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The Demand for First-Class Mail: An Econometric Analysis

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Abstract. This paper focuses on the demand for first-class letters in the U.S. using aggregate quarterly time-series data for the period 1971–1986. The main drivers of the volume of first class mail are found to be GNP, the relative price of a first-class letter, the volume of bulk regular third-class mail, and the number of financial accounts. A principal finding is that the size of the price elasticity varies seasonally, reaching a peak in the fourth quarter.

Key words. First-class mail, econometric demand analysis.

1. Introduction

Prior to the breakup of AT&T in 1984, the old Bell System was the country's largest non-government employer. Now, that distinction belongs to the U.S. Postal Service, which employs about 750,000 people and has revenues in excess of $45 billion. The Postal Service is regulated and has to have its rates approved by the U.S. Postal Rate Commission. For reasons not of concern in this paper, productivity gains in the Postal Service are sufficiently below the all-economy average that it has been necessary for rates to be raised on essentially a 3-year cycle. The question is never whether postal rates are going up, but rather how much and how the increases will be structured.

Always a key question in the rate hearings is the effect of the proposed higher rates on mail volumes – i.e., what are the relevant price elasticities of demand? For the last several rate hearings, this question has been dealt with in the framework of a comprehensive forecasting model of mail volumes that has been developed for the Postal Service by Professor George S. Tolley of the University of Chicago.[1] Tolley's model for first-class letters is an intricate econometric model which relates first-class letter volume per adult member of the population to the real price of first-class letters, the real price of first-class cards, the real price of bulk-regular third-class mail, the volumes of third-class bulk regular and non-profit mail, permanent income, cyclic income, advertising expenditures, a seasonal index, and a 'net' trend. Shiller distributed lags are imposed on all of the price variables, while one- and two-period lags are imposed on the volume of bulk-regular third-class mail and cyclic income. The cross elasticities with respect to the prices of first-class cards and bulk-regular third-class mail are not estimated directly, but are derived from the coefficients in the regressions for those two categories using the Slutsky

Table I. First-class mail[a] originating in households & nonhouseholds 1977 & 1987[b].

Sector	1977		1987	
	%	Pieces/HH per week	%	Pieces/HH per week
Household to household	12.4	1.7	9.1	1.6
Household to nonhousehold	16.9	2.4	12.2	2.1
Nonhousehold to household	38.8	5.5	40.5	7.0
Unknown outgoing[c]	–	–	1.9	0.3
Unknown incoming	–	–	0.6	0.1
Subtotal	68.1	9.5	64.2	11.1
Nonhousehold to nonhousehold	31.9	–	35.8	–
Total	100.0	–	100.0	–

[a]Includes packages.
[b]Calendar year for 1977, postal year for 1987.
[c]In the 1977 sample, unknown destination and origination First-Clas Mail was assigned to households and nonhouseholds in the same proportion as for the known destinations and originations.
Source: United States Postal Service, *The Household Diary Study Fiscal Year 1987*, Demand Research Division, Rates and Classification Department, July 1988, Table IV-1.

symmetry conditions. Permanent income is allowed to affect nonpresort and presort first-class mail differently, but the base elasticity for permanent income is extraneously estimated from cross-section data. Advertising expenditures are intended to pick up the increasing use of first-class mail for business advertising. Finally, the 'net' trend is a sophisticated function of time that is intended to reflect the increased use of first-class mail induced by the computer revolution.

Tolley's model for first-class mail is open to a number of criticisms,[2] and the purpose of the present paper is to take a fresh look at the demand for first-class letters using a framework that separates mail users into households and nonhouseholds and then to further disaggregate household and nonhousehold first-class letters into mail from:

1. Households to other households;
2. Households to nonhouseholds;
3. Nonhouseholds to households;
4. Nonhouseholds to nonhouseholds.

The analysis proceeds by specifying a demand function for each of these four categories of mail and then aggregating over the categories. The result is a model in which the "left-hand side" is an aggregate, but the 'right-hand side' is disaggregated.

The empirical basis for this four-fold bi-directional decomposition of first-class mail is data from the 1977 Household Mailstream Study and the 1987 Household Mailstream Study conducted by the U.S. Postal Service. The percentages of first-class mail that flowed along each of the four "links" in 1977 and 1987 are given in Table I. The fact that leaps from this table is that first-class mail is overwhelmingly business-driven. In 1977, less than 13% of first-class mail was from households to other households; in 1987, this figure had fallen to nearly 9%. The remainder was either household to nonhousehold, nonhousehold to household, or nonhousehold to nonhousehold.[3]

The primary advantage of this fourfold disaggregation of first-class mail is that it allows for each category of mail use to respond in a unique way to changes in common variables, such as price and income, but also allows for some predictors to be use-specific. Cases in point, as we shall see, are presort discounts which affect business first-class mail to households and the price of the first ounce of a first-class letter which appears to have its primary effect on Christmas mail in the fourth (calendar) quarter.

The key suppositions and protocols of the analysis can be stated briefly as follows:

1. The first-class mail is used by a variety of users for a variety of reasons. In view of this, one should not attempt to impose the same theoretical structure on all users.
2. At a conceptual level, mail demand is best approached in terms of the end uses that mail serves. Except for mail between households, most end uses for first-class mail (as we have just seen) are business-related.
3. First-class mail is subject to strong seasonal variation, much of which reflects end uses that are themselves calendar-dependent. The approach followed is to model seasonal variation directly through the use of seasonal shift (or dummy) variables. Changing seasonal effects are allowed for by interacting the seasonal shift variables with other predictors, such as price, income, and demographic characteristics of the population.
4. Changes in the structure of postal tariffs, such as the introduction of presort discounts, are allowed for through the use of appropriately defined shift variables.
5. The tariff structure of postal rates is represented directly, rather than through the use of an all-inclusive price index. The tariff for first-class letters is measured by two variables, the price for the first ounce (or part thereof) and the price per additional ounce for letters greater than one ounce. Presort discounts are measured by the amount of discount interacted with shift variables that correspond to the points in time that the discounts were introduced.

