

**Narrative Explanation of  
Econometric Demand Equations for Market Dominant Products  
Filed with Postal Regulatory Commission on January 21, 2020**

Prepared for the Postal Regulatory Commission

## **Estimation of Econometric Demand Equations**

### **A. Basic Demand Equation**

The econometric demand equations filed with the Postal Regulatory Commission on January 21, 2020 take the following form:

$$V_t = a \cdot x_{1t}^{e_1} \cdot x_{2t}^{e_2} \cdot \dots \cdot x_{nt}^{e_n} \cdot \varepsilon_t$$

(Equation 1)

where  $V_t$  is volume at time  $t$ ,  $x_1$  to  $x_n$  are explanatory variables,  $e_1$  to  $e_n$  are elasticities associated with these variables, and  $\varepsilon_t$  represents the residual, or unexplained, factor(s) affecting mail volume.

In general, variables which are believed to substantially influence the demand for mail are introduced into an econometric equation as a quarterly time series in which the elasticity of mail volume with respect to the particular variable is estimated using a Generalized Least Squares estimation procedure. The explanatory variables considered here include Postal prices, measures of macroeconomic activity (e.g., employment, investment), measures of mail trends (e.g., volume losses to electronic and Internet diversion), seasonal variables, and other variables as warranted.

The functional form of Equation 1 is used by the Postal Service because it has been found to model mail volume quite well historically, and because it possesses two desirable properties. First, by taking logarithmic transformations of both sides of Equation 1, the natural logarithm of  $V_t$  can be expressed as a linear function of the natural logarithms of the  $X_i$  variables as follows:

$$\ln(V_t) = \ln(a) + e_1 \cdot \ln(x_{1t}) + e_2 \cdot \ln(x_{2t}) + e_3 \cdot \ln(x_{3t}) + \dots + e_n \cdot \ln(x_{nt}) + \ln(\varepsilon_t) \quad (\text{Equation 1L})$$

Equation 1<sub>L</sub> satisfies traditional least squares assumptions and is amenable to solution by Ordinary Least Squares. Second, the  $e_i$  parameters in Equation 1<sub>L</sub> 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 to either the volume or any of the explanatory variables. Because of these properties, this demand function is sometimes referred to as a constant-elasticity demand specification.

For explanatory variables which are logged in the equation, then, the coefficients which come out of these demand equations can be interpreted directly as elasticities.

## **B. Explanatory Variables**

### **1. Price**

#### **a. Own-Price Measures**

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. That is, 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 Postal Service's demand equations by including the price of postage in each of the demand equations estimated by the Postal Service for mail categories and services which have a price (i.e., excluding Postal Penalty mail and Free for the Blind and Handicapped Mail).

The Postal prices entered into these demand equations are calculated as weighted averages of the various rates within each particular category of mail. For example, the price of First-Class single-piece letters is a weighted average of the single-piece stamped letters rate (55 cents), the single-piece metered letters rates (50 cents), the additional ounce rate (15 cents), and the nonstandard surcharge (15 cents)<sup>1</sup>. Product-

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<sup>1</sup> Rates as of January 27, 2019.

by-product billing determinants provide the components of the market baskets which are used as weights in developing these price measures. The price indices used in the demand equations filed with the Commission on January 21, 2020, were constructed using chain-weighted price indices.

Chain-weighted price indices compare each period with the proceeding one such that the weight and price reference periods are moved forward each period. In this way, chain-weighted price indices are able to capture the substitution effect of price changes, as consumers may shift consumption between categories in response to changes in relative prices. In addition, chain-weighted price indices are able to account for shifts in the mix of consumer goods over time due to non-price related consumer preferences which ultimately alters the effective average price of consumer goods. The periods referred to in the first sentence of the paragraph refer to specific price regimes so that the price indices do not change between quarters when Postal rates do not change.

The most recent set of weights used in constructing these prices were FY 2018 billing determinants.

Looking at the historical relationship between mail volumes and Postal prices suggests 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 may be entered into the demand equations lagged by up to four quarters. The exact number of lags used is an empirical question which is answered on a case-by-case basis.

Prices are expressed in the Postal Service's demand equations in real dollars. The consumer price index (CPI-U) is used to deflate the prices.

In general, when the Postal Service refers to own-price elasticities, the reference is to long-run own-price elasticities. The long-run own-price elasticity of a mail category is equal to the sum of the coefficients on the current and lagged price of mail in the

relevant demand equation. The long-run own-price elasticity therefore reflects the cumulative impact of price on mail volume after allowing time for all of the lag effects to be felt.

### **b. Other Price Measures**

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 may also be included explicitly in the demand equations used to explain mail volume.

There is one example of such a price included in some of the equations presented here, trade-weighted exchange rates, which are included as an explanatory variable in most of the econometric demand equations associated with International Mail (both inbound and outbound).

Changes in the value of the U.S. dollar vis-à-vis foreign currencies can make the price of foreign goods more or less attractive relative to the price of similar domestic goods, which may affect the volume of such goods delivered through the Postal Service.

### **c. Postal Cross-Price Relationships**

In the past, some of the Postal Service's econometric demand equations have included cross-price measures with other Postal products, such as First-Class Single-Piece and Workshared Letters, and Bound Printed Matter and Media Mail. In some cases, these cross-price variables entered the equations in the same way as the own-price variables, i.e., as a measure of the average price of the product. In other cases, however, cross-price variables were measured in relative terms (i.e., the difference between the prices of two Postal products).

As has been the case for several years now, the econometric demand equations filed with the Postal Regulatory Commission on January 21, 2020, do not include any such cross-price variables. The exclusion of such variables was first discussed in some detail in the response to the Chairman's Information Request No. 8, question 5, which was filed with the Commission on March 8, 2010. As explained in that response, the decision of whether or not to include a particular cross-price relationship in a particular econometric demand equation was made on a case-by-case basis. In all cases, the overriding goal of all of the Postal Service's econometric work is to produce the most accurate volume forecasts possible. As a general rule, the most accurate volume forecasts are obtained from econometric demand equations which best model the historical demand for mail volume. So, while it ended up being the case that, in fact, there were no cross-price or discount variables included in any of the econometric demand equations filed on January 21, 2020, this was not the result of a general decision to exclude all such variables from the Postal Service's equation, but was, instead, the result of a series of careful analyses of each of the Postal Service's individual demand equations.

This is not, however, to say that mailers may not at times shift from one mail subclass to another in response to a change in Postal rates. In fact, however, such changes tend to overwhelmingly be responses to specific and unusual changes in relative rate structures associated with a specific rate change. Rather than attempting to model such changes through a blunt one-size-fits-all instrument such as an aggregate price index or an average discount level, the effect of such changes is, instead, better modeled through the inclusion of either dummy variables or non-linear intervention analysis. An example of a case-specific mailer shift between mail subclasses is the impact of R2006-1 (May, 2007) on Marketing Mail Letters, when the elimination of Automation Carrier-Route Letters rates led to a shift of volume from Basic ECR to Marketing Mail Letters.

## **2. Impact of the Economy on Mail Volumes**

In addition to being affected by prices, mail volumes are also affected by the state of the economy. For example, as incomes rise, consumers are able to consume more, and this is generally true of the use of Postal services which tend to perform better during periods of strong economic growth and stagnate or decline during periods of weak economic growth and decline. A stronger economy is also likely to increase business use of the mail. To model these relationships, the demand equations used by the Postal Service typically include one or more macroeconomic variables which relate mail volumes to general economic conditions.

### **a. Macroeconomic Variables Used Here**

Three key macroeconomic variables are used in the Postal Service's econometric market-dominant demand equations: private employment, gross private domestic investment, and e-commerce retail sales. These data are compiled by the United States government and, with the exception of e-commerce sales, are obtained by the Postal Service from IHS Global Insight, an independent economic forecasting firm. At various times, consumption expenditures, total retail sales, mail-order retail sales, personal disposable income, gross domestic product (GDP), and the difference between actual and potential GDP (the output gap) have also been explored as candidate explanatory variables.

The specific variable choices are made on an equation-by-equation basis. The decision process in choosing macroeconomic variables includes an effort to develop equations which are both theoretically correct as well as empirically robust.

### **(i) Employment**

Total private employment is included in several of the Postal Service's econometric demand equations, including First-Class and Periodicals Mail. In addition, the demand equation for Alaska Bypass mail includes total non-farm employment in Alaska.

The theoretical rationale for including total employment as a macro-economic variable is that in many cases, mail volume is not affected by the dollar value of economic transactions, so much as by the number of such transactions. For example, the number of credit card bill payments one makes does not necessarily go up as the total amount charged per card goes up. While variables like GDP or retail sales may be good measures of the total dollar amount of economic activity (e.g., the total amount charged per credit card), employment appears to be a better measure of the number of business transactions (e.g., number of bills paid).

Ultimately, the choice of which macroeconomic variable to use in a demand equation is an empirical decision based on which variable best fits the volume data.

### **(ii) Investment**

Advertising can be viewed as a type of business investment in that it represents expenditures today for the purpose of generating revenues in the future. As such, direct-mail advertising volume is likely to be affected by the same factors which drive business investment spending. To reflect this relationship, real gross private domestic investment is included as an explanatory variable in the demand equations for Marketing Mail and Bound Printed Matter Flats filed with the Commission on January 21, 2020.

### **(iii) E-Commerce Sales**

Parcel and package service volumes, such as Bound Printed Matter Parcels and Media Mail volumes consist, in large part, of the delivery of products bought by the sender or recipient of the mail. This type of mail volume derives primarily from retail sales. More specifically, package delivery services are largely a function of retail sales which are generally purchased online and which are then delivered to the consumer. Hence, e-commerce retail sales are included directly in the demand equations for most of the Postal Service's parcel and package service equations.

### **3. The Internet and Electronic Diversion**

One of the most significant issues facing the Postal Service in recent decades has been the threat, both realized and potential, of electronic diversion of mail. E-mail has emerged as a potent substitute for personal letters and business correspondence. Bills can be paid online, and bills and statements can be received through the Internet rather than through the mail. Virtually all magazines and newspapers now have an online edition as a complement to their print editions, and in some cases, the print edition has been eliminated in favor of an all-online format. Understanding the emergence of the Internet and its role vis-à-vis the mail is critical in understanding mail volume, both today and in the future.

There are two general dimensions to the Internet which are important to understand in assessing the extent to which the Internet, and other electronic alternatives, may serve as possible substitutes for mail volume: the breadth of Internet usage and the depth of Internet usage.

### **i. Breadth of Internet Use**

The breadth of Internet usage refers generally to the number of people online. As more people use the Internet, there are simply more people for whom the Internet is available as a substitute for the mail.

Increases in the breadth of Internet use can explain a large share of historical electronic diversion. More recently, however, the breadth of Internet usage has not increased significantly as Internet penetration has largely levelled off in the United States.

### **ii. Depth of Internet Use**

The depth of Internet usage refers to the number of things which an individual does on the Internet. As the depth of Internet usage increases for a particular person, the number of activities for which the Internet can substitute for mail may increase, thereby increasing the overall level of substitution of the Internet for mail volume, even in the absence of an increase in the number of Internet users.

The breadth and depth of Internet usage have both been important in understanding the impact of the Internet on mail volumes historically. However, moving forward, the depth of Internet usage is a much more important consideration. The reason for this is that the breadth of Internet usage has a natural ceiling. Eventually, everybody who would ever obtain Internet access will have Internet access. At that point, the only source of increasing electronic diversion of the mail will be an increasing depth of Internet usage. Hence, in measuring the impact of the Internet and other electronic alternatives on mail volumes, it is important to measure the impact not only of the breadth of Internet usage in the United States, but the depth of Internet (and other electronic) usage as well.

### iii. Use of Trends to Model Internet Diversion

Beginning in the early 2000s, the Postal Service introduced one or more explicit measures of Internet usage in several of its demand equations as a means of capturing the impact of the Internet (and other electronic delivery alternatives) on mail volumes. These variables – which included consumption expenditures on Internet Service Providers, the number of households with Broadband Internet access, and the number of Global Internet Servers - reflected primarily the breadth of Internet use – i.e., the number of people on the Internet. As noted above, however, the story of Internet diversion of mail has more recently been a story of increasing depth of Internet use.

To better measure the increasing depth of Internet use, the Postal Service's methodology for modeling Internet and other electronic diversion has changed more recently. For the market-dominant demand equations filed with the Commission on January 21, 2020, diversion is not modeled via explicit Internet variables, but, instead, is measured through a series of linear time trends which start at various times within the sample periods over which the Postal Service's demand equations are estimated.

The use of trends to measure Internet diversion was discussed at length in Thomas Thress's responses to Presiding Officer's Information Requests (POIRs) in Docket No. R2013-11. See, for example, Mr. Thress's responses to POIR No. 3, question 1; POIR No. 6, question 12; and POIR No. 9, question 7 in that case.

