to 1984, growing at more than 17 percent per year over this time period. Since that time, the rate of growth of cable television expenditures has slowed considerably. Nevertheless, it has continued to grow at a strong 2.6 percent annual rate over this time period.

It seems likely that cable television would provide a closer substitute for magazines than network television. Cable television provides more specialized programming (e.g., CNN, ESPN) than traditional network TV, thereby becoming a closer substitute to more specialized magazines (for example, CNN substitutes for Newsweek and Time, and ESPN substitutes for Sports Illustrated). To reflect this substitution between cable television and Periodical mail, cable television expenditures were included as an explanatory variable in the demand equations for Periodical mail.

Periodical mail is divided into one regular subclass and three preferred subclasses: within-county, nonprofit, and classroom mail. Separate demand equations were modeled for each of the four subclasses of Periodical mail. Periodical regular mail accounts for nearly 70 percent of total Periodical mail, and is considered first below.

2. Regular Rate

The demand equation for Periodical regular rate mail models Periodical regular rate mail volume as a function of the explanatory variables outlined above. The specific variables used in the Periodical regular mail equation were as follows:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory income (lagged three quarters to reflect a lagged adjustment of economic conditions into changes in subscription bases)
- Real cable television expenditures per adult
- The wholesale price of pulp and paper
- Current and four lags of the price of Periodical regular mail

Elasticities are listed in Table II-9.

The own-price elasticity of Periodical regular mail is equal to -0.143, with a t-statistic of -2.730. The own-price elasticity of Periodical regular mail is smaller in magnitude than virtually all of the other price elasticities presented in my testimony. The reason for this is two-fold. First, the price of postage represents a relatively minor component of the total cost of preparing and delivering a periodical. Hence, the impact of a change in postal prices would be expected to have a relatively modest impact on subscription rates. Even if this were the case, however, the Postal price-elasticity of Periodical regular mail could be quite high if the delivery of periodicals were a highly competitive business. In fact, the delivery of magazines by sources other than the Postal Service is quite minimal, in part because Postal rates are quite favorable to Periodical mail due to Educational, Cultural, Scientific, and Informational (ECSI) considerations. These factors combine to account for the relative price-inelasticity of Periodical regular mail.

The price of paper also has a relatively modest impact on the demand for Periodical regular mail, with an estimated elasticity of -0.164 with a t-statistic of -1.182. This value is also quite small, suggesting that publishers are generally either unable or unwilling to pass increases in input costs along to consumers in the form of higher subscription rates.

The permanent income elasticity of Periodical regular mail is equal to 0.527 (t-statistic of 12.46), while the transitory income elasticity is negligible (coefficient of 0.034, t-statistic of 0.292). The significant difference in impacts of permanent and transitory incomes is consistent with the permanent income hypothesis and the nature of the demand for Periodical mail as being fundamentally consumer-driven.

Cable television is modeled to be a significant substitute for Periodical regular mail, with a small, but highly significant, estimated elasticity of -0.062 (t-statistic of -3.630) with respect to cable television expenditures. The volume of Periodical regular mail is surprisingly seasonal in nature.

The regression diagnostics are acceptable for Periodical regular mail. The mean-squared error is equal to 0.000821. This represents a slight improvement over R94-1 (0.000898).

3. Preferred Periodical Subclasses

a. Overview

The Postal Service offers preferred rates for certain types of periodical mailers. Preferred Periodical mail is divided into three subclasses on the basis of either the mailer or the mail content: within-county mail, which is mail sent within a particular county, and is comprised primarily of small local publications (mostly newspapers); nonprofit mail, which is mail sent by not-for-profit organizations; and classroom mail, which is mail for students sent to classrooms and educational institutions.

The basic theory of demand for the preferred categories of Periodical mail is expected to be similar to the theory outlined at the introduction to this section. The one exception to this may be the demand for classroom mail, which may be expected to be less obviously substitutable by television.

The price of paper was investigated in these demand equations, consistent with the theory outlined above. The price of paper was not found to affect the volume of Periodical preferred-rate mail, however. This could have occurred for a variety of reasons, including the possibility that preferred-rate mailers are less sensitive to these prices, or that there are fewer substitutes for printed material within these contexts, so that this type of mail would be less price-sensitive in general. In addition, all three preferred-rate subclasses were found to be more sensitive to Postal prices than Periodical regular mail is.

Television, including cable television, would be expected to be a substitute for both within county and nonprofit Periodical mail in much the same way as television and Periodical regular mail are substitutes. Hence, cable television expenditures were included in both of these demand equations. In the within-county equation, however, the cable television expenditure elasticity had to be constrained from the Periodical regular mail equation.

Cable television expenditures, which grew dramatically in the 1970s, are highly correlated with the price of within county mail, which also grew considerably in the 1970s. When both of these variables were freely estimated in the within county equation, the coefficient on cable expenditures was estimated to be equal to 0.107 (t-statistic of 1.315), while the own-price elasticity of within county mail was estimated to be equal to -0.810 (t-statistic of -5.339). The mean-squared error on this equation was 0.004687. When the coefficient on cable television expenditures was constrained instead to be equal to -0.062, from the Periodical regular equation, the own-price elasticity had a much lower standard error (elasticity of -0.530, t-statistic of -6.882), while the mean-squared error fell to 0.004615. Viewing both of these as improvements, the coefficient on cable television expenditures was constrained in the within county mail equation to a value equal to the cable television expenditures elasticity of Periodical regular mail.

The specific demand equations for Periodical within county, nonprofit, and classroom mail are described below.

b. Within-County

The demand equation for within-county mail models Periodical within-county mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Real cable television expenditures per adult, with the elasticity constrained to -0.062 from the Periodical Regular equation, as described above
- Dummy variable reflecting a change in the reported volume of within-county mail due to a change in the system for reporting within-county volume. Variable is equal to zero through 1984Q4, equal to one thereafter.
- Dummy variable reflecting a change in the sampling framework used to report within-county mail volume, starting in 1993Q2. Variable is equal to zero through 1993Q1, equal to one thereafter.
- Current and four lags of the price of within county mail

Elasticities are listed in Table II-10.

The own-price elasticity of within-county mail is equal to -0.530 (t-statistic of -6.882). This is considerably larger in magnitude than the own-price elasticity of Periodical regular rate mail. Within county mail is also the only subclass of Periodical mail unaffected by transitory income. This could suggest that the demand for newspapers is less affected by changes in the business cycle than the demand for magazines.

The regression diagnostics are less favorable for within county mail than for regular rate Periodical mail, due to the smaller and inherently more volatile volume series. The mean-squared error associated with within county mail is equal to 0.004615, although the adjusted-R^2 is quite impressive at 0.945.

c. Nonprofit

The demand equation for Periodical nonprofit mail models Periodical nonprofit mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory income (lagged three quarters to reflect a lagged adjustment of economic conditions into changes in subscription bases)
- Real cable television expenditures per adult
- Current and four lags of the price of Periodical nonprofit mail

Elasticities are listed in Table II-11.

The own-price elasticity of Periodical nonprofit mail is equal to -0.228, with a t-statistic of -1.634. The cross-elasticity with respect to cable television expenditures is equal to -0.101 (t-statistic of -1.139). Both of these elasticities are somewhat greater than for Periodical regular mail, suggesting that nonprofit periodicals have a somewhat greater degree of substitution with other alternatives, including cable television. Periodical nonprofit mail volume is also considerably more sensitive to changes in income than regular rate mail, with income elasticities of 0.535 (t-statistic of 14.01) and 0.458 (t-statistic of 1.588) with respect to permanent and transitory income, respectively.

The regression diagnostics from the Periodical nonprofit equation are comparable to those from the within-county equation, with a mean-squared error of 0.004412 and an adjusted-R^2 equal to 0.852.

d. Classroom

The demand equation for classroom mail models Periodical classroom mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory income (lagged three quarters)
- Dummy variable reflecting the addition of a new mailer in 1987 which served to double classroom mail volume. Variable is equal to zero through 1987Q2, equal to one thereafter.
- Current and four lags of the price of classroom mail

Elasticities are listed in Table II-12.

TABLE II-9
PERIODICAL REGULAR RATE

	Coefficient	T-statistic
Periodical regular rate price – SUM	-0.143	-2.730
current	-0.032	-1.014
lag 1	-0.037	-2.034
lag 2	-0.043	-2.310
lag 3	-0.032	-1.948
Permanent Income	0.527	12.46
Transitory Income (lag 3)	0.034	0.292
Wholesale price of pulp and paper	-0.164	-1.182
Cable television expenditures	-0.062	-3.630
Seasonal coefficients:		
September	-0.526	-3.344
October	-0.210	-2.427
Nov. 1 - Dec. 10	0.040	0.663
Dec. 11 - 24	-0.558	-3.544
Dec. 25 - Feb. 28	-0.096	-2.369
March	-0.279	-2.646
April 1 - 15	0.805	4.028
April 16 - June	-0.392	-3.637
REGRESSION DIAGNOSTICS :		
AR-1 coefficient	0.444	
AR-2 coefficient	0.173	
Mean Square Error	0.000821	
Degrees of Freedom	88	
Adjusted-R^2	0.845	

TABLE II-10
PERIODICAL WITHIN-COUNTY MAIL

	Coefficient	T-statistic
Periodical within-county price -- SUM	-0.530	-6.882
current	-0.275	-2.401
lag 1	-0.111	-1.166
lag 2	-0.105	-1.186
lag 3	-0.039	-0.427
Permanent Income	0.531	12.63
Cable television expenditures	-0.062	—
New reporting dummy	0.258	4.106
Change in paneling method	-0.337	-5.943
Seasonal coefficients:		
September	-0.314	-1.413
Oct. 1 - Dec. 10	0.004	0.089
Dec. 11 - Dec. 12	-4.262	-4.400
Dec. 13 - 19	1.447	3.381
Dec. 20 - 24	-1.238	-2.704
Dec. 25 - Jan. 1	0.429	1.540
Jan 2 - June	-0.058	-0.896

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.735
Mean Square Error	0.004615
Degrees of Freedom	91
Adjusted-R^2	0.945

TABLE II-11
PERIODICAL NONPROFIT

	Coefficient	T-statistic
Periodical nonprofit price – SUM	-0.228	-1.634
current	-0.106	-1.495
lag 1	-0.052	-0.972
lag 2	-0.051	-0.961
lag 3	-0.020	-0.374
Permanent Income	0.535	14.01
Transitory Income (lag 3)	0.458	1.588
Cable television expenditures	-0.101	-1.139
Seasonal coefficients:		
Sept. 1 - Oct. 31	0.199	1.475
Nov. 1 - Dec. 10	0.296	5.063
Dec. 11 - 24	0.246	1.408
Dec. 25 - Jan. 1	-0.154	-0.476
Jan 2 - Mar. 31	0.226	3.951
April 1 - 15	1.330	1.418
April 16 - May	-0.198	-0.618
June	0.350	2.524

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.541
AR-2 coefficient	0.279
Mean Square Error	0.004412
Degrees of Freedom	89
Adjusted-R^2	0.852

TABLE II-12
PERIODICAL CLASSROOM

	Coefficient	T-statistic
Periodical classroom price – SUM	-1.178	-4.401
current	-0.507	-1.666
lag 1	-0.255	-1.402
lag 2	-0.254	-1.233
lag 3	-0.163	-0.753
Permanent Income	0.533	11.02
Transitory Income (lag 3)	0.762	0.781
New mailer dummy variable	0.699	3.213
Seasonal coefficients:		
September	0.000	—
October	0.474	0.767
Nov. 1 - Dec. 23	-1.263	-3.713
Dec. 24 - Jan. 1	4.163	3.350
Jan. 2 - Mar. 31	-0.688	-5.927
April 1 - 15	4.193	3.909
April 16 - June	-1.788	-4.487
REGRESSION DIAGNOSTICS :		
AR-1 coefficient	0.314	
AR-2 coefficient	0.257	
Mean Square Error	0.074384	
Degrees of Freedom	91	
Adjusted-R^2	0.517	

D. Standard Bulk Mail

The demand for Standard bulk mail volume is the result of a choice by advertisers regarding how much to spend on direct mail advertising expenditures. The decision process made by direct mail advertisers can be decomposed into three separate, but interrelated, decisions:

(1) How much resources to invest in advertising?

(2) Which advertising media to use?

and, (3) Which mail category to use to send mail-based advertising?

These three decisions are integrated into the demand equations associated with Standard bulk mail volume by including a set of explanatory variables in the demand equations for Standard bulk mail that addresses each of these three decisions. Each of these three decisions, and the implications for Standard bulk mail equations, are considered separately below.

1. Advertising Decisions and Their Impact on Mail Volume

a. How Much Resources to Invest in Advertising

The amount of advertising expenditures made by a business is a decision made as part of a profit-maximizing optimization problem. Advertising expenditures are chosen so that the additional sales generated by the last dollar of advertising are equal to the cost of the advertising. Hence, advertising expenditures can be expected to be a function of expected sales. The majority of past work on advertising expenditures has therefore focused on advertising as a function of sales and/or personal consumption expenditures. Professor Richard Schmalensee, for example, hypothesized that total advertising expenditures are a constant percentage of retail sales (*The Economics of Advertising*, 1972).

In Docket No. R94-1, the effect of the decision by advertisers of how much to spend on advertising was included in the demand equations for third-class bulk mail through the inclusion of measures of permanent and transitory income variables, as well as an independent variable measuring total advertising expenditures excluding direct mail advertising expenditures. The theory of including this last variable was that as total advertising expenditures grew, third-class bulk mail volumes would also grow.

Because direct mail advertising expenditures were excluded from the advertising expenditures variable used in the third-class bulk mail equations, however, the advertising expenditures variable used by Dr. Tolley in Docket No. R94-1 also incorporated the effects of advertisers' decision between mail and non-mail advertising expenditures. For example, if mailers decided to spend a greater share of their total advertising expenditures on direct mail advertising, then advertising expenditures, excluding direct mail advertising, all other things being equal, would decline. Yet, in this case, third-class bulk mail volumes would be expected to increase. This severely limited the explanatory power of non-direct mail advertising expenditures as a measure of total advertising in the economy. Therefore, the advertising expenditures variable was replaced by a measure of total economic sales that would be expected to drive advertisers' expenditure decisions.

Following the lead of Schmalensee, retail sales were investigated for inclusion in the demand equations for Standard bulk mail. Retail sales, as measured by the U. S. Census Bureau, do not measure total economic activity within the U. S. economy, however. In particular, retail sales do not include any information on the consumption of services, which are of growing importance in the U. S. economy. In addition, retail sales do not provide any direct information on the sales of primary and intermediate goods. Hence, while retail sales may well be a driving force affecting retail advertising on consumer goods, total advertising expenditures would be expected to be a function of a more encompassing measure of economic activity. To incorporate the effect of consumption of primary and intermediate goods as well as consumption of services, personal consumption expenditures was deemed a more desirable variable than retail sales for modeling the effect of the overall economy on advertising expenditures.

In Docket No. R94-1, permanent and transitory income were included in the demand specifications for third-class bulk mail, based on Milton Friedman's permanent income hypothesis, that consumption is affected differently by permanent and transitory income. Directly including personal consumption expenditures and also including permanent and transitory income in a single demand equation may theoretically double-count the effect of consumption expenditures on Standard bulk mail volumes, therefore. The Postal Rate Commission, in their Opinion and Recommended Decision in Docket No. R94-1, questioned Dr. Tolley's use of permanent income in the third-class bulk mail equations, on the grounds that this mail is "business-driven," and would not, therefore, be expected to follow the "demand for a traditional consumption good." While this argument may be more semantic than substantive, it appears that directly including personal consumption expenditures in the demand equations associated with Standard bulk mail volume does provide a clearer view of the relationship between consumption expenditures and advertising expenditures from the point of view of the advertiser.

To eliminate the potential inconsistency between permanent income and consumption expenditures, as well as to allow for a more direct understanding of the answer by advertisers to the question of how much resources to invest in advertising, permanent and transitory income were removed from the Standard bulk mail specifications used in this case, with personal consumption expenditures alone left to account for the effect of the economy on advertisers' expenditure decisions.

b. Which Advertising Media to Use

The choice of advertising media can be thought of as a pricing decision, so that the demand equation for Standard bulk mail ought to include the prices of direct mail advertising, as well as the prices of alternate advertising media.

The "price" of advertising is usually expressed in the advertising industry as cost per thousand messages (CPM). CPM measures are typically reported as price indices, with CPM equal to 100 in some base year. The CPM measure combines two elements of advertising -- cost and number of people "hit" by a particular media. For example, direct mail advertising has a "hit" rate of 1 for each mail-piece sent -- each mailpiece reaches a single household. A network television advertisement, on the other hand, may "hit" several million people. As the number of people who watch television and the length of time individuals watch television have risen over time, the CPM index for television advertising has declined, all other things being equal.

i. Price of Direct Mail Advertising

The price of direct mail advertising does not merely include the price of mail. Rather, an advertiser faces several costs associated with preparing a direct mail advertising mailing, such as the costs associated with postage, paper, and printing, to name a few. Rather than simply including an aggregate CPM variable for direct mail advertising, the various components of direct mail advertising are included individually in the demand equations for Standard bulk mail to provide clearer insight into the relative importance of these components and of the effect of changes in individual components over time.

The various components of direct mail advertising costs can be combined into three broad categories, characterized as Delivery costs, Technological costs, and Production costs.

(a) Delivery Costs

Delivery costs represent the cost of sending direct mail advertising through the mail. Postage costs represent the overwhelming majority of delivery costs. The remaining delivery costs include the category of costs typically referred to as "user costs". These represent worksharing costs borne by mailers to presort and/or automate mail, thereby saving the Postal Service from having to bear these costs. These user-costs are incorporated into the price variables used by both witness Tolley and me in our work.

(b) Technological Costs

One of the principal advantages of direct mail advertising over other forms of advertising is that direct mail advertising allows an advertiser to address customers on a one-on-one basis. Hence, by identifying specifically who will receive a particular piece of direct mail advertising, direct mail advertising is able to provide an inherent level of targeting that is not necessarily available through other advertising media. The ability to target a direct mailing to specific individuals, based on specific advertiser-chosen criteria, has increased dramatically as a result of technological advances, particularly over the past fifteen to twenty years. The ease with which one is able to identify specific consumers or businesses at whom to target direct mail advertising is a key component of the cost of direct mail advertising. This aspect of direct mail advertising costs, called "technological costs" here, has been modeled by Dr. Tolley in recent rate cases through the use of a logistic market penetration variable, or "z-variable".

Technological costs are modeled here through the price of computer equipment. The actual variable used is the implicit price deflator of consumption expenditures on computers and related equipment, as tracked by the Bureau of Economic Analysis. The price of computer equipment has fallen dramatically over time, reflecting the increasing attractiveness of technology over time.

(c) Production Costs

The cost of producing a direct mail advertising piece includes many aspects. Production costs could be defined so as to include all aspects of preparing a direct mail advertising piece, including the creative costs of putting together direct mail advertising, the costs of identifying the market for the specific direct mail advertising, as well as the costs of producing the piece (e.g., paper, printing, ink). The costs of identifying the market are considered technological costs and are discussed above. Creative costs are more difficult to quantify, and are assumed to be captured implicitly in the price of printing index which will be discussed below. The remaining aspects of production costs are considered now.

Two types of production costs associated with direct mail advertising are included in the demand equations presented here for Standard bulk mail volume: paper and printing costs.

(i) Paper Costs

One of the primary non-postage costs of direct mail advertising is the cost of paper. This variable is tracked by the Bureau of Labor Statistics and reported by DRI within a variable called the wholesale price of pulp and paper (WPIP). This variable was included in the demand equations for third-class bulk mail used by Dr. Tolley in Docket Nos. R94-1 and R90-1.

(ii) Printing Costs

The Bureau of Labor Statistics' Advertising Printing Index

The Bureau of Labor Statistics reports a price index of advertising printing. This price index is measured based on a survey of printers. Printers are surveyed regarding the revenue received from advertising printing and related activities. This revenue measure is then divided by a quantity measure obtained in the same survey to convert it into a price index and is reported by the Bureau of Labor Statistics.

Since this price index reflects revenue received by printers, this index tracks printing costs -- e.g., the cost of ink and other printing materials. It would be expected to exclude postage costs, however, because postage would not be received by printers but would be paid directly to either the Postal Service or a lettershop (i.e., presort bureau). Hence, at first blush, this index would appear to be an excellent candidate for modeling printing costs associated with direct mail advertising.

There are, however, other aspects of the advertising printing index that are perhaps more subtle. First, the prices charged by advertising printers would be expected to be driven, at least in part, by the price of paper. Because the price of paper is considered separately as a cost component of direct mail advertising, the price of advertising printing to be included in the Standard bulk equations should exclude the effect of the price of paper on the price of advertising printing.

In addition, because it is deflated by sales volume this index will capture changes in the productivity of advertising printers. Thus, as advertising printers move away from printing presses and hand-made layouts and toward computerized printing and layout, the advertising printing index would be expected to decline over time. In this way, the BLS's advertising printing index captures technological innovations in the advertising printing industry. To the extent that the rate of such technological innovation is comparable to the rate of technological innovation in the preparation of direct mail advertising in general, this index will capture Technological direct mail preparation costs in addition to Production costs.

Given this understanding of the BLS's advertising printing index, this index would serve as a useful proxy for direct mail printing costs if the effects of the price of paper and technological costs were removed from the index as reported by the BLS.

Isolating the Factors Driving the Price of Advertising Printing as Measured by the Bureau of Labor Statistics

The price of advertising printing would be expected to be determined largely by the cost of those factors which are used as inputs in advertising printing -- primarily paper. The price of paper can be modeled through the wholesale price of pulp, paper, and allied products as tracked by the Bureau of Labor Statistics.

In addition, advertising printing is a technology-driven industry. Hence, the price of advertising printing would be expected to decline as the price of technology declines over time. The price of technology can be measured by the implicit price index of personal consumption expenditures on computers and related equipment.

An econometric model was constructed which regressed the BLS's price of advertising printing index on the price of paper and related products and the price of computer equipment. This model was estimated over Postal quarters from 1984Q1 - 1997Q2. A simple OLS regression was initially run. The residuals from this regression were inspected to assess the need for an AR-correction. Based on this assessment, an AR-1 was performed using the Cochrane-Orcutt technique.

Various lag structures of the price of paper were analyzed in the simple OLS model (no lag structures were tested on the price of computer equipment, since this variable is essentially a trend variable). Based on several experiments, it was found that the price of advertising printing was best explained as a function of the price of paper and related products in the current period and lagged four quarters and the price of computer equipment. The results of this regression are presented below in Table II-13.

Table II-13
Econometric Model of the Price of Advertising Printing
(t-statistics in parentheses)

Price of Paper and Related Products Current Lag 4 Aggregate	 0.233 (3.745) 0.263 (4.134) ***0.495 (5.513)***
Price of Computer Equipment	***0.055 (16.42)***
AR-Coefficient	0.711
Mean-Squared Error	0.000037
Degrees of Freedom	49
Adjusted-R^2	0.983

As expected, an important factor affecting the price of advertising printing is the price of paper and related products, with an aggregate elasticity of 0.495 (t-statistic of 5.513). The choice of paper in the current period and lagged four quarters may seem a bit unusual. Nevertheless, it is easily understood if one understands what is measured by the Bureau of Labor Statistics' wholesale price of pulp and paper index.

The price of paper would be one input factor affecting the prices charged by advertising printers. It seems likely, however, that changes in wholesale prices of paper would not fully affect printers immediately, but may, instead, affect printers with some delay. Further, and perhaps more importantly, advertising printers may not be in a position to pass along a full increase in the price of paper to their customers, due to competitive considerations. Hence, many printers may try to absorb transitory changes in the price of paper while only passing along more permanent, or long-run, changes in the price of paper, so that the effect of transitory changes in the price of paper would have less impact on advertising printing prices than long-run changes in the price of paper.

Based on the short-run and total elasticities with respect to the price of paper, it appears that printers incorporate about 23 percent of a current (i.e., transitory) change in the price of paper into their prices, while they incorporate nearly 50 percent of long-run (i.e., permanent) changes in the price of paper over time.

The falling price of technology has also contributed significantly to the price of advertising printing over time, with an elasticity of 0.055 and a t-statistic of 16.42.

The regression diagnostics on this model are quite favorable, with a mean-squared error of 0.000037 and an adjusted-R^2 of 0.983. A fairly strong AR-1 correction is estimated (0.711). This seems reasonable, however, insofar as the price of advertising printing would be expected to depend heavily on the price of advertising printing in the recent past.

Incorporating Information on Cost Components of Direct Mail Advertising into Demand Equations for Standard Bulk Mail

The equation presented in Table II-13 was used to remove technological costs and paper costs from the price of advertising printing index by subtracting out the influence of the price of computer equipment and the price of paper from the BLS's price of advertising printing index. The remaining time series, called the price of printing through the remainder of this testimony, isolates the price of printing, abstracting from the prices of paper and technology, which are entered directly into the Standard bulk mail equations as described above.

ii. Price of Competing Advertising Media

Advertisers have more options with regard to advertising than simply direct mail. Other advertising media include newspapers, magazines, television and radio.

McCann-Erickson publishes annual CPM data for magazines, newspapers, television and radio advertising. The CPM data for these media were converted into quarterly time series based upon a smoothing technique that has been used in the past to smooth advertising expenditures data from the same source. These data were available from McCann-Erickson through 1996 (although the 1996 data are labeled as preliminary).

These CPM data were introduced into the demand equations for Standard bulk mail volume to model substitution between direct mail advertising and other advertising media.

c. How to Send Mail-Based Advertising

Direct mail advertising could be sent as either First-Class or Standard A mail. Postal rates have tended to change at the same time and by approximately the same percentage across rate categories and subclasses historically. This makes it problematic to freely estimate cross-price elasticities for competing mail categories.

In Docket No. R94-1, substitution between First-Class letters and third-class bulk regular mail was modeled through a cross-price elasticity that was not calculated econometrically but was instead constructed based on Household Diary Study data. This basic technique is again used in this case, and is described in section II.B. above.

In addition to substitution between First-Class and Standard Mail, there may be some substitution within Standard mail between the Regular and Enhanced Carrier Route subclasses.

First-Class and Standard Mail represent unique products, which provide different service standards and, perhaps, different response rates. Hence, there are reasons why mailers may prefer to pay higher rates in exchange for the higher standards associated with First-Class Mail. The prices of First-Class and Standard mail may be reasonably expected, therefore, to influence advertisers' relative use of these two classes of mail.

On the other hand, Standard Regular and Standard Enhanced Carrier Route mail are delivered in the same manner by the Postal Service. In addition, there is no reason to believe that response rates would differ between these two subclasses, as most consumers would be unable to distinguish between these two subclasses of mail. Thus, the decision of an advertiser between using Regular and Enhanced Carrier Route mail would be based solely on which subclass of mail were less expensive for the advertiser's purposes.

Standard Enhanced Carrier Route mail has been uniformly less expensive than Standard Regular mail over the entire sample period over which demand equations are modeled here. For mailers with sufficient mail density to qualify for Enhanced Carrier Route mail, the less expensive option has therefore always been the Enhanced Carrier Route subclass. For mailers with insufficient mail density to qualify for ECR mail, the less expensive option has always been the Regular subclass. While there may be some mail for which the choice of density may be driven, at least in part, by the relative prices of Standard Regular and ECR mail, this category of mail would be expected to be relatively small. Hence, the expected cross-price elasticity between Standard Regular and Standard Enhanced Carrier Route mail would be expected to be positive, but quite small, and almost certainly smaller than the cross-price elasticity between Standard Regular mail and First-Class letters.

The prices of Standard Regular and Enhanced Carrier Route mail have changed at the same time due to general rate cases, and have generally changed by comparable amounts. Consequently, the simple correlation between these two prices over the sample period for which demand equations are modeled in my testimony is 0.95. Such a high degree of correlation makes it extremely difficult to isolate own-price and cross-price elasticities econometrically. Nevertheless, cross-price variables were added to the demand equations for Standard Regular and Standard Enhanced Carrier Route mail presented below. The estimated cross-price elasticity of Standard Regular mail with respect to the price of Enhanced Carrier Route mail was estimated to be equal to -0.157. This is clearly implausible if one expects these two subclasses to be substitutes for one another, most likely due to the high degree of correlation between these prices, as noted above. The estimated cross-price elasticity of Standard ECR mail with respect to the price of Regular mail was estimated to be equal to 0.141, with a t-statistic of 0.779. While this is at least of the correct sign, it is greater in magnitude than the cross-price elasticity between First-Class letters and Standard Regular mail. For the reasons discussed above, this seems implausible. Hence, no cross-price substitution was modeled between Standard Regular and Enhanced Carrier Route mail in the demand equations presented and discussed here.

2. Final Specifications for Standard Bulk Mail

a. Overview

Three separate demand equations were used in R94-1 to forecast third-class bulk mail volume -- equations for carrier-route presorted third bulk regular mail, noncarrier-route presorted third bulk regular mail, and third bulk nonprofit mail. In Docket No. R94-1, these equations all used the same basic explanatory variables (with the exception of several dummy variables and cross-price variables). The coefficients on these explanatory variables, with the exception of the own-price elasticities, were stochastically constrained, so that in R94-1 the non-rate elasticities associated with these three categories of mail were assumed to be very nearly identical.

For this case, the variables which are candidates for inclusion in the Standard bulk mail equations are the same for all three demand equations. The individual equations, however, are independently estimated, and the list of explanatory variables ultimately included differs across the three equations.

i. Sample Period

The Bureau of Labor Statistics did not begin to report its series on the price of advertising printing until midway through the fourth Postal quarter of 1982. This limits the possible starting date of these regressions to no earlier than the first Postal quarter of 1983. In fact, the regressions presented in this testimony were begun in 1984Q1. The regressions were not begun starting in 1983Q1 based on a comparison of regression results starting in 1983Q1 and those starting in 1984Q1. The results beginning in 1984Q1, while substantively comparable to the results obtained starting the regressions four quarters earlier, were generally more favorable in terms of regression diagnostics (particularly mean-squared error). The superiority of the results beginning in 1984Q1 vis-a-vis the results beginning in 1983Q1 appeared to be the result of two primary factors.

First, the price of advertising printing series appears to have been somewhat more volatile in the earliest portion of the sample period (i.e., in 1983) than in later years. This could be indicative of a learning period at the BLS in reporting this series. Hence, this series may be less reliable for the first few months for which it was reported than for the rest of history. If this were the case, then one would probably want to exclude the first few observations from consideration in trying to draw econometric relationships between the price of advertising printing and Standard bulk mail volumes.

In addition, casual observation of carrier-route third-class bulk regular mail volume indicates that it experienced virtually unimpeded growth through at least 1982 and well into 1983. This growth is probably best explained by either a movement from noncarrier-route third regular mail into carrier-route or by market penetration into carrier-route third regular mail attributable (at least in part) to the introduction of carrier-route presort discounts in 1979. Modeling the demand equations for Standard bulk mail starting in 1984Q1 avoids the potentially confounding effect of this market penetration.

The Standard bulk demand equations use data ending in the second Postal Quarter of 1997. This sample period covers more than 13 years, provides for a total of 54 observations, and spans six rate regimes (including MC95-1).

ii. Variables Included by Advertising Decision

The demand equations used for modeling Standard bulk mail volumes are based on the economic theory of advertising laid out above. Based on this theory, the demand equations for Standard bulk mail volume include three types of explanatory variables (excluding seasonal and other dummy variables) -- variables that affect total advertising expenditures, variables that affect advertisers' decision of which advertising media to use, and variables that affect the choice of mail category for direct mail advertising.

(a) Decision 1: Factors Affecting Total Advertising Expenditures

Total advertising expenditures are modeled as a function of personal consumption expenditures.

(b) Decision 2: Factors Affecting Choice of Advertising Media

The choice of advertising media is modeled through variables measuring the price of direct mail advertising as well as the prices of competing media. The price of direct mail advertising is decomposed in this report into delivery costs (modeled by the price of the relevant category of Standard bulk mail, including user costs), paper costs (modeled by the wholesale price of pulp and paper lagged one and four quarters), printing costs (modeled by the price of advertising printing, as measured by the Bureau of Labor Statistics' advertising printing index, excluding the prices of paper and computer equipment), and technological costs (modeled by the price of computer equipment). The price of paper was entered lagged one and four quarters to account for the fact that there is some lag in the effect of changes in the wholesale price of paper on the price of preparing direct mail advertising. Part of this lag in reaction of direct mail advertisers to changes in the price of paper is due to a lag in the effect of changes in wholesale paper prices on retail paper prices (i.e., paper prices paid by direct mail advertisers). Other factors which may help to explain this lag could be direct mail advertisers who contract out paper prices in advance, again leading to a lagged impact of rising paper prices on these mailers' costs, and a lagged adjustment period for direct mail advertisers who plan their direct mail advertising in advance, so that, for example, a mailing may well have been planned prior to a particular unanticipated change in the price of paper, so that the particular change in the price of paper was not factored into the planning decision made by the advertiser.

Prices of competing media are measured in this report using McCann-Erickson CPM indices for the various media. The following advertising media were evaluated as possible substitutes for direct mail advertising – newspapers, magazines, radio, and television.

