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Productivity at the Post: its Drivers and its Distribution

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Abstract

We study the economic, financial and distributional performance of the United States Postal Service subsequent to its 1971 reorganization. We investigate the economic sources 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 the US Treasury and consumers of postal services the main losers, from postal reorganization.

JEL codes: C60, D24, D33, L32

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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 geographic shift of residential and commercial customers to the south and west has stretched its delivery network. Increased competition from the private sector's overnight and package delivery services has eroded part of its customer base. New technologies such as facsimile, electronic mail, the internet and automatic bill payment systems have captured another part of its customer base. Thus its monopoly powers notwithstanding, the USPS operates 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. It is the eleventh largest US enterprise by revenue, with nearly $70 billion in current revenues, and the second largest domestic employer, with over 800,000 employees. It provides postal services to over 140 million delivery points. It may be the only public organization that interacts with the majority of citizens on a daily basis. In light of its size, its public ownership and its omnipresence, its economic and financial performance is worthy of investigation.

However 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 competing forms of communication, the desirability of continuing the postal monopoly, 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. 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 the causes and consequences, the financial consequences in particular, of productivity change at the USPS have not been systematically explored, either in the research community or by the President's Commission or by the USPS itself.[1]

We have three objectives. The first is to link productivity change at the USPS with change in its financial performance. The linkage is forged by the relationship between postal rate changes and input price changes, or by changes in price recovery. We use this linkage to address the second and third objectives, which are to identify the sources and the beneficiaries of productivity change.

We use data provided by the USPS to address the second and third objectives. The second concerns the *economic sources* of productivity change, which can be identified as technical change, change in the efficiency of resource allocation, and change in the exploitation of scale economies. The third concerns 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," by Kurosawa (1975) as an "absolute value system," and by Eldor and Sudit (1981) as "productivity-based financial net income analysis." Our application to time series data on a single organization is similar to those of Banker *et al*. (1996), who explored the sources and (some of) the beneficiaries of productivity change at "Aluminum Corporation," of Salerian (2003), who explored the sources and beneficiaries of productivity change at Australian National Railways, and of Lawrence and Richards (2004), who explored the distribution of the benefits (but not the sources) of productivity growth at the Australian waterfront. In both respects our framework is in the spirit of the French tradition as exemplified by Puiseux and Bernard (1965,1966), who explored the distributional impacts of productivity change at Electricité de France.

Our analytical framework improves upon and extends the methodologies used in these studies. We update the rudimentary index number approach used in all but the two most recent studies mentioned above, by using superlative indicators of price and quantity change. In addition, an exclusive reliance on index number or indicator techniques, as in all the studies mentioned above, permits the identification of the sources and beneficiaries of productivity change *by variable*. It does not enable the identification of the *economic sources* of productivity change mentioned in the preceding paragraph; this requires economic analysis. Consequently we augment our superlative indicator approach by exploiting the economic theory of production. This enables us to uncover the economic sources, as well as the distributional consequences, of productivity change at the USPS.

The paper unfolds as follows. Section 2 provides a brief historical background on reorganization and its consequences for productivity and financial performance at the USPS. The analytical model we use to identify the sources and beneficiaries of productivity change is developed in Section 3. The empirical technique we use to implement the decomposition, which is sequential cost data envelopment analysis, is also described in Section 3. Section 4 provides a description of the database, which is an aggregate time series of quantities and prices over the period 1963-2002. We describe the results of the empirical analysis in Section 5, where we identify the economic sources and the distributional consequences of productivity change. Section 6 concludes with a summary of our findings and their implications for postal reform.

2. Historical Background

In the 1960s, over a century after it became a Cabinet-level department, the POD was in economic and financial trouble. With its antiquated facilities, inadequate capital investment and ineffective managerial control in a highly politicized operating environment, it was increasingly incapable of distributing growing volumes of mail, and service quality was deteriorating. 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 rejected both the existing political organization and outright privatization, and 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 a public corporation, an independent establishment of the executive branch of government.

The PRA transferred operational authority from Congress to an ostensibly independent regulator, the Postal Rate Commission (PRC), having responsibility for postal rates and mail classifications, although subject to approval by the Postal Service Board of Governors. Thus the PRC does not actually set rates, it merely recommends rates that can be, and have been, overruled by the USPS Board of Governors. In addition, the PRC does not have power to regulate the quality of postal services. Consequently the independence of the PRC is limited; it has no control over quality and little control over cost. As a result, the USPS "postal inflation index," unadjusted for service quality, has increased faster than the core CPI since reorganization, with consequences to be explored below.

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 no mechanism to ensure comparability was established. It is widely believed that labor costs are substantially higher at the USPS than at comparable occupations in the private sector, and the gap has widened since reorganization. The consequences of a lack of comparability, of levels and growth rates, are explored below.

The PRA phased out the general public service subsidy, which the USPS ended earlier than required in 1983, and authorized appropriations to reimburse the USPS for revenue forgone from carrying congressionally established categories of free and reduced-rate mail.

The PRA also required the USPS to establish a break-even price structure that covers direct and indirect costs attributable to each class 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. The PRA also authorized the USPS to borrow from the Federal Financing Bank to finance long-term capital investment. Thus the residual claimant mentioned above is the Federal Financing Bank, which at the end of our study period held $11.1 billion of USPS long-term and short-term debt. The ultimate residual claimants are the taxpayers who, because their claims are not transferable, have no power to hold management accountable for the economic and financial performance of the USPS.

Productivity has improved since reorganization, although growth rates remain relatively low. Figure 1 tracks the USPS calculation of its total factor productivity over the period 1963-2002, indexed to unity in 1972. The annual growth rate has averaged a modest 0.3%, but has trended upward, improving from 0.04% before reorganization to 0.4% since. Thirty years after reorganization, USPS productivity was barely 12% higher than it was 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). For the same periods, the BLS reports annual growth rates of multifactor productivity of 0.9% over the period 1963-2002, slowing from 1.7% over the pre-reorganization period 1963-1971 to 0.7% over the post-reorganization period 1972-2002. Cumulative productivity in the non-farm business sector was 22% higher in 2002 than it was in 1972.

