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Productivity at the Post:
its Drivers and its Distribution
Authors
E. Grifell-Tatjé & C. A. K. Lovell

**School of Economics
University of Queensland
St. Lucia, Qld. 4072
Australia**

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E. Grifell-Tatjé

C. A. K. Lovell

Universitat Autònoma de Barcelona

University of Georgia

Abstract

We study the economic, financial and distributional performance of the United States Postal Service subsequent to its 1971 reorganization. We investigate the economic drivers of productivity change (technical change, change in cost efficiency, and scale economies), and the distribution of the financial benefits of productivity change (consumers of postal services, postal employees and other resource suppliers, and residual claimants). We find improvements in technology to have been the main driver of, and diseconomies of scale to have been the main drag on, productivity change. We find labor to have been the main beneficiary, and consumers of postal services the main losers, from postal reorganization.

Corresponding author: C. A. K. Lovell, Department of Economics, University of Georgia, Athens, GA 30602, USA, phone +1 706 542 3689, fax +1 706 542 3376, email knox@terry.uga.edu

Productivity at the Post: its Drivers and its Distribution[*]

1. Introduction

We study the economic, financial and distributional performance of the United States Postal Service (USPS) subsequent to its 1971 reorganization from the Post Office Department (POD) to an independent government agency. The reorganization preserved the monopoly powers originally granted to the POD (the "private express statutes"), as well as the universal service at uniform price requirement, and so the USPS remains a regulated public monopoly. However its operating environment has changed in ways that could not have been foreseen 35 years ago. The population shift to the south and west has stretched its delivery network. Increased competition for overnight and package delivery services has eroded its customer base. New technologies such as facsimile, electronic mail, the internet and automatic bill payment systems have further eroded its customer base. Thus its monopoly powers notwithstanding, the USPS has operated in a rapidly changing market environment constrained (or protected) by an aging regulatory framework. Consequently the relationship between its economic and financial performance is not straightforward.

Although its growth has slowed recently, and even reversed in some dimensions, the USPS remains a very large organization. Its 800,000 employees provide postal services to over 140 million delivery points and generate nearly $70 billion in revenue. In light of its size and its omnipresence, its economic and financial performance is worthy of investigation.

Surprisingly little research has been devoted to the performance of the USPS. Much of what is available is concerned with various reform proposals aimed at improving its performance. These include the potential for revenue cap regulation, the role of the universal service and uniform price obligations, the growth of worksharing and competing forms of communication, and the prospects for partial or complete privatization. The recent President's Commission on the United States Postal Service (2003) has recommended reforms that address some of these issues, and bills are pending in Congress. It is particularly noteworthy that productivity change, surely an essential component of any conception of "performance," has been largely ignored. The USPS does report its productivity performance together with its financial performance in its Annual Reports. However neither the causes nor the financial consequences of productivity change at the USPS have been systematically explored, either in the research community or by the USPS itself.[1]

We have three objectives. The first is to link productivity trends at the USPS with trends in its financial performance. The two need not move together, and the linkage is forged by the relationship between trends in postal rates and input prices. We use this linkage, and data provided by the USPS, to address the second and third objectives. The second objective is to explore the *economic*

drivers of productivity change, which can be identified as change in the efficiency of resource allocation, improvements in technology, and change in the exploitation of scale economies. The third objective is to investigate the *distribution of the financial benefits* of productivity change, which can be associated with consumers of postal services, postal employees and other resource suppliers, and residual claimants.

Our analytical framework is built around a detailed decomposition of year-to-year profit change at the USPS. Similar decompositions have been described by Davis (1955) as "productivity accounting," and used by Jorgenson and Griliches (1967) to provide the basis for primal and dual models of productivity change. Our application to time series data on a single public organization is similar to those of Denny *et al.* (1981), who explore the economic drivers (but not the beneficiaries) of productivity change at Bell Canada, of Salerian (2003), who explores the sources and beneficiaries of productivity change by variable at Australian National Railways, and of Lawrence and Richards (2004), who explore the distribution of the beneficiaries (but not the sources) of productivity growth at a large Australian container terminal. In both respects our framework is in the spirit of the French tradition as exemplified by Puiseux and Bernard (1965), who explore the distributional impacts of productivity change at Electricité de France.

Our analytical framework differs from those used in the studies just cited. We replace the rudimentary index number approach with superlative indicators of price and quantity change. In addition, an exclusive reliance on index numbers permits the identification of the sources and beneficiaries of productivity change *by variable*, but identification of the *economic drivers* of productivity change requires economic analysis. We therefore augment our superlative indicator approach by exploiting the economic theory of production, which enables us to uncover the economic drivers, as well as the distributional consequences, of productivity change at the USPS.

The paper unfolds as follows. Section 2 provides a brief background on reorganization and its consequences for productivity and financial performance at the USPS. The analytical framework we use to identify the drivers and beneficiaries of productivity change is developed in Section 3, where we also describe the empirical technique we use to implement the profit change decomposition. Section 4 provides a description of the USPS data, an aggregate time series of quantities and prices over the period 1963-2004. We describe the results of the empirical analysis in Section 5, where we identify the economic drivers and the distributional consequences of productivity change. Section 6 concludes with a summary of our findings and their implications for postal reform.

2. Background

In the 1960s, over a century after it became a Cabinet-level department, the POD was in economic and financial trouble. With inadequate capital investment and ineffective managerial control in a highly politicized operating environment, it was increasingly incapable of distributing growing volumes of mail through a

growing network. In addition, it was suffering from financial neglect, with high labor costs and subsidized rates that bore little relation to costs. Annual operating losses in excess of a billion current dollars were common.[2]

In April 1967 President Johnson appointed a Commission on Postal Reorganization. In June 1968 the Commission recommended that the POD be reorganized as an independent agency within the executive branch of government, one that would be run like a business, financially self-sustaining and insulated from political pressure. Following protracted negotiations, the POD was transformed into the USPS with the passage of the Postal Reorganization Act (PRA), signed by President Nixon in August 1970. The USPS began operations July 1, 1971 as an independent agency of the executive branch.

The PRA transferred operational authority from Congress to an ostensibly independent regulator, the Postal Rate Commission (PRC). However the authority of the PRC is limited in a number of important ways, with unfortunate consequences.

(a) The PRC cannot set postal rates, but merely recommends rates that can be, and have been, overruled by the USPS Board of Governors. Limited oversight applies not just to rate increases, but also to cross-subsidy from monopolized to competitive mail categories.

(b) The PRA established collective bargaining on wages and working conditions, with binding arbitration, and required postal worker wages and benefits to be comparable to those prevailing in similar occupations in the private sector. However it did not provide the PRC with an enforcement mechanism to ensure comparability, and it is widely believed that labor costs are higher at the USPS than at comparable occupations in the private sector, and that the gap has widened since reorganization.

(c) The USPS is exempt from SEC disclosure requirements, and the PRC is constrained by a lack of subpoena power in its ability to obtain information on USPS operations and finances. It is difficult to regulate in the dark.

(d) The PRA required the USPS to establish a break-even price structure that covers direct and indirect costs attributable to each category of mail, plus a proportion of institutional costs. However in prescient anticipation of future difficulties, the PRA provided for the recovery of operating losses through borrowing from the Department of Treasury's Federal Financing Bank, and through future rate increases. Thus the residual claimant mentioned above is the Federal Financing Bank, which at the end of our study period held $1.8 billion of USPS long-term and short-term debt (down from $11.1 billion two years earlier).

(e) The ultimate residual claimants are the taxpayers. Because the USPS was reorganized but not privatized, it remains a public organization. Consequently taxpayer residual claims are not transferable, and taxpayers have no power to hold management accountable for the economic and financial performance of the USPS.

The PRA did not endow the PRC with sufficient regulatory authority to do its job. Against this background, the President's Commission on the United States Postal Service (2003) recently released a set of reform proposals that address many of the inadequacies mentioned above. The shortcomings of the current regulatory regime and the nature of the reforms proposed by the President's Commission suggest several hypotheses about the economic and financial performance of USPS to date.