(c) Decision 3: Factors Affecting Mail Category Used

The only Postal cross-price elasticity which was included in these specifications was a cross-price between Standard regular mail and First-Class letters. The cross-price elasticity with respect to First-Class letters is constrained in the Standard regular equation based on information from the Household Diary Study to a value of 0.130. This figure is derived in section II.B. above.

In addition, the Standard bulk specifications include a dummy variable entitled RULE94 which reflected a rule change in 1994Q1 limiting nonprofit eligibility, which had the effect of shifting some third-class bulk mail from the nonprofit subclass into third-class bulk regular mail. The coefficient on this dummy variable is freely estimated in the Standard bulk nonprofit equation, and is constrained within the Standard regular and ECR equations so that the volume leaving the Standard bulk nonprofit subclasses is exactly equal to the volume entering the Standard bulk regular subclasses.

b. Standard Regular Mail

The demand equation for Standard regular mail models Standard regular mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Personal consumption expenditures
- Price of newspaper advertising
- Price of television advertising

- Price of paper, lagged one and four quarters
- Price of advertising printing, as constructed above
- Price of computer equipment
- Dummy variable reflecting the restriction of nonprofit eligibility beginning in 1994Q1, with the coefficient constrained from the Standard bulk nonprofit equation
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1
  [Coefficient constrained to a value of 0.012 based on analysis of government use of Standard regular mail from 1988Q1 through 1992Q4, as described in section III.A.4.b. below.]
- Current and four lags of the price of First-Class letters, with the sum of the coefficients constrained from the Household Diary Study as described in section B. above
- Current and four lags of the price of Standard regular mail

Elasticities are listed in Table II-14.

The Postal own-price elasticity of Standard regular mail is estimated to be equal to -0.382, with a t-statistic of -3.633. The elasticity of Standard regular mail with respect to the non-postal costs of direct mail advertising are -0.601 (t-statistic of -1.562) with respect to paper costs (-0.328 with respect to paper lagged one quarter, -0.273 with respect to paper lagged four quarters), -0.121 (t-statistic of -0.242) with respect to printing costs, and -0.077 (t-statistic of -3.926) with respect to technological costs. Adding these together, the aggregate price elasticity of Standard regular mail volume with respect to the cost of direct mail advertising is -1.180, with a t-statistic of -1.539.

Standard regular mail has cross-media price elasticities with respect to newspaper and television advertising. The cross-price elasticity with respect to newspaper advertising is equal to 0.793 (t-statistic of 2.422), while the cross-price elasticity with respect to television advertising is equal to 0.151 (t-statistic of 0.474).

Standard regular mail was not estimated to have a cross-price elasticity with respect to either magazine or radio advertising. The lack of substitution with magazine advertising was somewhat surprising, given the targetability of many magazines. The inability to estimate a cross-price elasticity with respect to magazine advertising econometrically is due primarily to a fairly high correlation between the CPMs associated with newspaper and magazine advertising, with the CPM for magazine advertising exhibiting a slightly more modest upward trend over time than the CPM for newspapers[4]. In fact, one recent change in the pricing of magazine advertising has been to discount advertising rates heavily over published rates, so that the true CPM of magazine advertising may be substantially lower than reported. Hence, the reported cross-media price elasticity of Standard regular mail with respect to newspaper advertising may well incorporate substitution with both newspapers and magazines.

The lack of a measurable cross-elasticity with respect to radio advertising is less surprising. Radio advertising is overwhelmingly local, and would therefore be expected to substitute most closely with local direct mail advertising. Local direct mail advertising would be predominantly carrier-route presorted. Hence, it should not be surprising that Standard regular (i.e., noncarrier-route presorted) mail does not have a cross-media price elasticity with respect to radio advertising.

Standard regular mail has a consumption elasticity of 1.618, with a t-statistic of 3.421. This indicates that Standard regular mail volume increases more than proportional with total consumption expenditures. If, as Schmalensee hypothesized in 1972, total advertising expenditures are proportional to total consumption expenditures, then this suggests that the use of targeted direct mail advertising can be expected to grow relative to other kinds of advertising as the economy grows. This may be the

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[4] The simple correlation between these two CPMs is equal to 0.669. A regression of the CPM of magazine advertising on the CPM of newspaper advertising and a time trend yields an R^2 of 0.980.

result of an increase in the technological abilities of advertisers to target advertisements, or in the increasing sophistication of advertisers in seeking more targeted advertising media as consumption increases.

The regression diagnostics associated with Standard regular mail are favorable. No AR-correction is required in the Standard regular equation. By comparison, the noncarrier-route third-class bulk regular regression used by Dr. Tolley in Docket No. R94-1 required an AR-2 correction (sum of the AR-coefficients of 0.631), and had a mean-squared error of 0.001659. The mean-squared error of the current Standard regular equation of 0.000583 represents a 65 percent improvement over the noncarrier-route third-class bulk regular specification used in R94-1.

c. Standard Enhanced Carrier Route

The demand equation for Standard Enhanced Carrier Route (ECR) mail models Standard ECR mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Personal consumption expenditures
- Price of newspaper advertising
- Price of radio advertising
- Price of paper, lagged one and four quarters
- Price of advertising printing, as constructed above
- Dummy variable reflecting the restriction of nonprofit eligibility beginning in 1994Q1, with the coefficient constrained from the Standard bulk nonprofit equation
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1
  [Coefficient constrained to a value of 0.024 based on analysis of government use of Standard regular mail from 1988Q1 through 1992Q4, as described in section III.A.4.b. below.]
- Current and four lags of the price of Standard ECR mail

Elasticities are listed in Table II-15.

The Postal own-price elasticity of Standard ECR mail is estimated to be equal to -0.598, with a t-statistic of -3.616. Standard ECR mail is more than 50 percent more sensitive to Postal rates than Standard regular mail. The elasticity of Standard ECR mail with respect to the non-postal costs of direct mail advertising are -0.861 (t-statistic of -2.166) with respect to paper costs (-0.330 with respect to paper lagged one quarter, -0.531 with respect to paper lagged four quarters), and -1.335 (t-statistic of -1.889) with respect to printing costs. Adding these together, the aggregate price elasticity of Standard ECR mail volume with respect to the cost of direct mail advertising is -2.794, with a t-statistic of -3.060. The aggregate direct-mail price elasticity of Standard ECR mail is more than 130 percent greater than the direct-mail price elasticity of Standard regular mail.

Standard ECR mail volume appears to be largely unaffected by technological costs. While the falling price and increasing power of technology have made direct mail advertising in general a more attractive advertising media over time, the benefits of technology are limited almost exclusively to Standard regular mail volume, as opposed to Standard ECR mail. In particular, technology has enabled advertisers to target potential customers more accurately, based particularly on past consumption decisions. By enabling advertisers to target to individual customers based on individual customer profiles, as opposed to having to target broader groups of customers based on more general demographic profiles, many advertisers may find that much of their mailings do not have sufficient density to be sent as ECR mail, but are instead sent as Standard regular mail. Hence, while technological improvements have had a positive effect on direct mail advertising in general, this effect appears to have been offset with regards to

Standard ECR mail volume by movement away from carrier-route level targeting toward finer non-carrier-route targeting of customers.

Standard regular and Standard ECR advertising have two key differences. First, Standard regular mail is more finely targeted to the individual recipient of the mail, while ECR mail, to the extent that it will be targeted at all, will generally be targeted more broadly to a particular area rather than a particular individual. Second, Enhanced Carrier Route mail will generally be more local in origin than Regular mail, which may be sent to a more disperse audience geographically, thereby not qualifying for Enhanced Carrier Route rates.

Standard ECR mail has cross-media price elasticities with respect to newspaper and radio advertising. The cross-price elasticity with respect to newspaper advertising is equal to 1.558 (t-statistic of 4.395). This is approximately twice as large as the cross-media elasticity between newspaper advertising and Standard regular mail volume, indicating that Standard ECR mail is a much closer substitute for newspaper advertising than is Standard regular mail, because of the local saturation non-targeted nature of newspapers in general.

The cross-price elasticity with respect to radio advertising is equal to 0.378 (t-statistic of 1.760). Radio advertising substitutes only with Standard ECR mail volume, and not with Standard regular mail volume, due to the local nature of the overwhelming majority of radio advertising.

Television advertising, on the other hand, is more nationally oriented than radio advertising. In addition, television advertising can provide a fairly high ability to target one's audience by choosing television stations and shows which are most likely to be attractive to potential customers. Both of these factors make television advertising more similar in nature to Standard regular direct mail advertising than to Standard ECR direct mail advertising. Because of this, television advertising substitutes with Standard regular mail but not with Standard ECR mail.

Standard ECR mail has a consumption elasticity of 0.851, with a t-statistic of 2.783. This indicates that Standard ECR mail volume increases somewhat less than proportional with total consumption expenditures. This may suggest that the use of ECR direct mail advertising can be expected to decline relative to other kinds of advertising, particularly Standard regular mail, as the economy grows. The consumption elasticity of Standard bulk regular mail in general (Regular and ECR) is approximately equal to 1.25. Hence, the overall use of direct mail as an advertising medium is expected to increase with growth in the overall economy. As noted above with respect to Standard regular mail, this may be attributed to an increasing sophistication on the part of advertisers as consumption grows, leading to an increased demand for more targeted advertising media. As evidence of this hypothesis, the modeled growth due to consumption is particularly strong in more-targeted Standard regular mail, as opposed to ECR mail, which includes more non-targeted saturation-type mailings.

The regression diagnostics associated with Standard ECR mail are noteworthy. A modest AR-1 correction (rho = 0.361) is required in the Standard ECR equation. By comparison, the carrier-route third-class bulk regular regression used by Dr. Tolley in Docket No. R94-1 required an AR-correction equal to 0.787. In addition, the R94-1 carrier-route specification had a mean-squared error of 0.001240. The current mean-squared error of 0.000552 represents a 55 percent improvement over the carrier-route third-class bulk regular specification used in R94-1.

d. Standard Bulk Nonprofit

The demand equation for Standard bulk nonprofit mail models Standard bulk nonprofit mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Personal consumption expenditures
- Price of magazine advertising
- Price of paper lagged one quarter
- Price of advertising printing, as constructed above
- Dummy variable reflecting the restriction of nonprofit eligibility beginning in 1994Q1
- Current and four lags of the price of Standard bulk nonprofit mail

Elasticities are listed in Table II-16.

The Postal own-price elasticity of Standard bulk nonprofit mail is estimated to be equal to -0.136, with a t-statistic of -4.909. This is considerably lower than the Postal price elasticities associated with Standard bulk regular mail due to the relatively lower percentage of total costs represented by postage costs for nonprofit mail, due to the favorable nonprofit rates offered by the Postal Service. The elasticity of Standard bulk nonprofit mail with respect to the non-postal costs of direct mail advertising are -0.279 (t-statistic of -2.372) with respect to paper costs (lagged one quarter), and -0.842 (t-statistic of -2.472) with respect to printing costs. Adding these together, the aggregate price elasticity of Standard bulk nonprofit mail volume with respect to the cost of direct mail advertising is -1.258, with a t-statistic of -3.324. This is quite similar to the direct-mail price elasticity of Standard regular mail.

Standard bulk nonprofit mail volume appears to be unaffected by technological costs. This could be due to either of two factors. This may indicate that nonprofit mailers are less quick to adapt to technological changes. On the other hand, Standard bulk nonprofit mail has much lower cross-media price elasticities than Standard bulk regular mail. This may suggest that the preferred Postal rates have long made Standard bulk nonprofit mail the preferred means of advertising for nonprofit firms. Consequently, improvements in technology may have had little marginal effect simply because there has been relatively little non-direct mail nonprofit advertising which could have been induced to shift into Standard bulk nonprofit mail volume due to technological considerations.

Standard bulk nonprofit mail has a cross-media price elasticity with respect to magazine advertising equal to 0.444 (t-statistic of 1.597). Standard bulk nonprofit mail has a consumption elasticity of 0.628, with a t-statistic of 2.647. This indicates that Standard bulk nonprofit mail volume increases somewhat less than proportional with total consumption expenditures.

As was the case above with Standard bulk regular mail, the regression diagnostics associated with Standard bulk nonprofit mail are quite favorable. The third-class nonprofit regression used by Dr. Tolley in Docket No. R94-1 had a mean-squared error of 0.001027. The current mean-squared error of 0.000621 represents a 40 percent improvement over the third-class bulk nonprofit specification used in R94-1.

TABLE II-14
STANDARD REGULAR MAIL

	Coefficient	T-statistic
Standard Regular price – SUM	**-0.382**	**-3.633**
current	-0.221	-4.087
lag 1	-0.121	-3.533
lag 2	-0.039	-1.159
lag 3	-0.001	-0.023
Price of Paper – SUM	**-0.601**	**-1.562**
lag 1	-0.328	-1.566
lag 4	-0.273	-1.125
Price of Printing	-0.121	-0.242
Price of Computer Equipment	-0.077	-3.926
Aggregate Direct Mail Advertising *Price Elasticity*	**-1.180**	**-1.539**
CPM, Newspaper Advertising	0.793	2.422
CPM, Television Advertising	0.151	0.474
First-Class Letters price – *SUM*	***0.130***	—
current	0.029	0.704
lag 1	0.036	2.578
lag 2	0.038	1.602
lag 3	0.026	1.058
RULE94	0.007	—
Personal Consumption Expenditures	1.618	3.421
GDIST	0.012	—
Seasonal coefficients:		
September	0.076	0.528
October	0.850	6.985
Nov. 1 - Dec. 24	-0.396	-3.464
Dec. 25 - Jan. 1	1.325	7.102
Jan. 2 - June	0.041	1.071

REGRESSION DIAGNOSTICS :

AR coefficients	None
Mean-Squared Error	0.000583
Degrees of Freedom	34
Adjusted-R^2	0.972

TABLE II-15
STANDARD ENHANCED CARRIER ROUTE MAIL

	Coefficient	T-statistic
Standard Enhanced Carrier Route price -- SUM	**-0.598**	**-3.616**
current	-0.223	-2.228
lag 1	-0.155	-2.269
lag 2	-0.114	-1.630
lag 3	-0.106	-1.498
Price of Paper -- SUM	**-0.861**	**-2.166**
lag 1	-0.330	-1.268
lag 4	-0.531	-2.158
Price of Printing	-1.335	-1.889
Aggregate Direct Mail Advertising Price Elasticity	**-2.794**	**-3.060**
CPM, Newspaper Advertising	1.558	4.395
CPM, Radio Advertising	0.378	1.760
RULE94	0.002	--
Personal Consumption Expenditures	0.851	2.783
GDIST	0.024	--
Seasonal coefficients:		
Sept. 1 - Oct. 31	0.382	3.771
Nov. 1 - Dec. 10	0.100	1.226
Dec. 11 - 17	-0.427	-2.539
Dec. 18 - 21	0.261	1.097
Dec. 22 - 24	1.838	3.629
Dec. 25 - Jan. 1	-1.455	-1.444
Jan. 2 - Feb. 28	0.187	2.029
March	-0.053	-0.595
April 1 - 15	0.491	3.253
April 16 - June	0.000	---
REGRESSION DIAGNOSTICS :		
AR coefficients	AR-1: 0.361	
Mean-Squared Error	0.000552	
Degrees of Freedom	33	
Adjusted-R^2	0.939	

TABLE II-16
STANDARD BULK NONPROFIT MAIL

	Coefficient	T-statistic
Standard Bulk Nonprofit price – SUM	**-0.136**	**-4.909**
current	-0.077	-3.008
lag 1	-0.030	-1.637
lag 2	-0.015	-0.840
lag 3	-0.015	-0.812
Price of Paper – SUM	**-0.279**	**-2.372**
lag 1	-0.279	-2.372
Price of Printing	-0.842	-2.472
Aggregate Direct Mail Advertising Price Elasticity	**-1.258**	**-3.324**
CPM, Magazine Advertising	0.444	1.597
RULE94	-0.039	-2.887
Personal Consumption Expenditures	0.628	2.647
Seasonal coefficients:		
Sept. 1 - Dec. 15	0.298	11.13
Dec. 16 - 21	-0.299	-1.743
Dec. 22 - Jan. 1	-0.547	-1.275
Jan. 2 - Apr. 15	0.215	6.027
April 16 - June	-0.030	-0.500

REGRESSION DIAGNOSTICS :

AR coefficients	AR-1: -0.236
Mean-Squared Error	0.000621
Degrees of Freedom	38
Adjusted-R^2	0.937

E. Standard Non-Bulk Mail

1. General Overview

Standard non-bulk mail can be classified broadly as the delivery of goods other than periodicals, advertisements, and correspondence. Examples of this type of mail include mail-order deliveries, such as clothes, and the delivery of books, tapes, or CDs (such as from book or CD clubs), as well as packages sent by households (e.g., Christmas presents).

As with Periodical mail, the demand for Standard non-bulk mail is a derived demand, emanating from the demand for the products being delivered. As such, the demand for Standard non-bulk mail would be expected to be a function of the usual factors affecting demand, including permanent and transitory income. The demand for Standard non-bulk mail will be affected not only by the price of Standard non-bulk mail, but also by the availability and price of alternate delivery forms, including non-Postal alternatives.

Separate demand equations are modeled for each of the subclasses making up Standard non-bulk mail, which are parcel post, bound printed matter, special rate, library rate, and single piece (which is being eliminated in this case). The specific demand equations associated with each of these types of mail are discussed below.

2. Parcel Post

a. General Overview

Parcel post mail volume consists of packages weighing between one and seventy pounds. The content of these packages may include mail-order deliveries (e.g., clothes, food), packages sent by households (e.g., Christmas presents), and other types of goods delivered through the Postal Service.

The demand for parcel post mail volume is a derived demand which is derived from the demand for the goods being delivered. Hence, the demand for parcel post mail volume is modeled as a traditional consumption good. As described in detail in section III.A.2.b. below, consumption may be affected differently by permanent and transitory income. In general, the permanent income elasticity of mail-order goods (and, hence, of mail-order delivery) might be expected to be quite high, as individuals with higher incomes may be expected to be more likely to use mail order to purchase goods than individuals with lower incomes due to the relatively high value of high-income individuals' time.

The demand for parcel post is derived not only from the demand for mail-order delivery in general, however, but also from the demand for parcel post as the means of delivery as opposed to some alternate source, such as Priority Mail or UPS. A case could be made that the use of parcel post as a delivery mechanism may be inversely related to income, as higher-income individuals may desire a more rapid means of delivery (e.g., Priority Mail).

In fact, econometric evidence can be found which support both of these statements. *The cross-sectional income elasticity calculated from the Household Diary Study* is equal to -0.15, with a t-statistic of -0.34. This is consistent with the hypothesis that the demand for parcel post as a means of delivery is inversely related to income. On the other hand, the permanent income elasticity estimated from the time series data is equal to 0.14 (t-statistic of 0.14), suggesting that the demand for parcel post mail is positively related to income, albeit quite modestly. In light of the lack of a clear and convincing result from either source, permanent income was excluded from the demand specification associated with parcel post mail. Transitory income was included, however, to reflect the observed relationship of parcel post mail volume to the business cycle.

As noted above, the demand for parcel post mail volume is not merely a function of the factors affecting the underlying demand for the products being delivered via parcel post, but is also affected by factors which influence consumers' decisions of how to send these deliveries. Parcel post competes directly with several outside competitors. Chief among these competitors is United Parcel Service, which currently possesses most of the surface parcel market nationally.

Besides non-postal competitors, parcel post also competes within the Postal Service with Priority Mail. This relationship is modeled by including a cross-price with respect to Priority Mail in the parcel post demand equation. This cross-price elasticity is calculated by applying the Slutsky-Schultz relationship to the cross-price elasticity with respect to parcel post mail calculated by Dr. Gerald Musgrave in his Priority Mail model (USPS-T-8).

b. Competition with United Parcel Service

i. Price Variables Related to Competition with UPS

(a) Traditional UPS Cross-Price Variable

Competition with UPS is modeled in the demand equation for parcel post through the inclusion of a cross-price with respect to UPS. In Docket No. R90-1, the cross-price with respect to UPS that was included in Dr. Tolley's parcel post equation was calculated as the average revenue per piece for UPS common carrier. Calculating a fixed-weight price index for UPS was not feasible because exact volume weights were not available for UPS. In R94-1, this problem was mitigated by Dr. Tolley by using parcel post billing determinants in calculating a fixed-weight price index for UPS. By using parcel post billing determinants, the cross-price with UPS is weighted most heavily toward those areas where parcel post has the largest volume, and hence, is most sensitive in terms of volume gains or losses to UPS rate changes.

(b) UPS's Residential Surcharge

UPS introduced a surcharge of $0.30 for residential parcel deliveries in the second Postal quarter of 1991. Beginning in 1995, UPS began to vary the residential surcharge by weight and by zone. The residential surcharge has risen progressively each year, until the average residential surcharge is currently equal to $0.80. Parcel post is most competitive with UPS in the residential-delivery market. Consequently, UPS's residential surcharge has had a positive effect on the volume of parcel post mail above the effect captured implicitly by the cross-price elasticity with respect to UPS. To more accurately capture the full impact of the introduction and subsequent increases in the UPS residential surcharge on parcel post volume, the level of the UPS residential surcharge, in 1992 dollars, is included as an additional explanatory variable in the demand equation for parcel post.

Because the residential surcharge did not exist (i.e., was equal to zero) prior to 1991, the natural logarithm of the residential surcharge does not exist prior to that time. Because of this the residential surcharge is entered into the parcel post equation unlogged. This means that the residential surcharge affects parcel post volume through the following relationship:

$$V = A \bullet [e^{rs}]^b \qquad (II.18)$$

The elasticity with respect to the residential surcharge is not equal to b in this case. Rather, the elasticity with respect to the residential surcharge is equal to b•[the value of the residential surcharge]. The real value of the residential surcharge is currently equal to \$0.714, while the coefficient on the residential surcharge in the parcel post equation is equal to 0.590. This yields an elasticity for parcel post mail volume with respect to the residential surcharge of 0.422.

(c) Change in Relationship of Parcel Post and UPS Rates

Table II-17 below presents the percentage of parcel post mail volume (using 1996 billing determinants) for which UPS rates were more expensive than parcel post rates over time. If mailers were to simply choose the less expensive of these two alternatives (and if 1996 parcel post billing determinants were representative of the parcel market in general), then this variable could be expected to approximate parcel post's share of the parcel market. In fact, these assumptions are not true.

Parcel post volume declined fairly regularly from long before the sample period considered here into at least the mid-to-late 1980s. This was primarily due to dramatic gains in market share by UPS over this time period. The early portion of Table II-17 (through at least 1988) shows that this gain in market share on the part of UPS was accomplished in part by a pricing structure whereby UPS rates were generally less expensive than parcel post rates for more than 90 percent of parcels.

The decline in parcel post market share at the expense of UPS has been modeled by a simple time trend in the parcel post demand equation (in addition to the UPS cross-price variables described above).

With the exception of nine weeks in early 1988, UPS rates were less expensive than parcel post rates for more than 87 percent of parcels from 1970 through the first quarter of 1990. In the second quarter of 1990, however, UPS raised its published rates significantly, so that more than 74 percent of UPS rates were higher than parcel post rates after this rate increase. Subsequent UPS rate increases have driven this percentage up to 92.2 percent currently.

Table II-17
Percentage of Parcel Post Volume for Which UPS Rates are More Expensive Than Parcel Post Rates

Postal Quarter	Percentage of Parcel Post Volume for which UPS Rates are Greater than Parcel Post Rates
1969Q2	0.000%
1974Q3	1.679%
1975Q2	5.064%
1975Q4	1.712%
1976Q1	0.165%
1976Q4	0.502%
1977Q2	0.835%
1977Q4	3.633%
1978Q3	2.835%
1979Q3	4.051%
1979Q4	4.442%
1980Q1	5.461%
1980Q2	5.942%
1980Q3	9.063%
1981Q1	12.988%
1981Q3	5.761%
1982Q1	4.501%
1982Q3	7.147%
1983Q4	7.040%
1985Q2	8.908%
1988Q2	74.084%
1988Q3	3.269%
1989Q2	7.282%
1990Q2	74.270%
1991Q2	74.822%
1992Q2	90.511%
1993Q2	93.941%
1994Q2	94.770%
1995Q2	90.718%
1996Q2	91.440%
1997Q2	92.211%

Over this same time period, between 1990Q2 and 1997Q2, parcel post mail volume rose by 82.2 percent, an annual growth rate of nearly 9 percent. While much of this growth is modeled through the UPS cross-price variable and the UPS residential surcharge, this change in the relationship of UPS rates to parcel post rates has also appeared to have ended the persistent downward trend in parcel post volume. This is modeled econometrically by stopping the time trend in the parcel post equation beginning in the second quarter of 1990.

ii. Non-Price Variables Related to Competition with UPS

In addition to the variables described above, additional structural variables are used in the parcel post regression that pertain to other aspects of the competitive relationship between UPS and parcel post. UPS man-days lost due to strikes is included, as is the UPS potential national market as determined by authority to operate in various areas. A dummy variable representing the 1976 authorization for UPS to deliver packages for Wards, Sears, and Penneys is also included. Finally, a dummy variable is included to represent 1980 authorization changes which permitted UPS to deliver packages for all retailers and to deliver more than 100 pounds a day between a given sender and receiver.

c. Demand Equation used for Parcel Post

The demand equation for parcel post mail models parcel post volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Transitory Income
- Time trend increasing by one per quarter until 1990Q1, remaining constant thereafter, to reflect change in the relationship of UPS and parcel post prices, as described above
- Measure of UPS's potential market, increasing from 0.506 in 1971Q1 to one in 1981Q2, remaining equal to one thereafter

- Man-days lost to strike by UPS
- Dummy variable reflecting the authorization for UPS to deliver packages for Wards, Sears, and Penneys is included, taking on a value of zero through 1976Q3, 0.67 from 1976Q4 through 1977Q2, and a value of one from 1977Q3 forward.
- Dummy variable reflecting the authorization for UPS to deliver packages for all retailers and to deliver more than 100 pounds per day between a given sender and receiver, equal to zero through 1980Q2, 0.1 in 1980Q3, 0.5 in 1980Q4, and one thereafter.
- UPS Residential surcharge, which enters the equation unlogged as described above
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the price of Priority Mail, with the sum of the coefficients constrained from the Priority Mail equation using Slutsky-Schultz equality constraint.
- Current and four lags of the price of UPS Ground Parcel service
- Current and four lags of the price of parcel post mail

Elasticities are listed in Table II-18.

The own-price elasticity of parcel post mail is equal to -0.965, with a t-statistic of -5.637. With the exception of Periodical classroom mail, parcel post mail is the most highly price-elastic volume of mail for which I present a demand equation. This is due to the high degree of competition between the Postal Service and UPS within the package-delivery market. The simple cross-price elasticity with respect to UPS is equal to 0.546, with a t-statistic of 1.808. The coefficient on UPS's residential surcharge in the parcel post demand equation is equal to 0.590 (t-statistic of 2.869). As noted earlier, this coefficient translates to an elasticity of 0.422 given the current level of the residential surcharge. Combining the cross-price elasticity with the elasticity with respect to the residential surcharge yields an aggregate price elasticity with respect to UPS (i.e., assuming UPS raises all rates, including the residential surcharge, proportionally) of 0.967, which is virtually identical to the own-price elasticity of parcel post mail.

Parcel post mail also has a cross-price elasticity with respect to Priority Mail of 0.447. Parcel post mail volume is strongly affected by transitory income, with a transitory income elasticity of 0.663 (t-statistic of 3.081).

Throughout the 1970s and 1980s, parcel post volume experienced a steady downward trend which is modeled through a time trend variable with a coefficient of -0.019 and a t-statistic of -8.346. This time trend is truncated in 1990Q1 due to a change in the relative prices of parcel post and UPS beginning at that time. Parcel post mail volume would have been 40.4 percent lower in the base period had this time trend continued to increase after the first quarter of 1990.

The demand equation for parcel post mail has quite favorable regression diagnostics compared with the equation presented by Dr. Tolley in R94-1. The mean-squared error is equal to 0.003210 in the present case, compared with 0.004337 in R94-1.

3. Non-Parcel Post Standard B Mail

a. Subclasses of Standard B Mail

There are three subclasses of Standard B mail in addition to parcel post: bound printed matter, special rate, and library rate. Bound printed matter refers to any mail that is bound and printed, and weighs between one and ten pounds[5]. Generally, bound printed matter falls into one of three categories: catalogs, books (including telephone books in some areas), and direct mail advertising weighing sixteen ounces or more. The special rate subclass is reserved for books, tapes, and CDs. The library rate

[5] The upper weight limit on bound printed matter is being proposed to increase to fifteen pounds in this case.

subclass is a preferred subclass, generally corresponding to the special rate subclass, available to libraries and certain other institutions.

b. History of Bound Printed Matter and Special Rate Mail

Prior to 1976, the bound printed matter subclass was called the Catalog subclass, and was composed entirely of catalogs. Beginning on or around the fourth quarter of 1976, an informal rule change occurred, whereby certain Post Offices began to allow books, which had previously been sent as special rate mail, to be sent as bound printed matter with the inclusion of a single page of advertising. This rule was gradually adopted by most Post Offices over the next several years.

In most cases, bound printed matter rates were, and still are, less expensive than special rate rates. However, bound printed matter rates are zoned, whereas special rate rates are unzoned. Thus, in order for mailers to shift from the special rate to bound printed matter subclass, mailers had to switch from unzoned rates to zoned rates. This structural adaptation, along with an apparent lag in realization by mailers of the existence of this rule change, made it difficult for mailers to immediately shift from special rate to bound printed matter.

Shifts between these two subclasses were particularly erratic in the first two years after this rule change was first implemented gradually. It was decided that it would be best econometrically, therefore, to avoid this early period entirely. Consequently, the demand equations for bound printed matter and special rate mail volume are not modeled using data prior to 1979Q1, allowing two full years for special rate mailers to begin to adapt to the enhanced opportunities available through bound printed matter.

Even after this time period, however, gradual migration from special rate into bound printed matter continued. This effect is modeled by including logistic market penetration variables in the demand equations for bound printed matter and special rate mail volumes. The market penetration variable in the bound printed matter equation is positive to reflect market penetration into bound printed matter, while the market penetration variable in the special rate equation is negative to reflect market penetration out of the special rate subclass.

c. Standard B Regression Equations

i. Bound Printed Matter

The demand equation for bound printed matter models bound printed matter volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Logistic Market Penetration variable (Z-Variable) as described in section III.B.5. below
- Permanent Income (as described in section III.A.2.b. below)
- Dummy variable to reflect a rule change in 1986 allowing bound printed matter and special rate mail to be bundled within a single mailing, equal to zero through 1985Q4, (17.5/66) in 1986Q1 (reflecting the timing of this rule change 17.5 business days into 1986Q1), and one thereafter.
- Dummy variable reflecting the year immediately following the cancellation of the Sears catalog, which had a significant negative initial impact on bound printed matter volume, which was mitigated by other catalog mailers within the next year. Variable is equal to one from 1993Q2 through 1994Q1, zero elsewhere.
- Current and four lags of the price of bound printed matter

Elasticities are listed in Table II-19.

The own-price elasticity of bound printed matter is equal to -0.335 (t-statistic of -3.024). Bound printed matter volume is strongly affected by permanent income, with a permanent income elasticity of 1.338 (t-statistic of 10.66). Bound printed matter volume has one of the strongest seasonal patterns of any mail category, with volumes particularly high in September (seasonal coefficient of 3.276, t-statistic of 2.594), the two weeks immediately preceding Christmas (coefficient of 2.116, t-statistic of 1.677), March (coefficient of 2.402, t-statistic of 2.100), and late April and May (coefficient of 1.559, t-statistic of 1.261). The regression diagnostics associated with the bound printed matter equation have improved very slightly from the results presented by Dr. Tolley in R94-1, with a mean-squared error of 0.009487 (versus 0.009936 in R94-1).

ii. Special Rate

The demand equation for special rate mail models the demand for Standard special rate mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Logistic Market Penetration variable (Z-Variable) as described in section III.B.5. below
- Permanent Income (as described in section III.A.2.b. below)
- Transitory Income
- Dummy variable to reflect a rule change in 1986 allowing bound printed matter and special rate mail to be bundled within a single mailing, equal to zero through 1985Q4, (17.5/66) in 1986Q1 (reflecting the timing of this rule change 17.5 business days into 1986Q1), and one thereafter.
- Dummy variable reflecting a rule change in 1994Q1 restricting library rate eligibility
- Dummy variable reflecting unusual reported volumes in the third and fourth quarters of 1995, equal to one in 1995Q3 and 1995Q4, zero elsewhere.
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the price of special rate mail

Elasticities are listed in Table II-20.

The own-price elasticity of special rate mail is -0.362, with a t-statistic of -2.837. Special rate volume is affected by both permanent and transitory income, with elasticities of 0.307 (t-statistic of 1.669) and 0.700 (t-statistic of 3.159), respectively. The regression diagnostics associated with the special rate demand equation are considerably more favorable than those presented by Dr. Tolley in R94-1. The mean-squared error for the present equation is equal to 0.004624 as compared with 0.006598 in R94-1.

iii. Library Rate

The demand equation for library rate mail models Standard library rate mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Dummy variable to reflect a rule change in 1977 extending library rates to include mail sent both to and from a library (previously only mail sent by libraries was eligible for library rates). Variable is equal to zero through 1976Q4, and equal to one thereafter.
- Dummy variable reflecting a rule change in 1994Q1 restricting library rate eligibility
- Current and four lags of the price of library rate mail

Elasticities for library rate mail are given in Table II-21.