Diversion trends of this kind are estimated in many of the Postal Service's demand equations. Time trends of this type are special cases of Intervention Analysis. The technical details of Intervention Analysis are described later in this document.

#### **4. The Great Recession**

The 2008-2009 recession, sometimes called the “Great Recession”, had a larger negative impact on many categories of mail volume than can be explained by the macro-economic variables included in the Postal Service’s demand equations. In these cases, the Postal Service models the unique impacts of the Great Recession on mail volumes using Intervention Analysis techniques. The technical details of Intervention Analysis are described next.

#### **5. Intervention Analysis**

In some cases, mail volumes may be affected by unique events, or “interventions”. Oftentimes, the effect of such factors can be modeled via trend or dummy variables. In other cases, however, the impact of such “interventions” on mail volumes may be more complicated than can be fully captured by a set of linear variables. In such cases, a more elaborate non-linear Intervention analysis is undertaken to more accurately model the impact of some factors on some types of mail.

Two examples of Interventions for which this type of analysis is undertaken are the two factors just discussed: Internet Diversion and the Great Recession.

##### **a. Non-Linear Intervention**

Intervention analysis is a time series technique which allows one to identify the effects of an event over time. An “intervention” is an event which affects the demand for a given product. There are essentially three different types of impact of intervention events: step functions, pulse functions, and trends. A generalized Intervention Analysis technique allows for a functional form which is flexible enough to accommodate all of these possibilities as dictated by the underlying data. This function is called the *transfer function*.

The role of the transfer function is to allow the input variable to affect the volume in different ways and rates over time. Therefore, the impact of an intervention on volume is the product of a particular transfer function and an input variable. The general form of the transfer function is given by:

$$I_t = \frac{\omega(B)}{\delta(B)} B^s \xi_t^T = \frac{\omega_0 - \omega_1 B - \omega_2 B^2 - \omega_3 B^3 \dots - \omega_i B^i}{1 - \delta_1 B - \delta_2 B^2 - \delta_3 B^3 \dots - \delta_j B^j} B^s \xi_t^T \quad (\text{Equation 2})$$

where  $B$  is the lag operator:  $B^s y_t = y_{t-s}$ . For the stability of the model, the roots of the equations  $\omega_0 - \omega_1 B - \omega_2 B^2 - \dots - \omega_i B^i = 0$  and  $1 - \delta_1 B - \delta_2 B^2 - \dots - \delta_j B^j = 0$  must lie outside the unit circle. Of course, a more generalized form of Equation 2 is necessary to limit the number of  $\omega$  and  $\delta$  parameters so that the equation can be uniquely estimated.

The  $\omega(B)$  terms represent the level impact of the intervention event. For example, in Equation 2, if  $\omega_i=0$ , for  $i>0$ , then the intervention will only affect volume in the current period, and Equation 2 will simplify to a dummy variable equal to one in the quarter of interest and zero elsewhere with coefficient  $\omega_0$ . If, on the other hand,  $\omega_i = \omega_j$ , for all  $i,j$ , with  $\delta_i = 0$  for all  $i$ , then Equation 2 simplifies to a dummy variable equal to one from the quarter of interest forward with coefficient  $\omega_0$  ( $=\omega_i$  for all  $i$ ). Finally, if  $\omega_i$  is an increasing (or decreasing) function of  $i$ , then the transfer equation identified above will simplify to a trend response to the intervention event of interest.

The  $\delta(B)$  terms represent the rate of increase or decrease of the intervention events, e.g., the rate of change from a short-run to a long-run impact. For simplicity,  $\delta_i$  is typically assumed to be constant across all  $i$ . That is, the rate of adoption of an intervention event is typically assumed to be constant over time.

A transfer function that allows for each of the three possibilities outlined above - pulse, step, or trend response to an intervention - is shown in Equation 3 below:

$$I_t = \{\omega_0 + \omega_1 B / (1 - \delta B) + (\omega_2 + \omega_3 t) B / (1 - B)\} P_t \quad (\text{Equation 3})$$

where  $P_t$  is a pulse function – i.e.,  $P_t = 1$  for the period of the intervention, zero elsewhere.

A step function (equal to 1 for the period of the intervention and all subsequent periods),  $S_t$ , can be expressed as a function of  $P_t$  using lag notation so that  $S_t = P_t / (1 - B)$ .

In Equation 3,  $\omega_0$  is equal to the initial response to the Intervention event. If  $\omega_1 = \omega_2 = \omega_3 = 0$ , then the response to the Intervention will be equal to zero in all subsequent periods, and the transfer function will be a pure pulse function ( $P_t$ ). If  $\omega_0 = \omega_1$  and  $\delta = \omega_2 = \omega_3 = 0$ , then the transfer function will be a pure step function ( $S_t = P_t / (1 - B)$ ). If  $\omega_1 = \omega_2 = 0$  and  $\omega_0 = \omega_3$ , then the transfer function will be a pure linear trend. If, on the other hand, none of these equalities are realized, then Equation 3 will explain a more flexible transfer function as dictated by the observed data.

The functional form of Equation 3, which expresses the transfer function as a function of the lag operators may not be intuitively obvious. Re-expressing the lag operator notation here into more conventional notation yields Equation 4:

$$I_t = \omega_0 \cdot P_t + \omega_1 \cdot (P_{t-1} + \delta^1 P_{t-2} + \delta^2 P_{t-3} + \dots) + \omega_2 \cdot S_t + \omega_3 \cdot T_t \cdot S_t \quad (\text{Equation 4})$$

where, as noted above,  $P_t$  is equal to one during the period of the intervention, zero elsewhere (both before and after),  $S_t$  is equal to zero prior to the intervention event being modeled, and equal to one thereafter, and  $T$  is a time trend equal to zero at the point of the intervention event, increasing by one each quarter thereafter.

While Equation 4 is a function of only 5 parameters –  $\delta$  and  $\omega_i$  for  $i = 0$  to 3 – it nonetheless technically requires the inclusion of an infinite number of terms in the demand equation of interest. It turns out, however, that, at any given point in time, each

of the  $P_{t-i}$  terms is equal to zero except for, at most, one. To see this, one can re-write Equation 4 as follows:

$$I_t = \omega_0 \cdot P_t + \omega_1 \cdot \sum_{i=1}^{\infty} (\delta^{i-1} P_{t-i}) + \omega_2 \cdot S_t + \omega_3 \cdot T_t \cdot S_t$$

When  $T_t = 1$ , the value of  $P_{t-1} = 1$ ,  $P_{t-i} = 0$ , for all  $i \neq 1$ . Similarly, when  $T_t = 2$ , the value of  $P_{t-2} = 1$ ,  $P_{t-i} = 0$ , for all  $i \neq 2$ . So, instead of a sum over all values of  $P_{t-i}$  one can instead replace  $i$  with  $T_{t-1}$  in the above equation. That is,

$$I_t = \omega_0 \cdot P_t + \omega_1 \cdot S_t \cdot (\delta^{T_{t-1}}) + \omega_2 \cdot S_t + \omega_3 \cdot T_t \cdot S_t$$

(Equation 5)

Intervention variables of the form in Equation 5 are then added to the Postal Service's econometric demand equations as necessary. The Intervention parameters -  $\omega_0$ ,  $\omega_1$ ,  $\omega_2$ ,  $\omega_3$ , and  $\delta$  - are estimated simultaneous with the other econometric parameters using non-linear least squares.

Intervention Analysis of this type is used to model unique aspects of the Great Recession on several classes of mail, including First-Class Single-Piece Letters and Flats, Commercial Marketing Letters, and Bound Printed Matter Parcels.

### **b. S-Curves**

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, commonly called an “s-curve” because its shape approximates the letter “s”.

S-curves take the form:

$$S_t = z_1 \cdot d_t / (1 + z_2 \cdot \exp(-z_3 \cdot t_t)) + \dots$$

(Equation 6)

where  $d_t$  is a dummy variable equal to one starting in the initial period of the s-curve and is one thereafter, and  $t_t$  is a time trend, equal to zero in the initial period of the s-curve, increasing by one each quarter thereafter. This variable has an initial value in of  $z_1/(1+z_2)$  and gradually attenuates to its ceiling value,  $z_1$ . The parameter  $z_3$  controls the rate of attenuation.

### c. Time Trends

Often the behavior of a variable that is being estimated econometrically is a function of other observable variables. For example, mail volume is a function of postal prices. Sometimes, however, the behavior of a variable is due to factors that do not easily lend themselves to capture within a time series variable suitable for inclusion in an econometric equation. In such cases, it is common for such phenomena to be modeled in part using trend variables. For example, it has been found by the Postal Service (and others<sup>2</sup>) that trend variables do a better job of modeling the impact of electronic diversion on mail volume than specific measures of Internet usage, which do not

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<sup>2</sup> e.g., Veruete-McKay, Leticia; Soteri, Soterios; Nankervis, John C.; and Rodriguez, Frank (2011) "Letter Traffic Demand in the UK: An Analysis by Product and Envelope Content Type," Review of Network Economics: Vol. 10: Issue 3, Article 10.

necessarily reflect the gradual substitution of the Internet for correspondence and transactions which had previously been undertaken via the mail.

Given that trend variables are needed within particular demand equations, an equally important question becomes what forms these trend variables 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

It is not sufficient to merely plug full-sample linear time trends into all of one's econometric equations. Rather, it is important to evaluate every demand equation individually and determine the appropriate trend specification for each equation, if any.

Many of the demand equations filed with the Commission on January 21, 2020, including the Periodicals Mail equation, and most of the First-Class Mail, Marketing Mail, and Special Service equations, include full-sample linear time trends to account for trends in the volumes of these types of mail over the sample periods used here, for which economic sources do not readily lend themselves to inclusion in an econometric time series equation. Such long-run changes in mail volume are therefore most readily modeled by a trend variable.

Several equations include linear time trends over only a portion of their sample period. These trends capture new and changing influences which have affected mail volumes, including the introduction and expansion of Internet and other types of electronic diversion, as well as changes in long-run mail trends that may have been caused by the Great Recession. Trends of this nature are included, for example, in several of the demand equations for First-Class, Marketing, and Periodicals Mail.

Time trends are special cases of the non-linear intervention analysis described above. Trends appear in the econometric output as an “Intervention” variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. This result is mathematically identical to including a simple linear time trend starting at the relevant time in the demand equation.

#### **d. Dummy Variables**

In some cases, the effect of specific events may be modeled using dummy variables. For example, certain equations include dummy variables for some rate or classification changes that are inadequately modeled by the price indices used here. Dummy variables are special cases of the non-linear intervention analysis outlined above.

### **6. Seasonality**

Seasonality is primarily modeled through simple quarterly dummy variables, equal to one in the quarter of interest (Quarter 1, Quarter 2, Quarter 3), zero otherwise.

In some cases, the seasonal pattern of certain mail categories appears to have changed somewhat over time. In these cases, additional or alternate seasonal variables may be introduced into the equation over sub-samples of the relevant sample period. In most cases, these take the form of quarterly dummies which start at some time after 2000. For example, the First-Class Single-Piece Letters equation includes a dummy variable equal to one in the first Postal quarter starting in 2012Q2 (i.e., beginning in 2013Q1).

One additional seasonal variable is used in some equations, which is equal to either the number of Sundays (SUNDAYS) or the number of non-weekdays (SAT\_SUN) within the quarter of interest.

### Impact of Federal Election Cycle

One fairly significant use for the mail is for pre-election advertising by candidates, political parties, and special interest groups. Because of this, volumes for several categories of mail fluctuate with the election cycle, most notably with the federal election cycle of every two (Congressional) or four (Presidential) years.

Dummy variables equal to one during specific quarters within federal election years are included in several of the Postal Service's demand equations, most notably in the demand equations associated with Nonprofit Marketing Mail.

### **First-Class Mail**

First-Class Mail is a heterogeneous class of mail. First-Class Mail 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 sub-streams 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).

First-Class Mail can be broadly divided into two categories of mail: Individual Correspondence, consisting of household-generated mail and non-household-generated mail sent a few pieces at a time; and Bulk Transactions, consisting of non-household-generated mail sent in bulk. Relating these two categories of First-Class Mail to rate categories, Individual Correspondence mail may be thought of as being approximately equivalent to First-Class Single-Piece Mail, while Bulk Transactions mail could be viewed as comparable to First-Class Workshared Mail. Of course, these equivalencies are only approximate.

For econometric estimation purposes, domestic First-Class Mail is divided into six mail categories: First-Class Single-Piece letters, First-Class Single-Piece cards, First-Class Single-Piece flats, First-Class Workshared letters, First-Class Workshared cards, and First-Class Workshared flats. In addition, separate demand equations are estimated for inbound and outbound First-Class International letters, cards, and flats.