The format for the remainder of the paper is as follows: The analysis begins in the next section with a discussion of the theoretical structure of the models that are estimated. This is followed in Section III with a discussion of the data that are used in estimation. The econometric procedures that have been followed are also discussed in this section. The empirical results are presented in Section IV. Some forecasting and robustness tests of the models are presented in Section V. Conclusions and suggestions for further research are given in Section VI.

II. Theoretical Considerations[4]

As noted in the introduction, a glaring fact about the mail is that is used by a large number of users for a large number of reasons. Accordingly, it would be mistake to approach mail demand in terms of an all-encompassing theoretical structure that posits maximizing behavior for a group of homogeneous economic agents. Instead, the approach that makes the most sense is to classify mail users into two broad categories, namely, households and nonhouseholds and then to consider the reasons that households send mail to other households and to nonhouseholds, and similarly for nonhouseholds.

The postal system can be viewed as providing a network that connects every household and business with every other household and business. The telephone system does much the same,[5] but with one important difference: access to the postal system by users is gratuitous, whereas it is not with the telephone system. *Use* of the postal system must be paid for, but there is no charge for *access* to the system.[6] The other distinguishing feature of the postal system is that the postal service has a monopoly at the receiving end. Only the Postal Service is allowed to put missives and parcels into the official "mailbox" that everyone has.

1. HOUSEHOLD MAIL DEMAND

Households use the mail for both pleasure and business. They correspond with family, friends, and acquaintances at birthdays, anniversaries, Christmas and other holidays, and other times "just to keep in touch," and they chronicle their vacations and travel with cards. Much of household business is conducted through the mail. Bill-paying heads the list, but they also place orders, often in response to direct-mail advertising, initiate and answer inquiries, pay taxes, and communicate with attorneys and accountants.

The usual point of departure for specifying a household model of demand is to relate the amount of a good purchased to the household's income, the price of the good, prices of related goods, and any socio-demographic factors that are thought to be relevant. The problem with applying this framework directly to mail demand is that mail is not the traditional type of good that is studied by economic theory. Non-leisure mail sent by households is not directed by utility calculations, but rather is consequent to other consumption decisions. Bills are paid by mail because it is convenient and cheap in comparison with alternatives. Goods are ordered by mail (although delivery may be by other means), again because it is convenient to do so. Income is an important driving force, but this is because income is the primary determinant of the volume of consumption transactions. Price is important because transactions by mail are convenient and the cost of doing so is low in comparison with the time cost of alternatives.

When we turn to the pleasure mail for households, I am hard put to imagine price and income playing much role at all, for the bulk of pleasure mail would

Table II. Determinants of household pleasure mail.

Event	Determinants
Christmas/New Year's	Population, income, price
Valentine's Day	Age distribution of population
Mother's Day	Population, price of toll calls
Father's Day	Population, price of toll calls
Birthdays	Population, price of toll calls
Anniversaries	Married households
Graduation	Population 18–24
Weddings	Marriages
Non-holiday correspondence	Income, price of toll calls
College	Enrollments

seem to be determined by cultural and socio-demographical factors. Birthdays and family holidays occur independently of price and income, and the same is true of Christmas, Hanukkah, and Mother's Day. The exchange of letters and greetings on these and other occasions is determined primarily by culture and tradition. Economic considerations might foreclose a birthday telephone call, but not the sending of a birthday letter or card. The only circumstance that I can think of where price may be a constraining factor on pleasure mail is one (such as Christmas) where a relatively large number of letters/cards are to be mailed at one time. In this situation, an increase in first-class rates might reasonably lead to a reduction in the amount of mail sent.[7]

We turn next to a specific list of cultural and socio-demographical factors for explaining household pleasure mail. All of the factors, it seems to me, can be viewed as being calendar-dependent, some of which (Christmas, Valentine's Day, etc.) occur at the same time for everyone and the rest of which are household specific (birthdays, anniversaries, etc.). The former are straightforward to deal with, for (with quarterly or monthly data) they can be represented by dummy variables. Household-specific events are more problematic, and will have to be measured by distributional characteristics of the population. A list of some of the factors to be considered is given in Table II.

2. BUSINESS MAIL DEMAND

Businesses use the mail for three primary reasons:

1. To facilitate business transactions with customers and vendors;
2. To exchange information with customers, vendors, associates, and colleagues;
3. To advertise.

At any point in time, the volume of mail falling into the first category will be determined primarily by the volume of economic activity and the cost of using the mail to accomplish the ends desired in relation to the costs of alternative modes of transport. The advantages of the mail are universal guaranteed access to the parties desired and low out-of-pocket costs. It also creates a record of transactions. The disadvantage is that the mail takes time. This means that the primary determinant of whether a communication will be sent by mail or some alternative mode is the opportunity cost of time.

First-class mail is ideal for most routine financial transactions between businesses and households, for time cost is minimal and convenience is overwhelming. The opportunity cost of time will also be instrumental in determining how correspondence of a purely informational character will be sent. An investor wishing to instruct her broker to buy a block of AT&T shares will in general not use the mail to do so, although it is perfectly reasonable that confirmation of the transaction be sent by mail. On the other hand, an academic whose learned paper must be in the hands of a discussant within 24 hours will clearly not trust it to regular mail.

The primary consideration for business use of direct-mail advertising is access combined with cost. Direct-mail advertising has grown rapidly in recent years and a principal reason has been the availability of efficient mailing lists that enable advertisers to pinpoint the markets that they are desirous of reaching. Targeted mailing lists enable 'rifles' to replace 'shotguns', and the result is much higher response rates and much lower advertising costs per response. The key, however, is access. Once a targeted group of households or businesses is identified, the mail provides guaranteed access. The Postal Service obviously cannot warrant that a targeted recipient will actually read an advertisement, but there is assurance that the advertisement will be put into the recipient's mailbox. Other advertising media cannot offer such a warranty.

3. ACCOUNTING FOR STRUCTURAL CHANGES

I now turn to one of the biggest challenges in modeling mail demand, namely, taking into account structural changes during the historical period of the sample. Since the data used in estimation of the econometric models are for 1971–1986, my focus will be on structural changes during that period. Four types of structural change need to be considered.

i. Changes in the general economic or social milieu which creates new uses for the mail or causes existing uses to weaken or disappear.