The own-price elasticity of library rate mail is equal to -0.634, with a t-statistic of -10.45. This is considerably greater than the own-price elasticity of special rate mail, reflecting, perhaps, the greater sensitivity of libraries and museums to costs in general due to their not-for-profit stature.

4. Single Piece

Standard single-piece mail volume is basically a Standard alternative to First-Class letters. The main factors affecting single-piece mail volume over time are structural in nature. As of 1981, Standard single-piece mail weighing up to four ounces paid the same price as First-Class letters. In 1982Q1, single-piece mail weighing up to five ounces was priced the same as First-Class letters. A 1985 rule change allowed mailers to send single-piece mail at lower parcel post rates if desired. Finally, in R94-1 (1995Q2), single-piece mail weighing up to eleven ounces was priced the same as First-Class letters. Each of these changes led to a general decline in the volume of Standard single-piece mail volume, as this mail migrated into single-piece First-Class letters and Standard parcel post. The first three of these structural changes are modeled by dummy variables which have a negative impact on single-piece mail volume. The last of these changes (the R94-1 pricing up to 11 ounces equal to First-Class rates) is modeled implicitly through the own-price elasticity.[6]

In addition, a time trend is also included in the demand equation for Standard single-piece mail to reflect a general downward trend in single-piece volume, attributable, at least in part, to the structural considerations noted above.

The demand equation for Standard single-piece mail models single-piece mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory income
- Dummy variable reflecting the pricing of Standard single-piece mail equal to First-Class Mail up to four ounces in 1981. Variable is equal to zero through 1981Q2, equal to one thereafter.
- Dummy variable reflecting the pricing of Standard single-piece mail equal to First-Class Mail up to five ounces in 1982. Variable is equal to zero through 1981Q4, equal to one thereafter.
- Dummy variable reflecting a classification change which had the effect of decreasing Standard single-piece volume in 1985. Variable is equal to zero through 1985Q1, equal to one thereafter.
- Time trend, reflecting a long-run negative trend in Standard single-piece mail volume
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the price of Standard single-piece mail.

Elasticities are listed in Table II-22 below.

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[6] A dummy variable was investigated, but was ultimately rejected in this case, due to surprisingly large single-piece volumes in 1996 and 1997, which caused the coefficient on this dummy variable to be unexpectedly positive.

TABLE II-18
STANDARD PARCEL POST

		Coefficient	T-statistic
Parcel post price -- SUM		-0.965	-5.637
	current	-0.552	-5.305
	lag 1	-0.307	-5.004
	lag 2	-0.106	-1.605
	lag 3	-0.000	-0.005
UPS price -- SUM		0.546	1.808
	current	0.284	1.319
	lag 1	0.115	1.056
	lag 2	0.074	0.754
	lag 3	0.072	0.742
Priority Mail price -- SUM		0.447	---
	current	0.150	1.573
	lag 1	0.106	2.306
	lag 2	0.096	1.651
	lag 3	0.095	1.576
Transitory Income		0.663	3.081
UPS Potential Market		-0.149	-1.255
UPS man-days lost to strikes		0.861	9.522
Lifting of UPS retail restriction		-0.100	-1.855
UPS Sears, Wards, Penneys' authorization		-0.092	-1.493
UPS Residential Surcharge		0.590	2.869
Parcel Post time trend		-0.019	-8.346
Dummy for use of Government-Distributed Volume		0.117	2.730
Seasonal coefficients:			
September		-0.192	-0.934
Oct. 1 - Dec. 10		0.474	9.408
Dec. 11 - 12		-0.950	-1.093
Dec. 13 - 17		0.376	0.770
Dec. 18 - 23		1.405	3.490
Dec. 24 - Jan. 1		0.764	2.867
Jan 2 - June		0.114	1.847
REGRESSION DIAGNOSTICS :			
AR-1 coefficient		0.160	
AR-2 coefficient		0.276	
Mean Square Error		0.003210	
Degrees of Freedom		78	
Adjusted-R^2		0.990	

TABLE II-19
STANDARD BOUND PRINTED MATTER

	Coefficient	T-statistic
Bound printed matter price – SUM	-0.335	-3.024
current	-0.069	-0.696
lag 1	-0.095	-2.133
lag 2	-0.103	-1.964
lag 3	-0.069	-1.365
Permanent Income	1.338	10.66
Bundling dummy variable	0.031	1.196
Sears catalog dummy	-0.211	-4.933
Parameters used in calculating Z-variable:		
Param1	1.566	7.966
Param2	3.307	2.843
Param3	0.052	4.332
Seasonal coefficients:		
September	3.276	2.594
Oct. 1 - Dec. 10	-0.370	-0.905
Dec. 11 - 24	2.116	1.677
Dec. 25 - Jan. 1	-1.429	-0.770
Jan 2 - Feb. 28	-0.178	-0.465
March	2.402	2.100
April 1 - 15	-8.224	-2.753
April 16 - May	1.559	1.261
June	-0.470	-0.375

REGRESSION DIAGNOSTICS :

AR-1 coefficient	-0.107
AR-2 coefficient	-0.095
AR-3 coefficient	-0.209
Mean Square Error	0.009487
Degrees of Freedom	52
Adjusted-R^2	0.972

TABLE II-20
STANDARD SPECIAL RATE

	Coefficient	T-statistic
Standard Special Rate price -- SUM	-0.362	-2.837
current	-0.213	-2.083
lag 1	-0.112	-2.149
lag 2	-0.037	-0.667
lag 3	-0.000	-0.001
Permanent Income	0.307	1.669
Transitory Income	0.700	3.159
Bundling dummy variable	0.087	2.692
1994 Rule Change affecting Library Rate Eligibility	0.142	5.194
Dummy variable, 1995Q3 - Q4	0.206	3.734
Dummy for use of Government-Distributed Volume	0.038	1.052
Parameters used in calculating Z-variable:		
Param1	-0.786	-4.161
Param2	23.43	0.739
Param3	0.167	2.498
Seasonal coefficients:		
Sept. 1 - Oct. 31	2.107	3.350
Nov. 1 - Dec. 10	-0.130	-0.711
Dec. 11 - Jan. 1	1.587	2.325
Jan 2 - Feb. 28	0.774	4.913
March	1.369	2.159
April 1 - 15	-2.316	-1.707
April 16 - June	1.782	2.739

REGRESSION DIAGNOSTICS :

AR-coefficients	None
Mean Square Error	0.004624
Degrees of Freedom	54
Adjusted-R^2	0.906

TABLE II-21
STANDARD LIBRARY RATE

	Coefficient	T-statistic
Standard Library Rate price -- SUM	-0.634	-10.45
current	-0.195	-1.026
lag 1	-0.154	-1.250
lag 2	-0.154	-1.215
lag 3	-0.131	-1.036
Permanent Income	0.231	1.286
Library dummy variable	0.726	10.61
1994 Rule Change affecting Library Rate Eligibility	-0.282	-4.367
Seasonal coefficients:		
September	0.000	—
October	1.747	3.221
Nov. 1 - Dec. 10	-0.152	-0.413
Dec. 11 - 24	0.313	0.742
Dec. 25 - Mar. 31	0.483	4.651
April 1 - May 31	0.370	4.784
June	0.713	1.902

REGRESSION DIAGNOSTICS :

AR-coefficients	None
Mean Square Error	0.034330
Degrees of Freedom	93
Adjusted-R^2	0.742

TABLE II-22
STANDARD SINGLE PIECE

	Coefficient	T-statistic
Standard single piece price – SUM	-0.654	-3.221
current	-0.308	-1.823
lag 1	-0.163	-1.369
lag 2	-0.094	-0.789
lag 3	-0.090	-0.784
Permanent Income	0.099	0.354
Transitory Income	0.220	0.564
Dummy variable for 4-oz. rate same as First-Class letters	-0.520	-5.580
Dummy variable for 5-oz. rate same as First-Class letters	-0.258	-2.689
Dummy variable for classification change	-0.128	-1.595
Time trend	-0.013	-5.163
Dummy for use of Government-Distributed Volume	0.390	4.911
Seasonal coefficients:		
September	-0.546	-1.475
Oct. 1 - Dec. 10	0.182	1.799
Dec. 11 - 17	-1.798	-3.004
Dec. 18 - 24	0.790	1.682
Dec. 25 - Mar. 31	-0.077	-0.634
April 1 - May 31	0.008	0.071
June	-0.236	-1.006

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.301
AR-2 coefficient	0.252
Mean Square Error	0.009692
Degrees of Freedom	86
Adjusted-R^2	0.985

F. Other Mail Categories

In addition to the mail volumes described above, demand equations are also modeled for three categories of mail and five special services which are not a part of either the First-Class, Periodical, or Standard mail classes. These categories of mail are Mailgrams, Postal Penalty mail, and Free-for-the-Blind mail. The five special services considered are registered mail, insured mail, certified mail, COD, and money orders.

1. Mailgrams, Postal Penalty, and Free-for-the-Blind Mail

Mailgrams are telegrams delivered by the Postal Service under an agreement with Western Union. Postal Penalty mail refers to mail sent by the Postal Service. Free-for-the-Blind mail is mail that is delivered free of charge by the Postal Service under certain circumstances.

Because there is no direct price charged for Mailgrams, Postal Penalty, and Free-for-the-Blind mail, price was not included in the demand specifications for these categories of mail. Because it was not necessary to estimate a price elasticity for these categories of mail, and due to the small and relatively volatile volumes within these categories of mail, only structural variables (e.g., seasonal variables and time trends) were used in these regressions.

Volume data for Mailgrams and Postal Penalty Mail do not extend back to 1971. In these cases, demand equations were run beginning in the first quarter for which volume data is available. Thus, the Mailgrams equation was run beginning in 1975q1, and the Postal Penalty equation was run beginning in 1988q1. The seasonal and trend elasticities from these equations are listed in Tables II-23 through II-25, respectively.

2. Special Services

Special services are not mail volumes, but represent add-ons to mail volumes (i.e., a certified letter would be counted as both a piece of certified mail as well as a First-Class letter), so that the volumes of special services are not included in a calculation of total Postal Service volume. The Postal Service provides these services for a fee. The demand for these services can be specified along the lines of traditional consumer demand theory.

The demand for special service mail is generally a function of permanent and transitory income and the price charged by the Postal Service for utilizing these services. In addition, the special service volumes modeled here have generally exhibited long-run trends. For this reason, a time trend is included in the demand equation associated with each of the special services (except for money orders).

Finally, because special services are merely add-ons to otherwise existing mail volumes, the demand for special services may be affected directly by the demand for complementary categories of mail. Insured mail volume is modeled in part as a function of the volume of parcel post mail, since a large portion of insured mail volume is sent as parcel post mail.

a. Registry

The demand equation for registered mail models registered mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory Income
- Time trend reflecting a long-run downward trend in registered mail volume
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the price of registered mail

Elasticities are listed in Table II-26.

b. **Insured**

The demand equation for insured mail models insured mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Time trend reflecting a long-run downward trend in insured mail volume
- Volume of parcel post mail reflecting complementarity of parcel post and insured mail
- Dummy variable reflecting a change in RPW data starting in 1993Q1, reflecting a revised methodology for reporting workshared First-Class Mail. Variable is equal to zero through 1992Q4, equal to one thereafter.
- Current and four lags of the price of insured mail

Elasticities are listed in Table II-27.

c. **Certified**

The demand equation for certified mail models certified mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory Income
- Time trend reflecting a long-run trend in certified mail volume
- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the price of certified mail

Elasticities are listed in Table II-28.

d. **Collect-on-Delivery (COD)**

The demand equation for COD mail models COD mail volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Time trend reflecting a long-run downward trend in COD volume

- Dummy variable reflecting the use of government-distributed volume beginning in 1988Q1.
- Current and four lags of the price of COD mail

Elasticities are listed in Table II-29.

e. Money Orders

The demand equation for money orders models money orders volume as a function of the following explanatory variables:

- Seasonal Variables (as described in section III.A.3. below)
- Permanent Income (as described in section III.A.2.b. below)
- Transitory Income
- Current and four lags of the price of money orders

Elasticities are listed in Table II-30.

TABLE II-23
MAILGRAMS

	Coefficient	T-statistic
Time trend	-0.040	-6.164
Seasonal coefficients:		
September	1.397	1.794
October	-0.410	-0.557
Nov. 1 - Dec. 10	0.322	0.540
Dec. 11 - 12	-2.925	-1.244
Dec. 13 - 19	5.234	4.693
Dec. 20 - Jan. 1	-0.308	-0.508
Jan 2 - Mar. 31	0.373	1.360
April 1 - 15	1.546	1.882
April 16 - June	0.109	0.213

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.581
AR-2 coefficient	-0.002
AR-3 coefficient	0.311
Mean Square Error	0.027395
Degrees of Freedom	77
Adjusted-R^2	0.965

TABLE II-24
POSTAL PENALTY MAIL

	Coefficient	T-statistic
Time trend	-0.018	-3.029
Dummy for mailing-statement adjustment to data	-0.020	-0.173
Seasonal coefficients:		
Sept. 1 - Oct. 31	-1.534	-1.892
Nov. 1 - Dec. 12	1.099	2.244
Dec. 13 - 17	-3.361	-2.413
Dec. 18 - 24	24.21	3.422
Dec. 25 - Jan. 1	13.85	2.293
Jan 2 - Feb. 28	-4.838	-4.128
Mar. 1 - Apr. 15	0.500	1.775
April 16 - June	-1.390	-1.956

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.410
Mean Square Error	0.015857
Degrees of Freedom	27
Adjusted-R^2	0.766

TABLE II-25
FREE-FOR-THE-BLIND-AND-HANDICAPPED MAIL

	Coefficient	T-statistic
Time trend	0.007	7.366
Seasonal coefficients:		
Sept. 1 - Oct. 31	0.799	0.448
Nov. 1 - Dec. 10	-0.040	-0.081
Dec. 11 - 21	-1.158	-0.548
Dec. 22 - Jan. 1	1.956	0.707
Jan 2 - Feb. 28	0.125	0.300
March	0.634	0.355
April 1 - 15	2.239	0.417
April 16 - May	-0.559	-0.278
June	0.627	0.328

REGRESSION DIAGNOSTICS :

AR-coefficients	None
Mean Square Error	0.097478
Degrees of Freedom	96
Adjusted-R^2	0.334

TABLE II-26
REGISTERED MAIL

	Coefficient	T-statistic
Registered mail price -- SUM	-0.413	-1.955
current	-0.177	-0.930
lag 1	-0.101	-0.544
lag 2	-0.091	-0.539
lag 3	-0.045	-0.275
Permanent Income	0.505	32.07
Transitory Income	0.202	0.612
Time trend	-0.019	-10.20
Seasonal coefficients:		
Sept. 1 - Oct. 31	1.026	2.426
Nov. 1 - Dec. 10	-0.105	-0.880
Dec. 11 - 17	2.473	4.054
Dec. 18 - 21	-0.076	-0.103
Dec. 22 - Jan. 1	2.020	3.158
Jan 2 - Feb. 28	0.094	0.948
March	1.289	3.100
April 1 - 15	-2.779	-3.076
April 16 - June	1.328	3.052

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.370
AR-2 coefficient	0.190
AR-3 coefficient	0.242
Mean Square Error	0.006633
Degrees of Freedom	86
Adjusted-R^2	0.964

TABLE II-27
INSURED MAIL

	Coefficient	T-statistic
Insurance price -- SUM	-0.105	-1.356
current	-0.022	-0.534
lag 1	-0.030	-1.190
lag 2	-0.032	-1.327
lag 3	-0.022	-1.111
Permanent Income	0.505	26.77
Parcel post volume	0.392	6.307
Time trend	-0.013	-10.50
Dummy variable for Mailing-Statement Adjustment to Data	-0.110	-1.985
Seasonal coefficients:		
September	-0.360	-1.163
Oct. 1 - Dec. 10	0.303	3.469
Dec. 11 - Jan. 1	0.526	2.585
Jan 2 - Mar. 31	-0.038	-0.380
April 1 - 15	-0.638	-1.785
April 16 - June	0.193	1.033

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.050
AR-2 coefficient	0.178
Mean Square Error	0.006355
Degrees of Freedom	90
Adjusted-R^2	0.983

TABLE II-28
CERTIFIED MAIL

	Coefficient	T-statistic
Certified mail price -- SUM	-0.287	-3.175
current	-0.085	-0.890
lag 1	-0.070	-1.051
lag 2	-0.070	-1.052
lag 3	-0.062	-0.938
Permanent Income	0.505	29.87
Transitory Income	0.200	0.793
Time trend	0.010	10.40
Dummy for use of Government-Distributed Volume	0.097	1.895
Seasonal coefficients:		
Sept. 1 - Oct. 31	1.057	2.395
Nov. 1 - Dec. 10	-0.070	-0.573
Dec. 11 - Jan. 1	1.023	1.936
Jan 2 - Feb. 28	0.280	2.557
March	1.123	2.588
April 1 - May 31	0.304	2.690
June	1.196	2.472

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.071
AR-2 coefficient	0.159
AR-3 coefficient	0.169
Mean Square Error	0.007086
Degrees of Freedom	88
Adjusted-R^2	0.950

TABLE II-29
COLLECT-ON-DELIVERY

		Coefficient	T-statistic
COD price -- SUM		-0.182	-1.072
	current	-0.043	-0.435
	lag 1	-0.046	-0.798
	lag 2	-0.050	-0.839
	lag 3	-0.043	-0.811
Permanent Income		0.505	31.54
Time trend		-0.019	-13.08
GDIST		0.002	0.033
Seasonal coefficients:			
September		0.000	---
Oct. 1 - Dec. 12		0.222	5.455
Dec. 13 - 21		0.590	2.018
Dec. 22 - 24		-0.536	-0.695
Dec. 25 - Jan. 1		0.762	1.735
Jan 2 - Feb. 28		0.079	1.602
March		0.363	2.833
April 1 - 15		-1.117	-2.705
April 16 - June		0.530	4.154

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.530
AR-2 coefficient	0.177
Mean Square Error	0.007461
Degrees of Freedom	89
Adjusted-R^2	0.973

TABLE II-30
MONEY ORDERS

	Coefficient	T-statistic
Money orders price – SUM	-0.391	-5.073
current	-0.198	-4.167
lag 1	-0.095	-2.908
lag 2	-0.050	-1.501
lag 3	-0.049	-1.499
Permanent Income	0.505	30.25
Transitory Income	0.223	1.123
Seasonal coefficients:		
September	-0.561	-3.798
Oct. 1 - Dec. 10	-0.061	-1.558
Dec. 11 - 12	-2.699	-3.848
Dec. 13 - 19	0.595	1.957
Dec. 20 - 24	-0.841	-2.478
Dec. 25 - Jan. 1	-0.096	-0.421
Jan 2 - Mar. 31	-0.122	-2.511
April 1 - 15	-0.100	-0.639
April 16 - June	-0.127	-1.484

REGRESSION DIAGNOSTICS :

AR-1 coefficient	0.542
AR-2 coefficient	0.363
Mean Square Error	0.002066
Degrees of Freedom	89
Adjusted-R^2	0.959

III. Econometric Methodology for Modeling Demand Equations

A. General Regression Procedure

1. Theory of Demand

Demand equations relate the demand for some good, in this case, mail volume, to variables that are believed to influence demand. The general form of the demand equations to be estimated express mail volume as a function of income, price, and other variables which are believed to influence mail volume:

$$V_t = f(Y_t, p_t, \text{etc.}) \qquad \text{(III.1)}$$

Conventionally, when economists discuss the impact of explanatory variables on the demand for a particular good or service, the measure used to describe this impact is the concept of "elasticity." The elasticity of a good, i, with respect to some explanatory variable, x, is equal to the percentage change in the quantity of good i resulting from a one percent change in x. Mathematically, the elasticity of V_t with respect to some variable, x_t, is defined as follows:

$$\eta_t^{Vx} = \frac{\partial V_t}{\partial x_t} \cdot \left[\frac{x_t}{V_t}\right] \qquad \text{(III.2)}$$

where the t subscript denotes the time period for which the elasticity is being calculated.

The goal in modeling demand equations can be thought of as calculating elasticities with respect to all relevant factors affecting demand.

2. Factors Affecting Demand

a. Price

The starting point for traditional micro-economic theory is a demand equation that relates quantity demanded to price. Quantity demanded is inversely related to price, so that if the price of a good were increased, the volume consumed of that good would be expected to decline, all other things being equal.

This fundamental relationship of price to quantity is modeled in the demand equations presented in this testimony by including the price of postage in each of the demand equations discussed above, with the exception of the demand equations associated with Mailgrams, Postal penalty mail, and Free-for-the-Blind mail. Postal prices are not included in these three demand equations because no price is paid directly by the users of these products to the Postal Service.

The Postal prices entered into the other demand equations are calculated as weighted averages of the various rates within each particular category of mail. For example, the price of single-piece First-Class letters is a weighted average of the single-piece letters rate (32¢), the additional ounce rate (23¢), and the nonstandard surcharge (11¢). The weights used to combine these rates into a single price are the relative proportions of the category which paid each rate in GFY 1996[7]. Because the weights used in constructing these prices do not change over time, these prices are sometimes referred to as "fixed-weight" price indices.

Experience indicates that mailers may not react immediately to changes in Postal rates. For some types of mail it may take up to a year for the full effect of changes in Postal rates to influence mail volumes. To account for the possibility of a lagged reaction to changes in Postal prices on the demand for certain types of mail, the Postal price in the current period is entered into the demand specifications described above as well as the Postal price one, two, three, and four quarters earlier.

[7] Due to complications brought about by the implementation of MC95-1 in the fourth quarter of 1996, the weights used in calculating prices for First-Class and Standard bulk mail are based on the first three quarters of 1996 only.

The price of postage is not the only price paid by most mailers to send a good or service through the mail. For those cases where the non-Postal price of mail is significant and for which a reliable time series of non-Postal prices is available, these prices are also included explicitly in the demand equations used to explain mail volume. For example, the price of paper is included as an explanatory variable in the demand equations for Periodical regular mail, as well as Standard regular, ECR, and bulk nonprofit mail, since paper is an important input in the production of newspapers and magazines as well as direct mail advertising.

One unique non-Postal price borne by some mailers is the cost to mailers of presorting or prebarcoding their mail in order to receive discounts from the Postal Service. These costs, called user costs, are incorporated to take account of the fact that mailers who presort or automate their mail do not receive the full savings of Postal discounts, but only save the difference between Postal discounts and the costs to the mailers necessary to earn these discounts. For those categories for which worksharing share equations are developed in section IV of my testimony below (First-Class and Standard bulk mail), these user costs can be calculated within the share equation system using equation (IV.28) below. These user costs are added to the fixed-weight price indices used in modeling the demand for mail.

All prices are expressed in real 1992 dollars. The Personal Consumption Expenditure deflator from the national income accounts is used to deflate the prices.

In general, the price elasticities cited in this testimony and elsewhere refer to long-run price elasticities. The long-run price elasticity of mail category i with respect to the price of mail category i is equal to the sum of the coefficients on the current price of mail category i as well as the price lagged one through four quarters. The long-run price elasticity therefore reflects the impact of price on mail volume after allowing time for all of the lag effects of be felt.

b. Income

With the exception of price, the most basic economic factor affecting consumption at a theoretical level is income. As incomes rise, consumers are able to consume more. It follows logically from this that as income rises in the overall economy, overall consumption, including the consumption of Postal services, will generally rise. Thus, mail volumes can be expected to be a function of income.

Leading economists have devoted a tremendous amount of attention to looking at the relationship between income and consumption and the proper means by which to model this relationship, at both a theoretical as well as an empirical level. (For a thorough treatment of the relationship between consumption and income, see, for example, Understanding Consumption, by Angus Deaton, 1992)

i. Distinction Between Current Income and Permanent Income

At a basic theoretical level, consumers have two choices of what to do with income, they can either consume it currently or they can save it, thereby increasing their ability to consume in the future. For a simple two-period model, consumption and income can be related as follows:

> Suppose that there is a single asset, of which the consumer possesses an amount equal to A_1 at the beginning of period 1, and which earns an interest rate r_2 on savings between period 1 and period 2. The consumer also receives income in both time periods equal to y_1 and y_2, respectively. The stock of assets, A_2, will be equal to $(1+r_2)(A_1+y_1-c_1)$, where c_1 is consumption in time period 1, so that $(A_1+y_1-c_1)$ is equal to savings in time period 1. If utility is only a function of consumption, so that savings only provide positive utility insofar as they provide for future consumption, then assets will be equal to zero at the end of period 2, and consumption will be related to income according to the following relationship:

$$c_1 + \frac{c_2}{1 + r_2} = A_1 + y_1 + \frac{y_2}{1 + r_2} \tag{III.3}$$

Extending the above formulation to a T-period model, equation (III.3) becomes the following:

$$\sum_{t=1}^{T} \frac{c_t}{(1 + r)^{t-1}} = A_1 + \sum_{t=1}^{T} \frac{y_t}{(1 + r)^{t-1}} \tag{III.4}$$

Looking at equation (III.4), it is clear that consumption today is affected by the level of not only current income, but also of both past as well as future income. In words, past income generates past savings, which, in turn, generate current income, while current savings generate future income, which, in turn, generate future consumption, so that an increase in current consumption necessarily leads to a decrease in future consumption.

In order for equation (III.4) to hold with certainty over the entire life-cycle of an individual, it would be necessary for the consumer to know with certainty at time t=1 the exact value of T (i.e., at what point in the future the consumer would die) as well as the value of y_t for all time periods, t = 1 to T. In reality, of course, there is uncertainty with respect to both of these things. Changes in expectations regarding future income (or regarding T) may therefore be expected to change consumption decisions even before these expectations are realized.

Milton Friedman, in his seminal work A Theory of the Consumption Function (1957), hypothesized that changes in income which affect expectations about future income would therefore be expected to affect consumption more directly and significantly than would changes in income which did not affect expectations about future income.

Specifically, Friedman distinguished between "permanent" income, which he defined as expected total wealth, and "transitory" income, which he defined as the difference between current income and "permanent" income. Under this set-up, permanent income differs from current income for two reasons: differences between current income and expected future income, and differences between income and wealth.

Friedman's permanent income hypothesis stated that the relationship between consumption and permanent income would be stronger than the relationship between consumption and transitory income. This hypothesis has become a staple of general micro-economic theory, and continues to be applied in a wide range of contexts throughout the economics profession.

The distinction between permanent income and current income in understanding consumption patterns is apparent, for example, in evaluating consumption patterns by age. Young people, anticipating increasing future income, will consume more than would be suggested by current income levels, incurring debt (e.g., student loans, mortgages), which, it is expected, will be paid for by higher future incomes. Using Friedman's terminology, the permanent income of young people exceeds their current income. On the other hand, middle-aged people generally consume less, saving for retirement, when their incomes are expected to decline. Hence, the permanent income of middle-aged people is less than their current income, explaining why middle-aged people consume a smaller proportion of their current income relative to young people.

Or, consider a single individual who receives a $1,000 raise at work versus an individual who wins $1,000 in the lottery. In both cases, the current income of the individual is $1,000 greater than it had been. In the first case, however, this $1,000 raise is expected to be permanent, in the sense that this additional $1,000 will also yield an additional $1,000 next year and on into the future. In the latter case, however, the additional $1,000 is not permanent, as expectations regarding future incomes should not be affected by having won the lottery. In this case, the different expectations inherent in the additional $1,000 of current income will likely have dramatically different impacts on current consumption patterns.

ii. Calculation of Permanent Income

Relating equation (III.4) to the permanent income hypothesis, permanent income can be expressed as a function of current and expected future income. Expected income can be expressed as a function of current and past values of income.

Combining these two relationships, Friedman suggested that permanent income could be expressed as a weighted average of current and past income, where the weights decline exponentially moving farther back from the current period. Thinking about this another way, we can think of permanent income today as being equal to permanent income last time period, adjusted based on new information drawn from the level of current income. This simplifies the calculation of permanent income into a simple function of past permanent income and current income:

$$Y^{p}_{t} = (1-\alpha)Y_{t} + \alpha Y^{p}_{t-1} \tag{III.5}$$

where Y refers to current income, and is equal to personal disposable income in my work, Y^p refers to permanent income, and α is equal to the weight given to last period's permanent income in calculating permanent income. Using annual data, Friedman hypothesized that the value of α was approximately equal to (2/3), or 0.67. This value is converted to a quarterly value by raising this value to the (1/4)th power, yielding a value of $\alpha = 0.905$, and a value of $(1-\alpha)$ of 0.095.

Based on historical evidence, it is known that income will, in general, rise over time. This expected rise in future income ought to be incorporated, therefore, into the calculation of permanent income. This is done in my work by adjusting the calculated value of permanent income in equation (III.5) above by a growth rate, G, which is equal to the historical quarterly compound growth rate of income. This presumes that expectations of future income growth are based on observed historical growth rates. The historical value of G used here is equal to 1.00326, or 0.326% quarterly compound growth over this time period, which is equal to the average quarterly growth in personal disposable income from 1966 to the present time. Hence, the permanent income variable is calculated based on the following equation:

$$Y^P_t = 1.00326 \cdot [(0.095) \cdot Y_t + (0.905) \cdot Y^P_{t-1}] \qquad \text{(III.6)}$$

iii. Income Variables used in Postal Demand Equations

(a) Use of Permanent and Transitory Income

For those types of mail which are either basic consumption goods or services (i.e., provide utility to consumers directly, such as greeting cards or personal correspondence) or which are derived demands which derive directly from basic consumption goods or services (e.g., bills and bill-payments, which derive from consumption purchases), personal consumption theory is appropriate in understanding the relationship between income and the demand for these types of goods and services. Hence, it is appropriate to distinguish the effects of permanent and transitory income on the demand for these types of mail.

For demand equations for this type of mail -- which includes First-Class, Periodical, and Standard non-bulk mail, as well as special services -- separate measures of permanent and transitory income are included in the demand equations estimated for this case.

Permanent income in the time series regressions is calculated using equation (III.6) above. Permanent income is expressed in constant 1992 dollars, and is deflated by adult population for consistency with the mail volume variables used as the dependent variables in the equations.

The measure of transitory income used is the Federal Reserve Board index of capacity utilization for the manufacturing sector of the economy, which has been found to track the general business cycle quite closely. For several categories of mail, transitory income is entered into the demand equations lagged, to reflect a lagged relationship between overall consumption and the derived consumption of mail volumes. In some cases, transitory income was found to have no impact on the demand for mail volumes. This is consistent with the permanent income hypothesis outlined above.

(b) Use of Personal Consumption Expenditures

Income does not play the same role in the demand for direct mail advertising as it does in the demand for other mail categories. The demand for direct mail advertising, from the perspective of the advertiser, is a function of expected consumption. The permanent income hypothesis can be used to express expected consumption as a function of expected permanent income. Hence, the demand for advertising mail volume could logically be expressed as a function of permanent (and transitory) income. In this case, however, the relationship is more directly between advertising mail volume and consumption expenditures, rather than between advertising mail volume and the factors which would be expected to drive consumption expenditures. Hence, for this case, the more direct relationship between direct mail advertising volume and consumption expenditures was modeled by including personal consumption expenditures in the demand equations for direct mail advertising (i.e., Standard bulk mail volume).

3. Treatment of Seasonality

The volume data used in modeling the demand for mail is quarterly in nature. In observing quarterly mail volumes historically, one of the dominant characteristics of the mail is the strong quarterly seasonal pattern. For example, Christmas is a strong season for most mail categories, with volumes being significantly greater than at other times of the year. Individual mail categories also have other individual seasonal patterns in specific time periods (e.g., single-piece First-Class letters volume is strong on April 15th due to individual tax returns, bound printed matter volume is strong in September due in part to the delivery of seasonal catalogs).

For quarterly time series data, the traditional econometric technique for modeling seasonality is to include dummy variables associated with the four quarters of the year (i.e., a variable equal to one in the first quarter of every year, and equal to zero otherwise; a variable equal to one in the second quarter of every year, and equal to zero otherwise; etc.). Three of these dummy variables are then traditionally included as explanatory variables in a regression (with the impact of the fourth season captured within the regression's constant term). Alternatively, more sophisticated techniques of modeling seasonality include introducing fourth-order autoregressive processes or more advanced mathematical techniques such as spectral analysis which model mail volume in a particular period as being determined in part by mail volume in the same period the year before.

a. The Postal Calendar

The Postal Service reports data using a 52-week Postal calendar, composed of 13 28-day accounting periods. Because the 52-week Postal year is only 364 days long, the beginning of the Postal year, as well as the beginning of each Postal quarter, shifts over time relative to the traditional Gregorian calendar. Specifically, the Postal calendar loses five days every four years relative to the Gregorian calendar.

Postal 1971 began on October 17, 1970. Postal 1996 ended on September 13, 1996. Hence, these twenty-six Postal years are, in fact, 33 days short of 26 full years. From the first day of Postal 1971 through the end of the second quarter of Postal 1997 (the longest sample period used for any of the demand equations modeled in my testimony), a total of 130 days shifted between Postal quarters (e.g., were in Quarter 1 for part of the time period and in Quarter 2 for the remainder of the time period) -- September 14th through October 16th, December 7th through January 8th, March 2nd through April 2nd, and May 25th through June 25th.