Weak PRC influence over labor costs motivates the distributional hypothesis that postal employees have been big winners from reorganization. The PRA break-even mandate requires losers, and the second distributional hypothesis is that weak PRC influence over postal rates has made consumers of postal services big losers. The PRA recommendation that the USPS be "run like a business" leads to a third distributional hypothesis, involving residual claimants, that operating losses have diminished subsequent to reorganization. However the PRA allowed the USPS access to the Federal Financing Bank, which leads to the expectation that losses have not diminished quickly. Whatever the speed, improved financial performance must come from somewhere. A hypothesis concerning the drivers of improved financial performance is that productivity improvements have been the main driving force behind improved financial performance. A corollary to the hypothesis that labor has been a big winner asserts that productivity change has been biased, and that substitution away from labor has occurred, either through improved cost efficiency or through the adoption of new technologies, particularly of the labor saving kind. We explore each of these hypotheses in Section 5.

Productivity has improved since reorganization, although growth rates remain relatively low. Figure 1 tracks the USPS calculation of its cumulative total factor productivity over the period 1963-2004. The annual growth rate has trended upward, improving from 0.04% before reorganization to 0.5% since. USPS productivity was barely 17% higher in 2004 than it was at reorganization in 1972. To put these figures in perspective, in its Annual Reports the USPS benchmarks its productivity performance against that of the US private non-farm business sector, as reported by the Bureau of Labor Statistics (2005, 2006). The BLS reports annual growth rates of multifactor productivity of 1.0% over the period 1963-2004, slowing from 1.7% over the pre-reorganization period to 0.8% over the post-reorganization period. Productivity in the non-farm business sector was 29% higher in 2004 than it was in 1972. However most of the divergence occurred prior to reorganization. Since reorganization, productivity growth at the USPS has been nearly as fast as in the private non-farm business sector.

Insert Figure 1 about here.

These modest but accelerating rates of productivity growth have contributed to a substantial improvement in the bottom line. Table 2 tracks annual operating profit, in current dollars, over the 1963-2004 period. Mean annual operating losses mounted through 1976, bottoming out at $2.6 billion. Losses then

diminished through 1991 and turned to operating profit through most of the period since 1992. Although productivity growth has contributed to the remarkable turnaround in the financial performance of the USPS, it is clear from Figures 1 and 2 that there must be more to the story. Trends in postal rates and resource prices have played an important role as well, as our analysis will demonstrate.

Insert Figure 2 about here.

3. The Analytical Framework

Testing the hypotheses developed in Section 2 requires an analytical framework, which we develop in Sections 3.1 and 3.2, and an estimation procedure, which we develop in Section 3.3. The analytical framework is an extension of that developed by Grifell-Tatjé and Lovell (1999).

3.1 Decomposing Change in Operating Profit

We begin with an expression for operating profit in period t,

$$\pi^t = R^t - C^t = p^t y^t - \Sigma_n w_n^t x_n^t, \tag{1}$$

where π is operating profit, R is revenue, C is cost, p is the price of output y and w_n is the price of input x_n, n=1,…,N.[3]

Operating profit changes through time because quantities change and because prices change. We decompose the change in operating profit between periods t and t+1 into an aggregate quantity effect and an aggregate price effect. We avoid having to choose between base period and comparison period weights by using arithmetic mean price weights ($\bar{p}$ and $\bar{w}_n$) and arithmetic mean quantity weights ($\bar{y}$ and $\bar{x}_n$) to generate

$$\pi^{t+1} - \pi^t = [\,\bar{p}\,(y^{t+1} - y^t) - \Sigma\,\bar{w}_n(x_n^{t+1} - x_n^t)] + [(\,\bar{y}\,(p^{t+1} - p^t) - \Sigma\,\bar{x}_n(w_n^{t+1} - w_n^t)], \tag{2}$$

which decomposes profit change into the contributions of changes in individual quantities and changes in individual prices. Because profit change is expressed in value terms, so is each component. The first term on the right side is an aggregate quantity effect that shows the contribution of 1+N individual quantity changes to profit change, and the second term is an aggregate price effect that shows the contribution of 1+N individual price changes to profit change.[4]

Expression (2) identifies the individual prices and quantities responsible for profit change. It is also useful to identify the beneficiaries of the fruits of productivity change. This can be accomplished by rearranging (2) to obtain

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$$[\,\bar{p}\,(y^{t+1} - y^t) - \Sigma\,\bar{w}_n(x_n^{t+1} - x_n^t)] = (\pi^{t+1} - \pi^t)\ -\ \bar{y}\,(p^{t+1} - p^t) + \Sigma\,\bar{x}_n(w_n^{t+1} - w_n^t). \qquad (3)$$

The left side is the aggregate quantity effect from (2). The right side quantifies the gains or losses of the individual recipients of the benefits of the quantity effect. The recipients are residual claimants who receive the change in operating profit $(\pi^{t+1} - \pi^t)$, consumers of postal services who pay the change in output price, with $p^{t+1} < p^t \Rightarrow [-\,\bar{y}\,(p^{t+1} - p^t)] > 0$, and individual resource suppliers who receive the changes in individual resource prices, with $w_n^{t+1} > w_n^t \Rightarrow \bar{x}_n(w_n^{t+1} - w_n^t) > 0$, n=1,…,N.[5]

3.2 Decomposing the Quantity Effect

The right side of (3) identifies the recipients of the benefits of the quantity effect, and quantifies their receipts. The left side, the quantity effect itself, identifies the agents responsible for the quantity effect, and quantifies their contributions. Both decompositions are based on observed data and superlative indicators. Together they constitute what Davis (1955) called productivity accounting. However decomposing the quantity effect into its economic drivers, as distinct from its responsible agents, requires economic analysis.

T^t and T^{t+1} in Figure 3 are sets of feasible production activities in periods t and t+1, and $L^t(y^t)$, $L^{t+1}(y^t)$ and $L^{t+1}(y^{t+1})$ in Figure 4 are input sets corresponding to T^t and T^{t+1}. In Figure 3 $T^t \subset T^{t+1}$ on the assumption that technical progress has occurred. The same assumption generates $L^t(y^t) \subset L^{t+1}(y^t)$ in Figure 4, in which $L^{t+1}(y^{t+1}) \subset L^{t+1}(y^t)$ on the assumption that $y^{t+1} > y^t$. In both Figures the objective is to decompose the change from (x^t,y^t) to (x^{t+1},y^{t+1}), which when weighted by arithmetic mean prices is the quantity effect on the left side of (3).

In both Figures x_{CE}^t and x_{CE}^{t+1} are cost-efficient input vectors for (y^t,w^t,T^t) and $(y^{t+1},w^{t+1},T^{t+1})$ respectively, that purge x^t and x^{t+1} of cost inefficiency in resource use. In addition, improvements in technology between periods t and t+1 enable cost-efficient input vector x_{CE}^t to be displaced by input vector x_E, which is cost-efficient for (y^t,w^t,T^{t+1}). The three cost minimizing input vectors x_{CE}^t, x_{CE}^{t+1} and x_E are unobserved. Identifying them enables us to identify the contributions to the quantity effect of a change in cost efficiency, by comparing $(x^{t+1} - x_{CE}^{t+1})$ with $(x^t - x_{CE}^t)$; an improvement in technology, represented by $(x_{CE}^t - x_E)$; and the exploitation of scale economies reflected in a movement along the surface of T^{t+1} from (y^t,x_E) to (y^{t+1},x_{CE}^{t+1}). These three sources comprise a productivity effect, which is one component of the aggregate quantity effect on the left side of (3).

Insert Figure 3 about here.

Insert Figure 4 about here.