The relationship between the macro-economy and domestic First-Class Mail is modeled by including private employment in each of the domestic First-Class Mail demand equations. Employment was chosen as the macro-economic variable to be included in the domestic First-Class Mail equations based on a comparison of econometric results including several candidate macro-economic variables, including retail sales, consumption, and GDP. The theoretical rationale for including total

employment as a macro-economic variable is that in many cases, mail volume is not affected by the dollar value of economic transactions, so much as by the number of such transactions. For example, the number of credit card bills one receives and bill payments one makes does not necessarily go up as the total amount charged per card goes up. While variables like GDP or retail sales may be good measures of the total dollar amount of economic activity (e.g., the total amount charged per credit card), employment appears to be a better measure of the number of business transactions (e.g., number of bills paid).

## **First-Class Single-Piece Letters**

### **1. Explanatory Variables used in First-Class Single-Piece Letters Equation**

The First-Class Single-Piece Letters demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variables: Employment**

The relationship between First-Class Single-Piece Letters and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the First-Class Single-Piece Letters equation.

Employment is entered into the First-Class Single-Piece Letters equation lagged one quarter.

#### **(2) Postal Prices**

The First-Class Single-Piece Letters equation includes a price index measuring the average price of First-Class Single-Piece Letters (PC01SP\_L). Prices are entered current and lagged one to four quarters.

#### **(3) Time Trends**

The First-Class Single-Piece Letters demand equation includes a full-sample linear time trend and a second linear time trend starting in 2016Q3. These trends reflect changes in the impact of mail-diverting technologies which have been continually adopted by businesses and households in recent years.

The combined effect of these two trends translates into a current annual trend of approximately -7.6 percent.

#### (4) Non-Linear Intervention Variable

The First-Class Single-Piece Letters demand equation includes a non-linear intervention variable that starts in 2008Q4 and takes the following form:

$$\text{Ln}(\text{Vol})_t = a + \dots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \dots) + \omega_2 \cdot S_t + \dots$$

where  $P_t$  is a pulse function and  $S_t$  is a step function, so that  $P_t = 1$  if  $t=2008Q4$  and 0 otherwise;  $S_t = 1$  if  $t > 2008Q4$  and 0 otherwise. This variable has an initial value in 2008Q4 of  $\omega_0$ , which decays toward a long-run value of  $\omega_2$ . The value of  $\omega_2$  is constrained to zero in this case.

This variable is included to capture additional volume declines in the immediate aftermath of the Great Recession, related to, for example, reductions in consumers' use of credit cards and a reduction in the rate of new household formation.

#### (5) Other Variables

The First-Class Single-Piece Letters equation includes R2006PHOP, which is a dummy variable equal to -1 in 2006Q1 and +1 in 2006Q2 and is related to the Postal Service's measure of Postage in the Hands of the Public (PHOP) just before and after the implementation of R2005-1 rates in January 2006.

The First-Class Single-Piece Letters equation includes four additional dummy variables. The first three of these: D2010Q2ON which is equal to one since 2010Q2 and zero prior; D2011Q2ON which is equal to one since 2011Q2 and zero prior; and D2012Q2ON which is equal to one since the start of calendar year 2012 and zero before that time; are included to capture additional declines in First-Class Single-Piece Letter volume in the immediate aftermath of the Great Recession due to apparent changes with respect to consumers' willingness to accumulate credit card debt and a

reduction in home ownership. The fourth dummy variable is D2014Q3, equal to one in 2014Q3 and zero elsewhere.

Finally, the First-Class Single-Piece Letters equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Single-Piece Letters

The effect of these variables on First-Class Single-Piece letters volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class Single-Piece Letters<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 20869.048                          |
| Own-Price  | -1.18%                        | -0.190     | 0.23%                              |
| EMPLOY(-1)   | 5.10%                         | 0.756      | 3.83%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2004Q1   |                               |            | -25.84%                            |
| 2016Q3   |                               |            | -5.88%                             |
| Intervention Starting in:  |                               |            |                                    |
| 2008Q4   |                               |            | 0.01%                              |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | -0.94%                             |
| Other Factors  |                               |            | 1.12%                              |
| Volume in FY 2019  |                               |            | 15953.934                          |
| Total Change in Volume   |                               |            | -23.55%                            |

## **First-Class Single-Piece Cards**

### **1. Explanatory Variables used in First-Class Single-Piece Cards Equation**

The First-Class Single-Piece cards demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variables: Employment**

The relationship between First-Class Single-Piece Cards and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the First-Class Single-Piece Cards equation.

Employment is entered into the First-Class Single-Piece Cards equation lagged one quarter.

#### **(2) Postal Prices**

The First-Class Single-Piece Cards equation includes a price index measuring the average price of First-Class Single-Piece Cards (PC01SP\_C). Prices are entered current and lagged one quarter.

#### **(3) Time Trends**

The First-Class Single-Piece cards demand equation includes a full-sample linear time trend and a second linear time trend starting in 2010Q2.

The first of these trends largely reflect diversion to the Internet and other electronic alternatives which has been ongoing for many years now.

The second trend, which starts in 2010Q2, captures a combination of longer-run trends associated with the Great Recession as well as increased technological diversion over this time period. The former of these includes, for example, declines in home ownership and a slowdown in the rate of household formation. In addition, mail volume

is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. Along with the lingering economic impacts of the Great Recession, the 2010Q2 trend may reflect increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced mail.

The combined effect of these three trends translates into a current annual trend of approximately -11.1 percent.

#### **(4) Other Variables**

The First-Class Single-Piece Cards equation includes four non-seasonal dummy variables: R2006PHOP, equal to -1 in 2006Q1 and +1 in 2006Q2 and is related to the Postal Service's measure of Postage in the Hands of the Public (PHOP) just before and after the implementation of R2005-1 rates in January 2006; D\_R07, equal to one since the implementation of R2006-1 rates in May 2007, zero earlier; D2017Q3, equal to one in 2017Q3, zero elsewhere; and, D2019Q2ON, which is equal to one from 2019Q1 forward.

Finally, the First-Class Single-Piece Cards equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Single-Piece Cards

The effect of these variables on First-Class Single-Piece cards volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class Single-Piece Cards<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Volume in FY 2014  |                               |            | 924.228                            |
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Own-Price  | -2.33%                        | -0.284     | 0.67%                              |
| EMPLOY(-1)   | 5.10%                         | 0.981      | 5.00%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2004Q1   |                               |            | -30.96%                            |
| 2010Q2   |                               |            | -19.57%                            |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | -4.72%                             |
| Other Factors  |                               |            | 3.77%                              |
| Volume in FY 2019  |                               |            | 563.453                            |
| Total Change in Volume   |                               |            | -39.04%                            |

## **First-Class Single-Piece Flats**

### **1. Explanatory Variables used in First-Class Single-Piece Flats Equation**

The First-Class Single-Piece flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variables: Employment**

The relationship between First-Class Single-Piece Flats and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the First-Class Single-Piece Flats equation.

Employment is entered into the First-Class Single-Piece Flats equation lagged one quarter.

#### **(2) Postal Prices**

The First-Class Single-Piece Flats equation includes a price index measuring the average price of First-Class Single-Piece Flats (PC01SP\_F). Prices are entered current and lagged one to three quarters.

#### **(3) Time Trend**

The First-Class Single-Piece flats demand equation includes a full-sample linear time trend. This trend reflects ongoing diversion of First-Class Mail to the Internet and other electronic alternatives.

#### (4) Non-Linear Intervention Variable

The First-Class Single-Piece Flats demand equation includes a non-linear intervention variable that starts in 2008Q4 and takes the following form:

$$\text{Ln}(\text{Vol})_t = a + \dots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \dots) + \omega_2 \cdot S_t + \dots$$

where  $P_t$  is a pulse function and  $S_t$  is a step function, so that  $P_t = 1$  if  $t=2008Q4$  and 0 otherwise;  $S_t = 1$  if  $t > 2008Q4$  and 0 otherwise. This variable has an initial value in 2008Q4 of  $\omega_0$ , which decays toward a long-run value of  $\omega_2$ .

This variable is included to capture volume declines associated with the Great Recession which appear to have been permanent.

#### (5) Other Variables

The First-Class Single-Piece Flats equation includes four non-seasonal dummy variables:  $D\_R07$ , which is equal to one since the implementation of R2006-1 rates in May 2007, zero earlier;  $D\_R14$ , which is equal to one since the implementation of R2013-11 rates in January 2014, zero earlier;  $D2017Q3$ , equal to one in 2017Q3, zero elsewhere; and,  $D2019Q2ON$ , which is equal to one from 2019Q1 forward.

Finally, the First-Class Single-Piece Flats equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Single-Piece Flats

The effect of these variables on First-Class Single-Piece flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class Single-Piece Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 1160.766                           |
| Own-Price  | -3.95%                        | -0.255     | 1.03%                              |
| EMPLOY(-1)   | 5.10%                         | 0.367      | 1.84%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2004Q1   |                               |            | -27.41%                            |
| Intervention Starting in:<br>2008Q4  |                               |            | -17.17%                            |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | -2.56%                             |
| Other Factors  |                               |            | 0.74%                              |
| Volume in FY 2019  |                               |            | 740.536                            |
| Total Change in Volume   |                               |            | -36.20%                            |

## **First-Class Workshared Letters**

### **1. Explanatory Variables used in First-Class Workshared Letters Equation**

The First-Class Workshared letters demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between First-Class Workshared Letters and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the First-Class Workshared Letters equation.

#### **(2) Postal Prices**

The First-Class Workshared Letters equation includes a single Postal price: the price of First-Class Workshared Letters (PC01WS\_L). Prices are entered current and lagged one to four quarters.

#### **(3) Non-linear Intervention Variables**

The First-Class Workshared Letters demand equation includes two non-linear intervention variables, starting in 2008Q1 and 2016Q3, which take the form of an s-curve, i.e.,

$$\ln(\text{Vol}_t) = a + \dots + z_1 \cdot d_t / (1 + z_2 \cdot \exp(-z_3 \cdot t_t)) + \dots$$

where  $d_t$  is a dummy variable equal to one starting in the first period of the intervention (2008Q1 and 2016Q3, respectively) and is one thereafter, and  $t_t$  is a time trend, equal to zero through the first period of the intervention, increasing by one each quarter thereafter. Intervention variables of this form have an initial value of  $z_1/(1+z_2)$

and gradually attenuates to a ceiling value of  $z_1$ . The parameter  $z_3$  controls the rate of attenuation.

The first of these coincides with the start of the Great Recession and likely includes trends associated with the Great Recession including, for example, declines in home ownership and a slowdown in the rate of household formation. In addition, mail volume is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. This trend likely captures increased electronic diversion as well, reflecting the impact of new technologies such as smartphones and social media to the extent such usage actually replaced mail.

The second s-curve coincides with recent increases in mail diversion, including increases in electronic presentation of some bills and statements.

#### **(4) Other Variables**

The First-Class Workshared Letters equation includes a dummy variable equal to one in the first Postal quarter of Federal election years and a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Workshared Letters

The effect of these variables on First-Class Workshared letters volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class Workshared Letters<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 38098.014                          |
| Own-Price  | -4.06%                        | -0.320     | 1.33%                              |
| EMPLOY   | 4.98%                         | 0.547      | 2.69%                              |
| Adult Population   |                               |            | 5.04%                              |
| S-Curves Starting in:  |                               |            |                                    |
| 2008Q1   |                               |            | -2.72%                             |
| 2016Q3   |                               |            | -13.40%                            |
| Seasonals  |                               |            | 0.00%                              |
| Elections  |                               |            | 0.21%                              |
| Other Factors  |                               |            | 0.14%                              |
| Volume in FY 2019  |                               |            | 35207.142                          |
| Total Change in Volume   |                               |            | -7.59%                             |

## **First-Class Workshared Cards**

### **1. Explanatory Variables used in First-Class Workshared Cards Equation:**

The First-Class Workshared cards demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between First-Class Workshared Cards and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the First-Class Workshared Cards equation.

#### **(2) Postal Prices**

The First-Class Workshared Cards equation includes a single Postal price: the price of First-Class Workshared Cards (PC01WS\_C). Prices are entered current only.

#### **(3) Time Trends**

The First-Class Workshared cards demand equation includes a full-sample linear time trend, a second linear time trend starting in 2008Q1, and a third linear time trend starting in 2014Q1.

The coefficient on the first of these trends is positive, reflecting the influence of factors which positively impacted First-Class Workshared Mail volume through the first decade of this century. These factors include shifts from First-Class Single-Piece to Workshared Mail, the increasing use of First-Class Mail for direct-mail advertising over this period, and the positive impacts of increases in credit card usage and home ownership in the years immediately prior to the Great Recession.