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 1963-2002 period. Mean annual operating losses mounted through 1976, bottoming out at \$2.6 billion. Losses then diminished through 1991, turned to operating profit through most of the 1990s, followed by (relatively) small losses since. Although productivity growth has contributed to improved financial performance at the USPS, it is clear that there must be more to the story. Trends in postal rates and resource prices have played an important role as well, as our decomposition of profit change will demonstrate.

Insert Figure 2 about here.

3. The Analytical Model

3.1 Decomposing Change in Operating Profit

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

$$\pi^t = R^t - C^t = p^t y^t - \Sigma_n w_n^t x_n^t, \qquad (1)$$

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, $(\pi^{t+1} - \pi^t)$, 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 weights to generate

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

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 quantity changes to profit change, and the second term is an aggregate price effect that shows the contribution of price changes to profit change.

The (1+N) components of the aggregate quantity effect are Bennet (1920) quantity indicators, with 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 quantity weights $\bar{y} = (½)(y^t + y^{t+1})$ and $\bar{x}_n = (½)(x_n^t + x_n^{t+1})$. These quantity and price indicators are arithmetic means of Laspeyres and Paasche indicators, expressed in difference rather than ratio form. 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 are superlative indicators that satisfy a large number of tests analogous to those satisfied by Fisher quantity and price indexes.[4]

The expression for profit change can be rearranged in two informative ways. First, as Salerian (2003) and others have noted, managers, regulators and residual claimants may be interested in distinguishing the contributions of price change and quantity change to value change. This can be accomplished by rearranging terms on the right side of (2) to yield

$$\pi^{t+1} - \pi^t = (R^{t+1} - R^t) – (C^{t+1} - C^t)$$

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

The first term on the right side of (3) decomposes revenue change into an output quantity effect and an output price effect, and the second term decomposes cost change into an aggregate input quantity effect and an aggregate input price effect. Since the effects are additive, (3) generates (1+N) individual quantity effects and (1+N) individual price effects, all being expressed in value terms. This rearrangement provides detailed information concerning whether revenue and cost changes are due primarily to quantity changes or to price changes, and which quantities and prices are most responsible.

Second, as Davis (1955), Courbis and Templé (1975) and others have noted, it is useful to be able to identify the beneficiaries of the fruits of productivity change.[5] This can be accomplished by rearranging the expression for profit change to obtain

$$[\bar{p}(y^{t+1} - y^t) – \Sigma\bar{w}_n(x_n^{t+1} - x_n^t)] = (\pi^{t+1} - \pi^t) – \bar{y}(p^{t+1} - p^t) + \Sigma\bar{x}_n(w_n^{t+1} - w_n^t). \quad (4)$$

The left side is the aggregate quantity effect from (2). The terms on the right side identify the individual recipients of the benefits of the quantity effect, and quantify their gains or losses. The recipients are residual claimants in the form of a change in operating profit $(\pi^{t+1} - \pi^t)$, consumers of postal services in the form of a change in output price, with $p^{t+1} < p^t \Rightarrow [-\bar{y}(p^{t+1} - p^t)] > 0$, and individual resource suppliers in the form of 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.[6]

3.2 Decomposing the Quantity Effect

The right side of (4) 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 indicator techniques. However decomposing the quantity effect into its economic sources, as distinct from its responsible agents, requires economic analysis. Figures 3 and 4 provide the framework.

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 in period t a producer uses input vector x^t to produce output y^t, and in period t+1 the producer uses input vector x^{t+1} to produce output y^{t+1}. The objective is to decompose this change, which when weighted by arithmetic mean prices is the quantity effect on the left side of (4).

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 technical and allocative 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, as 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 (4).

Insert Figure 3 about here.

Insert Figure 4 about here.

The quantity effect is often associated with, or defined as, 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

$$\bar{p}(y^{t+1} - y^t) - \Sigma \bar{w}_n(x_n^{t+1} - x_n^t)$$

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

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

Thus the quantity effect collapses to a pure productivity effect only if the margin effect is zero, as Courbis and Templé (1975), Kurosawa (1975), and Genescà and Grifell-Tatjé (1992) have noted. For nonzero output change the margin effect is zero if the margin $[\bar{p} - (\Sigma \bar{w}_n x_{nE})/y^t] = 0$.

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 difference between arithmetic mean output price and a measure of average cost. Since x_E is a cost-efficient input vector for (y^t, w^t, T^{t+1}), the weight applied to output change, $[\bar{p} - \Sigma \bar{w}_n x_{nE})/y^t]$, represents the margin between arithmetic mean output price and efficient average cost evaluated at arithmetic mean input prices. Expansion with a positive efficient margin $[\bar{p} - (\Sigma \bar{w}_n x_{nE})/y^t > 0]$ contributes positively to the quantity effect, and hence to profit change. Conversely, a negative efficient margin signals that arithmetic mean output price is insufficient to cover 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.

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 efficient average cost.[7]

The productivity effect in turn can be decomposed as follows:

$$\Sigma \bar{w}_n(x_{nE}/y^t)(y^{t+1} - y^t) - \Sigma \bar{w}_n(x_n^{t+1} - x_n^t)$$

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

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

$$+ \Sigma \bar{w}_n(x_{nE}/y^t)(y^{t+1} - y^t) - \Sigma \bar{w}_n(x_{nCE}^{t+1} - x_{nE}) \qquad \text{scale effect} \quad (6)$$

Figures 3 and 4 illustrate decomposition (6). The cost efficiency effect is the difference between a pair of Bennet quantity indicators. It 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. In both periods x is the observed input vector and x_{CE} is the input vector that minimizes cost. 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. As Figure 4 indicates, improvements in cost efficiency can be non-radial.