Prior to 1983, Christmas Day fell in the first Postal quarter of the year (the Postal year begins in the previous Fall -- e.g., Postal 1997 began on September 14, 1996). Since 1983, however, Christmas Day has fallen within the second Postal quarter. Between 1983 and 1997, the second Postal quarter gained nineteen days in December preceding Christmas (December 7th through December 25th) which are among the Postal Service's heaviest days in terms of mail volume. Not surprisingly, therefore, the relative volumes of mail in Postal Quarter 1 and Postal Quarter 2 have changed over this time period for most mail categories, as Christmas-related mailings have shifted from the first Postal quarter to the second Postal quarter, due solely to the effect of the Postal Service's moving calendar.

This creates a potential source of difficulty in attempting to model the seasonal pattern of mail volume using traditional econometric techniques, such as simple quarterly dummy variables. If the seasonal pattern of mail volume is due to seasonal variations within the Gregorian calendar (e.g., Christmas), then the perceived seasonal pattern across Postal quarters may not be constant over time, even if the true seasonal pattern across periods of the Gregorian calendar is constant over time.

b. Definition of Seasons for Econometric Purposes

In Docket No. R94-1, seasonality was modeled by simple quarterly dummies which corresponded to the Postal calendar. Movements in seasonality over time were accounted for by the use of an X-11 seasonal adjustment procedure.

For this case, the seasonal variables used in the regressions were redefined to correspond to constant time periods in the Gregorian calendar. Defining seasons in this way turns the moving Postal calendar into an advantage, because it allows us to isolate more than just four seasons, even with simple quarterly data.

A total of seventeen seasonal variables were developed for this report. These seasons correspond to the following periods of the Gregorian calendar:

September
October
November 1 - December 10
December 11 - December 12
December 13 - December 15
December 16 - December 17
December 18 - December 19
December 20 - December 21
December 22 - December 23
December 24

December 25 - January 1
January 2 - February 28
March 1 - March 31
April 1 - April 15[8]
April 16 - May 31
June 1 - June 30
July 1 - August 31

For any given quarter, the value of a seasonal variable is set equal to the proportion of business days within the quarter that fall within the season of interest. For purposes of calculating business days, Sundays are not counted, while Saturdays are counted as one-half business days. In addition, seven common business holidays are not counted as business days to reflect the lack of business activity (and hence, mail volume) on these days. The seven holidays excluded from the count of business days here are: January 1st, Memorial Day, July 4th, Labor Day, Thanksgiving, the day after Thanksgiving, and Christmas.

An example of the construction of two of these variables may be instructive. Consider, for example, the values of the seasons, September and October, for Postal 1996.

Postal 1996Q1 spans the time period from September 16, 1995 through December 8, 1995, and includes a total of 64 business days (12 weeks @ 5.5 business days per week minus Thanksgiving and the day after Thanksgiving). The period from September 16, 1995 through September 30, 1995 falls within the season of September as well as 1996Q1. This time period encompasses a total of 11.5 business days (15 total days less 2 Sundays and one-half of 3 Saturdays). Hence, the seasonal variable

[8] Actually, this season runs through the day that Federal income tax returns are due. This is April 15th unless April 15th falls on a weekend, in which case it is the Monday immediately following April 15th.

September has a value equal to (11.5/64) in 1996Q1. The period from October 1, 1995 through October 31, 1995 falls within the season of October as well as 1996Q1. This time period encompasses a total of 24 business days (31 total days less 5 Sundays and one-half of 4 Saturdays). Hence, the seasonal variable October has a value equal to (24/64) in 1996Q1.

Postal 1996Q2 spans the time period from December 9, 1995 through March 1, 1996. Postal 1996Q3 spans the time period from March 2, 1996 through May 24, 1996. Neither of these quarters overlap with any of September or October. Hence, the value of both September and October are set equal to zero for both 1996Q2 and 1996Q3.

Postal 1996Q4 spans the time period from May 25, 1996 through September 13, 1996, and includes a total of 85 business days (16 weeks @ 5.5 business days per week minus Memorial Day, July 4th, and Labor Day). The period from September 1, 1996 through September 13, 1996 falls within the season of September as well as 1996Q4. This time period encompasses a total of 9.5 business days (13 total days less Labor Day, 2 Sundays, and one-half of 1 Saturday). Hence, the seasonal variable September has a value equal to (9.5/85) in 1996Q4. The month of October does not intersect with 1996Q4 at all. Hence, the value of October is set equal to zero for 1996Q4.

c. Use of Seasonal Variables Econometrically

The 17 seasonal variables defined as outlined above are used to model the seasonal pattern of mail volumes econometrically. Sixteen of the 17 seasonal variables are included in each econometric equation. The excluded seasonal variable is the variable covering the period from July 1st through August 31st, the effect of which is captured implicitly within the constant term. The coefficients on the sixteen included seasonal variables are estimated along with the other econometric parameters as described below.

In an effort to maximize the explanatory power of the seasonal variables, taking into account the cost of including these variables, in terms of degrees of freedom, the coefficients on adjoining seasons that were similar in sign and magnitude were constrained to be equal. For example, the coefficients on the seasonal variables spanning the time period from December 18th through January 1st were constrained to be equal in the private First-Class cards equation. These constraints across seasons were done on an equation-by-equation basis. The criterion used for this constraining process was generally to minimize the mean-squared error of the equation, which is equal to the sum of squared residuals divided by degrees of freedom.

The estimated effects of the 16 seasonal variables can be combined into a seasonal index, which can be arrayed by Postal quarter to observe the quarterly seasonal pattern and to understand how this seasonal pattern changes over time as a result of the moving Postal calendar. Such an index is presented as part of the full econometric output from my demand equations filed in Workpaper 1 accompanying my testimony.

4. Functional Form of the Equation

a. General Specification of Demand Equations

The demand equations modeled in my testimony take on the following form:

$$V_t = \alpha \bullet X_{1t}^{\beta_1} \bullet X_{2t}^{\beta_2} \bullet X_{3t}^{\beta_3} \bullet \ldots e^{\varepsilon_t} \qquad \text{(III.7)}$$

where V_t is the volume of mail at time t; X_1, X_2, X_3, ... are explanatory variables which influence mail volume, and ϵ_t is a residual term reflecting other influences on mail volume, which is assumed to be identically and independently normally distributed with an expected value of zero (so that e^{ϵ_t} is lognormally distributed with an expected value of one).

This demand function is a common functional form in empirical econometric work. It was chosen in this case because it has been found to model mail volume quite well historically. In addition, the demand equation in equation (III.7) possesses two desirable properties. First, by taking logarithmic transformations of both sides of equation (III.7), the natural logarithm of V_t can be expressed as a linear function of the natural logarithms of the X_i variables as follows:

$$\ln(V_t) = \ln(\alpha) + \beta_1 \cdot \ln(X_{1t}) + \beta_2 \cdot \ln(X_{2t}) + \beta_3 \cdot \ln(X_{3t}) + \ldots + \epsilon_t \qquad \text{(III.8)}$$

Equation (III.8) satisfies the traditional least squares assumptions, and is amenable to solving by Ordinary Least Squares. To acknowledge this property, this demand function is sometimes referred to as a log-log demand function, to reflect the fact that the natural logarithm of volume is a linear function of the natural logarithm of the explanatory variables.

The second desirable property of equation (III.7) is that the β_i parameters are exactly equal to the elasticities with respect to the various explanatory variables. Hence, the estimated elasticities do not vary over time, nor do they vary with changes in either the volume or any of the explanatory variables. For this reason, this demand function is sometimes referred to as a constant-elasticity demand specification.

b. Data Used in Modeling Demand Equations

Quarterly mail volumes for the various mail categories are used in each regression as the dependent variable in the demand equations presented in my testimony. These quarterly volume figures were taken from the Postal Service's RPW system.

Quarterly volumes are divided by the number of business days in the quarter to obtain volume per business day. Mondays through Fridays are counted as one business day. Saturdays are counted as ½ business day. Sundays are not considered business days. In addition, seven holidays -- New Year's Day, Memorial Day, July 4th, Labor Day, Thanksgiving, the day after Thanksgiving, and Christmas -- are not considered business days.

One factor affecting mail volume historically is population. As the population of the United States grows, mail volume would be expected to grow in proportion. It is extremely difficult to estimate the impact of population growth on mail volume growth econometrically, however, due to the relatively smooth series of population historically. An assumption that a one percent change in the adult population of the United States would lead to a comparable one percent change in mail volume for all categories of mail seemed to provide a reasonable way around this unfortunate shortcoming. For this reason, mail volumes were further divided by the population of persons 22 years of age and older prior to being used in the demand equations.

The resulting series of quarterly volume per business day per adult is then used as the dependent variable in the demand equations described in section II above.

In Docket Nos. R90-1 and R94-1, the volumes forecasted by Dr. Tolley included federal government mail volume distributed by mail category, whereas the volumes used by Dr. Tolley in modeling his demand equations treated government mail as a separate class of mail. The reason for this difference was that the Postal Service did not begin to distribute government mail until 1988. Consequently, there was not a long enough time series of data with government mail distributed to allow for econometric estimation.

RPW data was restated going back to 1993Q1 to incorporate First-Class mailing statement data. The restated mail volumes were only reported, however, with government mail distributed. Hence, it has become necessary to incorporate data with government mail distributed into the econometric work presented here.

The volumes used in the demand equations discussed above exclude government mail prior to 1988. Since 1988, however, the volumes include government mail, distributed by mail category. This break in the data is modeled by the inclusion of a dummy variable (named GDIST) which is equal to zero through 1987Q4 and equal to one thereafter, to reflect that data after that time is Government-DISTributed, in the equations for those mail categories for which there is a non-trivial amount of government mail.

If the volume of government mail was proportional to the volume of non-government mail for a particular category of mail, then the volume of mail in that category including government mail could be related to the volume excluding government mail according to the following formula:

$$Vol_{incl\ govt.\ mail} = e^{k} \bullet Vol_{excl.\ govt.\ mail} \tag{III.9}$$

for some constant k. Taking the natural logarithm of both sides of equation (III.9) yields the following equation:

$$Ln(Vol_{incl\ govt\ mail}) = k + Ln(Vol_{excl.\ govt.\ mail}) \tag{III.10}$$

If the value of k were truly constant across all time periods, and the demand equation for mail volume were perfectly specified otherwise, then the coefficient on GDIST would be exactly equal to k for each mail category (where k could vary across mail categories). A fitted value of k can be calculated for any quarter for which mail volumes were reported both with and without government mail volume distributed, and would be equal to

$$k_t = Ln(Vol_{incl.\ govt\ mail}) - Ln(Vol_{excl.\ govt.\ mail}) \qquad \text{(III.11)}$$

Ideally, the coefficient on GDIST ought to be freely estimated in order to maximize its explanatory power. In fact, however, in several cases, the freely estimated coefficient of GDIST was either unreasonably large given the volume of government mail, or was negative, which is, of course, theoretically impossible. For those cases where the freely-estimated coefficient on GDIST was deemed unreasonable, the coefficient on GDIST was constrained based on the observed level of government mail volume between 1988 and 1992 using equation (III.11) above. In these cases, the value of GDIST was constrained to the average value of k_t for t from 1988Q1 through 1992Q4.

The natural logarithm of mail volume per adult per business day is modeled as a function of a set of explanatory variables of the form of equation (III.8) above. In general, the explanatory variables are entered into the demand equation in logarithmic form. An exception, however, is those variables which take on a value equal to zero over some portion of their relevant history. The natural logarithm of zero does not exist. Consequently, variables which take on a value of zero at some point in the regression period must be entered into the demand equations in their natural state, unlogged. For variables which are entered into the equation unlogged, the modeled relationship between mail volume and these variables is the following:

$$V_t = A \bullet e^{X_t \beta} \qquad (III.12)$$

and the elasticity of V with respect to X is equal to $\beta \bullet X$.

B. Methodology for Solving Equation (III.8)

1. Basic Ordinary Least Squares Model

Equation (III.8) can be re-written in matrix form as follows:

$$y = X\beta + \epsilon \qquad (III.13)$$

where y is equal to V_t, expressed as a vector, X is a matrix with columns equal to explanatory variables, X_1, X_2, X_3, etc., expressed as vectors, β is a vector of β_1, β_2, β_3, etc., and ϵ is equal to ϵ_t, expressed as a vector.

If $E(\epsilon_t) = 0$, and $var(\epsilon_t)$ is equal to σ^2 for all t, so that $var(\epsilon) = \sigma^2 I_T$, then the best linear unbiased estimate of the coefficient vector, β, is equal to

$$b = (X'X)^{-1}X'y \qquad (III.14)$$

This is the Ordinary Least Squares (OLS) estimate and is among the oldest and most traditional results in all of econometrics. If the error term is not identically distributed (i.e., $var(\epsilon_t)$ is not equal to σ^2 for all t), or if the error term is not uncorrelated through time (i.e., $cov(\epsilon_t, \epsilon_{t-j}) \neq 0$ for some $j \neq 0$), then the variance-covariance matrix of ϵ can be expressed as, $var(\epsilon) = \sigma^2\Sigma$, and the restriction on the variance of ϵ_t can be eased by introducing Σ into equation (III.14) as follows:

$$b = (X'\Sigma^{-1}X)^{-1}X'\Sigma^{-1}y \qquad (III.15)$$

Equation (III.15) is called the Generalized Least Squares (GLS) estimate of β. A version of equation (III.15) is used to estimate the demand coefficients presented and discussed here in my testimony. The exact specification of Σ used in estimation is developed below.

2. Introduction of Outside Restrictions into OLS Estimation

To introduce restrictions into the OLS estimator, define a vector of restrictions, d, and a restriction matrix, C, such that $C \bullet \beta = d$. If the restrictions are known with certainty, as for example, the restrictions imposed upon the seasonal variables that concurrent seasons with comparable coefficients are constrained to have equal coefficients, then the OLS estimator is modified as follows to yield a Restricted Least Squares (RLS) estimate of the regression coefficients:

$$\text{(OLS Estimator)} \qquad b = (X'X)^{-1}X'y$$
$$\text{(RLS Estimator)} \qquad b^{\wedge} = b + (X'X)^{-1}C'[C\,(X'X)^{-1}C']^{-1} \bullet (d - Cb) \qquad \text{(III.16)}$$

To introduce restrictions which are not known with certainty (i.e., stochastic restrictions), define a restriction matrix, R and a vector of restrictions, r, such that

$$r = R\beta + v$$

where v is a random variable, such that $E(v) = 0$ and $var(v) = \sigma^2\Omega$.

In all cases where stochastic restrictions are introduced in this case, the matrix Ω is a diagonal matrix with the variances associated with r along the diagonal.

The OLS estimator is modified as follows to yield a Least Squares estimate with stochastic restrictions:

$$\text{(Stochastic Restrictions Estimator)} \qquad b^{*} = (X'X + R'\Omega^{-1}R)^{-1}(X'y + R'\Omega^{-1}r) \qquad \text{(III.17)}$$

Finally, exact and stochastic restrictions can be combined within a single estimator, which satisfies the following formula:

(OLS Estimator incorporating outside information)

$$b^{*} = (X'X + R'\Omega^{-1}R)^{-1}(X'y + R'\Omega^{-1}r)$$
$$b^{**} = b^{*} + (X'X + R'\Omega^{-1}R)^{-1}C'[C\,(X'X + R'\Omega^{-1}R)^{-1}C']^{-1}\bullet(d\text{-}Cb^{*}) \qquad \text{(III.18)}$$

If $E(R\beta) = r$, then the most efficient, unbiased GLS estimator incorporating outside information is similarly modified from equation (III.15) as follows:

$$b^{*} = (X'\Sigma^{-1}X + R'\Omega^{-1}R)^{-1}(X'\Sigma^{-1}y + R'\Omega^{-1}r)$$
$$b^{**} = b^{*} + (X'\Sigma^{-1}X + R'\Omega^{-1}R)^{-1}C'[C\,(X'\Sigma^{-1}X + R'\Omega^{-1}R)^{-1}C']^{-1}\bullet(d\text{-}Cb^{*}) \qquad \text{(III.19)}$$

For a full treatment of the introduction of outside restrictions into the OLS model, see, for example, The Theory and Practice of Econometrics, by Judge, et al., pp. 51 - 62.

3. Multicollinearity

In order for the OLS estimator, b, to be defined, the value of $(X'X)^{-1}$ must also be defined. This requires that the matrix (X'X) must be of rank k if (X'X) is a k-by-k matrix. This will be strictly true as long as there is no independent variable in X which can be expressed as a linear combination of the other variables that make up X. So long as this is the case, perfect multicollinearity will not exist, and equation (III.14) above will be uniquely solvable.

As a practical matter, if there are variables within X which are near-perfect linear combinations of one another, however, there will exist some degree of multicollinearity. In such a case, the OLS estimators will be unbiased, but may have extremely large variances about the estimates.

Suppose, for example, that the X-matrix of explanatory variables in equation (III.14) were to be divided into two separate matrices, X_1 and X_2, so that

$$y = X_1\beta_1 + X_2\beta_2 + \epsilon \tag{III.20}$$

Suppose further that the explanatory variables that make up X_1 (e.g., x_1, x_2, x_3) are highly correlated, so that, for example, $x_1 \approx a_1 \cdot x_2 + a_2 \cdot x_3$, for some constants a_1, a_2. The aggregate impact of these variables on the dependent variable ($X_1\beta_1$ in equation (III.20)) will be accurately estimated. The estimated standard errors associated with the coefficients on x_1, x_2, and x_3 will be quite large, however, so that the values of b_1, b_2, and b_3, associated with x_1, x_2, and x_3, respectively, will be poorly estimated. If one's goal is to obtain the best possible estimate for each individual coefficient, β_i, it may therefore be necessary to develop independent estimates of some of the elasticities, in cases where high multicollinearity is known to exist,.

The need for additional information is expounded on quite clearly in The Theory and Practice of Econometrics, 2nd edition, by George G. Judge, et al. (1985):

> "Once detected, the best and obvious solution to [this] problem is to ... incorporate more information. This additional information may be reflected in the form of new data, a priori restrictions based on theoretical relations, prior statistical information in the form of previous statistical estimates of some of the coefficients and/or subjective information." (p. 897)

Multicollinearity will be a problem to at least some degree in any empirical econometric work. In the present work, multicollinearity is particularly acute with regard to a high degree of correlation between permanent income and other economic and trend variables, a high degree of correlation between current and lagged prices of Postal products, and a high degree of correlation between the prices of competing Postal products. The techniques by which the demand equation estimation procedure is refined to account for each of these cases of multicollinearity are described below.

a. Income Coefficients

Permanent income is highly correlated with many other economic and trend variables, making estimation of permanent income elasticities difficult using quarterly time series data. For example, the simple correlation between permanent income and a simple time trend between 1971Q1 and 1997Q2 is equal to 0.991, indicating near-perfect multicollinearity between these variables.

Because of the high degree of correlation between permanent income and other explanatory variables, permanent income elasticities estimated exclusively from the quarterly time series data are somewhat unstable, and often take on implausible values. Table III-1 below presents freely-estimated permanent income elasticities for those categories of mail for which permanent income is included in the demand equations discussed in section II above.

As Table III-1 indicates, the estimated permanent income elasticity is unexpectedly negative in many cases, and appears to be larger than might be expected from economic theory in several other cases. In addition, the standard errors on the permanent income elasticities in Table III-1 are extremely large, as evidenced by t-statistics that are less than one in most cases. In fact, the only categories of mail for which the results in Table III-1 provide evidence of a significant positive permanent income elasticity at a 95 percent confidence level are Standard bound printed matter, for which the permanent income elasticity appears to be implausibly large, and Standard special rate mail.

Table III-1
Permanent Income Elasticities Estimated from Time Series Data

Mail Category	Permanent Income Elasticity Estimated from Time Series Data (T-Statistics in Parentheses)	
First-Class Mail		
First-Class Letters		
Single-Piece	1.138	(1.612)
Workshared	-0.219	(-0.160)
First-Class Cards		
Stamped Cards	0.308	(0.288)
Private Cards	-0.177	(-1.697)
Periodical Mail		
Regular Rate	0.206	(0.840)
Within County	-3.094	(-3.765)
Nonprofit	-0.320	(-0.400)
Classroom	-3.519	(-2.710)
Standard Non-Bulk Mail		
Bound Printed Matter	5.754	(21.29)
Special Rate	1.450	(2.518)
Library Rate	-0.480	(-0.694)
Single-Piece	-0.002	(-0.001)
Special Services		
Registered Mail	2.099	(0.799)
Insured Mail	1.008	(1.000)
Certified Mail	-3.311	(-4.829)
COD	1.722	(0.670)
Money Orders	0.407	(0.678)

In addition to the quarterly time series data, however, it is also possible to estimate the relationship between income and mail volume from the Household Diary Study. The Household Diary Study contains cross-sectional data on mail volume received by households as well as on demographic characteristics including household income. The Household Diary Study can thus be used to measure the difference in mail volume received across households based on differences in the income of these households. This provides an estimate of the impact of mail volume received by households on changes in household income. At an aggregate level, this is equivalent to the impact on mail volume of changes in the level of income in the economy as a whole.

The permanent income elasticities are introduced into the quarterly time series regressions as stochastic restrictions using equation (III.19) above. The details of the cross-sectional estimation of the permanent income elasticities and their standard errors are given in Workpaper 2 accompanying my testimony.

The Household Diary Study does not provide explicit information on consumption expenditures by household. Hence, it was not possible to estimate the relationship between Standard bulk mail volumes and personal consumption expenditures from the Household Diary Study. The effect of personal consumption expenditures on direct mail advertising volume was hence estimated exclusively from the time series data on Standard bulk mail.

b. Shiller Smoothness Priors

Experience suggests that there is a lagged reaction by mailers to changes in Postal prices, so that mail volumes are affected not only by the current Postal price but also by lagged prices. Because Postal prices change relatively infrequently, however, the current Postal price is highly correlated with lagged Postal prices. For example, the simple correlation coefficient on the price of Periodical regular mail and the price of Periodical regular mail lagged one quarter is equal to 0.98 over the Periodical regular sample period used in this case. This represents a classic case of the multicollinearity problem outlined in equation (III.20) above. The aggregate effect of price on mail volume can be very accurately modeled, while the coefficients on the individual lags of price may be highly erratic and unstable.

Because the lags of price play an important role in forecasting the impact of the proposed rate changes in this case, it is important not only that the long-run (i.e., aggregate) impact of price on mail volume be accurately modeled, but also that the impacts of the individual lags be accurately modeled.

Dr. Robert Shiller proposed a solution to this problem in a 1973 article in Econometrica (Robert J. Shiller, "A Distributed Lag Estimator Derived from Smoothness Priors," Econometrica, July 1973, pp. 775-788). Dr. Shiller's technique allows a polynomial equation to be used to adjust a set of coefficients so that the coefficients will follow a reasonable pattern. For this testimony, the current and four lags of Postal prices are included in the demand equations for mail volumes. A quadratic pattern is stochastically imposed on the price coefficients. Dr. Shiller refers to the quadratic constraint used in this case as a constraint with a degree of smoothness equal to one.

Dr. Shiller's proposed technique represents a special case of a stochastic restriction, as outlined above in equation (III.19). In particular, the GLS estimator is modified as follows to generate Shiller distributed lags:

$$b^{S} = (X'\Sigma^{-1}X + \sum_{i=1}^{p} k_i^2 \cdot S_i'S_i)^{-1} X'\Sigma^{-1}y \qquad \text{(III.21)}$$

A unique matrix, S_i, is developed for each price distribution for which Shiller restrictions are applied. P in equation (III.21) refers to the number of such distributions. If there are k explanatory variables in the equation and variables j through j+4 are the current and first through fourth lag of price i, the S_i matrix will assume the following form:

$$\begin{array}{cc} & \begin{matrix} x_1 & x_2 & \ldots & x_{j-1} & x_j & x_{j+1} & x_{j+2} & x_{j+3} & x_{j+4} & x_{j+5} & \ldots & x_k \end{matrix} \\ S_i = & \begin{vmatrix} 0 & 0 & \ldots & 0 & 1 & -2 & 1 & 0 & 0 & 0 & \ldots & 0 \\ 0 & 0 & \ldots & 0 & 0 & 1 & -2 & 1 & 0 & 0 & \ldots & 0 \\ 0 & 0 & \ldots & 0 & 0 & 0 & 1 & -2 & 1 & 0 & \ldots & 0 \end{vmatrix} \end{array}$$

The variable k_i^2 is equal to the variance of the full model (σ^2) divided by the variance of the smoothness restriction (ρ_i^2). As ρ_i^2 approaches zero, k_i^2 will approach infinity, and b^S will approach a strict quadratic (Almon) distributed lag. As ρ_i^2 approaches infinity, k_i^2 will approach zero, and b^S in equation (III.21) will approach the GLS estimator, b in equation (III.15). A unique value of k_i^2 is estimated for each price to which the Shiller restriction is being applied.

The values of k^2_i are chosen prior to estimation. The goal of the estimation procedure used in this case was to minimize the value of k^2_i, subject to a prior expectation about the general shape of the price distribution. The values of k^2_i are minimized through a search technique which evaluates the price distribution for each value of k^2_i. An acceptable pattern for price coefficients must satisfy four conditions, which are determined on the basis of experience with expectations regarding mailers' reactions to changes in price:

(i) All price coefficients must have the same sign

(ii) The price distribution must have exactly one local maximum in absolute value

(iii) The coefficient on the price lagged three quarters must be less in absolute value than all previous lags

(iv) The coefficient on the price lagged four quarters (and, implicitly, on all longer lags) must be exactly equal to zero

The last of these requirements is imposed as a fixed restriction, as described in section 2 above. The smallest values of k^2_i for each price distribution which yield price coefficients satisfying the above requirements are chosen and used in making the final coefficient estimates presented in my testimony.

c. Slutsky-Schultz Symmetry Condition

i. Derivation of the Slutsky-Schultz Condition

In addition to Postal prices being highly correlated with their own lags, Postal prices are also highly correlated with one another. All Postal prices tend to rise at the same time every three years or so in response to omnibus rate cases. Between rate cases, all real Postal prices fall together at the rate of inflation. For example, the simple correlation coefficient between the prices of single-piece First-Class letters and private single-piece First-Class cards was equal to 0.795 between 1983Q1 and 1996Q3. This correlation between Postal prices makes it difficult to estimate cross-price relationships between Postal categories.

Cross-price relationships are modeled between First-Class letters and cards, between First-Class letters and Standard regular mail, and between parcel post and Priority Mail in my testimony. Because of the difficulty in isolating the effects of these prices separately due to multicollinearity, the cross-price elasticity between First-Class letters and Standard regular mail is not estimated from the quarterly time series data, but is instead derived from the Household Diary Study. The econometric estimation of cross-price relationships between First-Class letters and cards and between parcel post and Priority Mail are helped by a relationship known as the Slutsky-Schultz relationship.

The Slutsky-Schultz cross-price relationship is premised on the fact that, for two goods i and j, the change in the volume of good i attributable to a change in the price of good j is equal to the change in the volume of good j attributable to a change in the price of good i, or, mathematically,

$$\frac{\partial V_i}{\partial p_j} = \frac{\partial V_j}{\partial p_i} \tag{III.22}$$

The elasticity of V_i with respect to p_j is equal to

$$e_{ij} = \frac{\partial V_i}{\partial p_j} \cdot \frac{p_j}{V_i}, \text{ so that, rearranging terms: } \frac{\partial V_i}{\partial p_j} = e_{ij} \cdot \frac{V_i}{p_j} \tag{III.23}$$

Combining equation (III.22) with equation (III.23) yields the following relationship:

$$e_{ij} \cdot \frac{V_i}{p_j} = e_{ji} \cdot \frac{V_j}{p_i}, \text{ so that, rearranging terms, } \frac{e_{ij}}{e_{ji}} = \frac{V_j \cdot p_j}{V_i \cdot p_i} \tag{III.24}$$

In words, equation (III.24) states that the ratio of cross-price elasticities is equivalent to the ratio of expenditures on goods i and j. This is called the Slutsky-Schultz symmetry condition.

The Slutsky-Schultz symmetry condition can be used to gauge the reasonableness of the cross-price elasticities between Postal categories estimated from the quarterly time series data, and, if necessary, to adjust the cross-price elasticities to more reasonable values.

If the ratio of expenditures between goods i and j varies over time, equation (III.24) indicates that the ratio of the cross-price elasticities will vary in the same way. This suggests that one or both of the cross-price elasticities must be non-constant over time. The functional form used to model demand in my testimony treats both cross-price elasticities as if they were constant over time, however. Hence, at best, a strict application of equation (III.24) can only be imposed for a single point in time.

While it may be mathematically possible to devise an equation system whereby equation (III.24) holds at all points in time, such a procedure would introduce a significant level of complication into the present model, with relatively little gain in terms of understanding the factors which drive mail volume. It would, however, be ill-advised to forgo the underlying theory of equation (III.24) in modeling cross-price relationships between Postal categories simply because equation (III.24) cannot be made to hold with exact equality throughout the sample period.

For our purposes, equation (III.24) is imposed when necessary using a fixed set of expenditures, so that equation (III.24) is absolutely true at only one particular point in time. Since the primary purpose of the demand equations developed here is for forecasting, equation (III.24) is imposed using expenditure ratios over the most recent four Postal quarters. By using the expenditure ratio from the most recent year, the Slutsky-Schultz relationship is maintained as strictly as possible in the forecast period, while maintaining the overall simplicity of our demand equation estimation procedure.

ii. Cross-Price Relationship between First-Class Letters and Cards

The cross-price elasticity between First-Class letters and First-Class cards can be estimated from each of three equations: the single-piece First-Class letters equation, the workshared First-Class letters equation, and the private First-Class cards equation. These three estimates are as follows (t-statistics in parentheses):

Equation	Cross Price with respect to	Free	Slutsky-Schultz
Single-Piece Letters	Single-Piece Cards	0.017 (0.122)	0.005
Workshared Letters	Workshared Cards	0.146 (1.134)	0.005
First-Class Cards	First-Class Letters	0.197 (1.390)	2.206

The cross-price elasticities with respect to cards from the First-Class letters equations yield an implied Slutsky-Schultz cross-price elasticity with respect to letters in the First-Class cards equation of 2.206. This appears to be implausibly large, given that there is no other Postal price relationship (including own-price elasticities) presented in my testimony that is significantly greater than one (in absolute value). Hence, the cross-price relationship between First-Class letters and cards was estimated from the private First-Class cards equation, and the cross-price elasticities with respect to single-piece and workshared First-Class letters were calculated from the private cards equation using the Slutsky-Schultz relationship. The Slutsky-Schultz relationship was stochastically imposed on the sum of the current and lagged cross-price variables in the First-Class letters equations. The relationship was imposed stochastically to reflect the fact that the cross-price elasticity in the private cards equation was estimated with some degree of uncertainty. In addition, the stochastic constraint allows the estimated cross-price elasticities to differ somewhat with respect to single-piece and workshared First-Class letters.

iii. Cross-Price Relationship between Parcel Post and Priority Mail

Dr. Musgrave's Priority Mail equation includes a cross-price with respect to parcel post mail. His estimate of the cross-price elasticity of Priority Mail with respect to parcel post mail is equal to 0.092 (with a t-statistic of 1.086). Using the Slutsky-Schultz condition, this implies a cross-price elasticity of parcel post mail volume with respect to the price of Priority Mail of 0.447. In contrast, the cross-price elasticity of parcel post mail volume with respect to the price of Priority Mail estimated from the time series data was 0.011, with a t-statistic of 0.078. Due to the almost absolute insignificance of the Priority Mail cross-price elasticity from the parcel post equation, the value implied by the Priority Mail equation and the Slutsky-Schultz relationship (0.447) was used instead in estimating the parcel post equation.

4. Autocorrelation

The restriction on the OLS estimator in equation (III.14) that $var(\epsilon_t) = \sigma^2$ requires an assumption that the error term is independently distributed, so that $cov(\epsilon_t, \epsilon_{t-k}) = 0$ for all t, $k \neq 0$. If this is not the case, the residuals are said to be autocorrelated. In this case, the Least Squares estimator will be unbiased. It will not, however, be efficient. That is, the estimated variance of b will be very high, and the traditional least squares test statistics may not be valid.

Autocorrelation is tested for and corrected in the residuals using a method called the Cochrane-Orcutt procedure (D. Cochrane and G. H. Orcutt, "Application of Least Squares Regressions to Relationships Containing Autocorrelated Error Terms," Journal of the American Statistical Association, vol. 44, 1949, pp. 32-61).