The coefficient on the second trend, starting in 2008Q1, is negative, reflecting changes in the impact of Internet and other electronic diversion on First-Class

Workshared cards as well as changes in other underlying trends that might have affected mail volume (some positive, some negative) over this time period. This includes trends associated with the Great Recession including, for example, declines in home ownership and a slowdown in the rate of household formation. In addition, mail volume is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. This trend likely captures increased electronic diversion as well, reflecting the impact of new technologies such as smartphones and social media to the extent such usage replaced mail.

The coefficient on the third trend, starting in 2014Q1, is positive, suggesting some attenuation of some of the negative influences described in the previous paragraph.

The combined effect of these three trends translates into a current annual trend of approximately -4.8 percent.

#### **(4) Other Variables**

Finally, the First-Class Workshared cards equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Workshared Cards

The effect of these variables on First-Class Workshared cards volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class Workshared Cards<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 2198.318                           |
| Own-Price  | -4.09%                        | -0.204     | 0.86%                              |
| EMPLOY   | 4.98%                         | 0.840      | 4.17%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2004Q1   |                               |            | 31.88%                             |
| 2008Q1   |                               |            | -47.38%                            |
| 2014Q1   |                               |            | 12.43%                             |
| Seasonals  |                               |            | 0.00%                              |
| Other Factors  |                               |            | 1.61%                              |
| Volume in FY 2019  |                               |            | 1923.399                           |
| Total Change in Volume   |                               |            | -12.51%                            |

## **First-Class Workshared Flats**

### **1. Explanatory Variables used in First-Class Workshared Flats Equation:**

The First-Class Workshared flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between First-Class Workshared Flats and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the First-Class Workshared Flats equation.

#### **(2) Postal Prices**

The First-Class Workshared flats equation includes a single Postal price: the price of First-Class Workshared Flats (PC01WS\_F). Prices are entered current and lagged one to two quarters.

#### **(3) Time Trends**

The First-Class Workshared flats demand equation includes linear time trends starting in 2008Q1 and 2017Q2.

The coefficients on these trends are negative, reflecting changes in the impact of Internet and other electronic diversion on First-Class Workshared flats as well as changes in other underlying trends that might have affected mail volume (some positive, some negative) over this period. In the case of the first trend, this includes trends associated with the Great Recession including, for example, declines in home ownership and a slowdown in the rate of household formation due to the Great Recession. In addition, mail volume is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. This trend likely captures increased electronic diversion as

well, reflecting the impact of new technologies such as smartphones and social media to the extent such usage replaced mail. The second trend reflects more recent increases in the apparent rate of diversion of First-Class Workshared Flats.

The combined effect of these two trends translates into a current annual trend of approximately -8.0 percent.

#### (4) Other Variables

The First-Class Workshared flats equation includes one dummy variable: D\_R07, equal to one since the implementation of R2006-1 rates in May 2007, zero earlier, as well as a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Workshared Flats

The effect of these variables on First-Class Workshared flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class Workshared Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 598.673                            |
| Own-Price  | -7.87%                        | -0.482     | 4.03%                              |
| EMPLOY   | 4.98%                         | 1.587      | 8.02%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2008Q1   |                               |            | -15.15%                            |
| 2017Q2   |                               |            | -11.41%                            |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | 0.00%                              |
| Other Factors  |                               |            | 4.44%                              |
| Volume in FY 2019  |                               |            | 554.812                            |
| Total Change in Volume   |                               |            | -7.33%                             |

## **Outbound First-Class International Letters, Cards, and Flats**

### **1. Explanatory Variables used in Outbound First-Class International Letters, Cards, and Flats Equation**

The Outbound First-Class International Letters, Cards, and Flats demand equation includes the following explanatory variables.

#### **(1) Exchange Rates**

The relative price of domestic versus foreign goods is modeled through the inclusion of trade-weighted exchange rates (XRATE) as an explanatory variable in the Outbound First-Class International Letters, Cards, and Flats equation. Exchange rates are entered into the Outbound First-Class International Letters, Cards, and Flats equation lagged three quarters.

#### **(2) Macro-Economic Variable: Employment**

The relationship between Outbound First-Class International Letters, Cards, and Flats and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the Outbound First-Class International Letters, Cards, and Flats demand equation. Employment is entered into the Outbound First-Class International Letters, Cards, and Flats equation lagged four quarters.

#### **(3) Postal Prices**

The Outbound First-Class International Letters, Cards, and Flats equation includes a single Postal price: the price of Outbound First-Class International Letters, Cards, and Flats (PC1I\_LCF). Prices are entered current only.

#### (4) Time Trend

The Outbound First-Class International Letters, Cards, and Flats equation includes a full-sample linear time trend.

#### (5) Other Variables

The Outbound First-Class International Letters, Cards, and Flats equation includes three dummy variables: D2009Q2, which is equal to one in 2009Q2, zero elsewhere; D2009Q3, equal to one in 2009Q3, zero elsewhere; and D2009Q4, equal to one in 2009Q4, zero elsewhere.

The Outbound First-Class International Letters, Cards, and Flats equation also includes a set of seasonal variables.

## 2. Econometric Demand Equation: Outbound First-Class International Letters, Cards, and Flats

The effect of these variables on Outbound First-Class International letters, cards, and flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>First-Class International Letters, Cards, & Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |         |
|---|-------------------------------|------------|------------------------------------|---------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |         |
| Volume in FY 2014   |                               |            |                                    | 192.270 |
| Own-Price   | -5.41%                        | -0.125     |                                    | 0.70%   |
| EMPLOY(-4)  | 5.07%                         | 0.116      |                                    | 0.58%   |
| XRATE(-3)   | 14.84%                        | -0.162     |                                    | -2.22%  |
| Adult Population  |                               |            |                                    | 5.04%   |
| Trend Starting in:<br>2001Q3  |                               |            |                                    | -38.27% |
| Seasonals   |                               |            |                                    | 0.00%   |
| Dummy Vars  |                               |            |                                    | 0.00%   |
| Other Factors   |                               |            |                                    | 2.09%   |
| Volume in FY 2019   |                               |            |                                    | 126.054 |
| Total Change in Volume  |                               |            |                                    | -34.44% |

## **Inbound First-Class International Mail**

### **1. Explanatory Variables used in Inbound First-Class International Mail Equation**

The Inbound First-Class International Mail demand equation includes the following explanatory variables.

#### **(1) Exchange Rates**

The relative price of domestic versus foreign goods is modeled through the inclusion of trade-weighted exchange rates (XRATE) as the explanatory variable in the Inbound First-Class International Mail equation. Note that the expected coefficient on Exchange Rates has the opposite sign with respect to Inbound International Mail (positive) as it does with respect to Outbound International Mail (negative).

#### **(2) Postal Prices**

The Inbound First-Class International Mail demand equation includes average revenue per piece for Inbound First-Class International Mail (RPP1I\_I) as a measure of the average price of Inbound First-Class International Mail. Prices are entered current only.

#### **(3) Time Trends**

The Inbound First-Class International equation includes two linear time trends, one starting in 2015Q2 and another starting in 2017Q4. The combined effect of these two trends translates into a current annual trend of approximately -7.0 percent.

#### **(4) Other Variables**

The Inbound First-Class International Mail equation also includes a set of seasonal variables.

## 2. Econometric Demand Equation: Inbound First-Class International Mail

The effect of these variables on Inbound First-Class International Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Inbound First-Class International Mail<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 400.500                            |
| Own-Price  | 63.99%                        | -0.130     | -6.24%                             |
| XRATE  | 18.16%                        | 0.816      | 14.59%                             |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2015Q2   |                               |            | 100.70%                            |
| 2017Q4   |                               |            | -35.03%                            |
| Seasonals  |                               |            | 0.00%                              |
| Other Factors  |                               |            | -4.45%                             |
| Volume in FY 2019  |                               |            | 563.149                            |
| Total Change in Volume   |                               |            | 40.61%                             |

## **Marketing Mail**

### **1. Overview of Direct-Mail Advertising**

More than 90 percent of Marketing Mail can be characterized as direct-mail advertising. Hence, understanding the demand for direct-mail advertising is the key to understanding the demand for Marketing Mail volume.

The demand for Marketing 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 two separate, but interrelated, decisions:

- (1) How much to invest in advertising?
- (2) Which advertising medium to use?

These two decisions are integrated into the demand equations associated with Marketing Mail volume by including a set of explanatory variables in the demand equations for Marketing Mail that addresses each of these decisions. These decisions, and their implications for Marketing Mail equations, are considered separately below.

### **2. Advertising Decisions and Their Impact on Mail Volume**

#### **a. How Much to Invest in Advertising**

Advertising represents a form of business investment. Hence, the Marketing Mail equations include real gross private domestic investment as a measure of the overall demand for business investment.

In addition to macroeconomic factors, the overall level of advertising is also affected by certain other regular events. In the United States, the election cycle is one factor which drives advertising demand. Variables which coincide with the timing of federal elections are included in most of the Marketing Mail demand equations which were filed with the Commission on January 21, 2020.

## **b. Which Advertising Media to Use**

The choice of advertising media can be thought of as primarily a pricing decision, so that the primary determinant of the demand for direct-mail advertising (vis-à-vis other advertising media) would be the price of direct-mail advertising.

The most obvious way in which the price of direct-mail advertising is included in the Marketing Mail equations is through the price of Marketing Mail. Postage costs are included in the Marketing Mail equations through chain-weighted price indices which measure the average postage paid by Marketing Mailers.

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. By identifying specifically who will receive a particular piece of direct-mail advertising, direct-mail advertising is able to provide a 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, increased dramatically over the three decades preceding the Great Recession. This had a positive impact on the demand for many types of Marketing Mail, most prominently Marketing Commercial Letters. More recently, the emergence of Internet and Mobile Advertising have negatively affected the demand for Marketing Mail. These factors are modeled via linear time trends in several of the demand equations presented to the Commission this year.

Additional changes to the overall advertising market as well as direct mail's role within that market in the wake of the Great Recession are modeled via Intervention analysis. The general concept of Intervention analysis was described earlier in this document. The specific demand specifications associated with the demand equations developed here for Marketing Mail are described below.

## **Marketing Mail Commercial Letters**

### **1. Explanatory Variables used in Marketing Mail Commercial Letters Equation**

The Marketing Mail Commercial letters demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Commercial letters volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR).

#### **(2) Postal Prices**

The Marketing Mail Commercial Letters equation includes a price index measuring the average price of Marketing Mail Commercial letters (PC3R\_NCR\_L). Prices are entered current and lagged one to four quarters.

#### **(3) Time Trends**

The Marketing Mail Commercial letters demand equation includes a full-sample linear time trend, a second linear time trend starting in 2011Q2, and a third linear time trend starting in 2015Q2. The full-sample trend is included to capture general increases in the attractiveness of direct-mail advertising as a desirable advertising medium as well as in Marketing Mail Commercial letters volume specifically relative to other direct-mail alternatives (e.g., ECR Basic Mail).

The second trend is introduced in 2011Q2 to capture the lingering economic impacts of the Great Recession and increased electronic diversion due to the increased use of new technologies such as smart phones and social media to the extent such usage led to a decline in direct-mail advertising.

The third trend likely reflects increasing shifts of advertising from traditional media to the Internet and social media.

The combined effect of these three trends translates into a current annual trend of approximately -3.4 percent.

#### **(4) Non-Linear Intervention Variable**

The Great Recession hit advertising expenditures, and, hence, Marketing Mail volume, much harder and more permanently than would have been expected, even given the decline that occurred in private investment. To capture this effect econometrically, the Marketing Mail Commercial letters demand equation includes a non-linear intervention variable that starts in 2008Q2 and takes the following form:

$$\text{Ln}(\text{Vol})_t = a + \dots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \dots) + \omega_2 \cdot S_t + \dots$$

where  $P_t$  is a pulse function and  $S_t$  is a step function, so that  $P_t = 1$  if  $t=2008Q2$  and 0 otherwise;  $S_t = 1$  if  $t > 2008Q2$  and 0 otherwise. This variable has an initial value in 2008Q2 of  $\omega_0$ , which decays toward a long-run value of  $\omega_2$ .

#### **(5) Other Variables**

The Marketing Mail Commercial letters equation includes several dummy variables to reflect the impact of various one-time events and/or changes to the relative relationship between Marketing Mail Commercial Letters and other mail categories.

##### **(a) R2006-1**

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 ( $D\_R07$ ) is included in the Marketing Mail Commercial letters equation.

Commercial ECR automation letter discounts were eliminated at this time, leading this mail to migrate from Commercial ECR Basic to Commercial letters.