The technical change effect is a Bennet quantity indicator that captures the contribution to productivity change of an improvement in technology between periods t and t+1, evaluated with an input orientation at y^t, by comparing the cost of $x_{CE}{}^t$ on the surface of T^t with that of $x_E{}^t$ 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.[8]

The scale effect is the difference between a pair of Bennet quantity indicators corresponding 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 ($y^{t+1} > y^t$) 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.[9,10]

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), (4) and (5) thus state that profit change is attributable to price recovery change, 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. Expression (6) converts a standard economic paradigm concerning the sources of productivity change, typically expressed in percentage terms, into a decomposition expressed in value terms.

3.3 Implementing the Decomposition of the Quantity Effect

In decompositions (5) and (6) the output quantity y and the input quantity vector $x = (x_1,\ldots,x_N)$ are observed, as is the input price vector $w = (w_1,\ldots,w_N)$. 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 computed from observed data and the technologies T^t. However because the technologies are unobserved as well, we use a sequential form of cost 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

$$\min_x \quad w^{tT}x$$

subject to

$$x \geqq X^t\lambda$$

$$Y^t\lambda \geqq y^t$$

$$\lambda \geqq 0,\ \Sigma\lambda = 1$$

In this program y^t and w^t are observed, and the objective is to find an input quantity vector x that minimizes expenditure $w^{tT}x = \Sigma_n w_n^t x_n$ 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,…,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 best practice 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 the current year; this assumption rules out technical regress. The convexity constraint $\{\lambda \geqq 0, \Sigma\lambda = 1\}$ allows 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 (5) and (6).

Since x_E^t is the solution to the same cost minimizing problem, but using technology T^{t+1}, solving for x_E^t 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^t in Figures 3 and 4 and in decompositions (5) and (6).

Once the cost-efficient input quantity vectors x_{CE}^t and x_E^t are calculated for periods {1,…,T}, they can be inserted into decompositions (5) and (6) to quantify the margin effect and to quantify the contributions of the economic drivers of productivity change, and hence of profit change. The beneficiaries of productivity change are identified directly from the right side of (4).

4. Data

Our database consists of an aggregate time series over the period 1963-2002. Although we utilize the entire time series in sequential DEA to construct annual technologies, we restrict our empirical analysis to the post-reorganization period 1972-2002. Thus in our empirical analysis t=1 corresponds to the year 1972, with 1972 technology T^1_{DEA} being constructed sequentially from 1963-1972 data, t=2 corresponds to the year 1973, with 1973 technology T^2_{DEA} being 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.

With one exception, all variables are contained in an internal database provided by the USPS. 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 revenue foregone appropriation because they do not reflect revenue from operations. The two omitted revenue sources have declined from 18% of total revenue in 1972 to 0.07% of total revenue in 2002.

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.[11]

The output quantity ("workload") index y combines a mail quantity index and a delivery network index, the former incorporating seven mail classes and four miscellaneous services and the latter combining urban and rural delivery points. An output price index is defined residually as $p = R/y$. The output price index is set to unity in 1972, and the output quantity index is 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 post-reorganization improvement in financial performance is clear from the raw data, but its sources are not. Consider first decomposition (2), which defines quantity and price effects. The rate of output growth exceeds that of labor, but trails those of capital and materials, and so the direction of the quantity effect is unclear. On the price side, the rate of output price increase exceeds those of capital and materials and matches that of labor, so price recovery appears to have contributed positively to financial performance. Consider next decomposition (3), which identifies individual quantity effects and individual price effects. The slowest growing quantity is labor, which enhances profit change, but the fastest growing quantity is capital, which detracts from profit change. On the price side, the fastest growing prices are those of output and labor, which have contradictory impacts on profit change.[12]

Table 1 is not very informative about the sources of profit change. Additional insight is provided by the economic analysis underlying decompositions (5) and (6). A hint at this insight is provided by the trends in input quantities revealed in Table 1. The initially offsetting impacts of relatively rapid growth of capital and materials and relatively slow growth of labor may reflect substitution away from labor brought on by mechanization, automation and the introduction of information technology. Such labor saving technical progress would enhance profit change. It is also possible that trends in output and input quantities reflect a pattern of returns to scale that would either enhance or retard profit change. These and other factors are discussed in the next Section.

5. Results

Table 2 is organized around decomposition (2), which assigns profit change to price change and quantity change. During the first two decades after reorganization, operating losses declined by an average of $105 million annually, with price and quantity changes contributing more or less equally to improved financial performance. However during the third decade operating profit declined by an average of $40 million annually, as price recovery deteriorated dramatically, more than offsetting a large favorable quantity effect and leading to a mild deterioration in financial performance. Over the entire post-reorganization period, declining operating losses were achieved despite unfavorable price recovery.[13]

Table 3 is also organized around decomposition (2), and provides a decomposition of the quantity indicator by variable. Throughout the post-reorganization period the quantity indicator has contributed positively to improved financial performance. In both periods the value of output growth has exceeded the value of input growth. However decomposition (5) shows that it is inappropriate to infer productivity growth from a positive quantity effect; an investigation into the nature and contribution of productivity growth appears below. Table 3 also reveals that the composition of the value of input growth has changed. During the first two decades, the value of labor growth exceeded those of capital and materials, while during the third decade the pattern is reversed. This suggests the possibility of biased technical progress, also to be explored below.

Table 4 is organized around decomposition (4) of the quantity effect, in an effort to identify the winners and losers from reorganization. Table 4 reveals that the Federal Financing Bank has benefited, but in the perverse sense that annual operating losses have declined. Suppliers of capital and materials services have been modest nominal winners, with gains of the former diminished by declining interest rates in the 1990s. Labor has been a large nominal beneficiary, with labor's real wage having increased by 5.7% annually since reorganization and $w_L^{t+1} > w_L^t$ in every year. Consumers of postal services have suffered equally large nominal losses, with the real price of postal services having increased at the same rate and $p^{t+1} > p^t$ in every year also (recall that the price of a first class stamp has increased 362.5%, or by 5.1% per year, since reorganization). To put these figures in perspective, the core CPI has increased by 4.9% per year since reorganization.

Tables 2 - 4 exploit decompositions (2) and (4) that require only raw data, and the information they provide is limited. Table 5 augments raw data with economic analysis, and it provides additional information.