The quantity effect is often equated with a productivity effect. However this is not necessarily the case, since the quantity effect has a margin component as well as a productivity component, as evidenced by the decomposition

$$\bar{p}\,(y^{t+1} - y^t) - \Sigma\,\bar{w}_n(x_n^{t+1} - x_n^t) \qquad \text{quantity effect}$$

$$= [\,\bar{p}\, - (\Sigma\,\bar{w}_n x_{nCE}^t)/y^t](y^{t+1} - y^t) \qquad \text{margin effect}$$

$$+ (\Sigma\,\bar{w}_n x_{nCE}^t/y^t)(y^{t+1} - y^t) - \Sigma\,\bar{w}_n(x_n^{t+1} - x_n^t) \quad \text{productivity effect} \quad (4)$$

The quantity effect collapses to a productivity effect only if the margin effect is zero. For nonzero output change the margin effect is zero if the margin $[\,\bar{p}\, - (\Sigma\,\bar{w}_n x_{nCE}^t)/y^t] = 0$. The margin effect expresses the simple idea that expansion with a positive margin is profitable, quite independently of any improvement in productivity. The margin effect is expressed in value terms, and weights output change by the margin between arithmetic mean output price and cost-efficient average cost evaluated at arithmetic mean input prices. Expansion with a positive cost-efficient margin $[\,\bar{p}\, - (\Sigma\,\bar{w}_n x_{nCE}^t)/y^t > 0]$ contributes positively to the quantity effect, and hence to profit change. Conversely, a negative cost-efficient margin signals that arithmetic mean output price is insufficient to cover cost-efficient average cost, much less actual average cost, and contraction would reduce losses. We show below that the post-reorganization performance of the USPS illustrates both possibilities.[6]

The productivity effect also is expressed in value terms, as the difference between weighted output change and weighted input change. The weight on output change is cost-efficient average cost. The productivity effect decomposes as

$$\Sigma\,\bar{w}_n(x_{nCE}^t/y^t)(y^{t+1} - y^t) - \Sigma\,\bar{w}_n(x_n^{t+1} - x_n^t) \qquad \text{productivity effect}$$

$$= [\Sigma\,\bar{w}_n(x_n^t - x_{nCE}^t) - \Sigma\,\bar{w}_n(x_n^{t+1} - x_{nCE}^{t+1})] \quad \text{cost efficiency effect}$$

$$+ [\Sigma\,\bar{w}_n(x_{nCE}^t - x_{nE})] \qquad \text{technical change effect}$$

$$+ \Sigma\,\bar{w}_n(x_{nCE}^t/y^t)(y^{t+1} - y^t) - \Sigma\,\bar{w}_n(x_{nCE}^{t+1} - x_{nE}) \qquad \text{scale effect} \quad (5)$$

The cost efficiency effect captures the contribution to the productivity effect of a change in the cost efficiency of resource allocation between periods t and t+1, by comparing the value of $(x^{t+1} - x_{CE}^{t+1})$ with that of $(x^t - x_{CE}^t)$, using arithmetic mean input price weights. A positive cost efficiency effect measures the financial benefits of an improvement in cost efficiency, which contributes positively to the productivity effect and enhances profit change.

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The technical change effect captures the contribution to productivity change of an improvement in technology between periods t and t+1, evaluated with an input-saving orientation at y^t, by comparing the cost of x_{CE}^t on the surface of T^t with that of x_E on the surface of T^{t+1}, again using arithmetic mean input price weights. A positive technical change effect measures the financial benefits of cost-saving technical progress, which contributes positively to the productivity effect and enhances profit change. As Figure 4 indicates, technical change can be biased.

The scale effect corresponds to a movement along the surface of T^{t+1} from (y^t, x_E) to (y^{t+1}, x_{CE}^{t+1}), and captures the contribution of scale economies to the productivity effect. A positive scale effect reflects either expansion in the presence of increasing returns to scale, or contraction in the presence of decreasing returns to scale, either of which contributes positively to the quantity effect and enhances profit change.[7,8]

3.3 Implementing the Decomposition of the Quantity Effect

In decompositions (4) and (5) the output quantity y and the input quantity vector x are observed, as is the input price vector w. However the cost-efficient input quantity vectors x_{CE} and x_E are not observed, and as Figures 3 and 4 suggest they must be retrieved from observed data and the technologies. However because the technologies are unobserved as well, we use a sequential form of data envelopment analysis (DEA) to approximate them. This enables us to solve for the cost-efficient input quantity vectors x_{CE} and x_E.

Since x_{CE}^t is a cost minimizing input vector for (y^t, w^t, T^t), it can be identified as the solution to the linear program

$$\min_x \{w^{tT}x : x \geqq X^t\lambda, \ Y^t\lambda \geqq y^t, \ \lambda \geqq 0, \ \Sigma\lambda = 1\}. \tag{6}$$

In this program the objective is to find an input quantity vector x that minimizes expenditure $w^{tT}x = \Sigma w_n^t x_n^t$ required to produce y^t, provided that (x, y^t) is feasible with T^t. The data matrices Y^t and X^t contain all outputs and inputs observed in periods $\{1,\ldots,t\}$. Thus feasibility of (x, y^t) requires that (x, y^t) belong to the production set $T^t_{DEA} = \{(x, y^t) : x \geqq X^t\lambda, \ Y^t\lambda \geqq y^t, \ \lambda \geqq 0, \ \Sigma\lambda = 1\}$. T^t_{DEA} is the DEA approximation to the unobserved production set T^t. T^t_{DEA} is constructed sequentially, on the assumption that activities adopted in previous years are remembered and remain available for adoption in subsequent years; this assumption rules out technical regress. The convexity constraint $\{\lambda \geqq 0, \ \Sigma\lambda = 1\}$ allows the surface of T^t_{DEA} to satisfy variable returns to scale. The solution to this program is the cost-efficient input quantity vector x_{CE}^t in Figures 3 and 4 and in decompositions (4) and (5).

Since x_E is the solution to the same cost minimizing problem, but using technology T^{t+1}, solving for x_E requires expanding the data matrices to X^{t+1} and Y^{t+1} and retaining w^t and y^t. The solution to this program is the cost-efficient input quantity vector x_E in Figures 3 and 4 and in decompositions (4) and (5).

Once the annual cost-efficient input quantity vectors x_{CE} and x_E are calculated, they are inserted into decomposition (4) to quantify the margin effect and the productivity effect. The sources of productivity change are quantified on the right side of (5), and the beneficiaries of productivity change are quantified on the right side of (3). The input quantity vectors are *identified* using observed input prices, and their effects are *quantified* using arithmetic mean input prices.

4. Data

Our database is a 1963-2004 time series. Although we utilize the entire time series in sequential DEA to construct annual technologies, we restrict our empirical analysis to the post-reorganization period 1972-2004. Thus in our empirical analysis t=1 corresponds to the year 1972, with 1972 technology T^1_{DEA} constructed sequentially from 1963-1972 data, t=2 corresponds to the year 1973, with 1973 technology T^2_{DEA} constructed sequentially from 1963-1973 data, and so on. This enables us to focus on the performance of the USPS, and not that of its predecessor POD.

We divide the post-reorganization period into three decades and a terminal era, inspired by trends in profit depicted in Figure 2. The first, 1972-1982, plumbs the financial depths. The second, 1982-1992, tracks shrinking losses that turned to the first year of operating profit in 1992. The third, 1992-2001, was a generally profitable decade. The terminal era, 2001-2004, begins with the general business slowdown following the 9/11/01 terrorist attacks and the anthrax attacks at post offices, but it also marks the beginning of the term of the current Postmaster General.

With one exception, all variables are contained in an internal database the USPS provided to us. The exception is operating revenue R, which is obtained from USPS annual reports. Operating revenue is expressed in current dollars, and excludes the general public service subsidy and the foregone revenue appropriation because neither reflects revenue from operations. The two excluded items have declined from 18% of total revenue in 1972 to 0.05% of total revenue in 2004.