**(b) 2012**

A dummy variable, D2012Q1, equal to one in 2012Q1, zero otherwise, is included in the Marketing Mail Commercial letters equation. Another dummy variable, D2012Q2ON, equal to one from 2012Q2 forward, zero otherwise, is also included. These dummies are included to account for significant unexplained declines in Marketing Mail Commercial letters volume in FY 2013 that appear to be permanent.

**(c) 2016 - 2017**

A dummy variable, D2016Q1ON, equal to one from 2016Q1 forward, is included in the Marketing Mail Commercial letters equation, as well as a second dummy variable, D2017Q1ON, equal to one from 2017Q1 forward. The former of these is included to reflect unexpectedly strong Commercial Letters volume in FY 2016. The latter of these largely offsets the former, suggesting the unusual strength in FY 2016 was transitory.

**(d) Seasonal and Election Variables**

Finally, the Marketing Mail Commercial letters equation includes a set of seasonal and election variables.

## 2. Econometric Demand Equation: Marketing Mail Commercial Letters

The effect of these variables on Marketing Mail Commercial letters volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: Commercial Letters<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 38574.199                          |
| Own-Price  | -2.13%                        | -0.439     | 0.95%                              |
| INVR   | 12.05%                        | 0.386      | 4.49%                              |
| Adult Population   |                               |            | 5.04%                              |
| Intervention Starting in:<br>2008Q2  |                               |            | -0.00%                             |
| Trends Starting in:  |                               |            |                                    |
| 2004Q1   |                               |            | 19.90%                             |
| 2011Q2   |                               |            | -18.21%                            |
| 2015Q2   |                               |            | -12.58%                            |
| Seasonals  |                               |            | 0.00%                              |
| Elections  |                               |            | -0.21%                             |
| Dummy Vars   |                               |            | 0.68%                              |
| Other Factors  |                               |            | -0.13%                             |
| Volume in FY 2019  |                               |            | 36768.270                          |
| Total Change in Volume   |                               |            | -4.68%                             |

## **Marketing Mail Commercial High Density and Saturation Letters**

### **1. Explanatory Variables used in Marketing Mail Commercial High Density and Saturation Letters**

The Marketing Mail Commercial High Density and Saturation letters demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Commercial High Density and Saturation Letters volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR). Investment is entered lagged four quarters.

#### **(2) Postal Prices**

The Marketing Mail Commercial High Density and Saturation Letters equation contains a price index for the price of Marketing Mail Commercial High Density and Saturation Letters (PC3R\_HS\_L). Prices are entered current and lagged one quarter.

#### **(3) Time Trends**

The Marketing Mail Commercial High Density and Saturation Letters demand equation includes a full-sample linear time trend and a second linear time trend starting in 2018Q2. The combined effect of these two trends translates into a current annual trend of approximately -3.6 percent.

#### **(4) Other Variables**

The Marketing Mail Commercial High Density and Saturation Letters equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Marketing Mail Commercial High Density and Saturation Letters

The effect of these variables on Marketing Mail Commercial High Density and Saturation letters volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: Comm High-D/Saturation Letters<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Volume in FY 2014  |                               |            | 5096.888                           |
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Own-Price  | -1.10%                        | -0.483     | 0.53%                              |
| INVR(-4)   | 15.08%                        | 0.703      | 10.37%                             |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2012Q3   |                               |            | 24.40%                             |
| 2018Q2   |                               |            | -10.40%                            |
| Seasonals  |                               |            | 0.00%                              |
| Other Factors  |                               |            | 1.79%                              |
| Volume in FY 2019  |                               |            | 6740.495                           |
| Total Change in Volume   |                               |            | 32.25%                             |

## **Marketing Mail Commercial and ECR Basic Flats**

### **1. Explanatory Variables used in Marketing Mail Commercial and ECR Basic Flats Equation**

The Marketing Mail Commercial and ECR Basic flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Commercial and ECR Basic Flats volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR). Investment is entered lagged two quarters.

#### **(2) Postal Prices**

The Marketing Mail Commercial and ECR Basic Flats equation includes a price index measuring the average price of Marketing Mail Commercial and ECR Basic Flats. Prices are entered current and lagged one to two quarters.

#### **(3) Time Trends**

The Marketing Mail Commercial and ECR Basic Flats equation includes a full-sample linear time trend and a second linear time trend starting in 2016Q4.

The full-sample trend is included to capture modest declines in the volume of Marketing Mail Commercial and ECR Basic Flats over the past two decades. The second trend is introduced in 2016Q4 to capture increased declines in Marketing Mail Commercial and ECR Basic Flats volumes since that time.

The combined effect of these two trends translates into a current annual trend of approximately -10.1 percent.

#### **(4) Seasonal and Election Variables**

Finally, the Marketing Mail Commercial and ECR Basic Flats equation includes a set of seasonal and election variables.

## 2. Econometric Demand Equation: Marketing Mail Commercial and ECR Basic Flats

The effect of these variables on Marketing Mail Commercial and ECR Basic Flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: Commercial and ECR Basic Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |  |
|--|-------------------------------|------------|------------------------------------|--|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |  |
| Volume in FY 2014  |                               |            | 12256.353                          |  |
| Own-Price  | -0.11%                        | -0.837     | 0.09%                              |  |
| INVR(-2)   | 14.35%                        | 0.779      | 11.02%                             |  |
| Adult Population   |                               |            | 5.04%                              |  |
| Trends Starting in:  |                               |            |                                    |  |
| 2012Q2   |                               |            | -32.54%                            |  |
| 2016Q4   |                               |            | -7.68%                             |  |
| Seasonals  |                               |            | 0.00%                              |  |
| Elections  |                               |            | 1.33%                              |  |
| Dummy Vars   |                               |            | -6.65%                             |  |
| Other Factors  |                               |            | 0.89%                              |  |
| Volume in FY 2019  |                               |            | 8502.584                           |  |
| Total Change in Volume   |                               |            | -30.63%                            |  |

## **Marketing Mail Commercial High Density and Saturation Flats**

### **1. Explanatory Variables used in Marketing Mail Commercial High Density and Saturation Flats**

The Marketing Mail Commercial High Density and Saturation flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Commercial High Density and Saturation Flats volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR).

#### **(2) Postal Prices**

The Marketing Mail Commercial High Density and Saturation Flats equation contains a price index for the price of Marketing Mail Commercial High Density and Saturation Flats. Prices are entered current and lagged one to two quarters.

#### **(3) Time Trend**

The Marketing Mail Commercial High Density and Saturation Flats demand equation includes a linear time trend starting in 2015Q3.

#### **(4) Other Variables**

Finally the Marketing Mail Commercial High Density and Saturation Flats equation includes a set of election and seasonal variables.

## 2. Econometric Demand Equation: Marketing Mail Commercial High Density and Saturation Flats

The effect of these variables on Marketing Mail Commercial High Density and Saturation flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: Comm High-D/Saturation Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 10724.305                          |
| Own-Price  | -6.72%                        | -0.648     | 4.61%                              |
| INVR   | 12.05%                        | 0.142      | 1.63%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2015Q3   |                               |            | -9.68%                             |
| Seasonals  |                               |            | 0.00%                              |
| Elections  |                               |            | 0.21%                              |
| Other Factors  |                               |            | 0.76%                              |
| Volume in FY 2019  |                               |            | 10922.462                          |
| Total Change in Volume   |                               |            | 1.85%                              |

## **Marketing Mail Commercial Every Door Direct Mail (EDDM)**

### **1. Explanatory Variables used in EDDM Equation**

The Marketing Mail EDDM demand equation includes the following explanatory variables.

#### **(1) Postal Prices**

The Marketing Mail EDDM equation contains a price index for the price of Marketing Mail Commercial EDDM. Prices are entered current only.

#### **(2) Time Trend**

The Marketing Mail EDDM demand equation includes a linear time trend starting in 2015Q1.

#### **(4) Other Variables**

The Marketing Mail EDDM equation includes one non-seasonal, non-election dummy variable, D2016Q1ON, which is equal to one from 2016Q1 forward.

Finally, the Marketing Mail EDDM equation includes a set of election and seasonal variables.

## 2. Econometric Demand Equation: Marketing Mail EDDM

The effect of these variables on Marketing Mail EDDM volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Every Door Direct Mail<br>VOLUME SINCE FY 2014 |                               |            |                                    |  |
|--|-------------------------------|------------|------------------------------------|--|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |  |
| Volume in FY 2014  |                               |            | 886.857                            |  |
| Own-Price  | 0.37%                         | -0.358     | -0.13%                             |  |
| Adult Population   |                               |            | 5.04%                              |  |
| Trend Starting in:<br>2015Q1   |                               |            | -32.86%                            |  |
| Seasonals  |                               |            | 0.00%                              |  |
| Elections  |                               |            | -0.50%                             |  |
| Dummy Vars   |                               |            | 4.20%                              |  |
| Other Factors  |                               |            | 0.26%                              |  |
| Volume in FY 2019  |                               |            | 649.386                            |  |
| Total Change in Volume   |                               |            | -26.78%                            |  |

## **Marketing Mail Nonprofit Letters**

### **1. Explanatory Variables used in Marketing Mail Nonprofit Letters Equation**

The Marketing Mail Nonprofit letters demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Nonprofit Letters volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR).

#### **(2) Postal Prices**

The Marketing Mail Nonprofit Letters equation contains a price index for the price of Marketing Mail Nonprofit Letters (PC3N\_NCR\_L). Prices are entered current and lagged one to two quarters.

#### **(3) Time Trend**

The Marketing Mail Nonprofit Letters equation includes a full-sample linear time trend.

#### **(4) Other Variables**

The Marketing Mail Nonprofit Letters equation includes several dummy variables to reflect the impact of various one-time events and/or changes to the relative relationship between Marketing Mail Nonprofit Letters and other mail categories.

**(a) R2006-1**

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 (D\_R07) is included in the Marketing Mail Nonprofit Letters equation. D\_R07 is included current and lagged two quarters.

**(b) D\_R11**

A dummy variable equal to one since the Postal Service's April 2011, rate change (2011Q3) is included in the Marketing Mail Nonprofit Letters equation.

**(c) D\_R13**

A dummy variable equal to one since the Postal Service's January 2013, rate change (2013Q2) is included in the Marketing Mail Nonprofit Letters equation.

**(d) D2019Q1ON**

A dummy variable equal to one since 2019Q1 is included in the Marketing Mail Nonprofit Letters equation.

**(e) Seasonal and Election Variables**

Finally, the Marketing Mail Nonprofit Letters equation includes a set of seasonal and election variables.

## 2. Econometric Demand Equation: Marketing Mail Nonprofit Letters

The effect of these variables on Marketing Mail Nonprofit letters volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: Nonprofit Letters<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Volume in FY 2014   |                               |            | 9497.527                           |
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Own-Price   | 0.67%                         | -0.276     | -0.18%                             |
| INVR  | 12.05%                        | 0.345      | 4.00%                              |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2004Q1  |                               |            | -11.75%                            |
| Seasonals   |                               |            | 0.00%                              |
| Elections   |                               |            | 3.88%                              |
| Dummy Vars  |                               |            | -2.93%                             |
| Other Factors   |                               |            | -0.20%                             |
| Volume in FY 2019   |                               |            | 9197.906                           |
| Total Change in Volume  |                               |            | -3.15%                             |

## **Marketing Mail Nonprofit High-Density and Saturation Letters**

### **1. Explanatory Variables used in Marketing Mail Nonprofit High-Density and Saturation Letters Equation**

The Marketing Mail Nonprofit High-Density and Saturation letters demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Nonprofit High-Density and Saturation Letters volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR).

#### **(2) Postal Prices**

The Marketing Mail Nonprofit High-Density and Saturation Letters equation contains a price index for the price of Marketing Mail Nonprofit High-Density and Saturation Letters(PC3N\_HS\_L). Prices are entered current only.

#### **(3) Time Trend**

The Marketing Mail High-Density and Saturation Letters equation includes a linear time trend starting in 2017Q2.

#### **(4) Other Variables**

The Marketing Mail Nonprofit High-Density and Saturation Letters equation includes several dummy variables: D2011Q1ON, equal to one since 2011Q1, zero elsewhere; D2015Q3ON, equal to one since 2015Q3, zero elsewhere; and D2017Q2ON, equal to one since 2017Q2, zero elsewhere.

Finally, the Marketing Mail Nonprofit High-Density and Saturation Letters equation includes a set of election and seasonal variables.