Table 5 provides an alternative decomposition of the quantity indicator, built around decompositions (5) and (6), both of which augment raw data with economic analysis. The first three columns report the quantity indicator and decompose it into margin and productivity effects. The margin effect is negative during the first two decades, suggesting that expansion was unprofitable, although the pattern was reversed during the third decade. Throughout the post-reorganization period the margin effect is extremely small relative to most other effects, suggesting that arithmetic mean price has approximately covered efficient average cost. However because the USPS establishes its own best practice technology, the benchmark "*efficient average cost*" should be interpreted accordingly.

Recalling the growth version of the productivity effect provided in footnote 9, the productivity effect $(\Sigma \bar{w}_n x_{nE})G_y - (\Sigma \bar{w}_n x_n^t)[\Sigma(\bar{w}_n x_n^t/\Sigma \bar{w}_n x_n^t)G_{xn}]$ is a conventional productivity growth expression $G_y - \Sigma(\bar{w}_n x_n^t/\Sigma \bar{w}_n x_n^t)G_{xn}$, with G_y scaled by efficient cost and input growth scaled by actual cost, both using arithmetic mean input prices. The productivity effect thus converts a conventional percentage rate of change to a value that shows the contribution of productivity gains to the bottom line. Throughout the post-reorganization period, the productivity effect has dominated the margin effect by two orders of magnitude. On average, the productivity effect has contributed $140 million annually to the bottom line, and its contribution has increased through time at a rate far in excess of the rate of inflation. It is worth noting, however, that the productivity effect itself is dwarfed by the input price effect obtained by adding the capital, labor and materials price effects in Table 4. The result is rising unit costs that have exerted a drag on the bottom line. This finding is in accordance with the USPS "postal inflation index," which has increased 5.3% annually since reorganization.

The productivity effect in Table 5 is cumulated over time in Figure 5. A comparison of the productivity effect in Figure 5 with the USPS 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 final three columns of Table 5 decompose the productivity effect. Improvements in the cost efficiency of resource allocation have made virtually no contribution to productivity change, and hence to the bottom line. Again recalling that the USPS itself establishes best practice, it is not possible to discern whether this is due to consistent cost efficiency or to consistent resource misallocation.

The sole economic source of the productivity effect is technical progress. Throughout the post-reorganization period the contribution of technical progress to the bottom line exceeds that of the productivity effect itself, and even that of the quantity effect. The contribution of technical progress to productivity change, and hence profit change, has accelerated through time. Improvements in mail sorting and service delivery technologies are well documented by the USPS (2003), and their impact on operating profit is apparent in Table 5. Although not reported in Table 5, technical progress has been strongly biased in a labor saving direction. The ratio (x_{LE}/x_{KE}) declines by over 60% and the ratio (x_{LE}/x_{ME}) declines by nearly 50% during the period. This is the story behind the resource use patterns reported in Table 1 and the quantity indicator decomposition reported in Table 3.

The scale effect acts as a heavy drag on productivity growth, and hence on improvements in the bottom line, throughout the period. The consistently large negative scale effect is a consequence of expansion in the presence of decreasing returns to scale. Recalling the growth form of the scale effect appearing in footnote 9, the scale effect $\Sigma\bar{w}_n x_{nE}[G_y - \Sigma(\bar{w}_n x_{nE}/\Sigma\bar{w}_n x_{nE})((x_{nCE}^{t+1} - x_{nE})/x_{nE})]$ weights a conventional measure of returns to scale by efficient total cost, converting it to a value indicator. The implied magnitude of returns to scale is actually very close to unity, with a post-reorganization mean value of –0.005 (and a standard deviation of 0.011), and exhibits no trend whatsoever. Nonetheless expansion in the presence of very slight decreasing returns to scale exerts a large negative impact on productivity change, and hence on profit change. Conversely, contraction in the final two years of the period created a positive scale effect that contributed nearly $1.8 billion to profit change.

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 remained $11 billion 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 these data, but identification of the *economic* sources requires analysis.

At the initial stage of our exploration, we find negative price recovery to have exerted a drag on financial performance, particularly in the final decade of the post-reorganization period. 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, the Postal Rate Commission, to grant rate increases adequate to cover increases in operating cost in a timely manner.

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. However 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. In this regard it is ironic that the USPS expresses concern about the declines in output that occurred in 2001 and 2002, the first in its history, because they actually have been financially beneficial.

In sum, the primary drivers of declining losses at the USPS have been output price increases that have largely offset labor price increases. These two effects dwarf all others. Productivity gains have made a small but growing contribution, with labor saving improvements in technology more than sufficient to dominate adverse scale effects.

Our findings have bearing on recent reform proposals discussed by Geddes (2003a, 2004), the President's Commission on the United States Postal Service (2003), and the USPS (2004) itself. In 2002, at the end of our sample period, the USPS embarked on a "Transformation Plan" focused on near-term strategies designed to improve its financial performance without legislative reform. The USPS (2004) reports that these strategies have reduced its debt with the Federal Financing Bank from $11.1 billion to $1.8 billion, without postal rate increases, in the two years since the end of our sample period.

These impressive financial gains notwithstanding, the President's Commission projects rising deficits in the medium term, and suggests that the USPS "needs a new business model." It proposes sweeping legislative reforms, and reform bills are pending in Congress.

The Commission recommends a review of the delivery and mailbox monopolies enjoyed by the USPS. Our finding that the USPS is operating in the region of (slightly) decreasing returns to scale implies that its monopoly is not natural, if it ever was, and shows that expansion in the face of even numerically small diseconomies of scale exerts a large drag on financial performance. It also implies that the current contraction in mail volume, which is likely to continue, may bring unexpected benefits in the form of desired reductions in unit operating costs. This is consistent with the Commission's belief that the USPS can "grow smaller *and* stronger."

The Commission recommends 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 that ideally would be based on efficient unit costs. Our findings suggest that prices have exceeded efficient unit costs by a small margin, but until recently have fallen short of actual unit costs. This suggests that the current system seems to be providing adequate incentives to contain costs, although these incentives are dampened by the generosity of the Federal Financing Bank.