An OLS regression (with outside restrictions as outlined above, except for the Shiller restrictions) is initially run. The residuals from this regression are then inspected to assess the presence of autocorrelation. The exact nature of the autoregressive process is identified by testing the significance of the partial autocorrelation of the residuals at one, two, and three lags. A 90 percent confidence level is used to test for the presence of autocorrelation. The following relationship is then fit to the residuals:

$$e_t = \rho_1 \bullet e_{t-1} + \rho_2 \bullet e_{t-2} + \rho_3 \bullet e_{t-3} + u_t \qquad \text{(III.25)}$$

where u_t is assumed to satisfy the OLS assumptions. The values of ρ_1, ρ_2, and ρ_3 are estimated using traditional OLS. If significant third-order autocorrelation is not identified, ρ_3 is set equal to zero. If neither second- nor third-order autocorrelation are identified as significant, then $\rho_2 = \rho_3 = 0$. Finally, if neither first-, second-, nor third-order autocorrelation are identified, then no autocorrelation correction is made (i.e., $\rho_1 = \rho_2 = \rho_3 = 0$).

The values of ρ_1, ρ_2, and ρ_3 are used to adjust the variance-covariance matrix of the residuals, Σ, and the β-vector is re-estimated using the Generalized Least Squares equation:

$$\beta^{\wedge} = (X'\Sigma^{-1}X)^{-1}X'\Sigma^{-1}y \qquad \text{(III.15)}$$

The variance-covariance matrix of the residuals, Σ, is set equal to $(P'P)^{-1}$, where P is a (T-i)-by-T matrix (where T is the total number of observations in the sample period and i is the largest lag for which significant autocorrelation was detected) that takes on the following form:

$$P_0 = \begin{vmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \ldots & 0 \\ -\rho_1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & \ldots & 0 \\ -\rho_2 & -\rho_1 & 1 & 0 & 0 & 0 & 0 & 0 & \ldots & 0 \\ -\rho_3 & -\rho_2 & -\rho_1 & 1 & 0 & 0 & 0 & 0 & \ldots & 0 \\ 0 & -\rho_3 & -\rho_2 & -\rho_1 & 1 & 0 & 0 & 0 & \ldots & 0 \\ 0 & 0 & -\rho_3 & -\rho_2 & -\rho_1 & 1 & 0 & 0 & \ldots & 0 \\ 0 & 0 & 0 & -\rho_3 & -\rho_2 & -\rho_1 & 1 & 0 & \ldots & 0 \\ & & & & \ldots & & & & & \\ 0 & 0 & 0 & \ldots & 0 & -\rho_3 & -\rho_2 & -\rho_1 & 1 & 0 \\ 0 & 0 & 0 & \ldots & 0 & 0 & -\rho_3 & -\rho_2 & -\rho_1 & 1 \end{vmatrix}$$

where P_0 is a T-by-T matrix, and P is equal to the last T-i rows of P_0. In other words, if i=0, then $\rho_1=\rho_2=\rho_3=0$, P is simply equivalent to P_0, and the GLS equation above is exactly equivalent to Ordinary Least Squares. If i=1, then $\rho_2=\rho_3=0$, and the first row of P is equal to $[-\rho_1\ 1\ 0\ 0\ \ldots\ 0]$. If i=2, then $\rho_3=0$, and the first row of P is equal to $[-\rho_2\ -\rho_1\ 1\ 0\ 0\ \ldots\ 0]$. Finally, if i=3, the first row of P is equal to $[-\rho_3\ -\rho_2\ -\rho_1\ 1\ 0\ 0\ \ldots\ 0]$.

Modifying Σ in this way, and estimating $\beta^{\wedge}$ using Generalized Least Squares is equivalent to using the rho-coefficients (ρ_1, ρ_2, and ρ_3) to transform the dependent variable as well as all of the independent variables as follows:

$$x_t = x_t - \rho_1 \bullet x_{t-1} - \rho_2 \bullet x_{t-2} - \rho_3 \bullet x_{t-3} \qquad \text{(III.26)}$$

removing the first i observations of the regression period, re-defining y and X using the transformed data, and re-estimating β using the OLS estimator on the transformed variables.

5. Logistic Market Penetration Variable

a. Theory

It is always desirable to be able to explain the behavior of a variable which is being estimated econometrically as a function of other observable variables. Occasionally, however, the behavior of a variable is either unexpected or is due to factors which do not easily lend themselves to capture within a time series variable suitable for inclusion in an econometric experiment. For example, it is not uncommon for inexplicable and/or persistent trends in data series to be modeled in part through the use of a mechanical "trend" variable.

While it would certainly be better if one could include an explanatory variable that is more pleasing theoretically than simply "time" or a "trend", the failure to include any variable to account for observed behavior will unquestionably bias one's other coefficient estimates. In cases of this type, it may therefore be necessary to introduce some type of trend variable into certain demand equations.

Several mail volume equations include some type of trend. For example, the First-Class letters equations include mechanical trend variables in order to measure changes in the costs to mailers of worksharing. The Standard single-piece equation as well as several special service equations include linear time trends to account for long-run trends in the volumes of these types of mail, for which economic sources have not been found.

Once one makes a decision that a trend variable is needed within a particular demand equation, an equally important question becomes what form the trend variable ought to take.

A trend is a trend is a trend
But the question is, will it end?
Will it alter its course
Through some unforeseen force,
And come to a premature end?
Sir Alec Cairncross

One common source of trends in data that are difficult to model econometrically by relating behavior to other economic variables is the problem of market penetration. Research into the rate at which new products or new technology are adopted has shown that a typical adoption cycle for a new product is initially gradual, followed by increasingly-rapid adoption until some point in time at which the adoption curve reaches an inflection point and the rate of adoption slows until the adoption curve eventually plateaus and the product or technology exhibits a more traditional stable growth pattern attributable to common economic factors.

An adoption curve of this sort can be modeled through a type of logistic curve, referred to by Dr. Tolley in earlier rate cases as a "z-variable". The z-variable formulation fits the following equation:

$$z_t = (d_1 \cdot p_1) / (1+p_2 \cdot e^{(-p_3 \cdot t)}) \qquad \text{(III.27)}$$

where d_1 is a dummy variable which is zero before the initiation of the market penetration, and one thereafter, t is a time trend beginning the quarter after the beginning of the market penetration, and p_1, p_2, and p_3 are defined below, and are calculated econometrically.

In Docket No. R94-1, those subclasses of mail which included a significant direct mail advertising component, which included First-Class letters and cards, as well as third-class bulk regular and nonprofit mail, were all modeled incorporating a z-variable of the form of equation (III.27). This z-variable was incorporated to account for a dramatic rise in the volumes of these mail categories in the early 1980s, which is believed to have come about due to a tremendous surge in the use of direct mail advertising at that time, attributable primarily to tremendous gains in direct mail advertising technology. Due to the re-specification of First-Class letters and Standard bulk mail as described above, which limit the sample period to beginning in the mid-1980s, these demand equations no longer require the z-variable construction. The demand equation for private First-Class cards, however, is estimated over a sample period which begins in 1971Q1. As such, this advertising phenomenon described above must be accounted for within the private First-Class cards equation somehow. As in Dr. Tolley's R94-1 testimony, this is done so through the inclusion of a "z-variable" in the private First-Class cards demand equation. The dummy variable, d_1, in equation (III.27) is equal to one beginning in 1979Q2, as in R94-1.

Besides private First-Class cards, the demand equations for Standard bound printed matter and special rate mail also include z-variables. These variables model more pure market penetration from special rate mail into bound printed matter as a result of gradual rule changes and easing of Postal restrictions beginning in the late 1970s that allowed mailers to shift mail from special rate into bound printed matter, thereby saving significantly on the cost of postage. Coincidentally, these z-variables begin in 1979Q2, at the same time as the private First-Class cards z-variable.

b. Implementation

The z-variable methodology is implemented in two stages. The first stage involves nonlinear estimation. The general demand equation is modified as follows:

$$Ln(V_t) = X_t\beta + z_t + \epsilon_t \qquad \text{(III.28)}$$

where X_t is the full matrix of explanatory variables, and

$$z_t = (d_1 \cdot p_1) / (1 + p_2 \cdot e^{(-p_3 \cdot t)}) \qquad \text{(III.27)}$$

as described above. The z-parameters, p_1, p_2, and p_3 are estimated together with the b_i's in equation (III.28)

The parameter p_1 represents the maximum level of adoption. Market penetration into a particular mail volume is reflected by a positive value of p_1, as is the case with private First-Class cards and bound printed matter, while market penetration out of a particular mail volume is reflected by a negative value of p_1, as is the case with Standard special rate mail.

The parameter, p_2 is equal to $(p_1 / z_0) - 1$, where z_0 is the value of the market penetration variable in the first period for which z_t is not equal to zero. The parameter p_3 is referred to as the rate of adoption, and controls how rapidly z_t approaches p_1.

Both p_2 and p_3 must be positive. To enforce convergence to a minimum in a part of the parameter space where these conditions hold, two penalty function terms are added as follows:

$$Ln(V_t) = X_t\beta + z_t + 100000 \cdot (p_2 - abs(p_2)) + 100000 \cdot (p_3 - abs(p_3)) + \epsilon_t \qquad \text{(III.29)}$$

with abs indicating absolute value. The two new terms are equal to zero when p_2 and p_3 are positive, but would drive the sum of squared residuals excessively high if p_2 or p_3 were to be negative.

Equation (III.29) is fit via nonlinear least squares using a modified Gauss-Newton iteration procedure. The direction of change is that in which one would be carried by a linear approximation to the residuals, but which ensures that the criterion decreases at each stage.

The estimated values of p_1, p_2, and p_3 are then used to compute z_t using equation (III.27) above.

Finally, the dependent variable, y_t, is adjusted by subtracting z_t from it, and the coefficient vector, β, is estimated, taking account of autocorrelation, as well as Shiller and all other restrictions, as described above, using a transformed dependent variable,

$$\hat{y}_t = y_t - z_t.$$

C. Regression Model Used

1. Demand Equation Specification

Demand equations are estimated using a Generalized Least Squares technique, as outlined above. The basic demand equation specification used in this case is a demand equation of the form:

$$\begin{aligned} V_t = \; & \alpha \bullet Y_t^{\beta_1} \bullet \ldots \bullet [p_t^{\beta_2} \bullet p_{t-1}^{\beta_3} \bullet p_{t-2}^{\beta_4} \bullet p_{t-3}^{\beta_5} \bullet p_{t-4}^{\beta_6}] \bullet \\ & [e^{S_1 \beta_{s1}} \bullet e^{S_2 \beta_{s2}} \bullet e^{S_3 \beta_{s3}} \bullet e^{S_4 \beta_{s4}} \bullet e^{S_5 \beta_{s5}} \bullet \ldots \bullet e^{S_{16} \beta_{s16}}] \bullet e^{\epsilon_t} \end{aligned} \qquad \text{(III.30)}$$

where V_t is equal to mail volume per adult per business day in Postal quarter t, Y_t refers to permanent income at time period t (which is not used in the case of Standard bulk mail), p_t - p_{t-4} are the Postal price of the mail category in the current period, and lagged one through four quarters, S_1 - S_{16} correspond to the sixteen seasonal variables described in section A.3. above, and the ... reflects the presence of other explanatory variables in each of the demand equations as described in section II above.

The variable, ϵ_t captures non-modeled changes in V_t. The expected value of ϵ_t is assumed to be equal to zero.

2. Solution of β Coefficients

The natural logarithm of both sides of equation (III.30) is taken, and the resulting equation is solved using Generalized Least Squares. The vector of elasticities,

$$b^{\wedge} = [\beta_1 \; \beta_2 \; \beta_3 \; \ldots]$$

is calculated by the following formula:

$$
\begin{aligned}
b^{*} &= (X'\Sigma^{-1}X + R'\Omega^{-1}R + \sum_{i=1}^{P} k_i^2 S_i' S_i)^{-1}(X'\Sigma^{-1}y + R'\Omega^{-1}r) \\
b^{\wedge} &= b^{*} + (X'\Sigma^{-1}X + R'\Omega^{-1}R + \sum_{i=1}^{P} k_i^2 S_i' S_i)^{-1} C' [C((X'\Sigma^{-1}X + R'\Omega^{-1}R + \sum_{i=1}^{P} k_i^2 S_i' S_i))^{-1} C']^{-1} \cdot (d - C \cdot b^{*})
\end{aligned}
\tag{III.31}
$$

where C and d are a matrix and vector of fixed restrictions, such that $d = C \cdot \beta$, R and r are a matrix and vector of stochastic restrictions, such that $r = R\beta + v$, where $E(v) = 0$, and $var(v) = \sigma^2\Omega$, S_i is a matrix of Shiller smoothness priors for price distribution i as described in section B.3.b. above, k_i^2 is the ratio of the model variance to the variance of the smoothness restriction associated with S_i, and P is the number of price distributions for which Shiller distributed lag restrictions are imposed.

The matrix, Σ, is set equal to $(P'P)^{-1}$, where P is defined as a function of autocorrelation coefficients, ρ_1, ρ_2, and ρ_3, which are calculated using the Cochrane-Orcutt technique. The calculation of ρ_1, ρ_2, and ρ_3, as well as the construction of the matrix P are described in section B.4. above.

The vector y is a vector of length T, where T is the number of quarterly observations in the sample period, which contains the natural logarithm of mail volume per adult per business day. The matrix X is a T-by-k matrix, where k is the number of explanatory variables used to explain V_t. Each column of the matrix X corresponds to the natural logarithm of an explanatory variable from the demand equation (III.30) above.

The vector of coefficients, $b^{\wedge}$ calculated in equation (III.31) has the following statistical properties:

$$
\begin{aligned}
E(b^{\wedge}) &= \beta + [(X'\Sigma^{-1}X + R'\Omega^{-1}R + \sum_{i=1}^{P} k_i^2 S'S)^{-1} R'\Omega^{-1}] \cdot [E(r-R\beta) + \sum_{i=1}^{P} E(S_i\beta)] \\
var(b^{\wedge}) &= \sigma^2 (X'\Sigma^{-1}X + R'\Omega^{-1}R + \sum_{i=1}^{P} k_i^2 S'S)^{-1}
\end{aligned}
\tag{III.32}
$$

If the stochastic restrictions and Shiller restrictions are unbiased, so that:

$$E(r-R\beta) = 0 \text{ and } E(S_i\beta) = 0 \text{ for } i=1 \text{ to } P$$

then $b^{\wedge}$ will be an unbiased estimator of β and will be the best linear unbiased estimate which incorporates stochastic prior information, r, and Shiller information, S.

The variance-covariance matrix associated with $b^{\wedge}$ in equation (III.32) can be best understood if one respecifies equation (III.31) slightly. Define a matrix, $X^{\wedge}$, which is equal to X from equation (III.31) with rows added to the bottom of the matrix which are equal to R•W, where W'W equals Ω^{-1}, and k_iS_i, for i = 1 to P. That is,

$$
X^{\wedge} = \begin{vmatrix} X \\ R \cdot W \\ k_1 \cdot S_1 \\ \dots \\ k_P \cdot S_P \end{vmatrix}
$$

Now, define a vector ŷ equal to y from equation (III.31) with rows added to the bottom corresponding to r, as well as rows of 0 corresponding to Si, for i = 1 to P, so that

$$\hat{y} = \begin{vmatrix} y \\ r \\ 3 \bullet P \text{ rows of } 0 \end{vmatrix}$$

Equation (III.31) can be re-written in terms of $X^{\wedge}$ and $\hat{y}$, instead of X and y, as follows:

$$\begin{aligned} b^{*} &= (X^{\wedge\prime}\Sigma^{-1}X^{\wedge})^{-1}(X^{\wedge}\Sigma^{-1}\hat{y}) \\ b^{\wedge} &= b^{*} + (X^{\wedge\prime}\Sigma^{-1}X^{\wedge})^{-1}C^{\prime}[C(X^{\wedge\prime}\Sigma^{-1}X^{\wedge})^{-1}C^{\prime}]^{-1}\bullet(d - C\bullet b^{*}) \end{aligned} \qquad \text{(III.33)}$$

From equation (III.33), it is seen that $b^{\wedge}$ is simply equal to the traditional GLS estimate of β, with outside restrictions imposed. Hence, the variance-covariance matrix of $b^{\wedge}$ is simply equal to $\sigma^2(X^{\wedge\prime}\Sigma^{-1}X^{\wedge})^{-1}$ and $b^{\wedge}$ is the best linear unbiased estimate of β that incorporates the outside information within C, R, and S_i, i = 1 to P.

3. Example: Periodical Regular Mail

An example of the use of equation (III.31) to model the demand for mail volume may be instructive. Consider, for example, the demand for Periodical regular mail, which is modeled as follows:

$(\text{Vol2r / Population / Business Days})_t =$

$$\begin{aligned} &\alpha \bullet (Y^P)_t^{\beta_1} \bullet (Y^T \text{ lag } 3)_t^{\beta_2} \bullet (C^{CABTV})_t^{\beta_3} \bullet (P^{paper})_t^{\beta_4} \bullet \\ &[px2r_t^{\beta_{p0}} \bullet px2r_{t-1}^{\beta_{p1}} \bullet px2r_{t-2}^{\beta_{p2}} \bullet px2r_{t-3}^{\beta_{p3}} \bullet p_{t-4}^{\beta_{p4}}] \bullet \\ &[e^{S_1\beta_{s1}} \bullet e^{S_2\beta_{s2}} \bullet e^{S_3\beta_{s3}} \bullet e^{S_4\beta_{s4}} \bullet e^{S_5\beta_{s5}} \bullet \ldots \bullet e^{S_{16}\beta_{s16}}] \bullet e^{\varepsilon}_t \end{aligned} \qquad \text{(III.34)}$$

where Vol2r is the volume of Periodical regular mail, Y^P is permanent income in 1992 dollars, Y^T is transitory income, proxied by the Federal Reserve's index of capacity utilization for the manufacturing sector, C^{CABTV} is personal consumption expenditures per adult on cable television in 1992 dollars, P^{Paper} is the wholesale price of pulp, paper, and allied products in 1992 dollars, px2r is the fixed-weight average price of Periodical regular mail, and S_1 through S_{16} are the first sixteen seasonal variables defined in section A.3. above.

The vector y associated with equation (III.34) contains the natural logarithm of (Vol2r / Population / Business Days)$_t$ for t = 1971Q1 through 1997Q2. The matrix X contains the natural logarithm of the explanatory variables in equation (III.34), Y^P, Y^T, etc.[9] Matrix X has dimensions T-by-k, where k equals 26 and T equals 106.

The β-vector to be solved by equation (III.31) contains the following elements:

$$\beta_{2r} = [\alpha\ \beta_1\ \beta_2\ \beta_3\ \beta_4\ \beta_{p0}\ \beta_{p1}\ \beta_{p2}\ \beta_{p3}\ \beta_{p4}\ \beta_{s1}\ \beta_{s2}\ \beta_{s3}\ \beta_{s4}\ \beta_{s5}\ \beta_{s6}\ \beta_{s7}\ \beta_{s8}\ \beta_{s9}\ \beta_{s10}\ \beta_{s11}\ \beta_{s12}\ \beta_{s13}\ \beta_{s14}\ \beta_{s15}\ \beta_{s16}]$$

The matrix of restrictions which are imposed with certainty, C, is as follows:

$$C = \begin{vmatrix}
0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&-1&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&-1&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&-1&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&-1&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&-1&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&-1&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&-1&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&-1
\end{vmatrix}$$

The vector, d, associated with these restrictions is equal to [0 0 0 0 0 0 0 0 0]. This matrix restricts $\beta_{p4} = 0$, $\beta_{s4} = \beta_{s5} = \beta_{s6} = \ldots = \beta_{s10}$, $\beta_{s11} = \beta_{s12}$, and $\beta_{s15} = \beta_{s16}$, respectively. The first of these restrictions is a general restriction applied to all Postal prices based

[9] Note that the seasonal variables are e^{S_1}, e^{S_2}, etc. The natural logarithms of these variables are then equal to S_1, S_2, etc., which are entered into the X matrix in this form.

on historical observation. The latter eight restrictions were imposed on the basis of an earlier estimate of β without these restrictions imposed, which found these values to be approximately equivalent.

The permanent income elasticity, β_1, is constrained stochastically from the Household Diary Study, to a value of 0.536. The Household Diary Study estimate has a variance associated with it equal to 0.00145. Hence, R, r, and Ω in equation (III.31) are equal to the following:

$$R = [0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0]$$
$$r = [0.536]$$
$$\Omega = [0.00145]$$

Based on estimating equation (III.31) using the information presented thus far, the autocorrelation coefficients, ρ_1, ρ_2, and ρ_3 were estimated to be equal to 0.444, 0.173, and zero respectively. The variance-covariance matrix of the residuals, Σ, was adjusted using these values as described in section B.4. above.

The demand equation for Periodical regular mail contains a single Postal price to which a Shiller restriction is imposed. The S-matrix is equal to the following:

$$S = \begin{vmatrix} 0 & 0 & 0 & 0 & 0 & 1 & -2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & -2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{vmatrix}$$

The minimum value of k^2 which yielded a reasonable price distribution was chosen based on a search of alternate values for k^2. The chosen value of k^2 was 1.274.

Based on these results, the β-coefficient associated with Periodical regular mail was estimated using equation (III.31) above. The resulting β-vector was calculated to be equal to:

$$\hat{b}_{2r} = [-3.843\ 0.527\ 0.034\ -0.164\ -0.062\ -0.032\ -0.037\ -0.043\ -0.032\ 0.000\ -0.526\ -0.210\ 0.040\ -0.558\ -0.558\ -0.558\ -0.558\ -0.558\ -0.558\ -0.558\ -0.096\ -0.096\ -0.279\ 0.805\ -0.392\ -0.392]$$

IV. Shares of Mail within Worksharing Categories

A. Theory of Consumer Worksharing

1. Cost-Minimization Problem

Traditionally, economists have modeled consumer demand as an effort by consumers to maximize utility given income. On the other side of consumer demand, however, is a basic cost-minimization problem of minimizing costs for any given level of utility.

Mathematically, consumers' cost-minimization problem can be expressed as:

$$\min C(x) \text{ s.t. } U(x) \geq u_R \qquad \text{(IV.1)}$$

where x is the quantity of the good of interest, U in the consumer's utility function, C is the consumer's cost function, and u_R is the consumer's reservation utility.

In general, C(x) is equivalent to the price of good x, including any transactions costs, so that

$$C(x) = p \bullet x + \text{transactions costs} \qquad \text{(IV.2)}$$

where p is the price of good x.

Assuming that transactions costs are exogenous to the consumer and the consumer takes price as given in equation (IV.2), the minimand of equation (IV.1) will simply be x.

For some categories of mail, however, the Postal Service offers discounts to mailers who presort or barcode their mail, thereby making the Postal Service's job easier. In such a case, equation (IV.2) could be re-written as follows:

$$C(x) = (p-d+u(x))\cdot x + \text{transactions costs} \qquad \text{(IV.3)}$$

where d is the discount obtained by the consumer for doing additional work, and u is the unit cost to the consumer of doing the additional work, which may vary with x. In this case, in addition to choosing x in equation (IV.1), the consumer will also choose the level of worksharing.

For any given value of x, minimizing C(x) is equivalent to minimizing the price paid for good x, or minimizing [p - d + u(x)]. Taking p as fixed for the consumer, this can be further simplified to a simple choice of minimizing [-d + u(x)], or, rearranging terms, maximizing [d - u(x)].

This leads to the First Law of Consumer Worksharing:

A consumer will choose the worksharing option that maximizes his or her benefit of worksharing, where the consumer's benefit to worksharing is equal to d - u.

In general, the level of worksharing will not be a continuous function, but will instead involve a choice from among discrete levels of worksharing. Thus, the First Law of Consumer Worksharing can be expressed mathematically as follows:

$$\max_i (d_i - u_i(x)) \qquad \text{(IV.4)}$$

for i equals the set of all possible worksharing options, where d_i is the discount associated with worksharing option i, u_i is the cost to the consumer of qualifying for worksharing option i, and x is the quantity of the good consumed.

2. Making Equation (IV.4) a Tractable Problem

Solving equation (IV.4) requires information about the user costs associated with all possible worksharing categories. If there are N worksharing options, this becomes an N-dimensional problem. If N is very large at all, this can quickly become an intractable problem.

One possible way of making equation (IV.4) a more tractable problem is to introduce the concept of opportunity costs into u(x). Economists generally think of the opportunity cost associated with a product as the forgone benefit of not doing anything different with the product. In the context of equation (IV.4), then, the opportunity cost of using worksharing option i is the maximum benefit, where benefit is defined as d - u, that could be achieved by using a different worksharing category. Explicitly incorporating opportunity costs into equation (IV.4) yields the following consumer maximization problem:

$$\max_i \, [d_i - (w_i(x) + \max_{j \neq i}(d_j - u_j))] \qquad \text{(IV.5)}$$

where w_i equals the costs of qualifying for worksharing option i, excluding opportunity costs, and $u_i = (w_i(x) + \max_{j \neq i}(d_j - u_j))$.

If $\max_{j \neq i}(d_j - u_j) > d_i - w_i$, for some worksharing option j, then $d_i - (w_i(x) + \max_{j \neq i}(d_j - u_j))$ will be strictly less than zero. If worksharing discounts are defined as discounts from a base price for which consumers are eligible at no additional cost (i.e., d=0 and w=0 for the base worksharing option), then $\max_i (d_i - u_i) \geq 0$, since, if any given worksharing option were more costly to the consumer than the discount earned as a result of qualifying for the option, the consumer could still choose to do no worksharing at no cost.

Combining the two facts outlined in the above paragraph yields the following result:

$$d_i - u_i \geq 0 \text{ if, and only if, } d_i - w_i \geq d_j - w_j \text{ for all worksharing options } j.$$

Stated in words, this becomes the Fundamental Theorem of Consumer Worksharing:

A consumer will utilize a worksharing option if, and only if, the costs to the consumer of doing so are less than the discount offered by the seller for doing so.

3. Modeling Consumers' Use of Worksharing Options

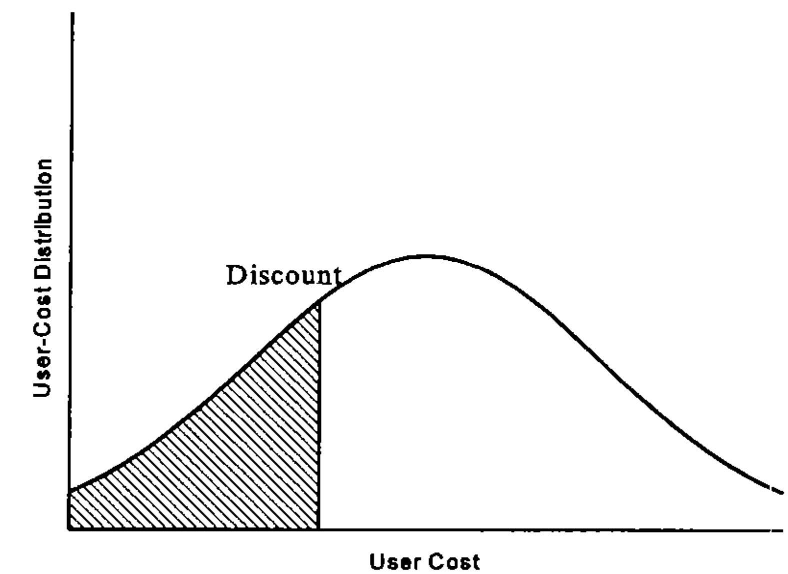
a. General Form of the Problem

The Fundamental Theorem of Consumer Worksharing reduces equation (IV.5) from an N-dimensional problem to a system of N 1-dimensional problems.[10] A consumer will use worksharing option i if, and only if, $d_i - u_i \geq 0$. Given a distribution of user costs associated with worksharing option i, the percentage of consumers who will use worksharing option i can be represented graphically as shown below in Figure IV-1.

---

[10] N-1 problems if one considers one of the N worksharing options to be no worksharing.

Figure IV-1
Generalized User-Cost Distribution



Consumers with user costs less than the discount, represented by the striped region to the left of the discount, will use worksharing option i, while consumers with user costs greater than the discount will not use worksharing option i.

Mathematically, the above picture could be represented by equation (IV.6) below:

(Percentage of mail within a category) = $\int_0^d$ p.d.f. (u) du (IV.6)[11]

---

[11] The integral in equation (IV.6) reflects the fact that the minimum bound on user costs must be equal to 0. This is based on the definition of user costs implicit in equation (IV.3) and the fact that there is a minimum worksharing option associated with d = 0 and u = 0. In this case, the user costs are the costs above the costs associated with the minimum category, which are accounted for in the transactions costs in equation (IV.3).

Thus, the share of a good that will be sent as part of a particular worksharing option can be solved for by estimating equation (IV.6).

b. Modeling User-Cost Distributions

i. Shape of User-Cost Distribution

The first step in solving equation (IV.6) is to define what type of distribution best describes the user-cost distribution. The most likely candidate would seem to be the normal distribution.

(a) Theoretical Appeal of the Normal Distribution

Probably the most common empirical distribution is the normal distribution. A number of social and economic variables have been shown to be generally normally distributed, including income. In addition, user costs that decline at a constant rate would lead to logistic growth in the use of worksharing options.[12] This is generally consistent with historical growth patterns in the use of presortation and automation discounts offered by the Postal Service.

Finally, the Central Limit Theorem states that:

> If an arbitrary population distribution has a mean μ and finite variance σ^2, then the distribution of the sample mean approaches the normal distribution with mean μ and variance σ^2/n as the sample size n increases. (Anderson and Bancroft, Statistical Theory in Research, McGraw-Hill, 1952, p. 71)

This means that any sample distribution with finite mean and variance is approximately normal. A consumer user-cost distribution would certainly be expected

[12] A normal user-cost distribution would lead to logistic growth in worksharing shares because, as user costs declined over time, the share of a product taking advantage of the worksharing option would take on the shape of the cumulative distribution function (c.d.f.) of user costs. The c.d.f. of the normal distribution is logistic in shape.

to have both a finite mean and variance. Thus, it is reasonable to assume that user costs are normally distributed for consumer worksharing options.

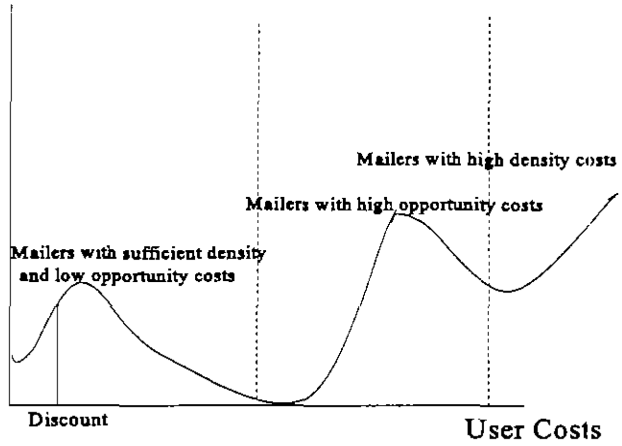
(b) Empirical Drawbacks to Normal Distribution

Despite the appeal of the normal distribution, it is not without its limitations. In particular, the normal distribution has three drawbacks which make it less than ideal for modeling consumer user costs: the likelihood of user-cost clusters about several different levels of user costs, the fact that user costs are non-negative by definition, and the non-integrability of the normal p.d.f., leaving equation (IV.6) unsolvable.

The first issue to be resolved in modeling the share of consumers that will use a particular worksharing option is to properly identify the consumer population of potential work sharers. For example, not everybody who mails a letter has a realistic option of presorting or automating their mail, due to limitations imposed by the Postal Service that presorted mailings must include at least 500 pieces or practical limitations against purchasing barcoding equipment that can cost more than $100,000. On the other hand, consider a mailer who sends a letter to every address in a particular city (e.g., utility bills and saturation advertising). This mailer will likely either presort as fine as possible (carrier-route presorting or saturation presorting) or not presort at all, but would have little reason to consider intermediate presort options (e.g., 3- or 5-digit presorting).

In reality, therefore, user-cost distributions may have several clusters of consumers. For example, the user-cost distribution associated with 3-digit Automated mail may look like Figure IV-2 below.

Figure IV-2
Multi-Peaked User-Cost Distribution



The right-most hump represents mailers who mail letters one or two at a time. The "costs" to these mailers of qualifying for the Postal Service's 3-digit presort requirement would basically involve preparing an additional 400-500 letters to meet the minimum mailing requirement for the 3-digit presort requirement. In addition, such mailers may have to purchase barcoding equipment, which would be prohibitively expensive. The middle hump, identified as "Mailers with high opportunity costs", represent mailers who would never consider only 3-digit presorting their mail as long as more attractive discounts existed for 5-digit or carrier-route presorting.

The user-cost distribution is normally distributed over the small subset of mailers who have sufficient density and low opportunity costs[13] associated with 3-digit Automation. As long as the discount for the worksharing category falls within this area

[13] These opportunity costs may still, however, be prohibitive for some of these mailers.

of the user-cost distribution, however, then a normal distribution over that subset of consumers will be a valid approximation to the true user-cost distribution.

Technically, a normal user-cost distribution would assume that user costs can take on any value from $-\infty$ to $+\infty$. If user costs are defined as the costs associated with qualifying for a worksharing category, above and beyond the cost of qualifying for the corresponding non-workshared category, then this means that the true distribution of user costs associated with any worksharing option must be non-negative. Thus, the true user-cost distribution associated with any worksharing category for which a non-worksharing option exists will have a lower bound of zero user costs.