Total cost C is the sum of expenditures on capital, labor and materials inputs, and also is expressed in current dollars. The operating profit series is defined as $\pi = R - C$ and is depicted in Figure 2.[9]

The output quantity index y is a convex combination of a mail quantity index and a delivery network index, the former incorporating seven mail categories and four miscellaneous services and the latter combining urban and rural delivery points. An output price index is defined as $p = R/y$ and set to unity in 1972, with the output quantity index expressed in 1972 dollars.

Quantity and price indexes for capital, labor and materials are defined in the same way, with input price indexes set to unity in 1972 and input quantity indexes expressed in 1972 dollars. These indexes incorporate seven, 12 and 29 categories, respectively.

The data are summarized in Table 1. Mean operating losses increased by 7.8% annually prior to reorganization, and declined by 10% annually thereafter. The impressive post-reorganization improvement in financial performance is clear from Table 1, as are the trends in individual quantities and prices. However the contributions of these trends to improved financial performance require indicators and analysis. In the next Section we use the analytical framework and estimation procedure developed in Section 3 to quantify the economic drivers and the individual beneficiaries of productivity change.

5. Results

Tables 2 – 4 are based on price and quantity indicators developed in Section 3.1, and convert price and quantity trends summarized in Table 1 into monetary contributions of price and quantity changes to profit change at USPS. Table 5 is based on the analytical framework developed in Sections 3.2 and 3.3, and quantifies the economic drivers of productivity change at USPS.

Table 2 is organized around decomposition (2), which allocates profit change to price change and quantity change. Over the entire post-reorganization period financial performance improved by nearly $120 million annually, despite unfavorable price trends that subtracted nearly $100 million annually from profit change. Prior to 2001, quantity trends made consistently positive and growing contributions to profit change, while price trends deteriorated from small positive contributions to large negative contributions. The trends magnified after 2001. Operating profit increased by nearly $900 million annually, despite a continuing deterioration in the price structure that cost $265 million annually. We explore the very large favorable quantity effect in Table 3.[10]

Table 3 also is organized around decomposition (2), and quantifies the contribution of each variable to quantity change. Prior to 2001, the value of output growth exceeded the value of input growth (obtained by adding the capital, labor and materials quantity effects), generating a positive and growing contribution of the quantity effect to profit change. The situation changed dramatically after 2001. The positive quantity effect magnified, contributing over $1 billion annually to profit change, despite an unprecedented decline in output that reduced operating revenue by more than $250 million annually. A positive quantity effect in the presence of a negative output quantity effect requires a larger negative input quantity effect. Most of the negative input quantity effect can be traced to labor shedding, which reduced operating expense by nearly $1.4 billion annually, and reduction in complementary materials use saved a lesser amount. We explore labor shedding further in Table 5.

It is noteworthy that expansion contributed positively to profit change prior to 2001, and contraction also contributed positively to profit change subsequently.

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Output contraction was brought on by economic stagnation following the events of 2001, and by consumer substitution into alternative forms of communication. However the input contraction that made this output contraction profitable was not guaranteed, and required good management. We refer to this period as one of "managing decline," largely through reductions in the USPS workforce.

Table 4 is organized around decomposition (3), and provides an alternative decomposition of the quantity effect, in an effort to quantify the financial gains of the winners and the financial losses of the losers from reorganization. Throughout the entire post-reorganization period two groups, postal employees and consumers of postal services, dominated the positive and growing quantity effect. Suppliers of materials and, to a lesser extent, suppliers of capital services were modest nominal gainers, with gains of the latter depressed by low interest rates beginning in the 1990s. The Federal Financing Bank was also a modest gainer (if $120 million annually can be called modest), but in the sense that annual operating losses declined and finally turned to operating profit. However all of these gains were dominated, by one and two orders of magnitude, by the gains of postal employees, whose rising compensation drained over $1.3 billion annually from USPS operating profit. These gains were funded by the only losers from postal reorganization, postal customers. The USPS has transferred over $1.3 billion annually from its customers to its employees. However unlike the dramatic changes beginning in 2001 noted in Tables 2 and 3, this redistribution process was impervious to change. The losses incurred by suppliers of capital services expanded, as did the gains accruing to the Federal Financing Bank, but the transfer of more than $1 billion annually from postal customers to postal employees continued despite the downturn. The results of Table 4 confirm and quantify the three distributional hypotheses put forth in Section 2.

Table 5 provides an alternative decomposition of the quantity effect, built around decompositions (4) and (5), both of which augment raw data with economic analysis. The first objective is to quantify the contribution of productivity change to quantity change, and hence to profit change. This is accomplished in the first three columns, which implement decomposition (4) by decomposing the quantity effect into margin and productivity effects. Throughout the entire post-reorganization period the margin effect was extremely small, suggesting that postal rates have approximately covered cost-efficient average cost. However the USPS establishes its own best practice technology, so the benchmark "*cost-efficient average cost*" should be interpreted accordingly.

Throughout the post-reorganization period, the productivity effect has dominated the margin effect by two orders of magnitude. On average, the productivity effect has delivered cost savings of $224 million annually, and its contribution has increased through time. Since 2001 productivity gains have reduced operating expenses by over $1 billion annually.[11] This finding confirms and quantifies the hypothesis that productivity growth has been the main driver of improvement in financial performance.

The productivity effect in Table 5 is cumulated over time in Figure 5. A comparison of the cumulative productivity effect in Figure 5 with the USPS

cumulative total factor productivity index in Figure 1 reveals that the two follow precisely the same pattern throughout the post-reorganization period, with peaks and troughs in the same years. The only difference between the two Figures is the vertical axis, with productivity gains reported in Figure 1 as a cumulative index number and in Figure 5 as a cumulative contribution to the bottom line. We have made no use of the USPS total factor productivity series in our analysis, and we have obtained a productivity effect that behaves in exactly the same way.

Insert Figure 5 about here.

The second objective of Table 5 is to quantify the contributions of the economic drivers of productivity change to profit change. This is accomplished in the final three columns, which implement decomposition (5).

The cost efficiency of resource allocation has not improved since reorganization, and has made virtually no contribution to productivity change, and hence to the bottom line. Again recalling that the USPS establishes its own best practice standards, it is not possible to discern whether this is due to persistent cost efficiency or to persistent resource misallocation. This finding contradicts the hypothesis of improvements in cost efficiency. It is, however, a predictable consequence of the limited ability of the PRC to regulate prices, which in turn offers the USPS little incentive to control costs.

The sole driver of productivity change has been technical progress, which has delivered cost savings of nearly $350 million annually, and the value of these savings has increased through time. Technical progress has taken (at least) two forms, although it is not possible to disentangle their separate impacts. One is continuing improvements in mail sorting and service delivery technologies, and the other is worksharing. The introduction of new technologies is well documented by the USPS (2003) and in its annual reports, and Cohen *et al.* (2004b) explore the impacts of worksharing. Technical progress has been strongly biased in a labor-saving direction. The ratio (x_{LE}/x_{KE}) declined by 68% and the ratio (x_{LE}/x_{ME}) declined by 50% during the period, and the former trend accelerated after 2001. One of the reasons managing decline was profitable is that it involved labor shedding. The findings that technical progress has been the main driver of productivity change, and that it has been biased in a labor-saving direction, confirm and quantify the hypotheses developed in Section 2.

The scale effect acted as a drag on productivity growth prior to 2001. The consistently large negative scale effect is a consequence of expansion in the presence of decreasing returns to scale. The implied magnitude of returns to scale is actually very close to zero, with a 1972 - 2001 mean value of –0.005 (and standard deviation of 0.011), and exhibits no trend whatsoever. Nonetheless expansion prior to 2001 in the presence of very slight decreasing returns to scale generated a large negative scale effect that depressed productivity change and hence profit change. Once again, however, the situation changed after 2001, when contraction in the presence of mildly decreasing returns to scale generated a large positive scale effect that enhanced productivity

change and hence profit change.[12] One of the reasons managing decline was profitable is that it exploited the structure of technology. This finding is unexpected.