Our findings suggest that the efficiency of resource allocation has not improved since reorganization. The cost efficiency effect is small, and so unit cost exceeds efficient unit cost by only one percent throughout the post-reorganization period. Nonetheless, even a one percent cost saving amounts to $665 million in 2002. Moreover, the USPS itself sets the cost efficiency standard in our analysis, and this standard may have been undemanding. This is clearly the view of the Commission, which deplores 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." Our finding of no improvement in cost efficiency lends support to the Commission's call for a new business plan and a modernization of the "1950s era postal network."

The Commission recommends that compensation of employees be held at levels comparable to those prevailing in the private sector. This has never been the case, and the gap has widened since reorganization. Our findings confirm that employee compensation is a major drain on financial performance, and that adherence to the Report's recommendation would enhance financial performance at the USPS. If, as has been suggested, compensation at the USPS exceeds comparability by 25%, achieving comparability would reduce annual operating costs by approximately $13 billion, and would reduce the adverse labor price effect by approximately $400 million annually. Although this is not feasible, it does illustrate the magnitude of the problem.

The Commission foresees four options for the USPS: roll back services, increase rates, fall further into debt, or root out inefficiencies. The first two options would perpetuate the burden borne by consumers of postal services, whom we have identified as the primary losers since reorganization. The third runs up against the current $15 billion debt ceiling. The fourth is consistent with our finding of no improvement in the efficiency of resource allocation. It is also consistent with our finding that labor saving improvements in technology have been the primary economic driver of productivity gains at the USPS.

References

Banker, R. D., H.-H. Chang and S. K. Majumdar (1996), "A Framework for Analyzing Changes in Strategic Performance," *Strategic Management Journal* 17:9 (November), 693-712.

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

CERC (1980), "*Productivité Globale et Comptes de Surplus*," Documents du Centre d'Etudes des Revenus et des Coûts 55/56, 3 et 4 trimestre, Paris: CERC.

Courbis, R., and P. Templé (1975), "La Méthode des 'Comptes de Surplus' et ses Applications Macroéconomiques," *Collections de l'INSEE* 160, Série C, nº 35, Juillet, 1–100.

Crew, M. A., and P. R. Kleindorfer, eds. (2005), *Regulatory and Economic Challenges in the Postal and Delivery Sector.* Boston: Springer.

Davis, H. S. (1955), *Productivity Accounting*. Philadelphia: University of Pennsylvania 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. (2003a), "The President's Commission on the Postal Service: An Assessment," Postal Reform Paper No. 4. Washington, DC: American Enterprise Institute for Public Policy Research.

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

Geddes, R. (2004), "Timid Steps Toward Postal Reform," Postal Reform Paper No. 6. Washington, DC: American Enterprise Institute for Public Policy Research.

Genescà, E., and E. Grifell-Tatjé (1992), "Profits and Total Factor Productivity: A Comparative Analysis," *Omega* 20:5/6, 553-68.

Kurosawa, K. (1975), "An Aggregate Index for the Analysis of Productivity and Profitability," *Omega* 3:2, 157-68.

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

Malmquist, S. (1953), “Index Numbers and Indifference Surfaces,” *Trabajos de Estadistica* 4, 209-42.

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/

Priest, G. L. (1975), “The History of the Postal Monopoly in the United States,” *Journal of Law and Economics* 18:1 (April), 33-80.

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.

Puiseux, L., and P. Bernard (1966), “Essai de Mesure de la Productivité Globale des Facteurs a L’Électricité de France de 1954 a 1962,” *Revue Française de L’Energie* 180 (Mai), 421-40.

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

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/

Vincent, A. L. A. (1968), *La Mesure de la Productivité*. Paris: Dunod.