   This is the most difficult type of structural change to pin down, because we are talking about big things and big things tend to move slowly. Examples of what I have in mind include:
   - The creation of a ubiquitous, efficient telephone system which, among other things, has made personal communication inexpensive and easy.
   - Ever-rising labor productivity which implies an ever-rising opportunity cost to the time needed to compose letters.[8]
   - The 'computer revolution' which, *inter alia*, has encouraged proliferation of

checking and credit-card accounts and greatly reduced the cost and increased the efficiency of direct-mail advertising.

ii. The emergence of competition.

One of the canons of economics is that the demand function faced by a firm depends upon the number of other suppliers in the market. In particular, the greater the number of suppliers, the greater will be the price elasticity of any one firm's demand function. Usually, this is dealt with by including the prices of other suppliers as arguments in the demand function. In principle, this is straightforward, but problems can be created if the number of suppliers changes during the period of the sample or if suppliers alter the vigor with which they compete. Either of these can lead to shifts in the structural parameters of the model.

iii. The introduction of new services.

Demand parameters can also be affected by the appearance of new services. During the period of the sample, the Postal Service introduced Express Mail, an overnight service, as well as introducing new presort categories of first- and third-class mail. In some cases, volume in the new services came at the expense of mail in existing categories, while in other cases the effect was almost certainly the creation of new demand. New services create two types of problems: (1) the need to estimate models for the new services in question, which may be problematic (or even impossible) because of insufficient sample observations, and (2) the need to take into account changes that might be induced in the parameters for existing services.

iv. Changes in postal rate structure.

Several times during the seventies and eighties, the Postal Service altered the postal rate structure in a fundamental way by introducing bulk and presort discounts. Since the discounts are tied to volume, their effect was essentially to segment the market. Mailers with low volume face one price, while mailers with high volume face another, lower price (at least on the margin). Among other things, this means that price can no longer be measured by a single variable, but must be represented by at least two variables, one for the base rate and a second for the volume discount. I say at least two variables, because additional variables may be needed if the volume at which the discount applies was changed during the period of the sample.

v. Feedback and Reciprocation

We now consider the situation in which mail in one direction gives rise to mail in the reverse direction: receipt of a 4th-class catalog (or 3rd-class advertisement) can generate a first-class order, which then generates a first-class invoice, which in turn generates a first-class payment, which finally generates a fourth-class parcel. Embedded in this example are interactions between classes of mail and between households and businesses. The former can be modeled on the basis of existing data, but allowing for feedback between households and businesses requires time-series information on directional mail volumes between households and businesses, which unfortunately is not available.[9]

III. Data and Econometrics

We now turn to a brief discussion of the data that are analyzed and the econometric procedures that have been followed in estimation. Although the discussion in the preceding section is in terms of total first-class mail, results are presented for first-class letters only.[10]

1. DATA

The U.S. Postal Service operates on its own fiscal year of 364 days, divided into four quarterly accounting periods. The first three postal quarters consist of consecutive 12-week calendar periods of 84 days each, while the fourth postal quarter consists of 16 calendar weeks of 112 days. Since the fiscal year begins one calendar day earlier each year (except during a leap year year when it begins two days earlier). The postal year for 1989, for example, started on September 24,1988 and ended on September 22, 1989. Since postal and calendar quarters do not correspond and since economic data are measured in terms of calendar quarters, it is necessary for purposes of econometric analysis that postal quantities be converted to calendar quarters or calendar variables be converted to postal quarters. Tolley estimates all of his models in postal quarters. This paper presents results for both postal and calendar quarters.[11]

The sample period used is from the first calendar quarter of 1971 (1971Q1) through the third quarter of 1986 (1986Q3), 63 quarters in total. The mail volume data are *not* seasonally adjusted. For the models that are reported, the dependent variables are measured on a per-capita basis, obtained by dividing the total quarterly volumes of first-class letters and cards by the total U.S. population, including military personnel overseas. This contrasts with Tolley's procedure in R87-1 of expressing mail volumes in terms of the adult population 22 and older.

As was noted in Section II, a number of changes were made in the structure of postal rates during the sample period that affected the ways in which first-class mail was priced, especially to high-volume mailers. For first-class letters, a 5-digit presort discount was offered beginning in 1976, and additional discounts for presorting at the carrier-route and ZIP+4 levels went into effect in 1981. Similar presort discounts were introduced (although at different times than for first-class letters) for first-class cards. Tolley's approach to measuring these presort discounts, as well as the cost per ounce of additional ounces beyond the first, was to construct a fixed-weight price-index that reflects all of the elements of the rate structure using 1981 volumes as weights.

My procedure is different. Rather than rolling everything into a single price index, I treat each element of a tariff structure as a different variable. As of the mid-1980's, for example, the tariff for first-class letters essentially consisted of five elements:

1. The cost for one ounce or less.
2. An additional charge per oz. for additional ounces (or part thereof).
3. A 5-digit presort discount.
4. A carrier-route presort discount.
5. A ZIP+4 presort discount.

This tariff is represented by the following six variables:

P1 = price of the first ounce (in cents)
P2 = price per ounce of additional ounces (or part thereof) beyond the first ounce (in cents)
P5D = 5-digit presort discount (in cents/oz. off P1)
D5 = dummy variable for introduction of 5-digit presort discount ($0, t < 1976Q3$; $1, t \geqslant 1976Q3$)
CRD = dummy variable for introduction of carrier-route presort discount ($0, t < 1981Q1$; $1, t \geqslant 1981Q1$)
DZ4 = dummy variable for introduction of ZIP+4 presort discount ($0, < t < 1981Q4$; $1, t \geqslant 1981Q4$).

In order to express price in real terms, the tariff variables are deflated by a general price index or, in cases where cross-price elasticities are tested for, by the price of the appropriate substitute. The implicit deflator for GNP is used for the general price index. The GNP deflator is used, rather than the CPI or the implicit deflator for personal consumption expenditures, because of the fact that first-class mail is in general driven by business rather than households. Possible cross- price elasticities are tested for with respect to bulk-regular third-class mail, express mail, long-distance telephone calls, and the "opportunity cost of time" for both households and businesses. The opportunity cost of time is measured by GNP per household for households and by business unit labor costs for businesses.