Table 5 quantifies the financial contributions of the drivers of productivity change. A central message is that, in a large organization, small rates of change convert to large monetary values. This is especially true for the technical change and scale effects. Prior to 2001, productivity growth averaged 0.5% annually, the result of a slightly faster rate of technical progress partly offset by expansion in the presence of slightly decreasing returns to scale. These small rates of change contributed approximately $135 million in annual cost savings. Subsequent to 2001 productivity growth increased to 1.7% annually, the result of a slightly slower rate of technical progress augmented by contraction in the presence of slightly decreasing returns to scale. These larger rates of change contributed over $1 billion in annual cost savings. Figure 5 shows that productivity growth has contributed over $7 billion to the bottom line since reorganization, most of it since 1999. This lends support to the USPS (2004) claim of $6.1 billion in productivity-related cost savings during the last five years.

6. Conclusions

The Postal Reorganization Act of 1970 sought to make the USPS a self-sustaining public corporation. The USPS has made impressive financial gains, but more than three decades after reorganization it remains in debt to the Federal Financing Bank. In this paper we have explored the sources and the beneficiaries of year-to-year profit change at the USPS. We have exploited an internal database provided by the USPS to conduct our exploration. Identification of the sources and beneficiaries *by variable* requires only the conversion of these data to price and quantity indicators, but identification of the *economic drivers* of profit change requires economic analysis.

At the initial stage of our exploration, we find poor price performance to have exerted an increasingly heavy drag on financial performance. This may reflect an inability of the USPS to contain costs by bargaining effectively with its input suppliers, particularly labor, whose price effect has dominated the input price effect throughout the period. This may also reflect an inability of the USPS to enhance revenue by persuading its regulator to grant rate increases adequate to cover increases in operating cost in a timely manner. In either event, had the USPS been forced by its regulator to maintain price discipline, it would have earned an additional $100 million annually since reorganization.

The dual inability to contain cost and enhance revenue leads to an identification of the primary winners and losers from reorganization. Although price recovery was negative, output price increases were sufficient to generate a large positive output price effect throughout the period, making consumers of postal services consistently large losers. However the output price effect was offset by the labor price effect, making postal employees consistently large winners.

At the second stage of our exploration we apply economic analysis to the database in order to derive an independent measure of productivity change at the USPS and to identify its drivers. This requires decomposing a favorable quantity effect into a margin effect and a productivity effect. We find a small but improving margin effect, suggesting that rates determined by the PRC in the final decade of the period have been sufficient to cover *ostensibly efficient* unit operating cost, if not *actual* unit operating cost.

We also find productivity gains to have been modest but consistently positive, and to have been the primary source of increases in the quantity effect. Productivity gains have not, however, come from improvements in cost efficiency, even as defined by the USPS best practice standards. They have come exclusively from improvements in sorting and delivery technologies that have involved substitution of capital and materials for labor, and from worksharing that has involved substitution of outside labor for USPS labor. However prior to 2001 the productivity gains associated with technical progress have been partly offset by the deleterious consequences of expansion in the presence of mildly decreasing returns to scale.

We offered no hypothesis concerning the post-2001 performance, during which profits increased, despite a continuing poor price performance and despite an unprecedented decline in mail volume. The era of managing decline has been achieved almost exclusively through an equally unprecedented labor shedding, despite a continuing inability of the regulator to maintain price discipline.

Our findings have bearing on recent reform proposals of the President's Commission on the United States Postal Service (2003). Deploring the "inefficiency of its operations and legacy network" and the resulting "billions of dollars in unnecessary costs that should be eliminated rather than passed on to ratepayers," the Commission suggests that the USPS "needs a new business model."

Foremost among the Commission's recommendations is the establishment of a truly independent Postal Regulatory Board having broader powers than those enjoyed by the current PRC. The Board would be responsible for setting postal rate ceilings that rise by less than the rate of inflation, a sort of revenue cap regime. Rate ceilings would in turn motivate downward pressure on employee compensation. This recommendation is consistent with our identification of the price effect as the source of losses at USPS, and also with our identification of employees and consumers as the beneficiaries and victims of lax regulation since reorganization. The post-2001 era of managing decline is consistent with the Commission's belief that the USPS can "grow smaller *and* stronger." If these quantity effects can be sustained, then they would reinforce the price effects recommended by the Commission.

References

Bennet, T. L. (1920), "The Theory of Measurement of Changes in Cost of Living," *Journal of the Royal Statistical Society* 83, 455-62.

Cohen, R., M. Robinson, G. Scarfiglieri, R. Sheehy, V. V. Conandini, J. Waller and S. Xenakis (2004a), "The Role of Scale Economies in the Cost Behavior of Posts," US Postal Rate Commission. www.prc.gov

Cohen, R. H., M. Robinson, R. Sheehy, J. Waller and S. Xenakis (2004b), "Postal Regulation and Worksharing in the U.S.," US Postal Rate Commission. www.prc.gov

Crew, M. A., and P. R. Kleindorfer, eds. (2006), *Progress Toward Liberalization of the Postal and Delivery Sector.* Boston: Springer.

Davis, H. S. (1955), *Productivity Accounting.* Philadelphia: University of Pennsylvania Press.

Denny, M., M. Fuss and L. Waverman (1981), "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries, with an Application to Canadian Telecommunications," in T. G. Cowing and R. Stevenson, eds., *Productivity Measurement in Regulated Industries.* New York: Academic Press.

Diewert, W. E. (2005), "Index Number Theory Using Differences Rather than Ratios," *American Journal of Economics and Sociology* 64:1 (January), 347-95.

Eldor, D., and E. Sudit (1981), "Productivity-based Financial Net Income Analysis," *Omega* 9:6, 605-11.

Geddes, R. (2003), *Saving the Mail.* Washington, DC: The AEI Press.

Geddes, R. R. (2005), "Reform of the U.S. Postal Service," *Journal of Economic Perspectives* 19:3 (Summer), 217-32.

Grifell-Tatjé, E., and C. A. K. Lovell (1999), "Profits and Productivity," *Management Science* 45:9 (September), 1177-93.

Jorgenson, D. W., and Z. Griliches (1967), "The Explanation of Productivity Change," *Review of Economic Studies* 34:3 (July), 249-83.

Lawrence, D., and A. Richards (2004), "Distributing the Gains from Waterfront Productivity Improvements," *Economic Record* 80 (September), S43-S52.

Miller, D. M. (1984), "Profitability = Productivity + Price Recovery," *Harvard Business Review* 62:3 (May/June), 145-53.

President's Commission on the United States Postal Service (2003), *Embracing the Future: Making the Tough Choices to Preserve Universal Mail Service.* http://www.treas.gov/offices/domestic-finance/usps/

Puiseux, L., and P. Bernard (1965), "Les Progrès de Productivité et Leur Utilisation a L'Électricité de France de 1952 a 1962," *Études et Conjoncture* (Janvier), 77-98.

Salerian, J. (2003), "Analysing the Performance of Firms Using a Decomposable Ideal Index Number to Link Profit, Prices and Productivity," *Australian Economic Review* 36:2 (June), 143-55.