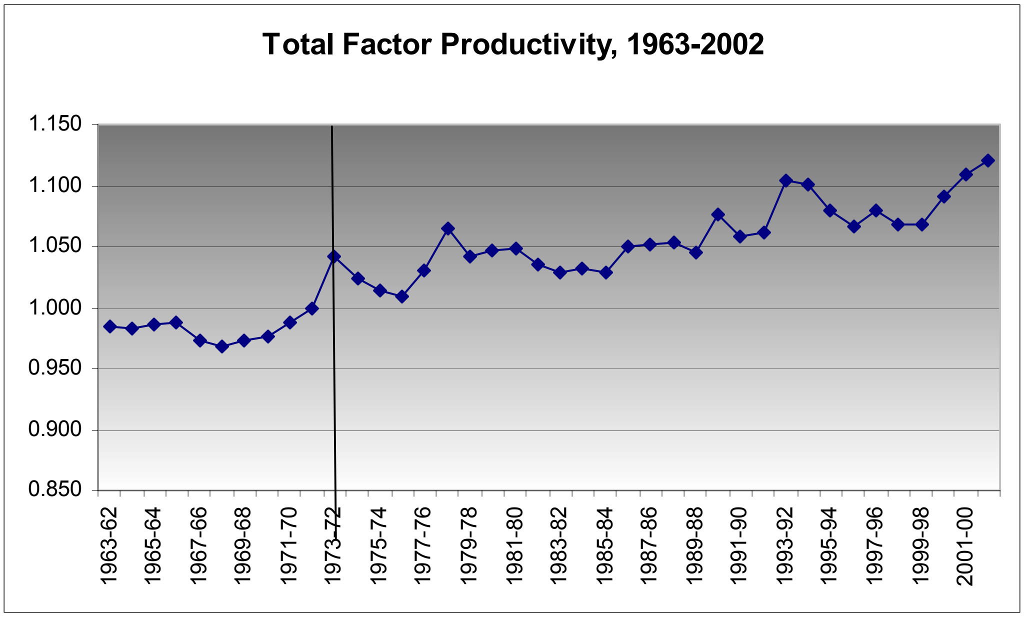

Figure 1. Total Factor Productivity Growth at the USPS

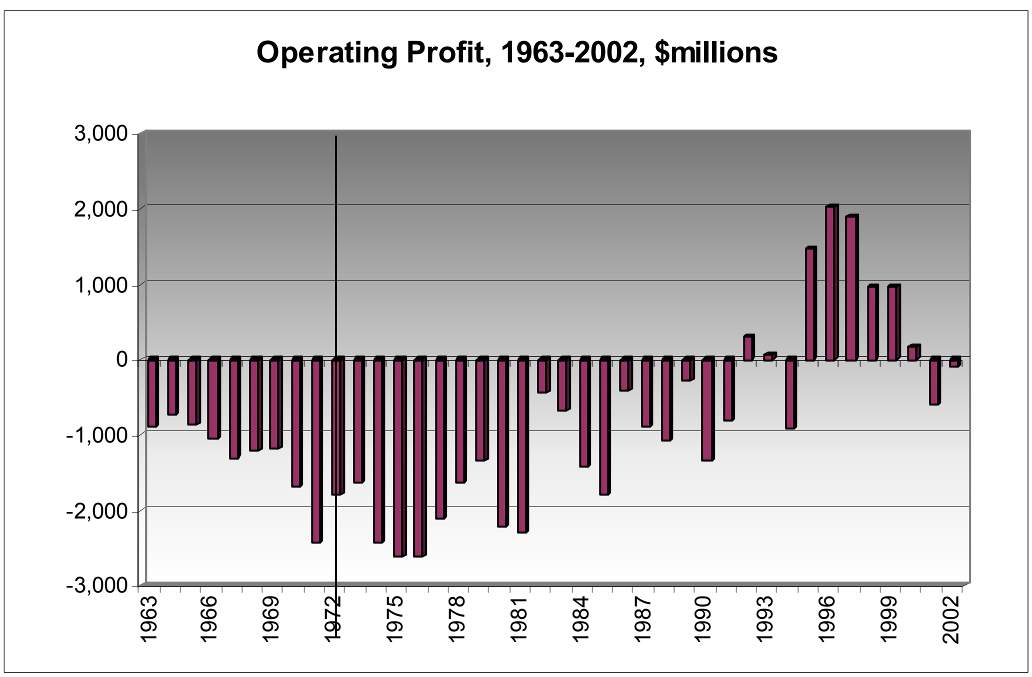

Figure 2. Annual Operating Profit at the USPS

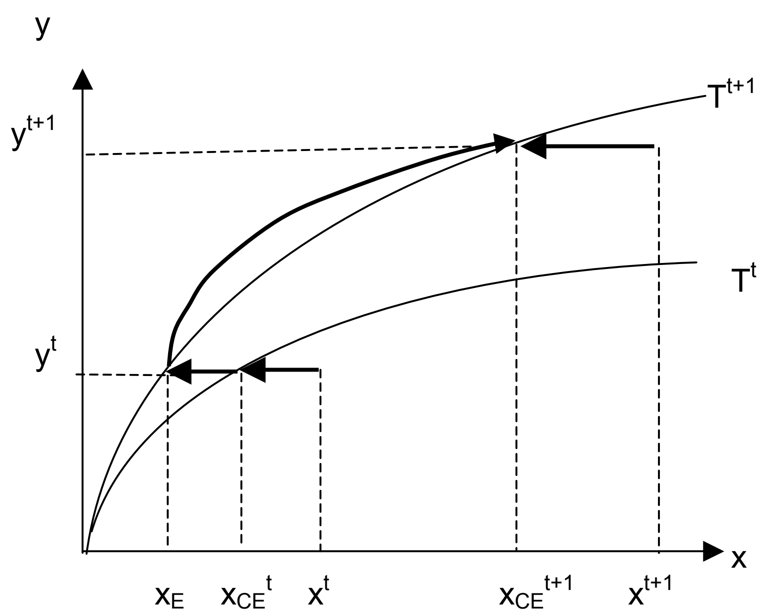

Figure 3. Decomposition of the Productivity Effect I

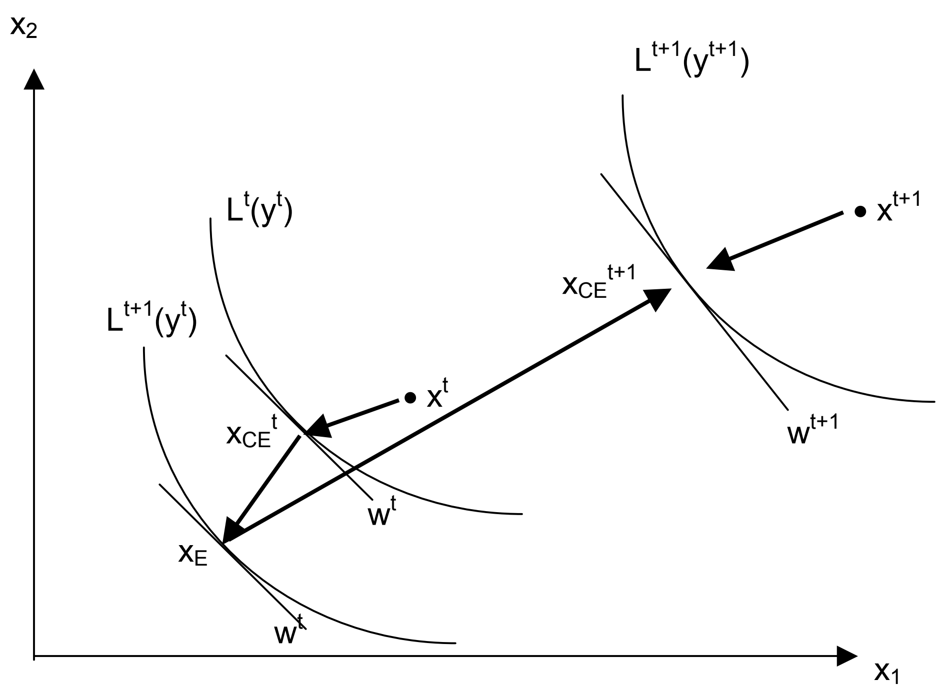

Figure 4. Decomposition of the Productivity Effect II

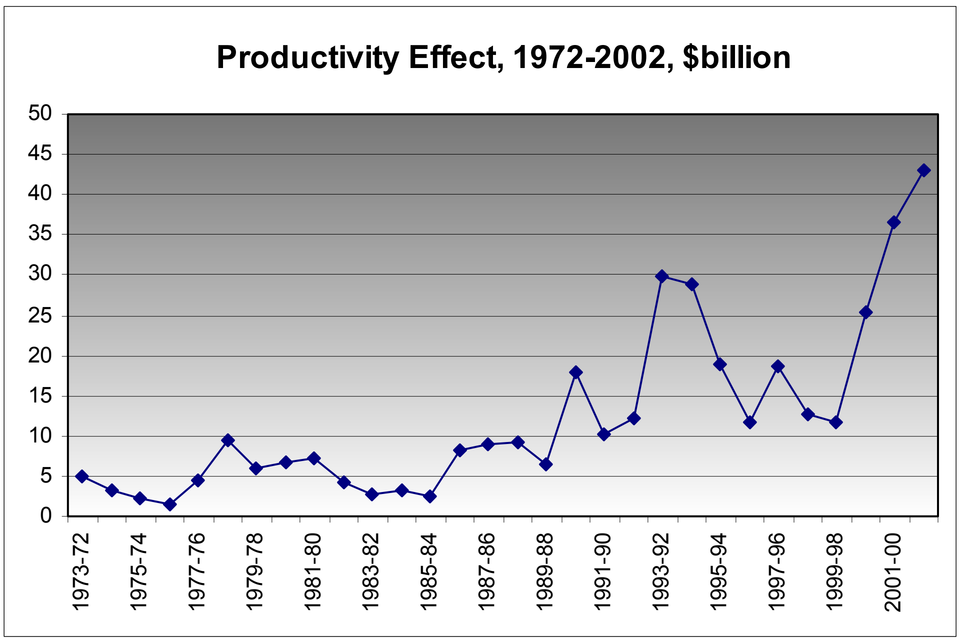

Figure 5. The Productivity Effect

Table 1. Summary Statistics for United States Postal Service, 1963 - 2002				
	1963 - 1972	**1972 - 1992**	**1992 - 2002**	**1972 - 2002**
Mean Operating Profit (current $)	-1,308	-1,403	572	-757
Growth Rate	-7.8%	4.2%	20.1%	10.0%
Mean Operating Revenues (current $)	5,473	8.8%	3.6%	34,617
Growth Rate	8.0%	9.3%	3.3%	7.1%
Y Mean Workload (1972 $)	7,362	8,787	11,551	9,716
Growth Rate	2.0%	1.4%	1.5%	1.4%
p Mean Output Price (1972 = 1.0)	0.737	2.544	4.946	3.335
Growth Rate	6.0%	7.4%	2.1%	5.7%
Mean Cost (current $)	6,781	24,666	56,770	35,374
Growth Rate	8.0%	7.8%	3.7%	6.4%
K Mean Capital Quantity (1972 $)	238	471	975	642
Growth Rate	7.2%	3.9%	6.1%	4.6%
w_k Mean Capital Price (1972 = 1.0)	0.855	2.293	3.547	2.696
Growth Rate	3.0%	6.4%	-1.0%	3.9%
L Mean Labor Quantity (1972 $)	7,601	8,354	9,574	8,758
Growth Rate	1.9%	0.7%	0.1%	0.5%
w_L Mean Labor Price (1972 = 1.0)	0.707	2.354	4.636	3.110
Growth Rate	6.9%	6.9%	3.2%	5.7%
M Mean Materials Quantity (1972 $)	1,367	1,566	2,795	1,982
Growth Rate	0.5%	2.6%	3.3%	2.8%
w_M Mean Materials Price (1972 = 1.0)	0.831	2.037	3.156	2.408
Growth Rate	3.2%	5.3%	2.1%	4.2%

Table 2. Operating Profit Change Decomposition