The level of economic activity is measured by GNP or disposable person income (DPI). Both are expressed in real (1982) dollars at seasonally adjusted annual rates. In the models in which mail volumes are per capita, GNP or DPI are per capita as well. Seasonal adjustment of GNP and DPI means that seasonal effects arising from these variables will be reflected in the coefficients for the seasonal dummy variables. With a view of taking into account the impact of financial deregulation on the volume of first-class letters, a proxy for the number of financial accounts has been constructed that is based on the M3 money supply and the amount of consumer installment credit outstanding. Specifically, the proxy is defined as the sum of these two quantities deflated by the implicit deflator for GNP and then divided by the number of households.

All of the models estimated take their point-of-departure from the theoretical considerations discussed in Section II. I say point-of-departure, because the number of independent variables that is implied by purely a priori theoretical considerations is simply too large to be meaningfully dealt with empirically using the time-series data that are available. In view of this, my procedure, to begin with, has been to estimate the fully specified theoretical model and then to remove variables until a plausible equation with a manageable number of independent variables is obtained. I have not followed mechanical statistical rules in removing variables from models, but have been guided by an informal amalgam of a priori, theoretical, and structural considerations. Whenever a strong statistical result conflicts with a priori considerations (such as positive own-price coefficient), the a priori considerations have prevailed. In view of the 'pretesting' and 'contamination' that such a procedure involves, I have refrained from applying conventional hypothesis tests of individual regression coefficients. In the end, a variable is retained in an equation if its sign and size of coefficient make sense a priori. Autocorrelation in the error term has been monitored through the Durbin-Watson coefficient and visual inspection of the residuals. At the outset, models were estimated in both aggregate and per-capita terms. Because the per-capita models yield results superior both in fit and plausibility of coefficients, only per-capita models are reported.

Possible dynamic effect have been tested for throughout the exercise through the estimation of Almon and Koyck distributed lags and, in a few instances, through the estimation of unrestricted distributed lags. Interestingly enough, there is little evidence that dynamical effects are important, although there are a few cases for which a priori considerations favor the use of single-period lags.

I have taken a purely empirical approach to the question of functional form. Both linear and double-logarithmic functional forms, as well as a variety of semi-logarithmic functions, have been estimated. Linear and double-logarithmic functions give similar results for first-class letters. The robustness of the final models has been examined in a variety of forms, including out-of-sample forecasting tests, use of alternative definitions or measures of the independent variables, and the sensitivity of key coefficients to the presence or absence of particular independent variables.

IV. Empirical Results

We begin with the estimation of a 'fully specified' model that follows from the discussion in Section II. The model in question is as follows:

1. $\text{LETPCI}=\beta_0 + \beta_1 S_1 + \beta_2 S_2 + \beta_3 S_3 + \beta_4\text{EASTER} + \beta_5\text{D5}$
   $+ \beta_6\text{CRD} + \beta_7\text{DX} + \beta_8\text{RP1} + \beta_9\text{RP1EASTER}$
   $+ \beta_{10}\text{RP1S3} + \beta_{11}\text{RP1S4} + \beta_{12}\text{RP1PBR3}$
   $+ \beta_{13}\text{RP1D5} + \beta_{14}\text{RP1CRD} + \beta_{15}\text{RP1DX}$
   $+ \beta_{16}\text{RP1PX} + \beta_{17}\text{RP1PMTSD5} + \beta_{18}\text{RP1PMTSCRD}$
   $+\beta_{19}\text{RP1PMTSS2} + \beta_{20}\text{RP1PMTSS3} + \beta_{21}\text{RP1PMTSS4}$

$$+ \beta_{22}\text{RP2} + \beta_{23}\text{RP5DU} + \beta_{24}\text{RPCRDU} + \beta_{25}\text{RGNPPC}$$
$$+ \beta_{26}\text{RDPIHHLS1} + \beta_{27}\text{RGNPPCS3}$$
$$+ \beta_{28}\text{RDPIHHS4} + \beta_{29}\text{RP1GNPPC}$$
$$+ \beta_{30}\%\text{DEGPOPS2} + \beta_{31}\%\text{POP16S1S4} + \beta_{32}\%\text{POP18–24S2}$$
$$+ \beta_{33}\text{POP60Q} + \beta_{34}\text{BR3CPC1}(-1)$$
$$+ \beta_{35}\text{FAHH} + u.$$

Full definitions of the variables in Equation (1) are given in an Appendix available from the author.

Remarks

1. Variables 1–7 are all dummy variables.[12] They are intended to capture residual seasonal effects (S1–S3), Easter, the introduction of presort discounts (D5, CRD), and the introduction of Express Mail from post office to addressee.[13] (The ZIP+4 presort discount was not included in the initial equation.)
2. Variables 8–21 and 29 all involve the price of the first ounce of a First-Class letter (RPI). RPI by itself represents the 'pure' effect of this price (measured in real terms), while variables 9–21 are all interactions with RP1 and are intended to reflect shifts in the coefficient of RP1 that might occur at Easter (variable 9), seasonally (variables 10, 11), with the introduction of presort discounts and Express Mail (variables 13–15), and in response to changes in the price of substitutes – e.g., the price of bulk-regular third-class mail (variable 12), the price of Express Mail (variable 16), and the price of long-distance telephone calls (variables 17–21). The interactions of RP1 with the price of long-distance calls are allowed to vary with the introduction of presort discounts (variables 17, 18) and by season (variables 19–21). Finally, variable 29 is intended to capture changes in the opportunity cost of the time that is required in writing a letter.
3. RP2 represents the real price per ounce of additional ounces (or part thereof) of a first-class letter.
4. The direct price effects of presort discounts are represented in variables 23 and 24. The variables are defined as ratios of the presort discounts to business unit labor costs in reflection of the fact that businesses will choose to presort only if the costs of doing so are less than the discounts involved.
5. Variables 25–28 represent the general level of economic activity. Real GNP per capita is allowed to have an overall effect (variable 25), as well as a separate effect in the third quarter (variable 27), intended to reflect the "dog days" of late summer. Real disposable income per household in the fourth quarter is included in order to capture Christmas ordering by mail (variable 28) and with a one-quarter lag in reflection of the fact that Christmas bills tend to be paid in January and February.
6. Variables 30–33 represent socio-cultural-demographic effects that can be identi-

fied with the age structure of the population. Variable 30 measures the percentage of the population receiving degrees. Since most of these are received in May and June, the variable is interacted with the second quarter seasonal dummy variable. The percentage of the population age 16 and under is included in the first and fourth quarters (variable 31) to capture Valentine and Halloween mail. The percentage of the population of age 18–24 in the second quarter (variable 32) is included with a view to the mail associated with early summer weddings. Finally, the percentage of the population age 60 and over (variable 33) is intended to reflect heavier use of the mail by senior citizens.