US Department of Labor, Bureau of Labor Statistics (2005), "Multifactor Productivity Trends, 2002" http://www.bls.gov/mfp

US Department of Labor, Bureau of Labor Statistics (2006), "Multifactor Productivity Trends, 2003 and 2004" http://www.bls.gov.mfp

United States Postal Service (2003), *The United States Postal Service: An American History, 1775-2002.* Washington, DC: United States Postal Service. http://www.usps.com/cpim/ftp/pubs/pub100.pdf

United States Postal Service (2004), *2004 United States Postal Service Annual Report.* http://www.usps.com/history/anrpt04/

Cumulative Total Factor Productivity, 1963-2004
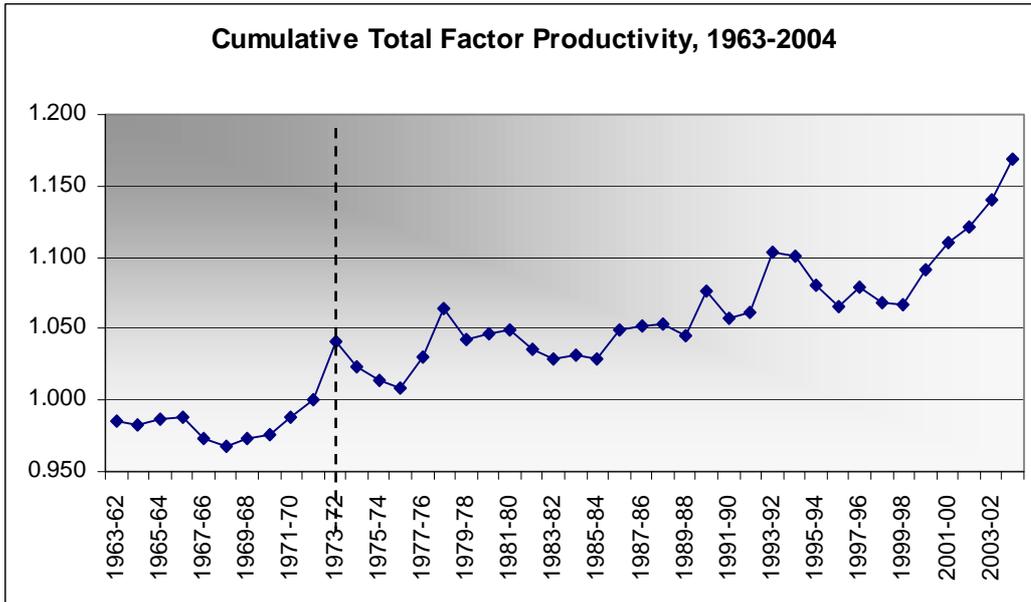
Figure 1. Total Factor Productivity Growth at the USPS

Operating Profit, 1963-2004, $millions
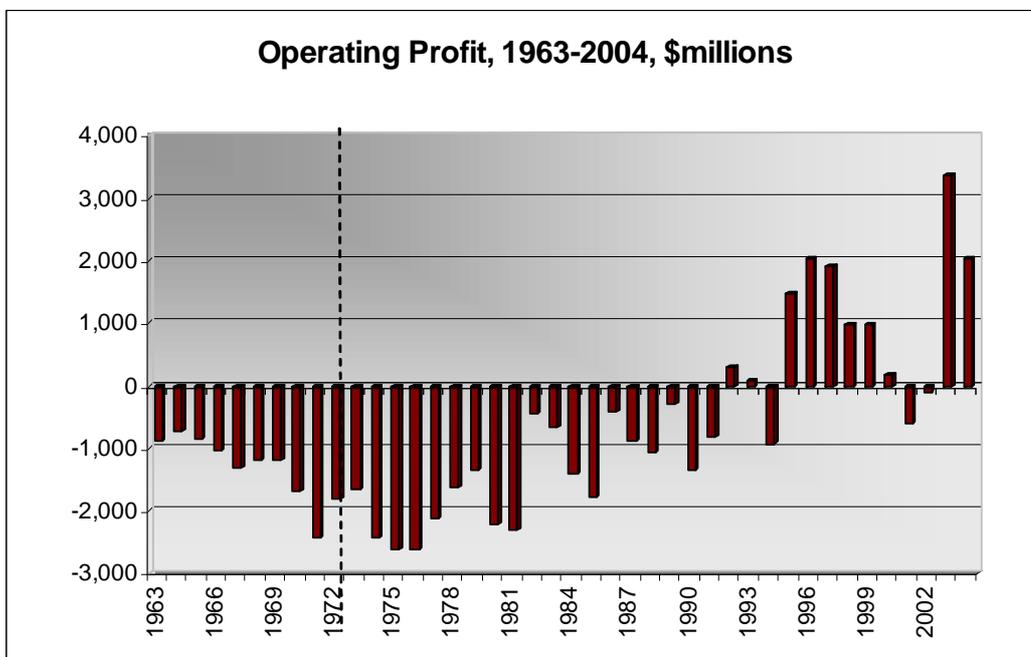
Figure 2. Annual Operating Profit at the USPS
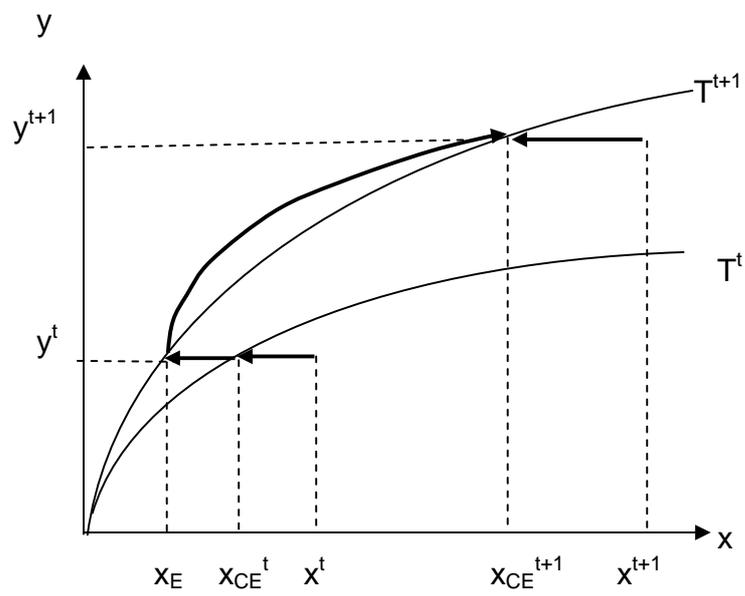
Figure 3. Decomposition of the Productivity Effect I

x_2

$L^{t+1}(y^{t+1})$

$L^t(y^t)$

$\bullet\, x^{t+1}$

$x_{CE}{}^{t+1}$

$L^{t+1}(y^t)$

$x_{CE}{}^t$

$\bullet\, x^t$

w^{t+1}

w^t

x_E

w^t

x_1
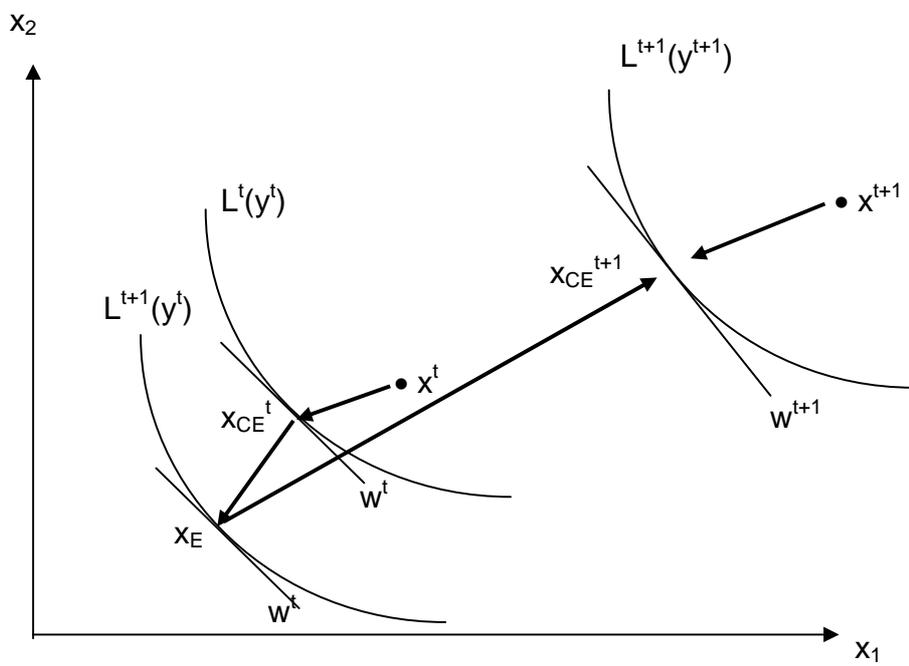
Figure 4. Decomposition of the Productivity Effect II