Mean Results by Period (millions of current dollars)

Year		Operating Profit Change	=	Bennet Price Indicator	+	Bennet Quantity Indicator
1972 - 1992	**Mean**	105.36		59.80		45.55
	Std. Dev.	*774.50*		*924.70*		*389.77*
1992 - 2002	**Mean**	-39.83		-372.50		332.67
	Std. Dev.	*1,025.75*		*1,696.82*		*947.73*
1972 - 2002	**Mean**	56.96		-84.30		141.26
	Std. Dev.	*851.11*		*1,223.41*		*630.26*

Table 3. Bennet Quantity Indicator Decomposition

Mean Results by Period (millions of current dollars)

Year		Bennet Quantity Indicator	=	Output Quantity	-	Capital Quantity	-	Labor Quantity	-	Materials Quantity
1972 - 1992	**Mean**	45.55		384.72		52.78		175.78		110.60
	Std. Dev.	*389.77*		*497.07*		*56.20*		*370.04*		*159.83*
1992 - 2002	**Mean**	332.67		807.01		210.52		13.72		250.10
	Std. Dev.	*947.73*		*926.90*		*64.68*		*1,030.87*		*526.39*
1972 - 2002	**Mean**	141.26		525.48		105.36		121.76		157.10
	Std. Dev.	*630.26*		*685.21*		*95.33*		*652.34*		*327.42*

Table 4. Bennet Quantity Indicator Decomposition

Mean Results by Period (millions of current dollars)

Year		Bennet quantity	=	Profit Change	-	Output Price	+	Capital Price	+	Labor Price	+	Material Price
1972 - 1992	***Mean***	45.55		105.36		1,528.62		59.77		1,271.55		137.51
	Std. Dev.	*389.77*		*774.50*		*1,138.34*		*110.79*		*554.68*		*111.23*
1992 - 2002	***Mean***	332.67		-39.83		1,219.39		-41.28		1,433.85		199.31
	Std. Dev.	*947.73*		*1025.75*		*1,255.84*		*171.02*		*908.45*		*199.45*
1972 - 2002	***Mean***	141.26		56.96		1,425.54		26.09		1,325.65		158.11
	Std. Dev.	*630.26*		*851.11*		*1,166.37*		*139.52*		*680.99*		*146.05*