## 2. Econometric Demand Equation: Marketing Mail Nonprofit High-Density and Saturation Letters

The effect of these variables on Marketing Mail Nonprofit High-Density and Saturation letters volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: NP High-D/Saturation Letters<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 873.245                            |
| Own-Price  | 2.06%                         | -0.804     | -1.63%                             |
| INVR   | 12.05%                        | 0.526      | 6.16%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2017Q2   |                               |            | -32.97%                            |
| Seasonals  |                               |            | 0.00%                              |
| Elections  |                               |            | 11.14%                             |
| Dummy Vars   |                               |            | -29.88%                            |
| Other Factors  |                               |            | 2.55%                              |
| Volume in FY 2019  |                               |            | 513.152                            |
| Total Change in Volume   |                               |            | -41.24%                            |

## **Marketing Mail Nonprofit and ECR Basic Flats**

### **1. Explanatory Variables used in Marketing Mail Nonprofit and ECR Basic Flats Equation**

The Marketing Mail Nonprofit and ECR Basic Flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Marketing Mail Nonprofit and ECR Basic Flats volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR). Investment enters the equation lagged two quarters.

#### **(2) Postal Prices**

The Marketing Mail Nonprofit and ECR Basic Flats equation contains a price index for the price of Marketing Mail Nonprofit and ECR Basic Flats. Prices are entered current only.

#### **(3) Time Trend**

The Marketing Mail Nonprofit and ECR Basic Flats equation includes a full-sample linear time trend.

#### **(4) Other Variables**

The Marketing Mail Nonprofit and ECR Basic Flats equation includes a dummy variable, D2013Q1, which is equal to one in 2013Q1, zero elsewhere, and a dummy variable, D2019Q2ON, which is equal from 2019Q2 forward.

Finally, the Marketing Mail Nonprofit and ECR Basic Flats equation includes a set of seasonal and election variables.

## 2. Econometric Demand Equation: Marketing Mail Nonprofit and ECR Basic Flats

The effect of these variables on Marketing Mail Nonprofit and ECR Basic Flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: Nonprofit and ECR Basic Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |  |
|---|-------------------------------|------------|------------------------------------|--|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |  |
| Volume in FY 2014   |                               |            | 1777.378                           |  |
| Own-Price   | -3.45%                        | -0.463     | 1.64%                              |  |
| INVR(-2)  | 14.35%                        | 0.201      | 2.73%                              |  |
| Adult Population  |                               |            | 5.04%                              |  |
| Trend Starting in:<br>2012Q1  |                               |            | -21.60%                            |  |
| Seasonals   |                               |            | 0.00%                              |  |
| Elections   |                               |            | 9.59%                              |  |
| Dummy Vars  |                               |            | -2.68%                             |  |
| Other Factors   |                               |            | 2.73%                              |  |
| Volume in FY 2019   |                               |            | 1674.366                           |  |
| Total Change in Volume  |                               |            | -5.80%                             |  |

## **Marketing Mail Nonprofit High Density and Saturation Flats**

### **1. Explanatory Variables used in Marketing Mail Nonprofit High-Density and Saturation Flats Equation**

The Marketing Mail Nonprofit High-Density and Saturation flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship Marketing Mail Nonprofit High-Density and Saturation Flats volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR).

#### **(2) Postal Prices**

The Marketing Mail Nonprofit High-Density and Saturation Flats equation contains a price index for the price of Marketing Mail Nonprofit High-Density and Saturation Flats (PC3N\_HS\_F). Prices are entered current and lagged one to four quarters.

#### **(3) Other Variables**

The Marketing Mail Nonprofit High-Density and Saturation Flats equation includes three non-seasonal, non-election dummy variables: D2005Q2ON, equal to one from 2005Q2 forward; D2006Q2ON, equal to one from 2006Q2 forward; and D2016Q3ON, equal to one from 2016Q3 forward.

Finally, the Marketing Mail Nonprofit High-Density and Saturation Flats equation includes a set of seasonal and election variables.

## 2. Econometric Demand Equation: Marketing Mail Nonprofit High-Density and Saturation Flats

The effect of these variables on Marketing Mail Nonprofit High-Density and Saturation flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Mail: NP High-D/Saturation Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |         |
|--|-------------------------------|------------|------------------------------------|---------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |         |
| Volume in FY 2014  |                               |            |                                    | 620.673 |
| Own-Price  | -8.76%                        | -0.627     | 5.91%                              |         |
| INVR   | 12.05%                        | 0.117      | 1.33%                              |         |
| Adult Population   |                               |            | 5.04%                              |         |
| Seasonals  |                               |            | -2.40%                             |         |
| Elections  |                               |            | 11.95%                             |         |
| Dummy Vars   |                               |            | -8.91%                             |         |
| Other Factors  |                               |            | -1.80%                             |         |
| Volume in FY 2019  |                               |            |                                    | 683.944 |
| Total Change in Volume   |                               |            |                                    | 10.19%  |

## **Marketing Parcels**

Marketing Parcels encompass all parcel-shaped Marketing Mail.

### **1. Explanatory Variables used in the Marketing Parcels Equation**

The Marketing Parcels demand equation includes the following explanatory variables.

#### **(1) Postal Prices**

The Marketing Parcels demand equation includes a price index for the average price of Marketing Parcels (PC3\_P). Prices are entered current and lagged one to three quarters.

#### **(2) Time Trend**

The Marketing Parcels equation includes a full-sample linear time trend.

#### **(4) Other Variables**

The equation also includes a dummy variable equal, D\_R12, which is equal to one since the implementation of new rates in January 2012 and a dummy variable, D2019Q2ON, which is equal to one from 2019Q2 forward.

Finally, the Marketing Parcels equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Marketing Parcels

The effect of these variables on Marketing Parcels volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Marketing Parcels<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 66.682                             |
| Own-Price   | 4.84%                         | -0.452     | -2.11%                             |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2011Q1  |                               |            | -47.64%                            |
| Seasonals   |                               |            | 0.00%                              |
| Dummy Vars  |                               |            | 9.93%                              |
| Other Factors   |                               |            | -5.03%                             |
| Volume in FY 2019   |                               |            | 37.483                             |
| Total Change in Volume  |                               |            | -43.79%                            |

## **Periodicals Mail**

The Periodicals mail class is available for mail that is sent at regular intervals and contains at least a minimum level of editorial (i.e., non-advertising) content. This type of mail may include magazines, newspapers, journals, and newsletters. The Periodicals Mail class is divided into four subclasses, Periodicals Regular and three subclasses which offer preferred rates for certain eligible mailers. In-County Periodicals Mail is open to Periodicals which are sent within the same county as they are printed. Periodicals Nonprofit mail is open to Periodicals sent by qualified not-for-profit organizations. Periodicals Classroom mail is open to Periodicals sent to educational institutions for educational purposes. The latter two of these subclasses are combined within a single demand equation.

### **1. Factors Affecting Demand for Periodicals**

The demand for Periodicals 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 Periodicals 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 the state of the overall economy, the price of periodicals, and the demand for goods which may serve as substitutes for newspapers and magazines.

The Periodicals demand equations include total private employment. Employment has historically worked better econometrically at explaining Periodicals mail volumes than other macro-economic variables tested, including personal disposable income, consumption expenditures, and retail sales.

The price of periodicals is measured by 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 Periodicals mail directly by affecting publishers' decisions over how to deliver their Periodicals. For example, the delivery requirements of many weekly newspapers can be satisfied by either mail or private delivery.

The Periodicals demand equations used here also include long-run time trends. These trends are the result of long-run shifts away from reading. In addition to the full-sample linear time trend, an additional negative trend is also included in the Periodical Regular demand equation to account for more recent declines in Periodicals Mail volume due to increased substitution faced by Periodicals from the Internet, mobile devices, and e-readers.

## **Periodical Regular Mail**

### **1. Explanatory Variables used in Periodical Regular Mail Equation**

The Periodical Regular Mail demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between Periodical Regular Mail and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the Periodicals Regular Mail equation. Employment enters the Periodical Regular Mail equation lagged one quarter.

#### **(2) Postal Prices**

The Periodical Regular Mail demand equation includes a price index measuring the average price of Periodicals Regular Mail (PC2R). Prices are entered current and lagged one quarter.

#### **(3) Time Trends**

The Periodical Regular Mail demand equation includes a full-sample linear time trend and a second linear time trend starting in 2011Q2. The combined effect of these two trends translates into a current annual trend of approximately -7.1 percent.

#### (4) Non-Linear Intervention Variable

The Periodical Regular Mail demand equation includes a non-linear intervention variable that starts in 2007Q4 and takes the following form:

$$\ln(\text{Vol})_t = a + \dots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \dots) + \omega_2 \cdot S_t + \dots$$

where  $P_t$  is a pulse function and  $S_t$  is a step function, so that  $P_t = 1$  if  $t=2007Q4$  and 0 otherwise;  $S_t = 1$  if  $t > 2007Q4$  and 0 otherwise. This variable has an initial value in 2007Q4 of  $\omega_0$ , which decays toward a long-run value of  $\omega_2$ .

#### (5) Other Variables

Finally, the Periodical regular mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Periodical Regular Mail

The effect of these variables on Periodical Regular mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Periodical Regular Mail<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 4024.397                           |
| Own-Price   | -2.98%                        | -0.170     | 0.52%                              |
| EMPLOY(-1)  | 5.10%                         | 1.110      | 5.68%                              |
| Adult Population  |                               |            | 5.04%                              |
| Trends Starting in:   |                               |            |                                    |
| 2000Q1  |                               |            | -9.99%                             |
| 2011Q2  |                               |            | -23.13%                            |
| 2007Q4  |                               |            | -0.11%                             |
| Seasonals   |                               |            | 1.44%                              |
| Dummy Vars  |                               |            | -7.62%                             |
| Other Factors   |                               |            | -0.16%                             |
| Volume in FY 2019   |                               |            | 2903.543                           |
| Total Change in Volume  |                               |            | -27.85%                            |

## **Periodicals Nonprofit and Classroom**

A single demand equation is estimated for Periodicals Nonprofit and Classroom mail.

### **1. Explanatory Variables used in Periodicals Nonprofit and Classroom Mail Equation**

The Periodicals Nonprofit and Classroom Mail demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between Periodicals Nonprofit and Classroom Mail and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the Periodicals Nonprofit and Classroom Mail equation.

Employment enters the Periodicals Nonprofit and Classroom Mail equation lagged four quarters.

#### **(2) Postal Prices**

The Periodicals Nonprofit and Classroom Mail demand equation includes a price index measuring the average price of Periodicals Nonprofit and Classroom Mail (PC12\_13). Prices are entered current and lagged one to four quarters.

#### **(3) Time Trend**

The Periodicals Nonprofit and Classroom Mail demand equation includes a full-sample linear time trend.

#### **(4) Other Variables**

The Periodicals Nonprofit and Classroom Mail demand equation includes three non-seasonal dummy variables: D2016Q3ON, which is equal to one from 2016Q3 forward;

D2018Q2, which is equal to one in 2018Q2, zero elsewhere; and D2018Q3, which is equal to one in 2018Q3, zero elsewhere.

Finally, the Periodicals Nonprofit and Classroom Mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Periodicals Nonprofit and Classroom Mail

The effect of these variables on Periodicals Nonprofit and Classroom Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Periodical Nonprofit & Classroom<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 1434.187                           |
| Own-Price  | -1.86%                        | -0.219     | 0.41%                              |
| EMPLOY(-4)   | 5.07%                         | 0.491      | 2.46%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2000Q1   |                               |            | -16.55%                            |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | -5.28%                             |
| Other Factors  |                               |            | 0.53%                              |
| Volume in FY 2019  |                               |            | 1231.762                           |
| Total Change in Volume   |                               |            | -14.11%                            |

## **Periodicals Within-County**

### **1. Explanatory Variables used in Periodicals Within-County Mail Equation**

The Periodicals Within-County Mail demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between Periodicals Within-County Mail and the general economy is modeled through the inclusion of private employment (EMPLOY) as an explanatory variable in the Periodicals Within-County Mail equation.

#### **(2) Postal Prices**

The Periodicals Within-County Mail demand equation includes a price index measuring the average price of Periodicals Within-County Mail (PC11). Prices are entered current only.

#### **(3) Time Trend**

The Periodicals Within-County Mail demand equation includes a full-sample linear time trend.

#### **(4) Other Variables**

The Periodicals Within-County Mail equation includes one dummy variable: D2016Q4\_17Q1, which is equal to one in 2016Q4 and 2017Q1, and is equal to zero both before and after this time period.

The Periodicals Within-County Mail equation also includes a set of seasonal variables.

## 2. Econometric Demand Equation: Periodicals Within-County Mail

The effect of these variables on Periodicals Within-County Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Periodical Within-County<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 586.130                            |
| Own-Price  | -3.79%                        | -0.230     | 0.89%                              |
| EMPLOY   | 4.98%                         | 0.909      | 4.52%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2008Q1   |                               |            | -24.20%                            |
| Seasonals<br>Dummy Vars  |                               |            | 0.00%<br>0.00%                     |
| Other Factors  |                               |            | 1.46%                              |
| Volume in FY 2019  |                               |            | 499.313                            |
| Total Change in Volume   |                               |            | -14.81%                            |

### **Package Delivery Services**

Package delivery services refer broadly to the delivery of goods other than Periodicals, advertisements, and correspondence. Examples of this type of mail include mail-order deliveries such as clothes or books, as well as packages sent by households (e.g., Christmas presents). Among market-dominant mail categories, this encompasses Marketing parcels, which were discussed earlier, and the Package Services mail class.