Cumulative Productivity Effect, 1972-2004, $millions
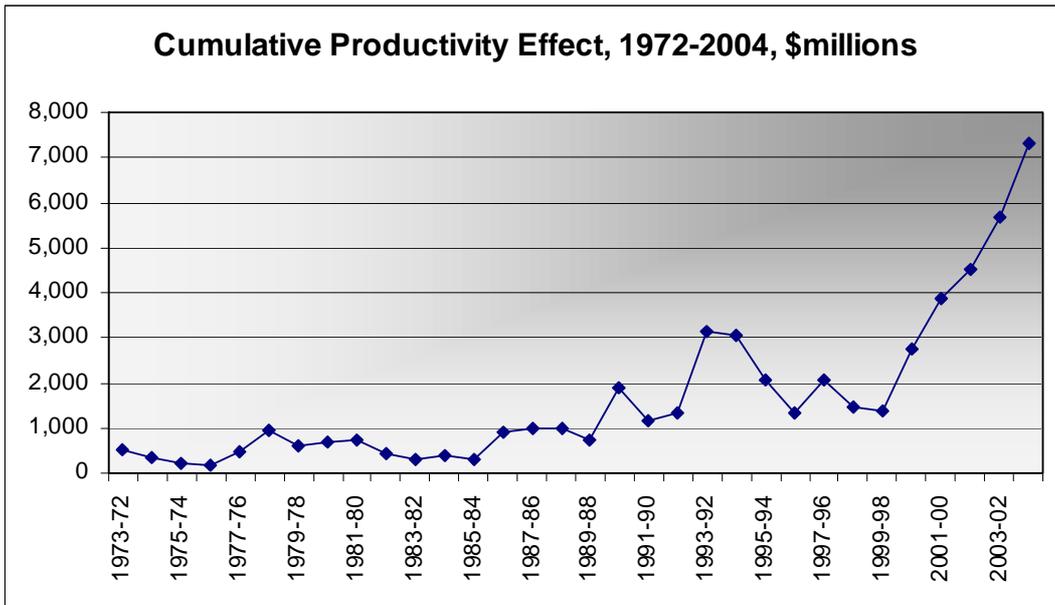
Figure 5. Cumulative Productivity Effect at the USPS

Table 1. Summary Statistics for United States Postal Service, 1963 – 2004[a]

	1963 - 1972	1972 - 1982	1982 - 1992	1992 - 2001	2001 - 2004	1972 - 2004
Mean Operating Profit (current $)	-1,308	-1,918	-799	638	1,176	-548
Growth Rate	-7.8%	13.0%	*b*	*b*	*b*	*b*
Mean Operating Revenues (current $)	5,473	13,506	32,959	56,434	67,410	36,684
Growth Rate	8.0%	9.6%	6.5%	3.5%	1.2%	7.2%
Y Mean Workload (1972 $)	7,362	8,019	9,496	11,495	12,165	9,861
Growth Rate	2.0%	0.3%	2.2%	1.7%	-0.3%	1.5%
p Mean Output Price (1972 = 1.0)	0.737	1.679	3.430	4.892	5.542	3.477
Growth Rate	6.0%	9.3%	4.2%	1.8%	1.5%	5.8%
Mean Cost (current $)	6,781	15,424	33,758	55,797	66,234	37,232
Growth Rate	8.0%	7.9%	6.3%	3.7%	0.2%	6.4%
K Mean Capital Quantity (1972 $)	238	394	543	941	1,307	684
Growth Rate	7.2%	1.9%	5.1%	5.5%	1.7%	4.6%
w_k Mean Capital Price (1972 = 1.0)	0.855	1.509	3.132	3.577	3.169	2.713
Growth Rate	3.0%	9.6%	2.0%	-0.3%	-3.9%	3.6%
L Mean Labor Quantity (1972 $)	7,601	7,846	8,815	9,595	9,300	8,776
Growth Rate	1.9%	-0.2%	1.5%	0.5%	-2.0%	0.4%
w_L Mean Labor Price (1972 = 1.0)	0.707	1.636	3.073	4.551	5.519	3.265
Growth Rate	6.9%	7.8%	4.8%	2.7%	2.4%	5.9%
M Mean Materials Quantity (1972 $)	1,367	1,311	1,809	2,771	3,009	2,043
Growth Rate	0.5%	0.7%	3.9%	3.3%	-0.7%	2.7%
w_M Mean Materials Price (1972 = 1.0)	0.831	1.520	2.583	3.117	3.598	2.483
Growth Rate	3.2%	7.8%	1.8%	2.1%	1.1%	4.4%

(a) Current $ and 1972 $ in millions
(b) Changes in sign.

Table 2. Operating Profit Change Decomposition

Mean Results by Period (millions of current dollars)

Period		Operating Profit Change	=	Bennet Price Indicator	+	Bennet Quantity Indicator
1972 - 1982	*Mean*	136.6		109.1		27.5
	Std. Dev.	765.0		827.8		271.5
1982 - 1992	*Mean*	74.1		10.5		63.6
	Std. Dev.	824.0		1,055.7		496.3
1992 - 2001	*Mean*	-102.0		-398.4		296.4
	Std. Dev.	1,067.8		1,797.7		997.8
2001 - 2004	*Mean*	879.7		-265.4		1,145.1
	Std. Dev.	2,418.6		2,645.5		486.7
1972 - 2004	*Mean*	119.6		-99.5		219.2
	Std. Dev.	1,053.4		1,361.8		685.2

Table 3. Bennet Quantity Indicator Primal Decomposition

Mean Results by Period (millions of current dollars)

Period		Bennet Quantity Indicator	=	Output Quantity	-	Capital Quantity	-	Labor Quantity	-	Material Quantity
1972 - 1982	Mean	27.5		38.6		8.3		-20.6		23.4
	Std. Dev.	271.5		205.3		24.1		185.6		96.2
1982 - 1992	Mean	63.6		730.9		97.3		372.2		197.8
	Std. Dev.	496.3		461.7		41.1		411.0		166.6
1992 - 2001	Mean	296.4		1,035.5		207.5		246.4		285.3
	Std. Dev.	997.8		615.7		67.9		765.9		545.7
2001 - 2004	Mean	1,145.1		-252.7		96.6		-1,387.7		-106.8
	Std. Dev.	486.7		1,103.1		126.4		747.7		45.0
1972 - 2004	Mean	219.2		508.0		100.4		49.1		139.3
	Std. Dev.	685.2		688.7		94.6		702.0		324.4

Table 4. Bennet Quantity Indicator Dual Decomposition

Mean Results by Period (millions of current dollars)

Period		Bennet Quantity Indicator	=	Profit Change	- Output Price	+	Capital Price	+	Labor Price	+	Material Price
1972 - 1982	*Mean*	27.5		136.6	1,433.0		76.7		1,068.4		178.8
	Std. Dev.	271.5		765.0	975.2		83.7		294.5		124.2
1982 - 1992	*Mean*	63.6		74.1	1,624.2		42.8		1,474.7		96.2
	Std. Dev.	496.3		824.0	1,328.2		135.2		686.3		83.1
1992 - 2001	*Mean*	296.4		-102.0	1,144.0		-13.0		1,338.6		216.8
	Std. Dev.	997.8		1,067.8	1,307.8		154.6		909.0		203.3
2001 - 2004	*Mean*	1,145.1		879.7	1,317.0		-219.9		1,649.9		152.5
	Std. Dev.	486.6		2,418.6	1,579.3		196.7		1,112.9		95.8
1972 - 2004	*Mean*	219.2		119.6	1,400.6		13.1		1,325.9		161.2
	Std. Dev.	685.2		1,053.4	1,194.5		151.8		702.7		141.8

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Table 5. Bennet Quantity Indicator Economic Decomposition

Mean Results by Period (millions of current dollars)