7. The last two variables (nos. 34 and 35) are intended to capture the large volumes of first-class correspondence between businesses and households. The volume of bulk- regular 3rd-class mail per capita with a one-quarter lag (variable 34) is intended to measure response (both direct and indirect) to direct-mil advertising. FAHH, which is the proxy for the number of financial accounts, is intended to capture the bi- directional mail traffic that financial accounts generate.

1. ECONOMETRIC RESULTS FOR FULL MODEL

The OLS results for calendar quarters from estimating the model represented by equation (1) for first-class letters per capita using data for 1971QI through 1986Q3 are not tabulated. As this is a huge regression using time-series data, it should be no surprise that the R^2 is high, *t*-ratios are small, and wrong signs are frequent, in short, all of the usual manifestations of too many independent variables for the amount of independent variation that they convey. In reducing the predictors in the model to a manageable number, my procedure was to explore for interactions, test for cross-price elasticities and distributed-lag effects, and examine the results for sensitivities to alternative definitions of variables and to alternative functional forms using a greatly reduced model with a small number of core variables. At the start, this core set of variables always included the seasonal dummy variables (S1, S2, S3), the dummy variables for the introduction of presort discounts and the introduction of Express Mail (D5, CRD, DX), the basic price variables (RP1, RP2, RP5DU, RPCRDU) and real GNP per capita (RGNPPC).

The first question investigated concerned the importance of the two basic price variables, RP1 and RP2, and whether price effects vary seasonally. Three conclusions emerged from this analysis:

(1) RP1 is important, but not RP2;
(2) The effect of RP1 is strongest in the fourth quarter;
(3) The effect of RP1 strengthened with the introduction of the 5-digit presort discount.

Once these results were found, they were incorporated into the core set of variables and survived intact to the final model reported below.

A second question that was investigated early on was for the presence of cross-elasticities with respect to the price of long-distance telephone calls, the price of bulk-regular third-class mail, and the opportunity cost of time. The analysis in Section II focused specifically on the possible first-class mail/telephone call tradeoff in the third quarter as students leave home for college, so particular attention was given to the existence of seasonal effects. The number of college-student enrollments was also taken into account. The results can be summarized briefly as follows: The price of long-distance telephone calls tended to have the wrong sign and was statistically unimportant. College- student enrollment, either separately or in combination with RP1 and PMTS, provided no help. Cross-effects with the price of bulk-regular third-class mail were explored in a variety of forms, including a direct interaction with RP1 and interactions with the presort discounts. No cross-effects with RP1 were found, but there was some evidence of a cross-effect with the presort discounts. Finally, there is no evidence of a cross-effect with respect to the opportunity cost of time.

The presort discounts were examined in a variety of forms, including being included directly in real terms (i.e., as RP5D and RPCRD) as well as relative to business unit labor costs (RP5DU, RPCRDU). The introduction of the ZIP+4 presort discount was investigated as well as the introductions of 5-digit and carrier-route presort discounts, but nothing notable was found. Equations were also estimated in which the presort discounts were measured relative to the price index for toll telephone calls and relative to the price of bulk-regular third-class mail. The results at this stage favored measuring the presort discounts in relation to business unit labor costs, in support of the notion that presorting is undertaken only when it can be done at a cost that is less than the discounts. As there was no reason a priori to expect seasonal variation in the impacts of the presort discounts, this was not explored. The price of bulk-regular third-class mail did not emerge as a factor at this stage, but did later on when the volume of bulk-regular third-class mail was taken into account.

The last stage of the analysis was to take into account direct-mail advertising and the first-class mail generated by financial accounts. This proceeded by including as predictors the volume of bulk-regular third-class mail (with a one-quarter lag) and the proxy for the number of financial accounts, both measured on a per-capita basis. The results were disturbing, for the proxy for financial accounts added nothing and the coefficient on the third-class mail variable was implausibly large. The problem seemed to be too much collinearity among the two new variables and real GNP and probably a problem as well with the proxy variable for financial accounts. This led to replacing the proxy variable with its interactions with the dummy variable for the introduction of carrier-route presort discounts, FAHHCRD.[14]

Things fell into place with the use of FAHHCRD. The coefficient on BR3CPCI(−1) becomes plausible and FAHHCRD begins to show some importance.[15] Many of the predictors previously eliminated were re-examined at this

Table III. First-class letters – final model.

Dependent variable: LETPC1 Time period: 1971Q1–1986Q3		
Independent variable	Coefficient	t-ratio
Constant	55.84	8.52
S1	−12.32	−4.16
S2	−14.75	−4.92
S3	−16.2	−5.37
D5	9.34	1.91
CRD	−23.28	−2.66
RP1	−0.184	−1.43
RP1S4	−0.392	−2.37
RP1D5	−0.587	−2.08
RP5DU	2.48	2.71
RGNPPC	0.11E-02	2.57
FAHHCRD	0.757E-03	2.53
BR3CPC1(−1)	0.198	1.48

No. of observations 63.
$R^2 = 0.9829$ (adj) = 0.9788.
Std. error of reg. = 0.939.
Durbin-Watson = 2.37.

stage, but the only changes of note involved the reappearance of RP1S3 and the disappearance of RPCRDU. The model which finally emerged is tabulated in Table III. From the t-ratios in Table III, we see, ignoring residual seasonal factors, that the most important predictor is RP5DU, followed by CRD, real GNP, FAHHCRD, and RP1 in the fourth quarter.