Finally, an empirical problem with a normal user-cost distribution is that the normal probability density function (p.d.f.) is not integrable, so that equation (IV.6) would be non-solvable. Solving equation (IV.6) for a normal user-cost distribution would require either a discrete approximation to the normal c.d.f., or an approximation to the normal p.d.f. which is integrable. The latter of these two options is chosen here.

(c) Solution: Censored Logistic Distribution over a Subset of Consumers

A distribution which is often used to approximate the normal distribution, due to its similarity to the normal distribution and numerical simplicity, is the logistic distribution. (See, for example, Judge, et al. The Theory and Practice of Econometrics, 2nd edition, John Wiley and Sons, 1985, p. 762).

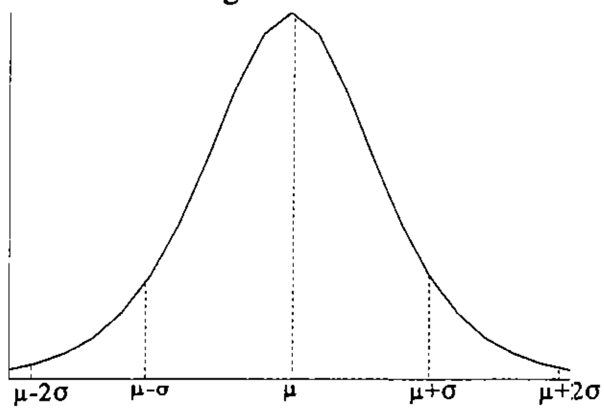
The logistic p.d.f. takes the following form:

$$Logistic\ p.d.f. = \frac{e^{-((x-\mu)/\sigma)}}{\sigma[1+e^{-((x-\mu)/\sigma)}]^2} \qquad \text{(IV.7)}$$

Graphically, the logistic p.d.f. is shown in Figure IV-3 below.

Figure IV-3

Logistic P.D.F.



The main advantage of the logistic distribution over the normal distribution is that the logistic p.d.f. is integrable. Inserting the logistic p.d.f. into equation (IV.6) allows the equation to be solved as follows:

$$(\textit{Pct. of good x within worksharing category i}) = \int_{-\infty}^{(d_i)} \frac{e^{-((u_i-\mu_i)/\sigma_i)}}{\sigma_i[1+e^{-((u_i-\mu_i)/\sigma_i)}]^2}\, du_i \quad \text{(IV.8)}$$

or, integrating the logistic p.d.f.

$$(\textit{Pct. of good x within worksharing category i}) = \frac{1}{1+e^{-(d_i-\mu_i)/\sigma_i}} \quad \text{(IV.9)}$$

As discussed above, user costs may be normally (or logistically) distributed only over a subset of the total consumers of good x. Equation (IV.9) actually measures the percentage of good x for which the user-cost distribution is normally distributed which will be sent within category i. The percentage of all of good x within worksharing category i is the product of equation (IV.9) and the percentage of good x over which the user-cost distribution associated with worksharing category i is logistically distributed, or

$$(\textit{Pct. of good x within worksharing category i}) = (\alpha_i)\cdot\left(\frac{1}{1 + e^{-(d_i - \mu_i)/\sigma_i}}\right) \qquad \text{(IV.10)}$$

where α_i is the percentage of good x for which user costs associated with worksharing category i are logistically distributed. The parameter α_i represents the maximum percentage of good x which would ever take advantage of worksharing category i, for any likely discount associated with category i.[14] Thus, α_i may be called the "ceiling" share associated with worksharing category i.

The general equation for the percentage of a good that will utilize a particular worksharing option is summarized by equation (IV.11) below.

$$(\textit{Pct. of good x within worksharing category i}) = \frac{\alpha_i}{1 + e^{-(d_i - \mu_i)/\sigma_i}} \qquad \text{(IV.11)}$$

The logistic distribution has the same drawback as the normal distribution that the logistic distribution assumes that user costs can take on any value from $-\infty$ to $+\infty$. In reality, however, user costs have a lower bound of zero, by definition, for reasons discussed above.

The simplest way of constraining user costs to be greater than or equal to zero is to assume that user costs falling below zero in equation (IV.8), are actually exactly equal to zero. This leads to a censored logistic distribution associated with user costs. A logistic distribution censored at zero has the following p.d.f. and c.d.f. associated with it.

[14] The term "likely discount" is intentionally left somewhat vague. At a minimum, a "likely discount" can be thought of as a discount that is strictly less than the base price of good x.

$$
p.d.f. = \begin{cases} \dfrac{e^{-((\tilde{u}_i-\mu_i)/\sigma_i)}}{\sigma_i[1+e^{-((\tilde{u}_i-\mu_i)/\sigma_i)}]^2}, & \tilde{u}_i > 0 \\[2ex] \dfrac{1}{1+e^{\mu/\sigma}}, & \tilde{u}_i = 0 \\[2ex] 0, & \tilde{u}_i < 0 \end{cases} \qquad \text{(IV.12)}
$$

$$
c.d.f. = \begin{cases} \dfrac{1}{1+e^{-((\tilde{u}_i-\mu_i)/\sigma)}}, & \tilde{u}_i \geq 0 \\[2ex] 0, & \tilde{u}_i < 0 \end{cases}
$$

where $\tilde{u}_i$ is the user cost associated with worksharing category i. The variable $\tilde{u}$ is used here rather than u to distinguish the censored logistic user-cost distribution from the logistic user-cost distribution in equation (IV.8) above.

As long as $d_i \geq 0$, equation (IV.11) above will be unchanged due to this type of censoring.

ii. Changes in the User-Cost Distribution over Time

If equation (IV.11) is to be used in evaluating the use of worksharing options over time or in forecasting the future use of worksharing options, then the user-cost distribution outlined in equation (IV.11) must be allowed to vary over time. There is no reason to believe that user costs are constant for any or all consumers over time. In fact, if the shares of worksharing categories change independent of changes in discounts, as has happened with Postal worksharing categories, then the user-cost distributions associated with these categories must be changing over time.

The crucial need, then, in modeling the use of worksharing categories is to adequately model the changes in user-cost distributions over time. There are four types of changes in user-cost distributions which may occur over time: changes in the type of distribution, changes in the standard deviation of the distribution (σ), changes in the percentage of the good over which user costs are normally distributed (α), and changes in the mean of the user-cost distribution (μ). These four issues are considered separately below.

(a) Changes in the Type of Distribution

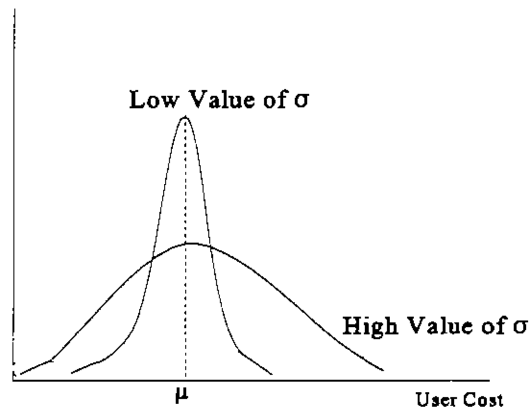
Arbitrary changes in the general shape of user-cost distributions over time would be extremely problematic empirically. At the extreme, if the type of user-cost distribution changed over time, then it would not be valid to base forecasts of future use of worksharing categories on historical patterns, as there would be no guarantee that the distribution might not change shape in the future.

Fortunately, there is no reason to believe that user-cost distributions would change type over time. The Central Limit Theorem suggests that, if anything, user-cost distributions ought to appear more normal over time. Thus, as an empirical matter, it is likely to be a valid assumption that all user-cost distributions are logistically distributed over their entire histories.

(b) Changes in the Standard Deviation of the Distribution

There is no *a priori* reason to assume that the standard deviation of the user-cost distribution, σ, would remain constant over time. A potential difficulty in modeling changes in σ, however, arises in interpreting changes in σ over time. Figure IV-4 below shows the difference in the user-cost distribution between a high value of σ and a low value of σ.

Figure IV-4
User-Cost Distributions with Alternate Values of σ



The effects of changes in σ are dependent on where the discount lies along the user-cost distribution. A decline in the standard deviation of the distribution will lead to an increase in the use of the worksharing option if the discount is greater than the mean of the user-cost distribution, but will lead to a decrease in the use of the worksharing option if the discount is less than the mean.

Another empirical difficulty in permitting σ to change over time is a computational difficulty in modeling unique shifts in both μ and σ over time in equation (IV.11). A convergent solution to (IV.11) is facilitated if one takes either the numerator (i.e., $-(d-\mu)$) or the denominator (i.e., σ) of the exponential expression as constant over time. Because of the lack of intuition behind changes in σ over time, as opposed to expected and explainable changes in d and μ over time, it is a reasonable empirical simplification that the standard deviations of user-cost distributions remain constant over time.

(c) Changes in the Ceiling of the Distribution

If new categories are introduced, the opportunity costs associated with older lower-discount categories may rise dramatically for many consumers as they shift into the newer more-discounted worksharing category. This may cause some consumers to shift from the left-most region of Figure IV-2 above into the middle section of Figure IV-2. Alternately, long-run shifts in the concentration of mail (to use the example diagramed in Figure IV-2) may lead some mail to shift from the right-most region of Figure IV-2 into the left-most region of Figure IV-2.

Shifts of this nature over time would be modeled in equation (IV.11) through a change in the value of α over time. Empirically, it should be cautioned, however, that it may be difficult to isolate gradual changes in α (modeled, for example, through a simple time trend) from changes in μ which will be discussed below. Thus, it may be desirable as a practical matter to be cautious in modeling changes in α over time.

(d) Changes in the Mean of the User-Cost Distribution

In estimating the share of a good which would take advantage of a particular worksharing option over time, the variable which would generally be expected to change the most over time (except, perhaps, for the discount) would be the mean of the user-cost distribution. Changing the mean of the user-cost distribution suggests that user costs shift proportionally across all consumers. This would generally be true of such things as fixed capital costs associated with worksharing (e.g., barcoding machines to prebarcode mail), shocks to costs from changes in worksharing requirements, and falling user costs in the initial periods following the introduction of worksharing options as consumers optimize their costs of worksharing.

Estimating the share of a good, x, that takes advantage of a particular worksharing option, i, historically then becomes a matter of incorporating historical changes in the discount associated with worksharing option i, the mean user-cost associated with worksharing i, and the percentage of good x for which user costs associated with worksharing category i are logistically distributed into equation (IV.11). Forecasting the share of good x that would be expected to use worksharing option i would require forecasts of d_i, μ_i, and α_i.

For consumer goods with multiple worksharing options (e.g., separate discounts for various levels of presortation offered by the Postal Service), a critical component of the user costs of worksharing will be opportunity costs as outlined in section A.2 above. The next section considers the empirical treatment of opportunity costs in estimating equation (IV.11).

iii. Opportunity Costs

Opportunity costs as derived in equation (IV.5) can be decomposed into the opportunity costs associated with not using all other categories. That is,

$$oc_i = \Sigma oc_{\text{not using } j} \text{ for all } j \neq i \qquad \text{(IV.13)}$$

For any individual mailer, the opportunity costs associated with not using category j will be equal to zero for all categories except for the one category that the mailer actually chooses. For the distribution of all mailers, however, equation (IV.13) makes the calculation of opportunity costs rather straightforward.

A logistical user-cost distribution is uniquely defined by three parameters -- α, μ, and σ. In general, opportunity costs do not directly affect α. For computational simplicity, it is best to treat σ as remaining constant over time. Thus, opportunity costs would only affect σ implicitly.

The mean of the user-cost distribution, μ, can be decomposed into the following equation, based on the theoretical implications of equation (IV.5) above.

$$\mu_i = \mu_{non\text{-}oc} + \Sigma_{j \neq i} E(oc_{ij}) \qquad \text{(IV.14)}$$

where $\mu_{non\text{-}oc}$ is equal to the mean user cost, excluding opportunity costs, and oc_{ij} is the forgone benefit of using category i instead of category j.

For those consumers for whom category j is the most attractive worksharing option (and would, thus, use worksharing category j), oc_{ij} will equal $d_j - u_j$, the benefit of using category j. For those consumers for whom category j is not the most attractive worksharing option, oc_{ij} is equal to zero. This leads to the following formula for the expected value of oc_{ij}:

$$E(oc_{ij}) = (d_j - \bar{u}_j) \bullet (\hat{s}_{ij}) \qquad \text{(IV.15)}$$

where $\bar{u}_j$ is equal to the average cost of using worksharing category j by consumers who actually use category j, and $\hat{s}_{ij}$ is equal to the percentage of good x for which user costs associated with worksharing category i are logistically distributed that take advantage of worksharing category j.

The derivation of $\bar{u}_j$ and $\hat{s}_{ij}$ are discussed next.

(a) Average User Costs: $\bar{u}_j$

The average user cost associated with worksharing category j borne by consumers who actually use category j can be expressed mathematically as the average user cost over the portion of the user-cost distribution associated with category j for which user costs are less than or equal to the discount, i.e.,

$$\bar{u}_j = E(\tilde{u}_j \mid \tilde{u}_j \leq d_j) \qquad \text{(IV.16)}$$

where $\tilde{u}_j$ is distributed using a censored logistic distribution, as described in equation (IV.12) above.

The following equality is true for any distribution of x

$$E(x\,|\,x\leq y) \;=\; E(x\,|\,x\leq 0)\cdot prob(x\leq 0\,|\,x\leq y) \;+\; E(x\,|\,0<x\leq y)\cdot prob(x>0\,|\,x\leq y),\ \text{for any value of } y\geq 0 \qquad \text{(IV.17)}$$

Thus, the average user cost associated with worksharing category j (if $d_j \geq 0$) must satisfy the following equation:

$$E(\tilde{u}_j\,|\,\tilde{u}_j\leq d_j) \;=\; E(\tilde{u}_j\,|\,\tilde{u}_j\leq 0)\cdot prob(\tilde{u}_j\leq 0\,|\,\tilde{u}_j\leq d_j) \;+\; E(\tilde{u}_j\,|\,0<\tilde{u}_j\leq d_j)\cdot prob(\tilde{u}_j>0\,|\,\tilde{u}_j\leq d_j) \qquad \text{(IV.18)}$$

The probabilities associated with $\tilde{u}_j \leq 0$ and $0 < \tilde{u}_j \leq d_j$ can be calculated directly from the c.d.f. in equation (IV.12) and are equal to

$$\frac{1}{1+e^{\mu_j/\sigma_j}} \quad \text{and} \quad \frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}} - \frac{1}{1+e^{\mu_j/\sigma_j}}$$

respectively.

The mean value of a truncated logistic distribution satisfies the following equation:

$$E(x\,|\,x\leq y) \;=\; y \;+\; \frac{\ln[1-F(y)]}{F(y)} \qquad \text{(IV.19)}$$

where $F(y) = \dfrac{1}{1+e^{-y}}$ is the c.d.f. of the logistic distribution evaluated at y.

(Maddala, G.S. Limited-Dependent and Qualitative Variables in Econometrics, Cambridge, 1983, p. 369)

Since equation (IV.11) relies on a non-standard logistic distribution (i.e., μ_j is allowed to differ from 0, and σ_j can be different from 1), the value x in equation (IV.19) needs to be replaced by the value $x = (u-\mu_t)/\sigma$.

If user costs followed an uncensored logistic distribution, the average user cost associated with mail in a given category could be calculated by solving equation (IV.19) above at the value $y = (d_t-\mu_t)/\sigma$. Substituting for x and y in equation (IV.19), we get:

$$E[((u_j-\mu_j)/\sigma_j) \mid ((u_j-\mu_j)/\sigma_j) \leq ((d_j-\mu_j)/\sigma_j)] = ((d_j-\mu_j)/\sigma_j) + \ln[1 - \frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}] \,/\, \frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}} \qquad \text{(IV.20)}$$

which could be simplified to:

$$\begin{aligned} (E(u_j) - \mu_j)/\sigma_j &= (d_j - \mu_j)/\sigma_j + \ln[1 - \frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]/[\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}], \\ E(u_j \mid u_j \leq d_j) &= d_j + \sigma_j \ln[1 - \frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]/[\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}] \end{aligned} \qquad \text{(IV.21)}$$

where $E(u_j|u_j \leq d_j)$ would be the average user cost associated with consumers actually utilizing worksharing category j, assuming user costs are logistically distributed.

The average user cost associated with users of worksharing category j for which user costs are less than or equal to zero can be calculated in the same way as follows:

$$E(u_j \mid u_j \leq 0) = 0 + \sigma_j \ln[1 - \frac{1}{1+e^{-(0-\mu_j)/\sigma_j}}]/[\frac{1}{1+e^{-(0-\mu_j)/\sigma_j}}] = \sigma_j \ln[1 - \frac{1}{1+e^{\mu/\sigma_j}}]/[\frac{1}{1+e^{\mu/\sigma_j}}] \qquad \text{(IV.22)}$$

The value $E(u_j|u_j \leq d_j)$ *can also be calculated from equation (IV.17) above, yielding:*

$$E(u_j \mid u_j \leq d_j) = E(u_j \mid u_j \leq 0) \cdot prob(u_j \leq 0 \mid u_j \leq d_j) + E(u_j \mid 0 < u_j \leq d_j) \cdot prob(u_j > 0 \mid u_j \leq d_j) \qquad \text{(IV.23)}$$

The probabilities in equation (IV.23) can be solved by evaluating the logistic c.d.f. at the values 0 and d_t. Finally, substituting equations (IV.21) and (IV.22) into equation (IV.23), we can solve for $E(u_j|0<u_j\leq d_j)$.

$$E(u_j|0<u_j\leq d_j) = \left(\frac{1}{prob(u_j>0\,|\,u_j\leq d_j)}\right)\Big[\Big(d_j + \sigma_j \ln[1-\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]/[\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]\Big) - \Big(\sigma_j \ln[1-\frac{1}{1+e^{\mu/\sigma_j}}]/[\frac{1}{1+e^{\mu/\sigma_j}}]\Big)prob(u_j\leq 0\,|\,u_j\leq d_j)\Big] \qquad \text{(IV.24)}$$

The distributions associated with u and ũ are equivalent for ũ>0. It therefore follows that

$$E(\tilde{u}_j|0<\tilde{u}_j\leq d_j) = E(u_j|0<u_j\leq d_j) \qquad \text{(IV.25)}$$

Equation (IV.18) can thus be rewritten:

$$E(\tilde{u}_j|\,\tilde{u}_j\leq d_j) = E(\tilde{u}_j|\,\tilde{u}_j\leq 0)\cdot prob(\tilde{u}_j\leq 0\,|\,\tilde{u}_j\leq d_j) + E(u_j|0<u_j\leq d_j)\cdot prob(\tilde{u}_j>0\,|\,\tilde{u}_j\leq d_j) \qquad \text{(IV.26)}$$

By definition, $E(\tilde{u}|\tilde{u}\leq 0) = 0$. Thus, the first term on the right-hand side in equation (IV.26) is equal to zero, and equation (IV.24) can be substituted for the second term, yielding:

$$E(\tilde{u}_j|\,\tilde{u}_j\leq d_j) = \Big\{\Big(\frac{1}{prob(u_j>0\,|\,u_j\leq d_j)}\Big)\Big[\Big(d_j + \sigma_j \ln[1-\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]/[\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]\Big) - \Big(\sigma_j \ln[1-\frac{1}{1+e^{\mu/\sigma_j}}]/[\frac{1}{1+e^{\mu/\sigma_j}}]\Big)prob(u_j\leq 0\,|\,u_j\leq d_j)\Big]\Big\}\cdot prob(\tilde{u}_j>0\,|\,\tilde{u}_j\leq d_j) \qquad \text{(IV.2}$$

For values greater than zero, the c.d.f. associated with u and ũ are equivalent, so that the $prob(\tilde{u}_j>0|\tilde{u}_j\leq d_j)$ term cancels with the $\frac{1}{prob(u_j>0\,|\,u_j\leq d_j)}$ term, yielding the following equation for the average user cost associated with users of worksharing category j:

$$\bar{u}_j = (d_j + \sigma_j \ln[1 - \frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]/[\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}}]) - (\sigma_j \ln[1 - \frac{1}{1+e^{\mu/\sigma_j}}]/[\frac{1}{1+e^{\mu/\sigma_j}}]) \cdot [(\frac{1}{1+e^{\mu/\sigma_j}})/(\frac{1}{1+e^{-(d_j-\mu_j)/\sigma_j}})] \qquad \text{(IV.28)}$$

(b) Share of Potential Users of Category i using Category j: $\hat{s}_{ij}$

As a first approximation, the share of category j in equation (IV.15), $\hat{s}_{ij}$, may be approximately equal to the total share of good x in worksharing category j. However, this share, $\hat{s}_{ij}$, need not be exactly equal to the total share of good x in worksharing category j, due to the presence of the ceiling parameter, α_i, in equation (IV.11) for worksharing category i.

If some portion of good x that is sent as part of worksharing category j could never reasonably be sent as part of worksharing category i then that portion of worksharing category j would not factor into the opportunity cost associated with potential users of category i.

Mathematically, this can be most easily accomplished by modifying equation (IV.15) above to include a "coefficient" on the opportunity cost of not using category j as follows:

$$E(oc_{ij}) = (d_j - \bar{u}_j) \cdot (\beta_{ij} \cdot s_j) \qquad \text{(IV.29)}$$

where $\bar{u}_j$ can be calculated from equation (IV.28) above, s_j can be calculated from equation (IV.11), and $\beta_{ij} \cdot s_j = \hat{s}_{ij}$, the share of potential users of category i using category j. The variable, $\hat{s}_{ij}$, can be re-stated as the share of α_i that uses worksharing category j. This yields the following interpretation for β_{ij}:

$$\beta_{ij} = [\text{the share of } \alpha_i \text{ that uses category j}] / s_j \qquad \text{(IV.30)}$$

Based on the understanding of β_{ij} inherent in equation (IV.30), three key restrictions can be developed associated with the value of β_{ij} for any worksharing categories i and j.

(1) $\beta_{ij} \geq 0$

Shares must, by definition, be between zero and one. Therefore, β_{ij}, as defined in equation (IV.30) is the quotient of two non-negative numbers. A non-negative number divided by a non-negative number must, of course, be equal to a non-negative number. Hence, $\beta_{ij} \geq 0$.

In layman's terms, this is equivalent to stating that distinct worksharing categories of a single good cannot be complementary goods. This elucidates a requirement implicit in this methodology that worksharing options must be fully specified and must be mutually exclusive. Suppose, for example, the Postal Service offered three levels of presort discounts -- basic, 3-digit, and 5-digit -- and two levels of barcoding discounts -- nonbarcoded and barcoded. The methodology outlined here would require a set of six equations of the form of equation (IV.11) to fully account for all possible worksharing categories -- basic nonbarcoded, basic barcoded, 3-digit nonbarcoded, 3-digit barcoded, 5-digit nonbarcoded, and 5-digit barcoded. The methodology of this paper would not, however, work for a set of five non-mutually exclusive equations for basic, 3-digit, and 5-digit presort, nonbarcoded, and barcoded. The user costs associated with the five non-mutually exclusive equations would not satisfy the Fundamental Theorem of Consumer Worksharing because a mailer may find more than one category (e.g., 5-digit presorting and barcoding) for which d - u > 0.

(2) $\beta_{ij} \le 1 / \alpha_i$

At most, all mail that uses worksharing category j could have potentially been sent using worksharing category i. In this case, the share of α_i that uses worksharing category j is equal to s_j / α_i. Substituting this into equation (IV.30) yields

$$\beta_{ij} \le (s_j / \alpha_i) / s_j = 1 / \alpha_i \qquad \text{(IV.31)}$$

This condition can be helpful in approximating β-coefficients for categories that are generally more similar than other categories.

(3) $\beta ij \ge \dfrac{1}{\alpha_i} - \dfrac{1-\alpha_i}{\alpha_i \bullet s_j}$

Among consumers who could not potentially use category i (i.e., $1 - \alpha_i$), suppose all of them actually used category j. Then, the share of mailers who could potentially use category i that are actually using category j would be equal to $s_j - (1-\alpha_i)$ (i.e., everybody using category j minus those using category j that could not potentially use category i). Substituting this into equation (IV.30) yields the following:

$$\beta_{ij} \ge \frac{\dfrac{s_j-(1-\alpha_i)}{\alpha_i}}{s_j} = \frac{1}{\alpha_i} - \frac{1-\alpha_i}{\alpha_i \bullet s_j} \qquad \text{(IV.32)}$$

Equation (IV.32) can be helpful in providing insight into approximate values of β_{ij} for cases where the requirements associated with worksharing categories i and j are quite different.

An extremely useful result of equations (IV.31) and (IV.32) is that, if $\alpha_i = 1$, then $\beta_{ij} = 1$ for all worksharing categories $j \neq i$.

4. Empirical Problem to Be Solved to Model Use of Worksharing

For a good x, whose seller offers consumers discounts from the basic price of good x associated with N distinct mutually exclusive worksharing options to consumers, identified as option 1, option 2, ..., option N, where option 1 reflects no worksharing and is offered for the base-line price of good x, the share of good x that will take advantage of each of the N various worksharing categories can be determined by a system of N equations, (N-1) of which are variations of equation (IV.11) as follows:

$$s_{it} = \frac{\alpha_{it}}{1 + e^{-(d_{it} - [\mu_{it} + \sum_{j \neq i} oc_{ijt}])/\sigma_i}}, \ for\ i,j = 2,\ \ldots,\ N \qquad \text{(IV.33)}$$

where

$$oc_{ijt} = (d_{jt} - \bar{u}_{jt}) \cdot (\beta_{ijt} \cdot s_{jt}),\ where\ \beta_{ijt}\ equals\ the\ share\ of\ \alpha_i\ that\ utilizes\ worksharing\ category\ j + s_{jt} \qquad \text{(IV.34}$$

where μ_{it} in equation (IV.33) excludes opportunity costs, with $\bar{u}_{jt}$ calculated as in equation (IV.28), and $\beta_{ijt} \geq 0$ and satisfying equations (IV.31) and (IV.32).

The share of good x that will take advantage of the base worksharing category, category 1, is then simply equal to

$$s_1 = 1 - \Sigma_{i=2,\ldots,N}\, s_i \qquad \text{(IV.35)}$$

The dependent variables of this equation system are s_{it}, i = 1 to N. Values of d_{it} must be taken as given. The values for α_{it}, μ_{it}, σ_i, and β_{ijt} for i,j = 2 to N, $i \neq j$ are then the parameters to be estimated in this system of equations.

Forecasting the shares of good x that will take advantage of each of the N various worksharing categories requires forecasted values of d_{it}, α_{it}, and μ_{it} for i = 2 to N, which are then placed into equations (IV.33), (IV.34), and (IV.35) to yield forecasted values of s_{it}, for i = 1 to N.

B. Econometric Share Equations

Equation (IV.33) is fit historically for each worksharing category of First-Class letters, First-Class cards, Standard regular, and Standard bulk nonprofit mail. The resulting econometric values of α_t, μ_t, and σ are then used to forecast the shares of the various worksharing categories. The forecasting equation is derived in section C. below. The econometric share equations are described next.

1. First-Class Letters

a. General Overview

i. Shares of Workshared First-Class Letters

First-Class letters are divided into two categories for forecasting purposes: single-piece and workshared First-Class letters. Share equations are used to model the shares of total worksharing First-Class letters. Individual share equations were estimated for nonautomation presort letters, flats, and IPPs; automation basic letters and flats; automation 3/5-digit letters and flats; carrier-route presort letters, flats, and IPPs; and 3/5-digit presort ZIP+4 letters.

ii. Share Equation Sample Period: 1988Q1 - 1997Q2

Worksharing discounts were first introduced in First-Class letters in 1976Q4 with the introduction of a presort discount. A carrier-route presort discount was added in the third quarter of 1981. The first automation-type discount was a ZIP+4 discount for letters in 1984Q1. Barcoding discounts were first offered in 1988Q3.

The share of total First-Class letters that are workshared has grown consistently since the inception of worksharing discounts. As higher-discount categories are introduced, the share of workshared mail taking advantage of these higher discounts has also grown considerably.

The share equations associated with First-Class letters are estimated over a sample period of 1988Q1 through 1997Q2. The Postal Service began to distribute government mail to the categories of mail by which it was sent beginning in the first quarter of 1988. Hence, the data since 1988Q1 is consistent. In addition, the overall level of worksharing mail appeared to be relatively stable and, with the exception of barcoding discounts, the worksharing categories were relatively mature in the sense that large and often unpredictable initial market penetration into worksharing categories had largely subsided by this time. The post-MC95 period was included in the share equation regressions to provide for a means of quantifying the impact of classification reform on the shares of the various worksharing categories.

iii. Opportunity Cost Relationships

The following opportunity cost relationships were modeled explicitly in the econometric share equations outlined below. Nonautomation presort First-Class letters, flats, and IPPs had opportunity cost relationships with respect to automation 3/5-digit First-Class letters and flats and with respect to carrier-route First-Class letters, flats, and IPPs. Automation 3/5-digit First-Class letters and flats had opportunity cost relationships with respect to nonautomation presort letters (flats and IPPs) and 3/5-digit presort ZIP+4 letters. Presort ZIP+4 letters had an opportunity cost relationship with respect to automation 3/5-digit letters. Substitution between other worksharing categories was assumed to be captured implicitly in the estimation of μ_t.

b. Nonautomation Presort

Nonautomation presort First-Class letters, flats, and IPPs are those pieces of mail which are presorted but would not qualify for either a ZIP+4 discount (prior to MC95-1) or a prebarcode discount. Prior to MC95-1, the volume of this category included mail classified as "Presort, Residual" mail. This was mail that was sent as part of a bulk mailing for which some mail qualified for a presort or automation discount but which had insufficient density to earn a 3/5-digit presort discount. Since MC95-1, the presort discount does not require a minimum density requirement. Hence, the category "Presort, Residual" no longer exists.

The value of α, the ceiling parameter, is constrained to be less than or equal to one. In this case, this has the effect of constraining the value of α to be exactly equal to one (i.e., any worksharing mail could have been sent as nonautomation presort mail at any point in time). The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_1 \bullet d_{90Q1} + \mu_3 \bullet bar_3 + \mu_t \bullet t - \mu_{11} \bullet bar_{11} - \mu_m \bullet ms_{unadj} - \mu_{mc} \bullet d_{mc95} + oc_{A3/5} + oc_{CR} \qquad \text{(IV.36)}$$

where d_{90Q1} is a dummy variable beginning in 1990Q1, bar_3 is a dummy variable reflecting the introduction of a 3-digit prebarcode discount in 1991q3, t is a time trend (equal to zero in 1988Q1, increasing by one each quarter thereafter), bar_{11} is a dummy variable reflecting the introduction of an 11-digit barcode requirement to receive a prebarcode discount (in 1993Q3), ms_{unadj} is a dummy variable equal to one from 1991Q3 through 1992Q4 reflecting a data inconsistency over these quarters in distinguishing between presorted nonautomated and presorted automated First-Class Mail, d_{mc95} is a dummy variable reflecting the implementation of MC95-1 in 1996Q4, $oc_{A3/5}$ is opportunity cost with respect to automation 3/5-digit letters and flats and is equal to $(d_{A3/5} - \bar{u}_{A3/5}) \cdot s_{A3/5}$, and oc_{CR} is opportunity cost with respect to carrier-route First-Class letters, flats, and IPPs, and is equal to $(d_{CR} - \bar{u}_{CR}) \cdot s_{CR}$.

The coefficients and regression diagnostics for the nonautomation presort share equation are (t-statistics in parentheses):

α	=	1.000000	---
μ_0	=	0.001166	(0.177)
μ_1	=	0.001039	(0.977)
μ_3	=	0.015860	(4.451)
μ_t	=	0.000893	(2.865)
μ_{11}	=	0.002033	(1.651)
μ_m	=	0.006146	(3.084)
μ_{mc}	=	0.010954	(2.927)
σ	=	0.031719	(5.024)

Adjusted-R^2	0.997
Mean Absolute Percentage Error	1.342%

c. Automation Basic

Automation basic letters and flats are made up of pieces which received one of the following discounts: nonpresort ZIP+4 letters, which was introduced in 1984Q1 and eliminated in 1996Q4 as part of MC95-1 classification reform; nonpresort prebarcoded flats, which was introduced in 1993Q1 and renamed automation basic flats in MC95-1; and automation basic letters, which was introduced in MC95-1.

The introduction of the automation basic letters discount in 1996Q4, as well as the setting of this discount greater than the discount associated with nonautomation presort letters is modeled as leading to an increase in the ceiling share, α. Specifically, α_t is fit to the following specification:

$$\alpha_t = \alpha_0 + \alpha_1 \cdot d_{mc95} \quad \text{(IV.37)}$$

The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \bullet t - \mu_3 \bullet bar_3 + \mu_m \bullet ms_{adj} - \mu_{95} \bullet d_{95} + \mu_{96} \bullet d_{96} \quad \text{(IV.38)}$$

where ms_{adj} is a dummy variable equal to one beginning in 1993Q1, reflecting a change in the methodology used to measure workshared First-Class Mail volume, d_{95} is a dummy variable equal to one beginning in 1995Q2, reflecting a change in the RPW sampling system, and d_{96} is a dummy variable equal to one beginning in 1996Q1.