The demand for package delivery services will be largely driven by the demand for the goods being delivered. In the cases of most package delivery services, this relationship is modeled through the inclusion of e-commerce sales as an explanatory variable.

Most Package Delivery Services face significant competition from other delivery firms, including United Parcel Service and Federal Express. Because of this, most categories of mail that can best be described as Package Delivery Services are classified as competitive mail products and are not included as part of this report.

As of January 2019, there were four market-dominant subclasses of mail in the Package Services class: Alaska Bypass, Bound Printed Matter (BPM) Flats, BPM Parcels, and Media and Library Rate Mail.

The specific demand equations for Market-Dominant Package Delivery Services are presented in more detail below.

## **Alaska Bypass**

### **1. Explanatory Variables used in the Alaska Bypass Equation**

The Alaska Bypass demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Alaska Non-Farm Employment**

The relationship between Alaska Bypass volume and the economy is modeled through the inclusion of Alaska non-farm employment (EMPL\_AK) as an explanatory variable in the Alaska Bypass demand equation.

#### **(2) Postal Prices**

The Alaska Bypass demand equation includes a price index for the average price of Alaska Bypass (PC25\_AB). Prices are entered current only.

#### **(3) Time Trend**

The Alaska Bypass equation includes a linear time trend starting in 2018Q1.

#### **(4) Other Variables**

Finally, the Alaska Bypass equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Alaska Bypass

The effect of these variables on Alaska Bypass volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Alaska Bypass<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 1.290                              |
| Own-Price   | -3.66%                        | -0.287     | 1.08%                              |
| EMPL_AK   | -6.81%                        | 0.625      | -4.31%                             |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2018Q1  |                               |            | -3.93%                             |
| Seasonals   |                               |            | 0.00%                              |
| Other Factors   |                               |            | 1.17%                              |
| Volume in FY 2019   |                               |            | 1.274                              |
| Total Change in Volume  |                               |            | -1.25%                             |

## **Bound Printed Matter Flats**

Bound Printed Matter refers to any mail that is bound and printed and weighs up to fifteen pounds. Generally, Bound Printed Matter Flats consist primarily of heavy catalogs and can be thought of as a heavier version of Marketing Mail Commercial Flats.

### **1. Explanatory Variables used in Bound Printed Matter Flats Equation**

The Bound Printed Matter Flats demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Investment**

The relationship between Bound Printed Matter Flats volume and the general economy is modeled through the inclusion of gross private domestic investment (INVR).

#### **(2) Postal Prices**

The Bound Printed Matter Flats equation includes a price index measuring the average price of Bound Printed Matter Flats (PC28\_F). Prices are entered current and lagged one to two quarters.

#### **(3) Time Trend**

The Bound Printed Matter Flats equation includes a linear time trend starting in 2017Q3.

#### **(4) Other Variables**

The Bound Printed Matter Flats equation includes a dummy variable, D2016Q1, which is equal to one in 2016Q1, zero elsewhere.

Finally, the Bound Printed Matter Flats equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Bound Printed Matter Flats

The effect of these variables on Bound Printed Matter Flats volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Bound Printed Matter Flats<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 249.745                            |
| Own-Price  | -5.32%                        | -0.569     | 3.16%                              |
| INVR   | 12.05%                        | 0.775      | 9.22%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2017Q3   |                               |            | -9.82%                             |
| Seasonals  |                               |            | -4.56%                             |
| Dummy Vars   |                               |            | 0.00%                              |
| Other Factors  |                               |            | -0.01%                             |
| Volume in FY 2019  |                               |            | 254.368                            |
| Total Change in Volume   |                               |            | 1.85%                              |

## **Bound Printed Matter Parcels**

Bound Printed Matters Parcels are packages containing bound, printed material that weigh up to 15 pounds and are not flat-shaped. Bound Printed Matter Parcels are primarily books.

### **1. Explanatory Variables used in Bound Printed Matter Parcels Equation**

The Bound Printed Matter Parcels demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: E-Commerce**

The relationship between Bound Printed Matter Parcels volume and the general economy is modeled by including e-commerce retail sales (ECOMM) in the Bound Printed Matter Parcels demand equation.

#### **(2) Postal Prices**

The Bound Printed Matter Parcels equation includes a price index measuring the average price of Bound Printed Matter Parcels (PC28\_P). Prices are entered current only.

#### **(3) Time Trend**

The Bound Printed Matter Parcels equation includes a full-sample linear time trend.

#### **(4) Non-Linear Intervention Variable**

The Bound Printed Matter Parcels equation includes a non-linear intervention variable that starts in 2014Q3 and takes the form of an s-curve, i.e.,

$$\ln(\text{Vol}_t) = a + \dots + z_1 \cdot d_t / (1 + z_2 \cdot \exp(-z_3 \cdot t_t)) + \dots$$

where  $d_t$  is a dummy variable equal to one starting at 2014Q3 and is one thereafter, and  $t_t$  is a time trend, equal to zero through 2014Q3, increasing by one each quarter thereafter. This variable has an initial value in 2014Q3 of  $z_1/(1+z_2)$  and gradually attenuates to its ceiling value,  $z_1$ . The parameter  $z_3$  controls the rate of attenuation.

### (5) Other Variables

Finally, the Bound Printed Matter Parcels equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Bound Printed Matter Parcels

The effect of these variables on Bound Printed Matter Parcels volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Bound Printed Matter Parcels<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 211.977                            |
| Own-Price  | -3.52%                        | -0.926     | 3.38%                              |
| ECOMM  | 74.63%                        | 0.403      | 25.16%                             |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2008Q1   |                               |            | -41.99%                            |
| S-Curve Starting in:<br>2014Q3   |                               |            | 71.66%                             |
| Seasonals  |                               |            | 0.00%                              |
| Other Factors  |                               |            | -0.34%                             |
| Volume in FY 2019  |                               |            | 285.933                            |
| Total Change in Volume   |                               |            | 34.89%                             |

## **Media and Library Rate Mail**

The Media Mail subclass is reserved for books, tapes, and CDs. The Library Rate subclass is a preferred subclass, generally corresponding to the Media Mail subclass, available to libraries and certain other institutions. A single demand equation is estimated for the combined volume of Media Mail and Library Rate mail.

### **1. Explanatory Variables used in Media and Library Rate Mail Equation**

The Media and Library Rate Mail demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: E-Commerce**

The relationship between Media and Library Rate Mail volume and the general economy is modeled by including e-commerce retail sales (ECOMM) in the Media and Library Rate Mail demand equation.

#### **(2) Postal Prices**

The Media and Library Rate mail equation includes the price of Media and Library Rate Mail (PC29\_30). Prices are entered current and lagged one to four quarters.

#### **(3) Time Trends**

While the growth of e-commerce vis-à-vis traditional retail sales has had a positive impact on Media and Library Rate mail volume, the Internet has also had a negative impact on Media mail volume by providing an alternative delivery source for such items as music, videos, and computer software. This negative impact has increased with the increasing availability of higher-speed Internet connections which have made it quicker and easier to download these types of things instead of having them delivered through the mail.

The Media and Library Rate mail demand equation includes two linear time trends to model this negative diversion, a full sample linear time trend (starting in 2003Q1) and a second time trend starting in 2011Q1. The latter of these trends may also be picking up ongoing negative influences of the Great Recession as well as the increasing use of mobile devices such as smartphones on Media and Library Rate mail volumes.

The Media and Library Rate mail demand equation includes a third time trend, which starts in 2015Q4. The coefficient on this third time trend is positive and may reflect an attenuation in the rate of diversion of this type of content and/or increases in sales of this type of product which are inadequately captured by the e-commerce retail sales variable.

The combined effect of these three trends translates into a current annual trend of approximately -3.9 percent.

#### **(4) Other Variables**

The Media and Library Rate Mail equation includes one dummy variable: D2010Q1, equal to one in 2010Q1, zero elsewhere, and a set of seasonal variables.

## 2. Econometric Demand Equation: Media and Library Rate Mail

The effect of these variables on Media and Library Rate Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Media and Library Rate<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 84.542                             |
| Own-Price  | -0.11%                        | -0.621     | 0.07%                              |
| ECOMM  | 74.63%                        | 0.388      | 24.16%                             |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2003Q1   |                               |            | -42.27%                            |
| 2011Q1   |                               |            | -14.16%                            |
| 2015Q4   |                               |            | 47.57%                             |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | 0.00%                              |
| Other Factors  |                               |            | -0.69%                             |
| Volume in FY 2019  |                               |            | 80.122                             |
| Total Change in Volume   |                               |            | -5.23%                             |

## **Free Mail Services**

There are two mail categories for which mail is free to the sender: Postal Penalty Mail, mail sent by the Postal Service; and Free-for-the-Blind Mail, which is free for blind or handicapped consumers. Because these mail categories are free, Postal prices are not included as explanatory variables in these equations. The specific demand equations used to model Postal Penalty and Free-for-the-Blind mail volumes are outlined below.

### **Postal Penalty Mail**

#### **1. Explanatory Variables used in the Postal Penalty Mail Equation**

The Postal Penalty mail demand equation models Postal Penalty mail volume per adult per day as a function of the following explanatory variables.

The Postal Penalty equation includes a full sample linear time trend (starting in 2011Q3). The Postal Penalty equation includes a dummy variable, D2013Q4, equal to one in 2013Q4, zero elsewhere, and a set of seasonal variables.

## 2. Econometric Demand Equation: Postal Penalty

The effect of these variables on Postal Penalty Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Postal Penalty<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 439.092                            |
| Adult Population   |                               |            | 5.04%                              |
| Trend Starting in:<br>2011Q3   |                               |            | -20.54%                            |
| Seasonals  |                               |            | -18.37%                            |
| Dummy Vars   |                               |            | 0.00%                              |
| Other Factors  |                               |            | -4.88%                             |
| Volume in FY 2019  |                               |            | 284.578                            |
| Total Change in Volume   |                               |            | -35.19%                            |

## **Free-for-the-Blind and Handicapped Mail**

### **1. Explanatory Variables used in the Free-for-the-Blind Mail Equation**

The Free-for-the-Blind Mail demand equation models Free-for-the-Blind mail volume per adult per day as a function of the following explanatory variables.

The Free-for-the-Blind demand equation includes a full-sample linear time trend (starting in 2005Q1) and a second time trend starting in 2009Q1.

### **2. Econometric Demand Equation: Free-for-the-Blind Mail**

The effect of these variables on Free-for-the-Blind Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Free-for-the-Blind<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 45.992                             |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2004Q4   |                               |            | -18.77%                            |
| 2009Q1   |                               |            | -12.90%                            |
| Seasonals  |                               |            | 0.00%                              |
| Other Factors  |                               |            | -0.21%                             |
| Volume in FY 2019  |                               |            | 34.109                             |
| Total Change in Volume   |                               |            | -25.84%                            |

## **Ancillary and Special Services**

### **1. General Overview**

Ancillary services are not mail volumes but represent add-ons to mail volumes. That is, a certified letter would be counted as both a piece of Certified Mail as well as a First-Class Letter. Therefore, the volumes of ancillary services are not included in a calculation of total Postal Service volume.

Because ancillary services are add-ons to existing mail volumes, the demand for ancillary services may be affected directly by the demand for complementary categories of mail. For example, the volume of Stamped Envelopes is modeled in part as a function of the volume of First-Class Single-Piece Letters since all Stamped Envelopes are, in fact, First-Class Single-Piece Letters.

Special services are not add-ons to mail volumes but represent separate volume. Special service volumes are not generally viewed as “mail” volume *per se*. Econometric demand equations are estimated for two special services: Money Orders and Post Office Boxes.

The ancillary and 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 most of these services.

Finally, the demand for ancillary and special services is also a function of the price charged by the Postal Service for these services. In addition, most of the ancillary and special service equations also include some equation-specific variables, which are described below.

Specific demand equations for ancillary and special services are described in detail below.

## **Registered Mail**

### **1. Explanatory Variables used in Registered Mail Equation**

The Registered Mail demand equation includes the following explanatory variables.

#### **(1) Postal Prices**

The Registered Mail equation includes a price index measuring the average price of Registered Mail (PC35). Prices are entered current and lagged one to four quarters.

#### **(3) Time Trends**

The Registered Mail equation includes a full-sample linear time trend and a second linear time trend starting in 2017Q3. The combined effect of these two trends translates into a current annual trend of approximately -13.1 percent.