The coefficient for BR3CPC1(−1) suggests that each piece of bulk-regular third-class mail generates about a fifth of a first-class letter.[16] At first glance, this seems high, but two points need to be kept in mind in interpreting this coefficient. The first point is that each response to a third-class advertisement can give rise to several first-class letters – the initial response plus an invoice and payment, plus possibly an enquiry or two. This means that the coefficient for BR3CPC1(−1) is akin to a multiplier, in that it measures not only the direct responses to third-class advertising, but also all subsequent first-class letters that the direct responses generate within the quarter in question.

The second point to be considered is the fact that advertisers have mail channels that can be used besides just bulk-regular third-class. There are also fourth-class channels such as catalogs, newspapers, and magazines. Also, an increasing amount of advertising is being sent first-class. Advertising through these other mail channels will almost certainly be correlated with bulk-regular third-class mail, and to the extent that they are correlated their effects on first-class letters will be picked up in the coefficient for BR3CPC1(−1). Television and radio advertising probably accounts for yet another 'add on', for broadcast advertising generates first-class letters and, again, is almost certainly correlated with the volume of bulk-regular third-class mail.

Table IV. First-class letters – alternate final model. Double-Logarithmic

Dependent variable: LNLETPC
Time period: 1971Q1–1986Q3

Independent variable	Coefficient	t-ratio
Constant	1.88	2.70
S1	−0.510	−3.68
S2	−0.549	−3.95
S3	−0.574	−4.11
D5	0.395	1.64
CRD	−4.38	−3.47
RP1	−0.052	−1.50
LNRP1	−0.149	−3.09
LNRP1S4	−0.130	−1.60
LNRP1D5	0.048	2.14
LNRP5DU	0.27	2.91
LNRGNPP	0.081	1.60
LNBR3CPC(−1)	0.424	3.45
LNFAHHCRD		

No. of observations 63.
$R^2 = 0.9807$ (adj) $= 0.9761$.
Std. error of reg. = 0.015.
Durbin-Watson = 2.22.

The conclusion which emerges is that the coefficient for BR3CPC1(−1) cannot be interpreted as representing just the direct response to third-class advertising, but must be seen as measuring the multiple first-class letters that each direct response in all likelihood generates plus the 'add on' that arise from omitted advertising media that are correlated with the volume of bulk-regular third-class mail. When these factors are taken into account, the value of 0.19 for the coefficient for BR3CPC1(−1) does not seem so large.

A double-logarithmic version of the model in Table III is given in Table IV. In general, the two models are peas of a pod and are statistically indistinguishable. The elasticities for price and the economic activity variables that are implied by the models in Tables III and IV are presented in Table V. The elasticities for the linear equation are calculated at both the means of the sample period. (1971/Q1–1986Q3) and at the last quarter in the sample (1986Q3). The elasticities from the end of the sample period are clearly most relevant in assessing the effects of future rate changes, but the elasticities calculated at the sample means are useful in showing how sensitive the elasticities are to the point on the demand function at which they are calculated. For the double-logarithmic model, the elasticities are simply the regression coefficients.

Two points are immediately evident from Table V. The first point is that the elasticities in the linear model are essentially the same at 1986Q3 as at the point of means. The only real exception to this is the elasticity with respect to bulk-regular third-class mail, which is about 50% larger at the end of the period. This reflects the strong upward trend at the end of the sample period in this category

Table V. First-class letters – elasticities for models in Tables III & IV.

Variable	Table III		Table IV
	Means	1986Q3	
RP1	−0.053	−0.049	−0.052
RP1S4	−0.112	−0.089	−0.149
RP1D5	−0.144	−0.153	−0.130
RP5DU	0.068	0.080	0.048
RGNPPC	0.259	0.253	0.276
BR3CPC1	0.080	0.121	0.081
FAHHCRD	0.374	0.397	0.424

Note: The elasticities for the linear equation in Table III are calculated, in the first column, at the means of the sample period (1971Q1–1986Q3) and, in the second column, at end of the sample period (1986Q3).

of third-class mail. The second point is that the elasticities from the linear model are in close agreement with the elasticities from the double-logarithmic model. In view of this, and since elasticities from double-logarithmic equations are statistically and mathematically more convenient to work with, the discussion that follows will focus on the elasticities from the double-logarithmic model.

From Table V, we see that the elasticity with respect to RP1 is estimated to be about −0.18 for each of the first three calendar quarters (as given by the sum of the coefficients for lnRP1 and lnRP1D5) and increases (in absolute value) to about −0.33 for the fourth quarter.[18] Changes in the price of first-class letters affect Christmas mail the most. The elasticity with respect to the size of the 5-digit presort discount relative to business unit labor costs is estimated to be about 0.05. This says that if the discount for 5-digit presorting should be increased by 10%, with no change in business unit labor costs, the per-capita volume of first-class letters would be expected to increase by about one-half of one percent. The elasticity with respect to real GNP is indicated to be about 0.28, while the elasticity with respect to the volume of bulk-regular third-class mail is estimated to be about 0.08. Finally, the elasticity with respect to FAHH (interpreted as a proxy for the number of financial 'accounts per household) is estimated to be about 0.42.

2. Results for postal quarters

For comparisons, the model in Table III has also been estimated on the basis of postal quarters. In converting from calendar to postal quarters, seasonal factors pose a special challenge. The problem is that, since the starting dates of postal quarters vary through calendar time, important seasonal events, like Christmas, need not always fall in the same postal quarter. Until 1982, Christmas was in the first postal quarter, but has since fallen in the second postal quarter. In short, events that are fixed in calendar time are not necessarily fixed in postal time. Dealing with this is straightforward in theory but is cumbersome in practice

Table VI. First-class letters – final model.

Dependent variable: LETPCPQ Time period: 1971Q2–1986Q4		
Independent variable	Coefficient	t-ratio
Constant	36.92	6.61
S11	36.54	2.11
S13	92.26	3.08
S21	−9.59	−2.35
S22	−29.75	−0.57
S31	2.09	0.42
S32	−12.99	−3.13
S42	3.72	0.79
S43	−13.14	−3.32
RP1PQ	−0.174	−1.88
RP1S14	−0.261	−1.22
RGNPPCPQ	0.192	6.26
BR3CPCPQ(−1)	0.392	14.20

No. of observations 63.
$R^2 = 0.9838$ 2adj) = 0.9800.
Std. error of reg. = 0.861.
Durbin-Watson = 2.03.

because in principle it requires the introduction of 11 seasonal variables – three each for postal quarters 1, 2 and 4 and two for postal quarter 3. This many seasonal variables clearly leads to problems with multicollinearity.