Period		Bennet Quantity Indicator	=	Margin Effect	+	Productivity Effect		Productivity Effect				
								Cost Efficiency	+	Technical Change Effect	+	Scale Effect
1972 - 1982	*Mean*	27.5		-5.6		33.1		-39.6		101.1		-28.4
	Std. Dev.	271.5		33.1		291.2		194.4		163.9		189.8
1982 - 1992	*Mean*	63.6		-26.2		89.8		47.6		324.2		-282.0
	Std. Dev.	496.3		24.2		508.0		150.5		368.1		282.1
1992 - 2001	*Mean*	296.4		13.4		282.9		0.0		541.3		-258.3
	Std. Dev.	997.8		22.5		1,008.3		0.0		684.4		656.8
2001 - 2004	Mean	*1,145.1*		10.6		1,134.6		0.0		680.1		454.5
	Std. Dev.	486.7		16.4		480.6		0.0		681.8		202.1
1972 - 2004	*Mean*	*219.2*		-5.2		224.3		2.5		348.9		-127.0
	Std. Dev.	685.2		30.0		689.7		137.0		489.3		442.9

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[1] The USPS (2004) does claim that its 2004 productivity growth "is equivalent to $1.6 billion in expense reductions," without identifying its sources. Much of the available research on USPS and other postal networks is collected in a series of volumes edited by Crew and Kleindorfer, the most recent being Crew and Kleindorfer (2006).

[2] This Section draws on USPS (2003) and Geddes (2003, 2005).

[3] The analytical model has a single output, although it easily generalizes to multiple outputs, as in Grifell-Tatjé and Lovell (1999). We specify a single output because in its internal database the USPS reports a single output quantity index which, when divided into operating revenue, yields an implicit output price index. It also reports a mail quantity index and a delivery point index, and more detailed decompositions of both, but it does not report corresponding implicit price indexes.

[4] Quantity and price *indexes* are expressed in ratio form, and quantity and price *indicators* are expressed in difference form. In (2) the (1+N) components of the aggregate quantity effect are Bennet (1920) quantity indicators, with arithmetic mean price weights $\bar{p} = (½)(p^t + p^{t+1})$ and $\bar{w}_n = (½)(w_n^t + w_n^{t+1})$, and the (1+N) components of the aggregate price effect are Bennet price indicators, with arithmetic mean quantity weights $\bar{y} = (½)(y^t + y^{t+1})$ and $\bar{x}_n = (½)(x_n^t + x_n^{t+1})$. Just as Fisher indexes are geometric means of Laspeyres and Paasche indexes, Bennet indicators are arithmetic means of Laspeyres and Paasche indicators. Diewert (2005) has demonstrated that Bennet quantity and price indicators satisfy a large number of tests analogous to those satisfied by Fisher quantity and price indexes.

[5] Some writers (e.g., Jorgenson and Griliches (1967), Eldor and Sudit (1981) and Lawrence and Richards (2004)) specify $\pi \equiv 0$ by defining the price of capital as a gross return. In this approach $\pi^{t+1} - \pi^t \equiv 0$ in (3), and suppliers of capital services become dual recipients, receiving the cost of capital and serving as residual claimants.

[6] The quantity effect can be expressed equivalently in growth rather than difference form, and decomposed as

$$\bar{p}\, y^t G_y - \Sigma\, \bar{w}_n x_n^t G_{xn} \qquad \text{quantity effect}$$

$$= (\bar{p}y^t - \Sigma\, \bar{w}_n x_{nCE}^t)G_y \qquad \text{margin effect}$$

$$+ (\Sigma\, \bar{w}_n x_{nCE}^t)G_y - (\Sigma\, \bar{w}_n x_n^t)[\Sigma(\bar{w}_n x_n^t / \Sigma\, \bar{w}_n x_n^t)G_{xn}] \quad \text{productivity effect}$$

In the margin effect output growth $G_y = [(y^{t+1}/y^t) - 1]$ is weighted by the difference between total revenue and cost-efficient total cost, using arithmetic mean output and input prices. In the productivity effect output growth is weighted by cost-efficient total cost, and input growth $\Sigma(\bar{w}_n x_n^t / \Sigma\, \bar{w}_n x_n^t)G_{xn}$ is weighted by actual total cost, with both weights using arithmetic mean input prices. The weights convert a conventional productivity growth accounting formula $G_y - \Sigma(\bar{w}_n x_n^t / \Sigma\, \bar{w}_n x_n^t)G_{xn}$ expressed in percentage

terms to one expressed in value terms that shows the cost saving impact of productivity gains.

[7] The productivity effect can be expressed equivalently in growth rather than difference terms, and decomposed as

$$(\Sigma \bar{w}_n x_{nCE}^t) G_y - (\Sigma \bar{w}_n x_n^t)[\Sigma(\bar{w}_n x_n^t / \Sigma \bar{w}_n x_n^t) G_{xn}] \qquad \text{productivity effect}$$

$$= \Sigma \bar{w}_n x_{nCE}^t[(x_n^t - x_{nCE}^t)/x_{nCE}^t] - \Sigma \bar{w}_n x_{nCE}^{t+1}[(x_n^{t+1} - x_{nCE}^{t+1})/x_{nCE}^{t+1}] \quad \text{cost efficiency effect}$$

$$+ \Sigma \bar{w}_n x_{nE}[(x_{nCE}^t - x_{nE})/x_{nE}] \qquad \text{technical change effect}$$

$$+ \Sigma \bar{w}_n x_{nCE}^t G_y - \Sigma \bar{w}_n x_{nE}[\Sigma(\bar{w}_n x_{nE}/\Sigma \bar{w}_n x_{nE})((x_{nCE}^{t+1} - x_{nE})/x_{nE})] \qquad \text{scale effect}$$

The scale effect is a productivity effect, measured net of cost efficiency change and technical change and using cost-efficient input cost shares $\bar{w}_n x_{nE}/\Sigma \bar{w}_n x_{nE}$. It is a pure scale effect evaluated on the surface of T^{t+1}, and signals increasing, constant or decreasing returns to scale according as $G_y \gtreqless \Sigma(\bar{w}_n x_{nE}/\Sigma \bar{w}_n x_{nE}) G_{xn}$. The weights convert a conventional scale economies formula expressed in percentage terms to one expressed in value terms that shows the cost saving impact of the exploitation of scale economies.

[8] The productivity effect is interpreted broadly to include the impact of scale economies as well as the impacts of technical change and efficiency change. This broad interpretation corresponds to the US Bureau of Labor Statistics (2005) definition of multifactor productivity change as being "*…designed to measure the joint influences on economic growth of technical change, efficiency improvements, returns to scale, reallocation of resources, and other factors.*" Expressions (2) and (4) thus state that profit change is attributable to pricing power, a margin effect and productivity change. Apart from the margin effect, this is consistent with the interpretations of Miller (1984) and others in the accounting literature who attribute profit change to productivity change and price recovery change (their terminology for our price effect). Expression (5) converts a standard economic paradigm concerning the sources of productivity change, typically expressed in percentage terms, into a decomposition expressed in value terms.

[9] The USPS reports total operating expense in its Annual Reports. This figure differs from the total cost figure reported in the USPS internal database. For the last five years, the two figures are very close.

	2004	2003	2002	2001	2000
USPS Annual Report	65851	63902	65234	65640	62992
USPS Internal Data	66929	65128	66503	66375	64294
% difference	1.6	1.9	1.9	1.1	2.1

In addition, because we do not include the general public service subsidy or the foregone revenue appropriation, our operating profit series is lower than what USPS reports as net income (loss) in its Annual Reports.

[10] Tables 2-5 report post-reorganization sub-period means and standard deviations. Most standard deviations exceed their means by a wide margin, revealing volatility in the data. For example, stamp prices change by discrete amounts, and at discrete and irregular intervals, which introduces volatility into the output price, revenue and profit series. In addition, volatility causes sub-period results to be sensitive to the specification of terminal years. Annual versions of Tables 2-5 are available on request.