Table 5. Economic Decomposition of the Bennet Quantity Indicator

Mean Results by Period (millions of current dollars)

Year		Bennet Quantity Indicator		Margin Effect	+	Productivity Effect		Productivity Effect				
								Cost Efficiency	+	Technical Change Effect	+	Scale Effect
1972 - 1992	**Mean**	*45.55*		-9.85		55.40		4.01		212.64		-161.25
	Std. Dev.	*389.77*		*25.15*		*397.27*		*175.01*		*299.99*		*267.51*
1992 - 2002	**Mean**	332.67		24.72		307.95		0.00		487.15		-179.19
	Std. Dev.	*947.73*		*25.30*		*946.70*		*0.02*		*667.61*		*682.35*
1972 - 2002	**Mean**	*141.26*		1.67		139.59		2.67		304.14		-167.23
	Std. Dev.	*630.26*		*29.79*		*629.45*		*141.67*		*463.26*		*437.55*

Footnotes

* We thank the Financial Reporting and Analysis Division of the USPS for sharing their internal data, and we are grateful to "Segunda Convocatoria de Ayudas a la Investigación en Ciencias Sociales" of the Fundación BBVA for its generous financial support. Kengjai Watjanapukka provided excellent research assistance.

1 Much of the available research is collected in a series of volumes edited by Crew and Kleindorfer, the most recent being Crew and Kleindorfer (2005).

2 This Section draws on USPS (2003) and Geddes (2003b), and to a lesser extent on Priest (1975), who focuses on the monopoly powers enjoyed by the POD and retained after reorganization by the USPS.

3 The analytical model has a single output, although it easily generalizes to multiple outputs. We specify a single output because the USPS reports a single output quantity index and its corresponding price index. The USPS also reports a mail quantity index and a delivery point index, and more detailed decompositions of both, but it does not report corresponding price indexes.

4 In the accounting literature the quantity effect is called productivity change and the price effect is called price recovery, although typically neither is measured using superlative index numbers or indicators. Miller (1984) provides an early and influential example, and many variants have followed.

5 Indeed French writers have emphasized the distributional aspect of productivity accounting. Vincent (1968) and CERC (1980) exemplify the French tradition, although they use Laspeyres and Paasche indexes.

6 There are three variations on the distributional story told by (4). Some writers (e.g., 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 owners of capital are dual recipients, receiving the cost of capital and serving as residual claimants. Other writers replace profit with profitability, defined as the ratio of revenue to cost (e.g., Kurosawa (1975), who analyzes both, and Salerian (2003)). Finally, most writers do not use superlative weights, relying instead on Laspeyres and Paasche weights (Salerian (2003) and Lawrence and Richards (2004) being exceptions).

7 The quantity effect can be expressed equivalently in growth rather than difference terms, and decomposes as

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

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

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

In the margin effect output growth $G_y = [(y^{t+1}/y^t) - 1]$ is weighted by the difference between total revenue and efficient total cost at y^t, using arithmetic mean output and input prices. In the productivity effect output growth G_y is weighted by 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 expressed in percentage terms to one expressed in value terms.

[8] It is possible to calculate x_E using period t+1 input prices instead of period t input prices, and to introduce the expression $\Sigma \bar{w}_n(x_{nE}^{t+1} - x_{nE}^{t})$ as an *input substitution effect,* where x_E^{t+1} is the cost minimizing input vector with period t+1 prices and x_E^{t} is the cost minimizing input vector with period t prices. We have calculated this effect for all years and it is always zero. Thus the use of period t input prices or period t+1 input prices generate the same technical change effect.

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

$$(\Sigma \bar{w}_n x_{nE})G_y - (\Sigma \bar{w}_n x_n^{t})[\Sigma(\bar{w}_n x_n^{t}/\Sigma \bar{w}_n x_n^{t})G_{xn}]$$

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

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

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

Here the scale effect is a productivity effect, measured net of cost efficiency change and technical change and using cost-efficient input shares $\bar{w}_n x_{nE}/\Sigma \bar{w}_n x_{nE}$. Since it is evaluated on the surface of T^{t+1}, it is a pure scale effect. Period t+1 technology exhibits increasing, constant or decreasing returns to scale according as the bracketed term is greater than, equal to or less than unity.

[10] Alternatively, it is possible to measure the scale effect along the period t production frontier and to measure technical change with an output-augmenting orientation at x_{CE}^{t+1}. It also is possible to construct the arithmetic mean of the two decompositions to create an indicator analogue to the Malmquist (1953) productivity index and its decomposition. In the multiple output case the scale effect would include a term capturing the contribution to productivity change of a change in the output mix.

[11] The USPS reports "total operating expense" in its annual reports. This figure differs from the total cost figure contained in the USPS internal database. For the last five years, the two figures are very close.

	2002	2001	2000	1999	1998
USPS Annual Report	65234	65640	62992	60642	57786
USPS Internal Data	66503	66375	64294	61681	59034
% difference	1.9	1.1	2.1	1.7	2.2

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

[12] The USPS reports a "postal inflation index," defined as C/y. This index increased by 6.0% per year prior to reorganization, and by 5.0% per year thereafter. These figures are very close to the annual rate of output price increase, as they should be if the USPS is to meet the break-even objective of the PRA. The annual rate of output price increase exceeded that of the core CPI from 1963 to 1972 (6.0% versus 3.6%), and from 1972 to 2002 (5.7% versus 4.9%). The USPS generates approximately 55% of its operating

revenue from first class mail. The price of a first class stamp increased 60% (from five cents to eight cents) from 1963 to 1971, and by 362.5% (to 37 cents) from 1971 to 2002.

[13] Tables 2-5 report post-reorganization 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, period means conceal the impacts of special events such as the simultaneous occurrence of the general business slowdown following the 9/11/01 terrorist attacks and the anthrax attacks at post offices.