The model finally obtained for postal quarters is given in Table VI.[19] The model includes eight of the eleven seasonal factors, and (in comparison with the model in Table VI) excludes the presort dummy variables, the ratio of the 5-digit presort discount to business unit labor costs, and the proxy for the number of financial accounts. Of the excluded variables, I am surprised most by the disappearance of the proxy for financial accounts.

Comparing the coefficients in the PQ equation in Table VI with their counterparts in the CQ equation in Table III, we see that the coefficients for RP1 are essentially the same, while the coefficient for RP1S14 is about two-thirds its value for RP1S4. The coefficient for real GNP per capita is about 50% higher in the PQ equation, while the coefficient for BR3CPC is about twice as large. *T*-ratios for the price terms are smaller in the PQ equation, but much larger for real GNP and bulk-regular third-class mail. Indeed, the t-ratio for bulk-regular third-class mail is nearly 10 times larger. A comparison of the elasticities from the postal- and calendar-quarter equations for first-class letters is presented in Table VII. The PQ elasticities are calculated for the equation in Table VII, while the CQ elasticities are calculated at both the sample means and last quarter of the sample (1986PQ4 and 1986CQ3). Two conclusions are apparent: the price elasticity is smaller in the PQ equation,[20] while the elasticities for real GNP and the volume of bulk-regular third-class mail are larger.

Table VII. First-class letters – elasticities for models in Tables VI & III – postal & calendar quarters.

Variable	Means		1986PQ4	
	PQ[a]	CQ[b]	PQ[a]	CQ[b]
RP1PQ	−0.054	−0.053	−0.050	−0.048
RP1S14	−0.081	−0.112	−0.076	−0.103
RP1D5DPQ	–	−0.168	–	−0.145
RP5DUPQ	–	0.068	–	0.0801
RGNPPCPQ	0.413	0.251	0.407	0.243
FAHHCRDPQ	–	0.377	–	0.400
BR3CPCPQ	0.160	0.078	0.248	0.118

[a]Postal-quarter equation in Table VI.
[b]Calendar-quarter equation in Table III.

V. Forecasting Results and Tests

Tables VII and IX present a comparison of post-sample forecasts from the two models. Postal quarters appear in Table VII and calendar quarters in Table XI. The forecast periods are 1987PQ1–1989PQ3 for postal quarters and 1986CQ4–1989CQ2 for calendar quarters. From the tables, we see that, on balance, the PQ equations provide the superior forecasts for both postal and calendar quarters. The mean absolute percentage forecast error for the postal-quarter equation is 1.79 for postal quarters and 1.78 for calendar quarters. The respective figures for the CQ equations are 3.13 and 3.03. These are interesting results and raise an obvious question: What is going on? Why does an apparently simpler postal-quarter equation do better on the CQ model's own turf, that is, in forecasting calendar quarters?

In approaching this question, the first thing that I have done is to estimate a CQ equation that has the same form as the PQ equation, namely, LETPC1 regressed on S1, S2, S3, RGNPPC, and BR3CPC1(−1). The results are similar to the PQ equation in Table VI. The only real differences are that the coefficients are sharper (i.e., have larger t-ratios) and are somewhat larger in absolute value.

I next compared forecasts from this equation for both postal and calendar quarters with the like forecasts from the equation in Table III. On balance, the forecasts from the respecified CQ equation are superior to the forecasts from the equation in Table III, especially latter part of the forecast period. The average absolute percentage forecast errors for the two models are 2.19 and 3.03 for calendar quarters and 2.72 and 3.13 for postal quarters. The only disturbing aspect of the forecasts from the respecified CQ equation is the consistent under-forecasts from 1987CQ4 on, which suggests the presence of structural change or omitted variables.

In an effort to dig deeper into the relative merits of the calendar- and postal-quarter models, I undertook tests of the two models *vis-à-vis* one another using the non-nested hypothesis-testing procedure suggested by Davidson and MacKinnon (1982). Essentially, this involves testing whether one hypothesis can be rejected in favor an alternative and then repeating the test with the two hypotheses switched. In the present context, one of the hypotheses is represented by the CQ model in Table III and the other hypothesis by the PQ model in Table VI. The CQ model is tested against the PQ model by first estimating the PQ model and then using the predicted values from the equation as an additional predictor in the CQ equation. The CQ model will be rejected if there is a significant *t*-ratio for the predicted values from the PQ equation. The PQ model is tested in the same way.[21] The results of the tests support the PQ model for the *t*-ratio for the predicted values from the PQ model in the CQ equation is 4.34, whereas the t-ratio for the predicted values from the CQ model in the PQ equation is only 1.48.

At this point, the PQ model would seem to emerge on statistical grounds as the clear winner. Before awarding the olympic medal, however, the behavioral implications of the PQ model need to be assessed, and on this front, the situation is clouded. The value of 0.39 for the coefficient for BR3CPPQ(−1) in the PQ equation in Table V is disturbing, for this implies that every bulk-regular third-class regular stimulates about 0.4 of a first-class letter. This seems high, even when it is allowed that the figure represents in effect a reduced-form multiplier.

VI. Conclusions

The results of this study indicate that the main determinants of the demand for first-class letters are the four seasons, the real price of the first ounce of a first-class letter, the general level of economic activity, and the volume of bulk-regular third-class mail lagged one quarter. Fourth quarter mail clearly has a greater sensitivity to price than mail in the other three quarters. There is evidence that presort discounts serve to segment the first-class letter market into low- and high-volume users, and there is evidence as well that first-class letter volume has been stimulated by the computer revolution.