#### **(4) Other Variables**

The Registered Mail equation contains two non-seasonal dummy variables: D2015Q3, equal to one in 2015Q3, zero elsewhere; and D2015Q4, equal to one in 2015Q4, zero elsewhere. The Registered Mail equation also includes a set of seasonal variables.

## 2. Econometric Demand Equation: Registered Mail

The effect of these variables on Registered Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Registered<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 2.333                              |
| Own-Price  | -1.98%                        | -1.035     | 2.09%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2002Q1   |                               |            | -28.28%                            |
| 2017Q3   |                               |            | -14.60%                            |
| Seasonals  |                               |            | 0.00%                              |
| Dummy Vars   |                               |            | 0.00%                              |
| Other Factors  |                               |            | -5.59%                             |
| Volume in FY 2019  |                               |            | 1.447                              |
| Total Change in Volume   |                               |            | -37.99%                            |

## **Insured Mail**

### **1. Explanatory Variables used in Insured Mail Equation**

The Insured Mail demand equation includes the following explanatory variables.

#### **(1) Postal Prices**

The Insured Mail equation includes a price index measuring the average price of Insured Mail (PC36). Prices are entered current and lagged one to four quarters.

#### **(2) Time Trend**

The Insured Mail equation includes a full-sample linear time trend.

#### **(3) Other Variables**

The Insured Mail equation includes three dummy variables: D\_FREEINS, which is set equal to one since the introduction of free insurance attached to Priority Mail, in the fourth Postal Quarter of FY 2013; D2015Q4, equal to one in 2015Q4, zero elsewhere; and D2018Q1ON, which is equal to one since 2018Q1.

Finally, the Insured Mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Insured Mail

The effect of these variables on Insured Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Insurance<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 19.634                             |
| Own-Price   | -5.78%                        | -0.700     | 4.25%                              |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2008Q1                                    |                               |            | -45.61%                            |
| Seasonals   |                               |            | 0.00%                              |
| Dummy Vars  |                               |            | 17.84%                             |
| Other Factors   |                               |            | 4.12%                              |
| Volume in FY 2019   |                               |            | 14.348                             |
| Total Change in Volume  |                               |            | -26.92%                            |

## **Certified Mail**

### **1. Explanatory Variables used in Certified Mail Equation**

The Certified Mail demand equation includes the following explanatory variables.

#### **(1) Postal Prices**

The Certified Mail equation includes a price index measuring the average price of Certified Mail (PC37). Prices are entered current and lagged one quarter.

#### **(2) Intervention Variable**

The Certified Mail equation includes a non-linear intervention variable starting in 2011Q2 to model significant declines in Certified Mail volume that started around this time. This variable takes the following form:

$$\ln(\text{Vol})_t = a + \dots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \dots) + \omega_2 \cdot S_t + \dots$$

where  $P_t$  is a pulse function and  $S_t$  is a step function, so that  $P_t = 1$  if  $t=2011Q2$  and 0 otherwise;  $S_t = 1$  if  $t > 2011Q2$  and 0 otherwise. This variable has an initial value in 2011Q2 of  $\omega_0$ , which decays toward a long-run value of  $\omega_2$ .

#### **(3) Other Variables**

Finally, the Certified Mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Certified Mail

The effect of these variables on Certified Mail volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Certified<br>VOLUME SINCE FY 2014 |                               |            |                                    |         |
|---|-------------------------------|------------|------------------------------------|---------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |         |
| Volume in FY 2014   |                               |            |                                    | 207.970 |
| Own-Price   | 0.44%                         | -0.531     |                                    | -0.24%  |
| Adult Population  |                               |            |                                    | 5.04%   |
| Intervention Starting in:<br>2011Q2                             |                               |            |                                    | -14.05% |
| Seasonals   |                               |            |                                    | 0.00%   |
| Other Factors   |                               |            |                                    | -0.20%  |
| Volume in FY 2019   |                               |            |                                    | 186.950 |
| Total Change in Volume  |                               |            |                                    | -10.11% |

## Collect-on-Delivery Mail

### 1. Explanatory Variables used in Collect-on-Delivery Mail Equation

The Collect-on-Delivery (COD) Mail demand equation includes the following explanatory variables.

#### (1) Time Trend

The COD Mail demand equation includes a full-sample linear time trend.

#### (2) Other Variables

The COD Mail equation also includes a set of seasonal variables.

### 2. Econometric Demand Equation: Collect-on-Delivery Mail

The effect of these variables on COD volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>COD<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 0.364                              |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2016Q2                              |                               |            | -22.04%                            |
| Seasonals   |                               |            | 0.00%                              |
| Other Factors   |                               |            | 23.57%                             |
| Volume in FY 2019   |                               |            | 0.368                              |
| Total Change in Volume                                    |                               |            | 1.19%                              |

## **Return Receipts**

### **1. Explanatory Variables used in Return Receipts Equation**

The Return Receipts demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between Return Receipts volume and the general economy is modeled through the inclusion of private employment (EMPLOY) in the Return Receipts demand equation.

#### **(2) Certified Mail Volume**

Return Receipts must be attached to Express Mail or one of Certified, Insured, or COD Mail. The vast majority of Return Receipts are attached to Certified Mail. Because of this, the Return Receipts demand equation includes the volume of Certified Mail per adult per day (BGVOL37) as an explanatory variable.

The relationship between Return Receipts volume and Certified Mail volume appears to have shifted since the Great Recession. Two terms are included in the Return Receipts equation to capture this shift:  $BGVOL37*(1-D2012Q4ON)$ , which estimates the relationship between Certified Mail volumes and Return Receipts prior to 2012Q4 and  $BGVOL37*D2012Q4ON$  which estimates the relationship between Certified Mail volumes and Return Receipts since 2012Q4.

#### **(3) Postal Prices**

The Return Receipts demand equation includes a price index measuring the average price of Return Receipts (PC\_RR). Prices are entered current and lagged one to four quarters.

#### (4) Time Trend

The Return Receipts demand equation includes a full-sample linear time trend.

#### (5) Other Variables

The Return Receipts demand equation includes five non-seasonal dummy variables: D\_R07 equal to one since the implementation of R2006-1 rates in May 2007, zero earlier; D\_R11, equal to one since the Postal Service's April 2011, rate change (2011Q3), zero earlier; D2012Q4ON which is equal to one since 2012Q4, zero earlier; D\_R14, equal to one since the Postal Service's January 2014 rate change; and D2016Q3ON, equal to one since 2016Q3, zero earlier.

Finally, the Return Receipts equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Return Receipts

The effect of these variables on Return Receipts volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Return Receipts<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 154.025                            |
| Own-Price   | 2.62%                         | -0.229     | -0.59%                             |
| EMPLOY  | 4.98%                         | 0.628      | 3.10%                              |
| BGVOL37*(1-D2012Q4ON)   | 0.00%                         | 0.804      | 0.00%                              |
| BGVOL37*D2012Q4ON   | -14.43%                       | 0.548      | -8.18%                             |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2016Q3  |                               |            | -8.25%                             |
| Seasonals   |                               |            | 0.00%                              |
| Dummy Vars  |                               |            | -1.99%                             |
| Other Factors   |                               |            | 0.65%                              |
| Volume in FY 2019   |                               |            | 137.806                            |
| Total Change in Volume  |                               |            | -10.53%                            |

## **Stamped Envelopes and Cards**

### **1. Explanatory Variables used in Stamped Envelopes and Cards Equations**

The Postal Service's RPW system only reports revenue for Stamped Envelopes and Cards, not volume. Volume is calculated here by dividing RPW revenue by the average price of Stamped Envelopes and Cards. For Stamped Envelopes and Cards, RPW revenue tends to be highly volatile across quarters. Because of this, the dependent variables in the Stamped Envelopes and Cards equations are the sum of Stamped Envelopes and Cards volume over the previous four quarters (per adult per business day).

Stamped Envelopes and Cards are modeled separately as a function of First-Class Single-Piece Letters and Cards volumes, respectively (BGVOL01SP\_L, BGVOL01SP\_C) and the price of Stamped Envelopes (PC\_SE) and Cards (PC\_SC). The coefficients on volume and price are constrained to be equal to 1 and -1, respectively.

The Stamped Envelopes equation also includes a linear time trend starting in 2016Q2.

The Stamped Cards equation also includes a full-sample time trend.

## 2. Econometric Demand Equation: Stamped Envelopes and Cards

The effect of these variables on Stamped Envelopes and Cards volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Stamped Envelopes<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Volume in FY 2014   |                               |            | 433.653                            |
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Own-Price   | -12.42%                       | -1.000     | 14.18%                             |
| BGVOL01SP_L   | -27.22%                       | 1.000      | -27.22%                            |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2016Q2  |                               |            | 28.92%                             |
| Seasonals   |                               |            | 0.00%                              |
| Other Factors   |                               |            | -3.56%                             |
| Volume in FY 2019   |                               |            | 470.655                            |
| Total Change in Volume  |                               |            | 8.53%                              |

| CONTRIBUTIONS TO CHANGE IN<br>Stamped Cards<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Volume in FY 2014   |                               |            | 142.342                            |
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Own-Price   | -7.22%                        | -1.000     | 7.78%                              |
| BGVOL01SP_C   | -41.96%                       | 1.000      | -41.96%                            |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2012Q4  |                               |            | -37.84%                            |
| Seasonals   |                               |            | 0.00%                              |
| Other Factors   |                               |            | 0.25%                              |
| Volume in FY 2019   |                               |            | 58.290                             |
| Total Change in Volume  |                               |            | -59.05%                            |

## **Money Orders**

### **1. Explanatory Variables used in Money Orders Equation**

The Money Orders demand equation includes the following explanatory variables.

#### **(1) Macro-Economic Variable: Employment**

The relationship between Money Orders volume and the general economy is modeled by including private employment (EMPLOY) in the Money Orders demand equation.

#### **(2) Postal Prices**

The Money Orders equation includes a price index measuring the average price of Money Orders (PC39). Prices are entered current and lagged one quarter.

#### **(3) Time Trends**

Money Orders volume has been declining significantly and consistently since late 2000. The likely cause of this downturn is increasing competition from electronic alternatives to transfer funds, such as pre-paid debit cards and alternate suppliers of money orders.

To account for these factors, the Money Orders equation includes a full sample linear time trend (starting in 2002Q1) and a second linear time trend starting in 2016Q3. The coefficient on the latter of these trends is positive, reflecting an attenuation in the negative Money Orders trend.

The combined effect of these two trends translates into a current annual trend of approximately -5.3 percent.

#### **(4) Other Variables**

Finally, the Money Orders equation includes a set of seasonal variables.



## 2. Econometric Demand Equation: Money Orders

The effect of these variables on Money Orders volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Money Orders<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|--|-------------------------------|------------|------------------------------------|
| Variable   | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014  |                               |            | 97.401                             |
| Own-Price  | -6.77%                        | -0.297     | 2.11%                              |
| EMPLOY   | 4.98%                         | 0.864      | 4.29%                              |
| Adult Population   |                               |            | 5.04%                              |
| Trends Starting in:  |                               |            |                                    |
| 2002Q1   |                               |            | -29.40%                            |
| 2016Q3   |                               |            | 4.73%                              |
| Seasonals  |                               |            | 0.00%                              |
| Other Factors  |                               |            | 0.88%                              |
| Volume in FY 2019  |                               |            | 81.268                             |
| Total Change in Volume   |                               |            | -16.56%                            |

## Post Office Boxes

Historically, the Postal Service's RPW system did not report volumes for Post Office Boxes, only revenues. For this reason, the PO Box volumes that are used as the dependent variable for this equation are imputed by dividing PO Box revenue from the RPW system by a price index for PO Boxes constructed based on billing determinant data.

The Post Office Box equation includes a price index measuring the average price of Post Office Boxes (PC\_PO). Prices are entered current and lagged one quarter. The Post Office Boxes demand equation also includes a full-sample linear time trend.

The effect of these variables on PO Box volume over the past five years is shown in the table below.

| CONTRIBUTIONS TO CHANGE IN<br>Post Office Boxes<br>VOLUME SINCE FY 2014 |                               |            |                                    |
|---|-------------------------------|------------|------------------------------------|
| Variable  | Percent Change<br>In Variable | Elasticity | Effect of<br>Variable on<br>Volume |
| Volume in FY 2014   |                               |            | 12.728                             |
| Own-Price   | 15.96%                        | -0.624     | -8.83%                             |
| Adult Population  |                               |            | 5.04%                              |
| Trend Starting in:<br>2012Q4  |                               |            | -6.69%                             |
| Seasonals   |                               |            | 0.00%                              |
| Other Factors   |                               |            | 0.82%                              |
| Volume in FY 2019   |                               |            | 11.468                             |
| Total Change in Volume  |                               |            | -9.90%                             |