The coefficients and regression diagnostics for the automation basic letters and flats share equation are (t-statistics in parentheses):

α_0 =	0.018479	(1.754)
α_1 =	0.108629	(8.882)
μ_0 =	0.003357	(0.282)
μ_t =	0.000768	(0.683)
μ_3 =	0.014105	(0.387)
μ_m =	0.003716	(0.175)
μ_{95} =	0.001739	(0.227)
μ_{96} =	0.007263	(0.525)
σ =	0.004651	(0.977)

Adjusted-R^2	0.852
Mean Absolute Percentage Error	24.110%

d. Automation 3/5-Digit

Automation 3/5-digit letters and flats are made up of pieces which received one of the following discounts: 5-digit prebarcoded letters, which was introduced in 1988Q3 and renamed automation 5-digit letters as part of MC95-1 classification reform; 3-digit prebarcoded letters, which was introduced in 1991Q3 and renamed automation 3-digit letters as part of MC95-1; and, 3/5-digit presort prebarcoded flats, which was introduced in 1993Q1 and renamed automation 3/5-digit flats in MC95-1.

The introduction of the automation 5-digit letters discount in 1988Q3, and the introduction of the automation 3-digit letters discount in 1991Q3 are both modeled as leading to an increase in the ceiling share, α. It should be noted that prior to 1988Q3, the ceiling share for automation 3/5-digit letters and flats was equal to zero, since no such discounts existed. The ceiling parameter, α_t is fit to the following specification:

$$\alpha_t = d_{Bcode} \bullet (\alpha_0 + \alpha_1 \bullet bar_3) \tag{IV.39}$$

where d_{Bcode} is a dummy variable beginning in 1988Q3 to reflect the introduction of the 5-digit prebarcoded letters discount (the first prebarcode discount offered by the Postal Service).

The mean of the user-cost distribution is fit to the following specification:

$$\begin{aligned} \mu_t = \mu_0 + \mu_{88q3} \bullet d_{88q3} + \mu_{1st4} \bullet d_{88q4\_89q2} - \mu_t \bullet t_5 + \mu_3 \bullet t_3 + \mu_m \bullet ms_{unadj} \\ + \mu_{11} \bullet bar_{11} - \mu_{mc} \bullet d_{mc95} + oc_{NA} + oc_{3/5ZIP} \end{aligned} \tag{IV.40}$$

where d_{88q3} is a dummy variable equal to one in 1988Q3; d_{88q4_89q2} is a dummy variable equal to one in 1988Q4, 1989Q1, and 1989Q2; t_5 is a time trend, equal to zero through 1989Q3, increasing by one each quarter thereafter; and t_3 is a time trend, equal to zero prior to the introduction of the 3-digit prebarcoded letters discount (1991Q3), increasing by one each quarter thereafter. The variables, oc_{NA} and $oc_{3/5ZIP}$ refer to opportunity costs with respect to nonautomation presort and 3/5-digit ZIP+4 letters, respectively, and are equal to $(d_{NA} - \bar{u}_{NA}) \bullet s_{NA}$ and $(d_{3/5ZIP} - \bar{u}_{3/5ZIP}) \bullet s_{3/5ZIP}$, respectively.

The coefficients and regression diagnostics for the automation 3/5-digit letters and flats share equation are (t-statistics in parentheses):

α_0 =	0.337351	(6.278)
α_1 =	0.371044	(6.433)
μ_0 =	0.056794	(10.60)
μ_{88q3} =	0.031536	(0.533)
μ_{1st4} =	0.018774	(1.747)
μ_t =	0.002123	(3.278)
μ_3 =	0.001270	(2.280)
μ_m =	0.005756	(4.186)
μ_{11} =	0.001071	(1.042)

μ_{mc} = 0.010475 (0.703)

σ = 0.014380 (5.947)

Adjusted-R^2	0.999
Mean Absolute Percentage Error	1.763%

e. Carrier-Route Presort

Carrier-route presort First-Class letters, flats, and IPPs includes all mail which received a carrier-route presort discount. As part of classification reform in MC95-1, carrier-route discounts were restricted to letter-sized mail which was barcoded and was sent to a carrier-route which met certain operational restrictions. Hence, the volume of carrier-route presorted First-Class Mail was considerably less after the implementation of classification reform than before. This shift in volume is modeled in the carrier-route share equation as an increase in the user cost associated with carrier-route First-Class Mail.

The value of α, the ceiling parameter, is modeled to be constant over the entire sample period, while the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 - \mu_t \bullet t_5 + \mu_3 \bullet bar_3 + \mu_m \bullet ms_{adj} + \mu_{95} \bullet d_{95} - \mu_{q2} \bullet qtr_{2\&3} + \mu_a \bullet d_{90q4\_91q3} - \mu_b \bullet d_{91q1} + \mu_{mc} \bullet d_{mc95} \quad \text{(IV.41)}$$

where $qtr_{2\&3}$ is a dummy variable equal to one in the second and third quarter of each Postal year, d_{90q4_91q3} is a dummy variable equal to one in 1990Q4, 1991Q1, 1991Q2, and 1991Q3, and d_{91q1} is a dummy variable equal to one in 1991Q1.

The coefficients and regression diagnostics for the carrier-route presort share equation are (t-statistics in parentheses):

α = 0.133527 (1.868)

μ_0 = 0.058115 (3.327)
μ_t = 0.001286 (1.567)
μ_3 = 0.011616 (2.327)
μ_m = 0.007898 (1.469)

μ_{95} = 0.014957 (2.455)
μ_{q2} = 0.003313 (1.712)
μ_{a} = 0.008723 (1.935)
μ_{b} = 0.013871 (1.773)
μ_{mc} = 0.056557 (3.608)

σ = 0.016985 (1.666)

Adjusted-R^2	0.869
Mean Absolute Percentage Error	5.095%

f. 3/5-Digit Presort ZIP+4

The 3/5-digit presort ZIP+4 letters discount was introduced in 1984Q1 and was eliminated with the implementation of MC95-1 in 1996Q4. Consequently, this share equation is not used for forecasting. It is included here, however, due to an historical opportunity cost relationship between ZIP+4 letters and prebarcoded letters.

The value of α, the ceiling parameter, was assumed to be constant prior to MC95-1, after which time it was set equal to zero, due to the elimination of the ZIP+4 letters discounts as part of classification reform. The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \cdot t + \mu_3 \cdot bar_{3b} + \mu_m \cdot ms_{unadj} + oc_{A3/5} \qquad \text{(IV.42)}$$

where bar_{3b} is a dummy variable beginning in 1992Q2, reflecting a lagged reaction to the introduction of a 3-digit prebarcode discount in 1991q3, and $oc_{A3/5}$ is opportunity cost with respect to automation 3/5-digit letters and flats and is equal to $(d_{A3/5} - \bar{u}_{A3/5}) \cdot \hat{s}_{A3/5}$, where $\hat{s}_{A3/5}$ is equal to $[(1/\alpha) - \beta \cdot t_3] \cdot s_{A3/5}$.

The coefficients and regression diagnostics for the 3/5-digit presort share equation are (t-statistics in parentheses):

α = 0.192965 (9.074)

μ_0 = 0.000000 (0.000)

$$\mu_t = 0.000000 \quad (0.000)$$
$$\mu_3 = 0.012458 \quad (0.765)$$
$$\mu_m = 0.007300 \quad (0.946)$$

$$\beta = 0.066806 \quad (0.504)$$

$$\sigma = 0.012304 \quad (0.959)$$

Adjusted-R^2	0.948
Mean Absolute Percentage Error	11.347%

2. First-Class Cards

a. General Overview

i. Shares of Workshared First-Class Cards

Private First-Class cards are divided into two categories for forecasting purposes: single-piece and workshared First-Class cards. Share equations are then used to model shares of total worksharing First-Class cards. Individual share equations were estimated for nonautomation presort cards, automation basic cards, automation 3/5-digit cards, carrier-route presort cards, and 3/5-digit presort ZIP+4 cards.

ii. Share Equation Sample Period: 1988Q1 - 1997Q2

The share equations associated with First-Class cards are estimated over a sample period of 1988Q1 through 1997Q2. This is consistent with the sample period used to estimate the share equations associated with First-Class letters. The reasons cited above as justification of the sample period chosen for the share equations of workshared First-Class letters apply equally well to the workshared First-Class cards share equations.

iii. Opportunity Cost Relationships

The following opportunity cost relationships were modeled explicitly in the econometric share equations outlined below. Nonautomation presort First-Class cards had opportunity cost relationships with respect to automation 3/5-digit First-Class cards and with respect to carrier-route First-Class cards. Automation 3/5-digit First-Class cards had opportunity cost relationships with respect to nonautomation presort cards and 3/5-digit presort ZIP+4 cards. Presort ZIP+4 cards had an opportunity cost relationship with respect to automation 3/5-digit cards. Finally, carrier-route presort cards had an opportunity cost relationship with respect to nonautomation presort cards. Substitution between other worksharing categories was assumed to be captured implicitly in the estimation of μ_t.

b. Nonautomation Presort

Nonautomation presort First-Class cards include those pieces of mail which are presorted but would not qualify for either a ZIP+4 discount (prior to MC95-1) or a prebarcode discount. Prior to MC95-1, the volume of this category included mail classified as "Presort, Residual" mail. This was mail that was sent as part of a bulk mailing for which some mail qualified for a presort or automation discount but which had insufficient density to earn a 3/5-digit presort discount. Since MC95-1, the presort discount does not require a minimum density requirement. Hence, the category "Presort, Residual" no longer exists.

The value of α, the ceiling parameter, is constrained to be less than or equal to one. In this case, this has the effect of constraining the value of α to be exactly equal to one (i.e., any worksharing mail could have been sent as nonautomation presort mail at any point in time). The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_1 \bullet d_{90Q1} + \mu_t \bullet t + \mu_m \bullet ms_{adj} + \mu_{mc} \bullet d_{mc95} + oc_{A3/5} + oc_{CR} \quad \text{(IV.43)}$$

where $oc_{A3/5}$ is opportunity cost with respect to automation 3/5-digit cards and is equal to $(d_{A3/5} - \bar{u}_{A3/5}) \bullet s_{A3/5}$, and oc_{CR} is opportunity cost with respect to carrier-route First-Class cards and is equal to $(d_{CR} - \bar{u}_{CR}) \bullet s_{CR}$.

The coefficients and regression diagnostics for the nonautomation presort cards share equation are (t-statistics in parentheses):

α =	1.000000	---
μ_0 =	-0.009943	(-1.246)[15]
μ_1 =	0.008298	(3.178)
μ_t =	0.000220	(1.255)
μ_m =	0.007124	(1.862)
μ_{mc} =	0.004852	(2.478)
σ =	0.015165	(3.230)

Adjusted-R^2	0.977
Mean Absolute Percentage Error	3.388%

c. Automation Basic

Automation basic cards are made up of pieces which received one of the following discounts: nonpresort ZIP+4 cards, which was introduced in 1984Q1 and eliminated in 1996Q4 as part of MC95-1 classification reform, and nonpresort prebarcoded cards, which was introduced in 1991Q3 and renamed automation basic cards in MC95-1.

The automation basic cards discount was set greater than the discount associated with nonautomation presort letters as a result of the implementation of MC95-1 in

[15] As noted in section A. above, user costs must be non-negative by definition. A negative value of μ does not strictly speaking mean that the average user cost is negative. Rather, it suggests that more than ½ of the mail over which the user-cost distribution is defined have user costs exactly equal to zero, so that a change in μ between negative values will affect the percentage of mail with user costs equal to zero.

1996Q4. This is modeled as leading to an increase in the ceiling share, α. In addition, the observed ceiling share increased in 1993Q1 due to a change in the methodology used to report workshared First-Class Mail volumes. Overall, α_t is fit to the following specification:

$$\alpha_t = \alpha_0 + \alpha_1 \bullet ms_{adj} + \alpha_2 \bullet d_{mc95} \qquad \text{(IV.44)}$$

The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 - \mu_t \bullet t \qquad \text{(IV.45)}$$

The coefficients and regression diagnostics for the automation basic letters and flats share equation are (t-statistics in parentheses):

α_0 =	0.779918	(0.251)
α_1 =	0.144443	(37429)
α_2 =	0.075637	(0.203)
μ_0 =	0.126427	(0.235)
μ_t =	0.000448	(0.402)
σ =	0.095207	(0.202)

Adjusted-R^2	0.923
Mean Absolute Percentage Error	15.812%

d. Automation 3/5-Digit

Automation 3/5-digit cards are made up of pieces presorted to the 3- or 5-digit level which received a prebarcode discount. The 5-digit prebarcoded cards discount was introduced in 1988Q3 and renamed automation 5-digit letters as part of MC95-1 classification reform; the 3-digit prebarcoded cards discount was introduced in 1991Q3 and renamed automation 3-digit letters as part of MC95-1.

The introduction of the automation 5-digit discount in 1988Q3 is modeled as leading to an increase in the ceiling share, α, since prior to 1988Q3 the ceiling share for automation 3/5-digit letters and flats was equal to zero, since no such discounts existed. The introduction of the automation 3-digit discount was not observed to affect the ceiling share. The ceiling parameter, α_t is fit to the following specification:

$$\alpha_t = d_{Bcode} \bullet \alpha_0 \qquad \text{(IV.46)}$$

The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_{88q3} \bullet d_{88q3} + \mu_{88q4} \bullet d_{88q4} + \mu_{89q1} \bullet d_{89q1\_89q2} - \mu_t \bullet t_5 + \mu_m \bullet ms_{unadj} - \mu_{11} \bullet bar_{11} + oc_{NA} + oc_{3/5ZIP} \qquad \text{(IV.47)}$$

where d_{88q4} is a dummy variable equal to one in 1988Q4 and d_{89q1_89q2} is a dummy variable equal to one in 1989Q1 and 1989Q2.The variables, oc_{NA} and $oc_{3/5ZIP}$ refer to opportunity costs with respect to nonautomation presort and 3/5-digit ZIP+4 cards, respectively, and are equal to $(d_{NA} - \bar{u}_{NA}) \bullet s_{NA}$ and $(d_{3/5ZIP} - \bar{u}_{3/5ZIP}) \bullet s_{3/5ZIP}$, respectively.

The coefficients and regression diagnostics for the automation 3/5-digit cards share equation are (t-statistics in parentheses):

α_0 =	0.575255	(15.87)
μ_0 =	0.044184	(5.265)
μ_{88q3} =	0.030298	(0.421)
μ_{88q4} =	0.024590	(0.751)
μ_{89q1} =	0.021290	(1.255)
μ_t =	0.000612	(1.995)
μ_m =	0.003943	(1.985)
μ_{11} =	0.004508	(2.274)
σ =	0.011526	(3.243)

Adjusted-R^2	0.989
Mean Absolute Percentage Error	5.802%

e. Carrier-Route Presort

The value of α associated with carrier-route presort cards is modeled to be constant over the entire sample period, while the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \bullet t - \mu_m \bullet ms_{adj} + \mu_{mc} \bullet d_{mc95} + oc_{NA} \quad \text{(IV.48)}$$

where oc_{NA} is the opportunity cost with respect to nonautomation presort cards, and is equal to $(d_{NA} - \bar{u}_{NA}) \bullet s_{NA}$.

The coefficients and regression diagnostics for the carrier-route presort cards share equation are (t-statistics in parentheses):

α	=	0.239181	(0.455)
μ_0	=	0.035545	(0.459)
μ_t	=	0.000371	(0.898)
μ_m	=	0.022184	(0.535)
μ_{mc}	=	0.048952	(0.934)
σ	=	0.016985	(0.487)

Adjusted-R^2	0.699
Mean Absolute Percentage Error	20.668%

f. 3/5-Digit Presort ZIP+4

The 3/5-digit presort ZIP+4 cards discount was introduced in 1984Q1 and was eliminated with the implementation of MC95-1 in 1996Q4. Consequently, this share equation is not used for forecasting. As with 3/5-digit presort letters above, it is included here, however, due to an historical opportunity cost relationship between ZIP+4 cards and prebarcoded cards.

The value of α, the ceiling parameter, was assumed to be constant prior to MC95-1, after which time it was set equal to zero, due to the elimination of the ZIP+4 discount as part of classification reform. The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 - \mu_x \bullet d_{xo3r} + \mu_t \bullet t + \mu_3 \bullet bar_{3b} + oc_{A3/5} \quad \text{(IV.49)}$$

where d_{xo3r} is a dummy variable equal to one beginning in 1989Q3, reflecting the impact of a rate crossover between First-Class cards and third-class bulk regular mail in R87-1.

The variable, $oc_{A3/5}$, is the opportunity cost with respect to automation 3/5-digit cards and is equal to $(d_{A3/5} - \bar{u}_{A3/5})\bullet\hat{s}_{A3/5}$, where $\hat{s}_{A3/5}$ is equal to $[(1/\alpha) - \beta\bullet t_3]\bullet s_{A3/5}$.

The coefficients and regression diagnostics for the 3/5-digit presort cards share equation are (t-statistics in parentheses):

α	=	0.179384	(0.566)
μ_0	=	0.030016	(1.108)
μ_x	=	0.030017	(1.107)
μ_t	=	0.000000	(0.005)
μ_3	=	0.018083	(0.387)
β	=	0.009801	(0.032)
σ	=	0.009579	(2.063)

Adjusted-R^2	0.886
Mean Absolute Percentage Error	14.817%

3. Standard Regular Mail

a. General Overview

i. Shares of Total Standard Regular Mail

For the purpose of estimating econometric share equations, shares are taken as shares of total Standard regular mail. Standard regular mail is divided into four categories: basic mail (i.e., non-workshared), for which no share equation is estimated; presort nonautomation mail; automation basic letters and flats; and automation 3/5-digit letters and flats.

For forecasting, letters and nonletters are separated and are forecasted as shares of Standard regular letters and nonletters, respectively. The reason for this distinction in the forecast period is due to a desire to forecast letters and nonletters separately.

Separate shares of letters and nonletters are required in this case in order to distinguish between basic letters and basic nonletters in the residual category.

Separate historical volume series of Standard regular letters and nonletters are not available prior to R90-1. No distinction was made between these categories prior to this time period because letters and nonletters faced the same rate schedule. This is not a sufficiently long time series, nor does it span a sufficiently large number of rate changes, to be useful in estimating econometric parameters.

ii. Share Equation Sample Period: 1990Q1 - 1997Q2

The Standard regular share equations are estimated over a sample period of 1990Q1 through 1997Q2. This is two years shorter than the sample period used to estimate the First-Class share equations. The reason for the shorter time period is due to the shorter history of automation discounts in third-class mail. The first automation discounts were not introduced into third-class (now renamed Standard) mail until R87-1 in 1988Q3, with the introduction of 5-digit prebarcode and basic and 3/5-digit ZIP+4 discounts. basic and 3-digit prebarcoded discounts were not introduced until R90-1 (1991Q3). Because ZIP+4 discounts were introduced in First-Class Mail in 1984, the initial impact of introducing prebarcoding discounts in 1988Q3 was less dramatic in First-Class Mail than in third-class (i.e., Standard) mail. It was decided to estimate the equations starting in 1990Q1 to allow for two years of adaptation to automation discounts prior to attempting to model user costs. As with First-Class Mail, the post-MC95 period was included in the share equation regressions to provide for a means of quantifying the impact of classification reform on the shares of worksharing categories.

iii. Opportunity Cost Relationships

The following opportunity cost relationships were modeled explicitly in the econometric share equations outlined below. Nonautomation presort Standard regular and automation 3/5-digit Standard regular mail have opportunity cost relationships with respect to each other, while automation basic letters and flats have no opportunity cost relationships which are explicitly modeled, but are assumed to be captured implicitly in the estimation of μ_t.

b. Presort Nonautomation

Presort, nonautomation mail is mail which is presorted to the 3/5-digit level which receives no additional barcoding or ZIP+4 (prior to MC95-1) discounts. The value of α, the ceiling parameter, is constrained to be less than or equal to one. This has the effect of constraining the value of α to be exactly equal to one in this case (i.e., any worksharing mail could have been sent as nonautomation presort mail at any point in time). The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \bullet t_3 - \mu_{96} \bullet d_{96} + \mu_{mc} \bullet d_{mc95} + oc_{A3/5} \qquad \text{(IV.50)}$$

where $oc_{A3/5}$ is opportunity cost with respect to automation 3/5-digit letters and flats and is equal to $(d_{A3/5} - \bar{u}_{A3/5}) \bullet s_{A3/5}$.

The coefficients and regression diagnostics for the nonautomation presort Standard regular share equation are (t-statistics in parentheses):

α	=	1.000000	---
μ_0	=	0.029986	(17.58)
μ_t	=	0.001577	(3.481)
μ_{96}	=	0.003946	(1.371)
μ_{mc}	=	0.018380	(3.828)
σ	=	0.025226	(3.774)

Adjusted-R^2	0.958
Mean Absolute Percentage Error	4.305%

c. Automation Basic

Automation basic letters and flats are made up of pieces which received one of the following discounts: required presort ZIP+4 letters, which was introduced in 1988Q3 and eliminated in 1996Q4 as part of MC95-1 classification reform; required presort prebarcoded letters, which was introduced in 1991Q3 and renamed automation basic letters in MC95-1; and required presort prebarcoded flats, which was introduced in 1993Q1 and renamed automation basic flats in MC95-1.

The pricing of the automation basic letters discount greater than the discount associated with nonautomation presort in 1996Q4 is modeled as leading to an increase in the ceiling share, α. Specifically, α_t is fit to the following specification:

$$\alpha_t = \alpha_0 + \alpha_1 \bullet d_{mc95} \quad \text{(IV.51)}$$

The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \bullet t_{3r} + \mu_{t11} \bullet t_{11} + \mu_{11} \bullet bar_{11} \quad \text{(IV.52)}$$

where t_{3r} is a time trend, equal to zero in 1990Q1, increasing by one each quarter thereafter, and t_{11} is a time trend, equal to zero through 1993Q2, increasing by one each quarter thereafter.

The coefficients and regression diagnostics for the automation basic letters and flats share equation are (t-statistics in parentheses):

α_0 =	0.051297	(1191530)
α_1 =	0.047611	(4.534)
μ_0 =	-0.0000002	(-3.370)
μ_t =	0.00000002	(3.140)
μ_{t11} =	0.000079	(0.213)
μ_{11} =	0.015217	(3.884)

$$\sigma = 0.004872 \quad (0.905)$$

Adjusted-R^2	0.860
Mean Absolute Percentage Error	13.727%

d. Automation 3/5-Digit

Automation 3/5-digit letters and flats are made up of pieces which received one of the following discounts: 5-digit prebarcoded letters, which was introduced in 1988Q3 and renamed automation 5-digit letters as part of MC95-1 classification reform; 3-digit prebarcoded letters, which was introduced in 1991Q3 and renamed automation 3-digit letters as part of MC95-1; 3/5-digit presort prebarcoded flats, which was introduced in 1993Q1 and renamed automation 3/5-digit flats in MC95-1; and 3/5-digit presort ZIP+4 letters, which was introduced in 1988Q3 and eliminated as part of classification reform in 1996Q4.

The introduction of the automation 3-digit letters discount in 1991Q3 is modeled as leading to an increase in the ceiling share, α. The ceiling parameter, α_t is fit to the following specification:

$$\alpha_t = \alpha_0 + \alpha_1 \bullet bar_3 \qquad \text{(IV.53)}$$

The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 - \mu_t \bullet t_{3r} + \mu_{95} \bullet d_{95} + oc_{NA} \qquad \text{(IV.54)}$$

where oc_{NA} is the opportunity cost with respect to nonautomation presort Standard regular mail and is equal to $(d_{NA} - \bar{u}_{NA}) \bullet s_{NA}$.

The coefficients and regression diagnostics for the automation 3/5-digit letters and flats share equation are (t-statistics in parentheses):

$$\alpha_0 = 0.454679 \quad (5.143)$$
$$\alpha_1 = 0.198940 \quad (2.250)$$

$$\mu_0 = 0.043550 \quad (18.13)$$

$$\mu_t = 0.000226 \quad (1.107)$$
$$\mu_{95} = 0.005106 \quad (3.623)$$

$$\sigma = 0.007573 \quad (7.291)$$

Adjusted-R^2	0.986
Mean Absolute Percentage Error	5.033%

4. Standard Bulk Nonprofit Mail

a. General Overview

i. Shares of Total Standard Bulk Nonprofit Mail

For the purpose of estimating econometric share equations, shares are taken as shares of total Standard bulk nonprofit mail. Standard bulk nonprofit mail is divided into five categories: basic mail (i.e., non-workshared), for which no share equation is estimated; presort nonautomation mail; automation basic letters and flats; automation 3/5-digit letters and flats; and Enhanced Carrier Route mail.

For forecasting, Nonprofit letters and nonletters, excluding Standard Nonprofit ECR mail, are separated and are forecasted as shares of Standard Nonprofit letters and nonletters, respectively. The reason for this distinction in the forecast period is due to a desire to forecast letters and nonletters separately. Separate shares of letters and nonletters are required in this case in order to distinguish between basic letters and basic nonletters in the residual category. Nonprofit ECR mail is excluded at this point to distinguish between the subclasses, Standard Nonprofit and Standard Nonprofit ECR. The nonprofit ECR share equation is neither affected by nor affects the share of any other worksharing category of Standard bulk nonprofit mail, so that this difference between the econometrics and the forecasting is of no practical significance.

ii. Share Equation Sample Period: 1990Q1 - 1997Q2

The Standard bulk nonprofit share equations are estimated over a sample period of 1990Q1 through 1997Q2 for the same reasons as were enumerated above with respect to Standard regular mail.

iii. Opportunity Cost Relationships

The following opportunity cost relationships were included in the econometric share equations outlined below. Nonautomation presort Standard regular and automation 3/5-digit Standard regular mail have opportunity cost relationships with respect to each other, while automation 3/5-digit and automation basic letters and flats also have an opportunity cost relationship which is explicitly modeled. Any substitution between automation basic and nonautomation presort mail and between nonprofit ECR mail and any other category of bulk nonprofit mail was assumed to be captured implicitly in the estimation of μ_t.

b. Presort Nonautomation

The value of α, the ceiling parameter, is constrained to be less than or equal to one, which has the effect of constraining the value of α to be exactly equal to one in this case (i.e., any worksharing mail could have been sent as nonautomation presort mail at any point in time). The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \bullet t_3 - \mu_q \bullet qtr_{2\&3} + \mu_{mc} \bullet d_{mc96} + oc_{A3/5} \qquad \text{(IV.55)}$$

where d_{mc96} is a dummy variable equal to one beginning in 1997q1, reflecting the implementation of MC96-2 (nonprofit reclassification), and $oc_{A3/5}$ is opportunity cost with respect to automation 3/5-digit letters and flats and is equal to $(d_{A3/5} - \bar{u}_{A3/5}) \bullet s_{A3/5}$.

The coefficients and regression diagnostics for the nonautomation presort Standard nonprofit share equation are (t-statistics in parentheses):

α	=	1.000000	---
μ_0	=	0.094668	(1.070)
μ_t	=	0.002041	(1.026)
μ_q	=	0.009377	(0.942)
μ_{mc}	=	0.037819	(0.894)
σ	=	0.117945	(0.956)

Adjusted-R^2	0.733
Mean Absolute Percentage Error	4.805%

c. Automation Basic

Automation basic letters and flats are made up of pieces which received one of the following discounts: required presort ZIP+4 letters, which was introduced in 1988Q3 and eliminated in 1997Q1 as part of MC96-2 classification reform; required presort prebarcoded letters, which was introduced in 1991Q3 and renamed automation basic letters in MC96-2; and required presort prebarcoded flats, which was introduced in 1993Q1 and renamed automation basic flats in MC96-2.

The ceiling parameter α is assumed to be constant over the regression period. The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 - \mu_t \cdot t_{3r} + \mu_{t3} \cdot t_3 - \mu_{mc} \cdot d_{mc96} + oc_{A3/5} \qquad \text{(IV.56)}$$

where $oc_{A3/5}$ is opportunity cost with respect to automation 3/5-digit letters and flats and is equal to $(d_{A3/5} - \bar{u}_{A3/5}) \cdot s_{A3/5}$.

The coefficients and regression diagnostics for the automation basic letters and flats share equation are (t-statistics in parentheses):

α	=	0.108123	(0.546)

μ_0 = 0.059289 (0.830)
μ_t = 0.004699 (1.123)
μ_{t3} = 0.004934 (1.179)
μ_{mc} = 0.041453 (0.605)

σ = 0.023070 (1.788)

Adjusted-R^2	0.832
Mean Absolute Percentage Error	11.128%

d. Automation 3/5-Digit

Automation 3/5-digit letters and flats are made up of pieces which received one of the following discounts: 5-digit prebarcoded letters, which was introduced in 1988Q3 and renamed automation 5-digit letters as part of MC96-2 classification reform; 3-digit prebarcoded letters, which was introduced in 1991Q3 and renamed automation 3-digit letters as part of MC96-2; 3/5-digit presort prebarcoded flats, which was introduced in 1993Q1 and renamed automation 3/5-digit flats in MC96-2; and 3/5-digit presort ZIP+4 letters, which was introduced in 1988Q3 and eliminated as part of classification reform in 1997Q1.

The ceiling parameter α is assumed to be constant over the regression period. The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 - \mu_t \bullet t_{3r} + \mu_{94} \bullet d_{94} + oc_{AB} + oc_{NA} \qquad \text{(IV.57)}$$

where d_{94} is a dummy variable equal to one beginning in 1994Q1, reflecting a rule change restricting nonprofit eligibility at that time, oc_{AB} is the opportunity cost with respect to automation basic Standard nonprofit mail and is equal to $(d_{AB} - \bar{u}_{AB}) \bullet s_{AB}$ and oc_{NA} is the opportunity cost with respect to nonautomation presort Standard regular mail and is equal to $(d_{NA} - \bar{u}_{NA}) \bullet s_{NA}$.

The coefficients and regression diagnostics for the automation 3/5-digit letters and flats share equation are (t-statistics in parentheses):

α = 0.366146 (7243820)

μ_0 = 0.029734 (9.104)
μ_t = 0.000548 (2.018)
μ_{94} = 0.001352 (0.979)

σ = 0.006142 (3.380)

Adjusted-R^2	0.960
Mean Absolute Percentage Error	7.759%

e. Nonprofit Enhanced Carrier Route

Nonprofit Enhanced Carrier Route (ECR) mail is carrier-route presorted. This category includes both barcoded and nonbarcoded mail.

The share of nonprofit ECR mail has a slight seasonal pattern to it. This is modeled through the ceiling parameter, α, as follows:

$$\alpha_t = \alpha_0 - \alpha_1 \bullet qtr_{2\&3} \qquad \text{(IV.58)}$$

The mean of the user-cost distribution is fit to the following specification:

$$\mu_t = \mu_0 + \mu_t \bullet t_{3r} + \mu_{mc} \bullet d_{mc96} \qquad \text{(IV.59)}$$

The coefficients and regression diagnostics for the nonprofit ECR share equation are (t-statistics in parentheses):

α_0 = 0.299741 (1.328)
α_1 = 0.014624 (1.053)

μ_0 = 0.021877 (5.424)
μ_t = 0.000363 (1.948)
μ_{mc} = 0.011282 (1.662)

σ = 0.009946 (0.339)

Adjusted-R^2	0.025
Mean Absolute Percentage Error	7.239%

C. Technique for Forecasting Shares

1. Derivation of Share Forecasting Formula

The basis for forecasting the worksharing proportions is equation (IV.33) described in Section A which says for any category of worksharing mail:

$$s_t = \frac{\alpha_t}{1 + e^{-(d_t - \mu_t)/\sigma}} \tag{IV.33}$$

where

s_t is the share of worksharing mail during time t,

α_t is the proportion of worksharing mail for which this worksharing activity is a reasonable alternative at time t.

d_t is the discount offered by the Postal Service at time t,

μ_t is the mean of the user-cost distribution at time t, and

σ is the standard deviation of the user-cost distribution

In applying (IV.33) to forecasting share equations, a base share approach is used. The base share approach utilizes the ratio of equation (IV.33) evaluated at time t and equation (IV.33) evaluated during a base time period to determine the forecast share during time t. The base period for calculating shares in this case is the first two quarters of 1997. The value of α is not expected to change between 1997Q1 and the forecast period for any category of mail forecasted here. Therefore, the time subscript may be removed from α in equation (IV.33) above.

Using equation (IV.33) from above, the forecasting formula is derived as follows:

$$s_t = \frac{\alpha}{1 + e^{-(d_t - \mu_t)/\sigma}} \quad ; \quad s_{base} = \frac{\alpha}{1 + e^{-(d_{base} - \mu_{base})/\sigma}}$$

$$s_t = s_{base} \bullet \left[\frac{\left(1 + e^{-(d_{base} - \mu_{base})/\sigma}\right)}{\left(1 + e^{-(d_t - \mu_t)/\sigma}\right)}\right] \qquad \text{(IV.60)}$$

Because the time subscript was removed from α in equation (IV.60) above, the α term drops out of the final forecasting formula.

2. Values used in the Forecasting Formula

a. Base Shares Used in Forecasting

i. General Methodology

While classification reform did not, in general, affect the volume of First-Class and Standard A mail volume at the level at which the demand equations were modeled in section II above, classification reform had a dramatic effect on the volumes of some of the categories below the level of detail of the base volumes, for which share equations are to be forecasted. For example, the category First-Class automation basic letters was first introduced in MC95-1, as was the category Standard ECR high density letters. Other categories, such as First-Class carrier-route letters and cards have dramatically different requirements now than prior to the implementation of MC95-1 (and MC96-2).