Estimation of the calendar-quarter model on a postal quarter basis confirms the importance of seasonality, price, the level of economic activity, and the volume of bulk-regular third-class mail, but questions the stimulative effects of presort discounts and the computer revolution (at least as measured by the number of financial accounts). Post-sample forecasting tests of the calendar-quarter and postal-quarter models favor the simpler postal-quarter model. This could reflect an 'over-fitting' in the calendar-quarter model. Further support for the postal-quarter model is provided by the Davidson-McKinnon version of the Cox test for non-nested hypotheses.[22]

The demand for first-class letters has a structure that is undoubtedly more complicated that what is represented by the models in Tables III and VI. I am not convinced by the results with the postal-quarter model that indicate that the volume of first-class letters is not driven, even strongly so, by the number of financial accounts. A measure of these accounts that is more direct than the one I have used is clearly in order. In order, as well, is to embed the demand for first-class letters in a system that also includes the demand for first-class cards and certain categories of third-class mail.

Notes

* This paper derives from research undertaken for the U.S. Postal Rate Commission, much of which was presented in Taylor (1989). The Postal Commission staff was extremely helpful in answering questions and in providing data and comments. I have also benefitted from the comments of Charles Trozzo and Ted Pearsall. The views expressed in the paper are my own and do not necessarily reflect the views of the Postal Rate Commission, its staff, or its consultants. Finally, I am indebted to Nicholas Karlson for research assistance and to Mary Flannery and Anna Puente for manuscript preparation.

[1] See Tolley (1987, 1990).

[2] One critique of Tolley's model from R87-1 was presented in testimony by J.A. Hausman. See Hausman (1987).

[3] Henceforth, I will refer to all nonhouseholds (including government) as businesses.

4 The discussion in this section draws heavily from Sections II and IV of Taylor (1988).

[5] The parallel is not complete because telephone service is not completely universal. Everyone has some form of mail service, but not everyone has a telephone.

[6] Access in this context is taken to mean the placing of a first-class piece of mail into the postal network. Telephone subscribers have to pay a monthly fee for access to the telephone network, but there is no such fee for mail. Mailboxes, post-office boxes, etc. that individuals provide for originating and recurring mail are not free, but these represent 'terminal equipment'. They are necessary for using the postal system, but they do not constitute access as it is meant in this paragraph.

[7] More particularly, it might provide a reason for assessing and up-dating holiday mailing lists.

[8] The mechanism that I have in mind here is as follows: an increase in labor productivity leads to increases in wage rates, which in turn leads to an increase in the opportunity cost of labor.

[9] Models which allow for feedbacks and reciprocation are being found increasingly useful in analyzing the demand for toll cals in the telephone industry. See Larson, Lehman, and Weisman (1990) and Appelbe, et al.(1988).

[10] Results for first-class cards are in general noticeably inferior to the results for first-class letters. See Taylor (1989).

[11] The procedures followed in converting postal quantities to calendar quarters is described in Appendix I of Taylor (1989). A similar procedure is used in converting calendar quantities to postal quarters.

[12] Variable numbers refer to the subscripts of the coefficients.

[13] Express Mail was initially introduced on a pilot (or experimental) basis in 1970, and was expanded to an airport-to-airport basis in December 1976. In 1977, it was included in the Domestic Mail Classification Schedule, becoming available on a post office-to-addressee basis in October of that year. This is the basis for which would seem most competitive with regular first-class mail, and is the one that I have used in the analysis. As rates varied according to zones until April 1988, the rate that has been used refers to Zone 9.

[14] This variable does not in itself make sense a priori. The rationale for the variable is that the introduction of the carrier-route presort generally coincided with the events (financial deregulation and high interest rates) that spurred a rapid increase in the number of financial accounts. This emphasizes, of course, the need to have a direct estimate of the number of financial accounts.

[15] However, one cannot conclude that replacing FAHH with FAHHCRD has eliminated the collinearity among RGNPPC, BR3CPC(−1), and FAHHCRD, for there remains a lot of collinearity that is reflected in the relatively small *t*-ratios for these variables. Indeed, the collinearity is sufficiently severe between RGNPPC and BR3CPC(−1) that RGNPPC loses its significance unless FAHHCRD is also included. As an empirical curiosity, BR3CPC(−1) together with the seasonal dummy variables yields an R^2 of 0.95. Such a model, however, has no structural significance.

[16] The use of a one-quarter lag on bulk-regular third-class mail was arrived at empirically. The results are statistically much weaker with no lag.

[17] A lot of effort was given to trying to find a cross-elasticity with respect to the price of bulk-regular third-class mail. First-class letters are clearly a substitute for third-class mail for direct mail advertising,

and the question arises whether the substitution is sensitive to the relative prices of the two classes of mail. If this were the case, one should expect it to be with respect to the relative prices after presort discounts are taken into account. The model in Table III was also estimated with the ratio of the price of the first ounce of a first-class letter minus the carrier-route presort discount to the minimum price of a third-class piece minus the carrier-route presort discount as an additional predictor and also in place of RP5DU. The sign was negative in both cases, but neither model is an improvement over the model in Table III.

[18] These values for the own-price elasticity compare with Tolley's estimates of −0.212 in R87-1 and −0.245 in R90-1. A comparable figure from a recent study by Cuthbertson and Richards (1990) for first-class inland letter demand in the U.K. is −0.5.)

[19] The notation S_{ij} denotes the proportion of calendar quarter) that overlaps with postal quarter i. The three excluded seasonal factors are S14, S24, and S44.

[20] The critical factor in the smaller price elasticity for postal quarters is clearly the absence of RP1 interacted with the dummy variable for the introduction of the 5-digit presort discount, as this variable adds −0.17 to the price elasticity in the CQ equation.

[21] There is now a large literature on testing non-nested hypotheses, all of which has its origin in two papers by Cox (1961, 1962) who extended the likelihood-ratio test to separate families of hypotheses. The test was first applied in a regression context by Pesaran (1974). The Davidson-MacKinnon test is a simplification of tests developed by Pesaran and Pesaran and Deaton (1978). Judge, et al. (1985) provide a textbook discussion. A detailed critique of the Cox and Cox-like tests is given by Sands and Trosset (1990).

[22] This apparent superiority of the postal-quarter model surprises me. A priori, I had expected the calendar-quarter model to perform better because of a lessened problem with errors-in-variables and also because of a much more complicated seasonality.

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