To ensure that the volume forecasts at the category level are consistent with the new categories of mail and requirements in effect since the implementation of MC95-1 and MC96-2, base shares were calculated using only the first two quarters of 1997, since the implementation of MC95-1 and MC96-2.[16]

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[16] Technically, MC96-2 was not in effect for the first three weeks of 1997Q1.

ii. First-Class Mail

Single-piece First-Class letters and private cards as well as stamped cards are not forecasted at any finer level of detail. Hence, these categories are forecasted using a base and forecasted share equal to 100 percent. Workshared First-Class letters and cards are subdivided into specific presort and automation categories as described below.

(a) Shares of Workshared First-Class Letters

Workshared First-Class letters are divided into seven categories for forecasting purposes. The volume of total workshared First-Class letters in the first two quarters of 1997 is equal to 18,472.440 million pieces. The base shares used in forecasting workshared First-Class letters are then calculated as follows.

Nonautomation Presort		
	1997Q1	1,486.816
	1997Q2	1,389.262
	Total Volume	**2,876.078**
	Base Share	**15.570%**
Automation Basic Letters		
	1997Q1	916.915
	1997Q2	969.082
	Total Volume	**1,885.997**
	Base Share	**10.210%**
Automation Basic Flats		
	1997Q1	9.715
	1997Q2	11.231
	Total Volume	**20.947**
	Base Share	**0.113%**
Automation 3-Digit Letters		
	1997Q1	4,335.408
	1997Q2	4,586.704
	Total Volume	**8,922.111**
	Base Share	**48.300%**

Automation 5-Digit Letters

1997Q1	1,927.556
1997Q2	2,115.166
Total Volume	**4,042.722**
Base Share	**21.885%**

Automation 3/5-Digit Flats

1997Q1	54.463
1997Q2	48.022
Total Volume	**102.484**
Base Share	**0.555%**

Automation Carrier Route Letters

1997Q1	303.931
1997Q2	318.169
Total Volume	**622.100**
Base Share	**3.368%**

(b) Shares of Workshared First-Class Cards

Workshared First-Class cards are divided into five categories for forecasting purposes. The volume of total workshared First-Class cards in the first two quarters of 1997 is equal to 1,109.417 million pieces. The base shares used in forecasting workshared First-Class cards are then calculated as follows.

Nonautomation Presort

1997Q1	162.683
1997Q2	159.095
Total Volume	**321.779**
Base Share	**29.004%**

Automation Basic

1997Q1	72.247
1997Q2	75.406
Total Volume	**147.653**
Base Share	**13.309%**

Automation 3-Digit

1997Q1	169.217
1997Q2	165.522
Total Volume	**334.740**
Base Share	**30.173%**

Automation 5-Digit

1997Q1	115.271
1997Q2	123.420
Total Volume	**238.691**
Base Share	**21.515%**

Automation Carrier Route

1997Q1	29.128
1997Q2	37.426
Total Volume	**66.554**
Base Share	**5.999%**

iii. Standard Regular Mail

Standard regular mail is divided into letters and nonletters for forecasting purposes. This is done by applying the share equation results calculated above with respect to total Standard regular mail to base shares which separate letters from nonletters.

(a) Shares of Standard Regular Letters

Standard regular letters are divided into five categories for forecasting purposes. The volume of total Standard regular letters in the first two quarters of 1997 is equal to 8,765.239 million pieces. The base shares used in forecasting Standard regular letters are then calculated as follows.

Basic Letters

1997Q1	439.030
1997Q2	363.814
Total Volume	**802.844**
Base Share	**9.159%**

Presort Letters

1997Q1	759.346
1997Q2	570.161
Total Volume	**1,329.508**
Base Share	**15.168%**

Automation Basic

1997Q1	656.323
1997Q2	645.297
Total Volume	**1,301.620**
Base Share	**14.850%**

Automation 3-Digit

1997Q1	2,079.768
1997Q2	1,999.352
Total Volume	**4,079.119**
Base Share	**46.537%**

Automation 5-Digit

1997Q1	642.085
1997Q2	610.062
Total Volume	**1,252.148**
Base Share	**14.285%**

(b) Shares of Standard Regular Nonletters

Standard regular nonletters are divided into four categories for forecasting purposes. The volume of total Standard regular nonletters in the first two quarters of 1997 is equal to 6,279.282 million pieces. The base shares used in forecasting Standard regular nonletters are then calculated as follows.

Basic Nonletters

1997Q1	324.136
1997Q2	276.211
Total Volume	**600.346**
Base Share	**9.561%**

Presort Nonletters

1997Q1	677.407
1997Q2	569.607
Total Volume	**1,247.014**
Base Share	**19.859%**

Automation Basic Flats

1997Q1	56.156
1997Q2	53.199
Total Volume	**109.355**
Base Share	**1.742%**

Automation 3/5-Digit Flats

1997Q1	2,276.038
1997Q2	2,046.528
Total Volume	**4,322.566**
Base Share	**68.839%**

iv. Standard Enhanced Carrier Route Mail

As with Standard regular mail, Standard ECR mail is divided into letters and nonletters for forecasting purposes. Since no econometric share equations were estimated with respect to Standard ECR mail above, these shares are simply projected to remain constant into the forecast period, except as noted in section 5.b. below.

(a) Shares of Standard ECR Letters

Standard ECR letters are divided into four categories for forecasting purposes. The volume of total Standard ECR letters in the first two quarters of 1997 is equal to 5,327.067 million pieces. The base shares used in forecasting Standard ECR letters are then calculated as follows.

Basic Letters

1997Q1	1,642.961
1997Q2	1,296.642
Total Volume	**2,939.603**
Base Share	**55.182%**

<u>Automation Letters</u>

1997Q1	433.250
1997Q2	482.305
Total Volume	**915.555**
Base Share	**17.187%**

<u>High Density</u>

1997Q1	83.863
1997Q2	81.167
Total Volume	**165.030**
Base Share	**3.098%**

<u>Saturation</u>

1997Q1	715.370
1997Q2	591.509
Total Volume	**1,306.879**
Base Share	**24.533%**

(b) Shares of Standard ECR Nonletters

Standard ECR nonletters are divided into three categories for forecasting purposes. The volume of total Standard ECR nonletters in the first two quarters of 1997 is equal to 9,523.616 million pieces. The base shares used in forecasting Standard ECR nonletters are then calculated as follows.

<u>Basic</u>

1997Q1	2,857.064
1997Q2	2,215.488
Total Volume	**5,072.552**
Base Share	**53.263%**

<u>High Density</u>

1997Q1	277.445
1997Q2	278.479
Total Volume	**555.925**
Base Share	**5.837%**

Saturation

	1997Q1	2,069.881
	1997Q2	1,825.259
	Total Volume	**3,895.140**
	Base Share	**40.900%**

v. Standard Bulk Nonprofit Mail

Standard bulk nonprofit mail is divided in the same way as Standard bulk regular mail, so that shares are calculated of Standard nonprofit letters and nonletters, as well as of Standard nonprofit ECR letters and nonletters.

(a) Standard Nonprofit Mail

(i) Shares of Standard Nonprofit Letters

Standard nonprofit letters are divided into five categories for forecasting purposes. The volume of total Standard nonprofit letters in the first two quarters of 1997 is equal to 4,122.626 million pieces. The base shares used in forecasting Standard nonprofit letters are then calculated as follows.

Basic Letters

	1997Q1	343.617
	1997Q2	294.449
	Total Volume	**638.065**
	Base Share	**15.477%**

Presort Letters

	1997Q1	625.162
	1997Q2	497.315
	Total Volume	**1,122.477**
	Base Share	**27.227%**

Automation Basic[17]

1997Q1	243.927
1997Q2	238.880
Total Volume	**482.807**
Base Share	**11.711%**

Automation 3-Digit

1997Q1	632.409
1997Q2	607.399
Total Volume	**1,239.808**
Base Share	**30.073%**

Automation 5-Digit

1997Q1	379.177
1997Q2	260.291
Total Volume	**639.468**
Base Share	**15.511%**

(ii) Shares of Standard Nonprofit Nonletters

Standard nonprofit nonletters are divided into four categories for forecasting purposes. The volume of total Standard nonprofit nonletters in the first two quarters of 1997 is equal to 799.572 million pieces. The base shares used in forecasting Standard nonprofit nonletters are then calculated as follows.

Basic Nonletters

1997Q1	92.065
1997Q2	81.992
Total Volume	**174.057**
Base Share	**21.769%**

[17] Because MC96-2 was not implemented until three weeks into 1997Q1, some ZIP+4 letters were still reported in 1997Q1. These volumes were added to the automation basic and 3-digit letters volumes in calculating base shares.

Presort Nonletters

1997Q1	138.615
1997Q2	110.819
Total Volume	**249.434**
Base Share	**31.196%**

Automation Basic Flats

1997Q1	11.703
1997Q2	10.309
Total Volume	**22.012**
Base Share	**2.753%**

Automation 3/5-Digit Flats

1997Q1	186.342
1997Q2	167.727
Total Volume	**354.069**
Base Share	**44.282%**

(b) Standard Nonprofit Enhanced Carrier Route Mail

(i) Shares of Standard Nonprofit ECR Letters

Standard nonprofit ECR letters are divided into four categories for forecasting purposes. The volume of total Standard nonprofit ECR letters in the first two quarters of 1997 is equal to 1,171.892 million pieces. The base shares used in forecasting Standard nonprofit ECR letters are then calculated as follows.

Basic Letters

1997Q1	535.431
1997Q2	198.424
Total Volume	**733.855**
Base Share	**62.621%**

Automation Letters

1997Q1	88.821
1997Q2	86.109
Total Volume	**174.930**
Base Share	**14.927%**

High Density

1997Q1	11.790
1997Q2	7.516
Total Volume	**19.306**
Base Share	**1.647%**

Saturation

1997Q1	112.688
1997Q2	131.113
Total Volume	**243.801**
Base Share	**20.804%**

(ii) Shares of Standard Nonprofit ECR Nonletters

Standard nonprofit ECR nonletters are divided into three categories for forecasting purposes. The volume of total Standard nonprofit ECR nonletters in the first two quarters of 1997 is equal to 378.001 million pieces. The base shares used in forecasting Standard nonprofit ECR nonletters are then calculated as follows.

Basic

1997Q1	181.965
1997Q2	102.379
Total Volume	**284.344**
Base Share	**75.223%**

High Density

1997Q1	5.068
1997Q2	2.066
Total Volume	**7.134**
Base Share	**1.887%**

Saturation

1997Q1	47.689
1997Q2	38.834
Total Volume	**86.523**
Base Share	**22.890%**

b. Summary of Values used in Forecasting Shares of First-Class and Standard A Mail

The base shares, before- and after-rates discounts, and base values of μ and σ associated with First-Class and Standard bulk non-carrier-route mail are summarized in Table IV-1 below. The values of μ presented in Table IV-1 do not include opportunity costs. The opportunity cost relationships used in share forecasting in this case are summarized in section 3. below.

Table IV-1
Summary of Parameters used in Forecasting Shares

	Base Share	$d_{Before\text{-}Rates}$	$d_{After\text{-}Rates}$	μ_{Base}	σ
First-Class Letters					
Workshared					
Presort Nonautomation	15.570%	2.5¢	2.0¢	3.77¢	3.17¢
Automation Basic Letters	10.210%	5.9¢	5.5¢	2.83¢	0.47¢
Automation Basic Flats	0.113%	3.0¢	3.0¢	2.83¢	0.47¢
Automation 3-Digit Letters	48.300%	6.6¢	6.5¢	1.25¢	1.44¢
Automation 5-Digit Letters	21.885%	8.2¢	8.1¢	1.25¢	1.44¢
Automation 3/5-Digit Flats	0.555%	5.0¢	5.0¢	1.25¢	1.44¢
Automation Carrier-Route	3.368%	9.0¢	8.4¢	10.83¢	1.70¢
First-Class Cards					
Private Workshared					
Presort Nonautomation	29.004%	2.0¢	2.0¢	1.35¢	1.52¢
Automation Basic	13.309%	3.4¢	3.4¢	11.01¢	9.52¢
Automation 3-Digit	30.173%	4.1¢	4.0¢	2.10¢	1.15¢
Automation 5-Digit	21.515%	5.7¢	5.1¢	2.10¢	1.15¢
Automation Carrier Route	5.999%	6.0¢	5.4¢	7.59¢	1.70¢
Standard Regular					
Letters					
Basic Nonautomation	9.159%	0.0¢	0.0¢	NA	NA
Presort Nonautomation	15.168%	4.7¢	3.8¢	8.15¢	2.52¢
Automation Basic	14.850%	7.3¢	5.8¢	1.64¢	0.49¢
Automation 3-Digit	46.537%	8.1¢	6.9¢	3.71¢	0.76¢
Automation 5-Digit	14.285%	10.1¢	8.7¢	3.71¢	0.76¢
Nonletters					
Basic Nonautomation	9.561%	0.0¢	0.0¢	NA	NA
Presort Nonautomation	19.859%	8.1¢	6.0¢	8.15¢	2.52¢
Automation Basic Flats	1.742%	2.9¢	5.7¢	1.64¢	0.49¢
Automation 3/5-Digit Flats	68.839%	11.7¢	9.3¢	3.71¢	0.76¢
Standard Nonprofit					
Letters					
Basic Nonautomation	15.477%	0.0¢	0.0¢	NA	NA
Presort Nonautomation	27.227%	1.8¢	2.2¢	16.17¢	11.79¢
Automation Basic	11.711%	3.3¢	4.1¢	1.53¢	2.31¢
Automation 3-Digit	30.073%	3.7¢	5.3¢	1.55¢	0.61¢
Automation 5-Digit	15.511%	5.0¢	7.0¢	1.55¢	0.61¢
Nonletters					
Basic Nonautomation	21.769%	0.00¢	0.00¢	NA	NA
Presort Nonautomation	31.196%	4.48¢	6.30¢	16.17¢	11.79¢
Automation Basic Flats	2.753%	2.11¢	4.90¢	1.53¢	2.31¢
Automation 3/5-Digit Flats	44.282%	6.92¢	8.40¢	1.55¢	0.61¢

3. Incorporation of Opportunity Cost

The following opportunity cost relationships are incorporated into the share forecasts presented here. In all cases, $\hat{s}_{ij}$ is estimated to be equal to s_{ij}, so that the value of β_{ij} is set equal to one for all opportunity costs included in forecasting.

Presort nonautomation First-Class letters have opportunity costs included with respect to automation basic letters, automation 3-digit letters, and automation 5-digit letters. Automation basic First-Class letters have an opportunity cost with respect to presort nonautomation First-Class letters. Automation 3-digit First-Class letters have opportunity costs with respect to presort nonautomation letters and automation 5-digit letters, while automation 5-digit First-Class letters have opportunity costs with respect to presort nonautomation letters and automation 3-digit letters.

Presort nonautomation First-Class cards have opportunity costs with respect to automation basic cards, automation 3-digit cards, and automation 5-digit cards. Automation basic cards have opportunity costs with respect to presort nonautomation cards and automation 3-digit cards. Automation 3-digit cards have opportunity costs with respect to presort nonautomation cards, automation basic cards, and automation 5-digit cards. Automation 5-digit First-Class cards have opportunity costs with respect to presort nonautomation cards and automation 3-digit cards.

Standard regular presort, nonautomation letters have opportunity costs with respect to automation basic, 3-digit, and 5-digit letters. Automation basic letters have opportunity costs with respect to presort nonautomation letters. Automation 3-digit letters have opportunity costs with respect to presort nonautomation letters and automation 5-digit letters, and automation 5-digit letters have opportunity costs with respect to presort nonautomation letters and automation 3-digit letters. Standard regular presort, nonautomation nonletters and automation 3/5-digit flats have opportunity costs with each other.

Standard Nonprofit presort, nonautomation letters have opportunity costs with respect to automation basic, 3-digit, and 5-digit letters. Automation basic letters have opportunity costs with respect to presort nonautomation letters, and automation 3-digit letters. Automation 3-digit letters have opportunity costs with respect to presort nonautomation letters, automation basic letters, and automation 5-digit letters, and automation 5-digit letters have opportunity costs with respect to presort nonautomation letters and automation 3-digit letters. Standard Nonprofit presort, nonautomation nonletters and automation 3/5-digit flats have opportunity costs with each other.

4. The Residual Share

Standard regular and nonprofit, basic letters and nonletters are not forecasted using equation (IV.60) above. Instead, these represent "residual" categories. These are the categories from which the Standard discounts used in forecasting are based. Consequently, these categories have no discounts by definition. The forecasted shares of these categories are estimated using equation (IV.35) above, and are equal to one minus the forecasted shares of all of the worksharing categories within the particular category of interest.

Because the shares of workshared First-Class letters and cards are taken as shares of total workshared First-Class letters and cards, respectively, there is no residual category associated with these two groups of mail. Instead of calculating a residual share, therefore, using equation (IV.35), the forecasted shares of workshared First-Class letters and workshared First-Class cards are normalized to sum to 100 percent.

5. Enhanced Carrier Route Shares

a. Basic Overview

Standard ECR shares are not forecasted using equation (IV.60) above. The before-rates shares of Standard ECR and nonprofit ECR mail are simply projected to be equal to the base shares into the forecast period, due to a lack of available historical data on the shares of Standard carrier-route mail over time and under alternate discount structures. The after-rates shares of ECR nonletters are equivalent to the before-rates shares of these categories. The after-rates shares of ECR letters differ from the before-rates shares (after the implementation of rates), however, due to a complication in the after-rates rate structure of Standard ECR letters.

b. Migration of ECR Basic Letters to Automation 5-Digit Letters

The automation basic ECR letters rate is only available to mail sent to specific Post Offices, which are either equipped with a CSBCS machine or which sort mail manually. Only 33.28 percent of ECR regular letters and 31.33 percent of ECR nonprofit letters fall into this category. For letters which are not sent to a qualifying Post Office, the lowest rate available (excluding High Density and Saturation rates) is currently the ECR basic letters rate. Hence, it is presumed that all such mail is currently sent as ECR basic letters, even if this mail could have been prebarcoded by the mailer (e.g., was part of a mailing for which some mail was sent to qualifying Post Offices and received the automation basic ECR letters rate).

Under the rates proposed by the Postal Service in this case, automation 5-digit letters will be priced below ECR basic letters. Hence, mailers who can prebarcode their mail and have sufficient density to qualify for the automation 5-digit rates would have an incentive to shift from the ECR and nonprofit ECR subclasses into the regular or nonprofit subclasses to take advantage of the lower automation 5-digit letters rates.

If it is assumed that any non-high-density, non-saturation, enhanced carrier route letters which could be automated are either already automated or are not automated only because they are sent to a non-qualifying Post Office, then current automation basic ECR letters represent exactly 33.28 percent of potentially barcoded regular ECR letters and 31.33 percent of potentially barcoded nonprofit ECR letters.

Applying these percentages to the base shares of ECR basic letters from the first two quarters of 1997 (17.187 percent and 14.927 percent of ECR letters and nonprofit ECR letters, respectively), the percentage of total regular ECR letters that could be automated is calculated as follows:

$$S_{\text{Auto Letters}} = (17.187\%) \div (33.28\%) = 51.643\%$$

and the percentage of total nonprofit ECR letters that could be automated is calculated as follows:

$$S_{\text{Auto Letters}} = (14.927\%) \div (31.33\%) = 47.645\%$$

The shares of automation basic ECR letters are 17.187 percent and 14.927 percent of regular and nonprofit letters respectively. Subtracting these figures from the 51.643 percent and 47.645 percent figures calculated above yield base shares of 34.456 percent of regular ECR letters and 32.718 percent of nonprofit ECR letters that could be automated but are not currently.

The density requirement for automation 5-digit letters is 150 pieces per 5-digit tray, while the density requirement for ECR basic letters is 10 pieces per carrier route. Hence, some Enhanced Carrier Route mail may not qualify for automation 5-digit letters rates. Based on the Standard Mail Characteristics Study, it is estimated that 86.03

percent of ECR regular letters and 78.82 percent of nonprofit ECR letters have sufficient density to qualify for automation 5-digit letters rates. Multiplying the shares of ECR letters that could be automated by these percentages yields the following shares of ECR letters that could potentially qualify for automation 5-digit rates: 29.643 percent of regular ECR basic letters and 25.788 percent of nonprofit ECR basic letters.

Those letters which are expected to take advantage of automation 5-digit letters rates after-rates are forecasted separately from the rest of ECR basic letters. The base shares for this category of letters are 29.643 percent of regular ECR letters and 25.788 percent of nonprofit ECR letters as derived above. This mail is assumed to face basic ECR letter rates before the implementation of R97-1 rates and automation 5-digit letter rates after the implementation of R97-1. The before-rates volume of this category of mail is included in the before-rates volume of ECR basic letters reported by Dr. Tolley in his testimony. The after-rates volume of this category is included in the after-rates volume of automation 5-digit letters reported by Dr. Tolley in his testimony. The total after-rates volume of mail that is projected to shift from ECR basic letters into automation 5-digit letters as a result of this rate crossover is equal to 3,346.050 million regular and 581.544 million nonprofit letters, for a total of 3,927.594 million Standard letters which are projected to shift subclasses.

D. Final Forecasted Shares of Worksharing Categories of First-Class and Standard A Mail

Tables IV-2 and IV-3 below present final forecasted shares of First-Class and Standard A mail before- and after-rates from 1997Q3 through 2000Q1.

Table IV-2
Before-Rates Share Forecasts

	1997Q3	1997Q4	1998Q1	1998Q2	1998Q3	1998Q4	1999Q1	1999Q2	1999Q3	1999Q4	2000Q1
First-Class Letters											
Single-Piece	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
Workshared											
Presort Nonautomation	14.836%	14.397%	13.968%	13.550%	13.143%	12.745%	12.359%	11.982%	11.616%	11.260%	10.914%
Automation Basic Letters	10.216%	10.243%	10.269%	10.294%	10.317%	10.339%	10.359%	10.377%	10.392%	10.405%	10.415%
Automation Basic Flats	0.110%	0.110%	0.110%	0.111%	0.111%	0.111%	0.112%	0.112%	0.112%	0.113%	0.113%
Automation 3-Digit Letters	48.592%	48.888%	49.176%	49.456%	49.730%	49.995%	50.254%	50.507%	50.753%	50.993%	51.227%
Automation 5-Digit Letters	21.963%	22.064%	22.163%	22.261%	22.357%	22.451%	22.544%	22.636%	22.726%	22.815%	22.903%
Automation 3/5-Digit Flats	0.559%	0.563%	0.566%	0.570%	0.573%	0.577%	0.580%	0.583%	0.586%	0.589%	0.592%
Automation Carrier-Route Letters	3.724%	3.735%	3.747%	3.758%	3.769%	3.781%	3.792%	3.803%	3.814%	3.825%	3.836%
First-Class Cards											
Postal Cards	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
Private Single-Piece	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
Private Workshared											
Presort Nonautomation	28.085%	27.479%	26.880%	26.288%	25.702%	25.124%	24.554%	23.991%	23.436%	22.889%	22.350%
Automation Basic	13.369%	13.409%	13.450%	13.492%	13.535%	13.578%	13.622%	13.667%	13.712%	13.758%	13.805%
Automation 3-Digit	31.037%	31.606%	32.169%	32.724%	33.273%	33.813%	34.346%	34.871%	35.387%	35.894%	36.393%
Automation 5-Digit	21.649%	21.736%	21.820%	21.903%	21.984%	22.064%	22.142%	22.219%	22.295%	22.369%	22.443%
Automation Carrier Route	5.861%	5.770%	5.681%	5.592%	5.506%	5.420%	5.336%	5.252%	5.170%	5.089%	5.010%
Standard Regular											
Letters											
Basic Nonautomation	9.695%	9.741%	9.787%	9.833%	9.880%	9.927%	9.973%	10.020%	10.067%	10.114%	10.161%
Presort Nonautomation	14.603%	14.543%	14.483%	14.423%	14.363%	14.304%	14.244%	14.185%	14.127%	14.068%	14.010%
Automation Basic	14.850%	14.850%	14.850%	14.850%	14.850%	14.850%	14.850%	14.850%	14.850%	14.850%	14.850%
Automation 3-Digit	46.565%	46.579%	46.592%	46.605%	46.618%	46.630%	46.642%	46.653%	46.664%	46.675%	46.686%
Automation 5-Digit	14.287%	14.287%	14.288%	14.289%	14.290%	14.290%	14.291%	14.291%	14.292%	14.293%	14.293%
Nonletters											
Basic Nonautomation	10.368%	10.488%	10.608%	10.728%	10.846%	10.964%	11.081%	11.198%	11.313%	11.428%	11.543%
Presort Nonautomation	19.055%	18.936%	18.818%	18.701%	18.584%	18.469%	18.353%	18.239%	18.126%	18.013%	17.901%
Automation Basic Flats	1.739%	1.736%	1.734%	1.732%	1.730%	1.728%	1.726%	1.724%	1.721%	1.719%	1.717%
Automation 3/5-Digit Flats	68.839%	68.839%	68.839%	68.839%	68.839%	68.839%	68.839%	68.839%	68.840%	68.840%	68.840%
Standard Enhanced Carrier Route											
Letters											
Basic	55.182%	55.182%	55.182%	55.182%	55.182%	55.182%	55.182%	55.182%	55.182%	55.182%	55.182%
Automation	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%
High Density	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%
Saturation	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%
Nonletters											
Basic	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%

	1997Q3	1997Q4	1998Q1	1998Q2	1998Q3	1998Q4	1999Q1	1999Q2	1999Q3	1999Q4	2000Q1
Standard Nonprofit											
Letters											
Basic Nonautomation	14.908%	16.246%	16.253%	14.943%	15.003%	16.408%	16.501%	15.305%	15.443%	16.886%	17.046%
Presort Nonautomation	24.836%	22.903%	22.546%	23.707%	23.339%	21.498%	21.158%	22.261%	21.911%	20.161%	19.837%
Automation Basic	14.571%	14.548%	14.491%	14.402%	14.345%	14.317%	14.257%	14.166%	14.105%	14.074%	14.011%
Automation 3-Digit	30.133%	30.733%	31.129%	31.360%	31.716%	32.166%	32.465%	32.643%	32.909%	33.238%	33.458%
Automation 5-Digit	15.552%	15.570%	15.582%	15.588%	15.598%	15.611%	15.620%	15.624%	15.632%	15.642%	15.648%
Nonletters											
Basic Nonautomation	23.549%	25.721%	25.778%	24.389%	24.818%	26.914%	26.986%	25.642%	26.054%	28.074%	28.458%
Presort Nonautomation	28.685%	26.523%	26.422%	27.807%	27.387%	25.302%	25.192%	26.533%	26.130%	24.120%	23.747%
Automation Basic Flats	3.482%	3.472%	3.514%	3.517%	3.507%	3.497%	3.534%	3.537%	3.527%	3.517%	3.507%
Automation 3/5-Digit Flats	44.283%	44.284%	44.286%	44.287%	44.287%	44.287%	44.288%	44.288%	44.288%	44.288%	44.289%
Standard Nonprofit Enhanced Carrier Route											
Letters											
Basic	62.621%	62.621%	62.621%	62.621%	62.621%	62.621%	62.621%	62.621%	62.621%	62.621%	62.621%
Automation	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%
High Density	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%
Saturation	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%
Nonletters											
Basic	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%
High Density	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%
Saturation	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%

Table IV-3
After-Rates Share Forecasts

	1998Q1	1998Q2	1998Q3	1998Q4	1999Q1	1999Q2	1999Q3	1999Q4	2000Q1
First-Class Letters									
Single-Piece	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
Workshared									
Presort Nonautomation	13.001%	12.369%	11.989%	11.620%	11.262%	10.913%	10.575%	10.246%	9.927%
Automation Basic Letters	10.448%	10.502%	10.514%	10.522%	10.528%	10.529%	10.526%	10.518%	10.504%
Automation Basic Flats	0.113%	0.114%	0.114%	0.114%	0.114%	0.115%	0.115%	0.115%	0.116%
Automation 3-Digit Letters	50.147%	50.659%	50.924%	51.182%	51.434%	51.682%	51.924%	52.162%	52.396%
Automation 5-Digit Letters	22.614%	22.819%	22.910%	23.000%	23.090%	23.178%	23.266%	23.353%	23.440%
Automation 3/5-Digit Flats	0.578%	0.584%	0.588%	0.591%	0.594%	0.597%	0.600%	0.603%	0.606%
Automation Carrier-Route Letters	3.101%	2.954%	2.962%	2.970%	2.978%	2.986%	2.994%	3.002%	3.010%
First-Class Cards									
Postal Cards	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
Private Single-Piece	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
Private Workshared									
Presort Nonautomation	28.331%	28.091%	27.474%	26.866%	26.265%	25.672%	25.088%	24.512%	23.945%
Automation Basic	13.513%	13.570%	13.606%	13.644%	13.683%	13.723%	13.764%	13.806%	13.848%
Automation 3-Digit	32.440%	33.063%	33.606%	34.142%	34.669%	35.187%	35.698%	36.199%	36.692%
Automation 5-Digit	21.100%	20.983%	21.094%	21.203%	21.309%	21.413%	21.516%	21.616%	21.715%
Automation Carrier Route	4.617%	4.293%	4.219%	4.146%	4.074%	4.004%	3.935%	3.867%	3.800%
Standard Regular									
Letters									
Basic Nonautomation	11.037%	11.576%	11.584%	11.593%	11.602%	11.613%	11.625%	11.638%	11.652%
Presort Nonautomation	14.169%	14.022%	13.966%	13.910%	13.854%	13.798%	13.743%	13.687%	13.632%
Automation Basic	14.847%	14.845%	14.844%	14.844%	14.844%	14.844%	14.844%	14.844%	14.844%
Automation 3-Digit	45.716%	45.350%	45.397%	45.442%	45.486%	45.529%	45.570%	45.611%	45.650%
Automation 5-Digit	14.231%	14.207%	14.210%	14.212%	14.214%	14.216%	14.218%	14.220%	14.222%
Nonletters									
Basic Nonautomation	13.098%	13.833%	13.926%	14.019%	14.112%	14.204%	14.295%	14.386%	14.476%
Presort Nonautomation	16.224%	15.515%	15.419%	15.325%	15.230%	15.136%	15.043%	14.951%	14.859%
Automation Basic Flats	1.870%	1.871%	1.871%	1.871%	1.871%	1.871%	1.871%	1.871%	1.871%
Automation 3/5-Digit Flats	68.808%	68.781%	68.783%	68.785%	68.787%	68.789%	68.790%	68.792%	68.794%
Standard Enhanced Carrier Route									
Letters									
Basic	25.540%	25.540%	25.540%	25.540%	25.540%	25.540%	25.540%	25.540%	25.540%
Automation 5-Digit	29.643%	29.643%	29.643%	29.643%	29.643%	29.643%	29.643%	29.643%	29.643%
Automation ECR	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%	17.187%
High Density	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%	3.098%
Saturation	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%	24.533%
Nonletters									
Basic	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%	53.263%
High Density	5.837%	5.837%	5.837%	5.837%	5.837%	5.837%	5.837%	5.837%	5.837%

	1998Q1	1998Q2	1998Q3	1998Q4	1999Q1	1999Q2	1999Q3	1999Q4	2000Q1
Standard Nonprofit									
Letters									
Basic Nonautomation	12.439%	10.986%	11.342%	13.098%	13.441%	12.420%	12.781%	14.474%	14.818%
Presort Nonautomation	22.136%	23.169%	22.804%	20.989%	20.652%	21.737%	21.390%	19.668%	19.349%
Automation Basic	14.906%	14.913%	14.856%	14.832%	14.774%	14.682%	14.623%	14.596%	14.536%
Automation 3-Digit	34.802%	35.207%	35.272%	35.354%	35.405%	35.432%	35.477%	35.532%	35.568%
Automation 5-Digit	15.716%	15.726%	15.726%	15.728%	15.728%	15.729%	15.729%	15.730%	15.731%
Nonletters									
Basic Nonautomation	23.674%	21.731%	22.175%	24.368%	24.782%	23.476%	23.899%	25.994%	26.388%
Presort Nonautomation	27.811%	29.629%	29.190%	27.001%	26.592%	27.904%	27.485%	25.396%	25.007%
Automation Basic Flats	4.226%	4.352%	4.347%	4.342%	4.337%	4.332%	4.327%	4.321%	4.316%
Automation 3/5-Digit Flats	44.289%	44.289%	44.289%	44.289%	44.289%	44.289%	44.289%	44.289%	44.289%
Standard Nonprofit Enhanced Carrier Route									
Letters									
Basic	36.833%	36.833%	36.833%	36.833%	36.833%	36.833%	36.833%	36.833%	36.833%
Automation 5-Digit	25.788%	25.788%	25.788%	25.788%	25.788%	25.788%	25.788%	25.788%	25.788%
Automation ECR	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%	14.927%
High Density	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%	1.647%
Saturation	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%	20.804%
Nonletters									
Basic	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%	75.223%
High Density	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%	1.887%
Saturation	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%	22.890%