Costs for Better Management Decisions: CRA Versus Fully Distributed Costs

September 17, 2012

Sponsored by U.S. Postal Service Office of Inspector General
Report Number: RARC-WP-12-016

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Introduction

The Postal Service reports the cost of its products annually in its Cost and Revenue Analysis (CRA) report. The costs included in this report are designed to represent estimates of economic costs — costs that are caused by the provision of a product or groups of products. A feature of economic costs is that the sum of product costs will not equal total costs. Instead, there will be a residual "institutional" cost — costs that do not vary with product volume and are not directly assignable to any products.[1]

As discussed in the U.S. Postal Service Office of Inspector General's paper *A Primer on Postal Costing Issues*,[2] it has been suggested that the Postal Service could make better management and pricing decisions if it were to use a fully distributed costing (FDC) methodology to allocate all of its costs to products.[3] In order to shed light on this subject, the Office of Inspector General asked Professor John C. Panzar, an economist with expertise in postal costing, for his opinion on whether FDC would be a good tool to use to evaluate the profitability of new initiatives. The following paper, *Costs for Better Management Decisions: CRA Costs versus Fully Distributed Costs*, is the result of this effort. We offer the following summary of the key points of Professor Panzar's paper.

Professor Panzar's analysis reveals that institutional costs, and therefore FDC, should not be used to judge the profitability of new initiatives. Instead, profitability should be evaluated based on the comparison of the revenue the new initiative will produce to the incremental costs it adds. If the revenue exceeds the incremental costs, the initiative should be offered on the market. Otherwise, the Postal Service is missing an opportunity to earn more revenue.

Next, the author finds that employing Postal Service CRA costing methods provides a close approximation of the cost of a new product, with a very small upward bias. Professor Panzar provides a specific example of an initiative where a lower price is offered to encourage additional volume. Multiplying the expected increase in volume by the unit volume variable cost reported in the CRA slightly overstates the true cost change, because it fails to take into account the existence of economies of scale (unit costs decline as volume increases). While this overestimation of costs is likely small, the use of FDC can lead to a serious distortion of the proper economic signal one needs to select the best new initiative.

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[1] An example of a source of institutional costs for the Postal Service is the cost associated with the carrier traversing his route. The carrier will have to travel his entire route each delivery day regardless of volume.
[2] U.S. Postal Service Office of Inspector General, *A Primer on Postal Costing Issues*, Report No. RARC-WP-12-008, March 20, 2012, http://www.uspsoig.gov/foia_files/RARC-WP-12-008.pdf.
[3] Fully distributed costing (FDC) refers to the process of distributing all costs to products; there are numerous methodologies that can be used to reach this goal.

Professor Panzar also concludes that FDC should not be used when, due to resource constraints, management needs to choose between two profitable initiatives. He demonstrates that using FDC can lead to poor decisions, such as choosing to offer a product with little contribution (profit) over a more profitable product. He proposes that if some sort of guideline were needed to ensure that a new product would have a significant profit, even a simple rule requiring a fixed dollar amount of contribution would be a better guide as to which products to choose.[4]

This paper should not be interpreted to mean that the Postal Service should not be concerned with earning sufficient revenues to cover its institutional costs. This is a laudable and necessary goal. Rather, this paper points out the potential problems the Postal Service would incur if it were to use FDC to estimate the profitability of new initiatives and make decisions about which products to bring to market. Using FDC would create a conservative policy that would help the Postal Service to avoid bad initiatives. However, it could rob the Postal Service of revenue opportunities at a time when they are greatly needed.

[4] Dr. Panzar demonstrates that a fixed dollar threshold is preferred when each NSA requires the same amount of the "scarce, un-priced limiting resource" such as management's time and attention. However, if the resource cost varied across NSAs there may be justification for using another type of rule, such as a percentage threshold requirement. Regardless, any threshold policy should be flexible enough to include the possibility that the Board of Governors may choose to waive any quantitative provision.

Costs for Better Management Decisions: Economic Costs versus Fully Distributed Costs

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1. Introduction

Fully distributed costing (FDC) describes any of a class of processes through which *all* of the costs of the enterprise are assigned, or *allocated*, to one or another of its products or services. The concept is not controversial in and of itself.[1] Rather, it is the ways the results of an FDC analysis are used in decision-making that often give rise to controversy. The use of FDC has a long history in utility rate-making. However, economists have severely criticized its use for decades.[2] And, its use in current regulatory practice has been greatly curtailed.[3] The shortcomings of FDC as a pricing methodology are well-known, and will not be repeated here. Rather, this paper analyzes the use of FDC methodology for evaluating the profitability of new projects or services such as negotiated service agreements (NSAs).[4] As far as I can determine,

[1] In the literature, the terms *distributed*, *allocated*, *assigned*, and *attributed* are used almost interchangeably. I will try to use the latter term *only* when referring to the specialized costing process used by the Postal Service.

[2] See Kahn (1970) for a detailed survey and critique.

[3] For example, Viscusi et al. (2005), the current leading regulation text, devotes only three pages to the discussion of FDC.

[4] An NSA is a contractual agreement between the U.S. Postal Service and an individual company that provides customized pricing incentives or other arrangements justified by a shift in the company's mail operations (Source: https://www.usps.com/nationalpremieraccounts/nsa/welcome.htm). The use of the term in this paper should not be taken to reflect a detailed analysis of the specific costing procedures employed by the Postal Service for the

this topic has not been studied in the economics literature. My analysis of FDC takes place in the context of cost measurement and attribution processes used by the Postal Service.

I have three primary findings. First, when evaluating the profitability of a new undertaking such as an NSA, the appropriate comparison is between the project's incremental revenues and the incremental costs associated with the expected volume changes. *Allocations of overhead or institutional costs play no role*. Second, the cost attribution methodology used by the Postal Service and embodied in the Cost and Revenue Analysis (CRA) report routinely produces estimates of *volume variable costs*. These can be used to generate reasonably accurate (but conservative) approximations of the theoretically correct incremental cost values. Third, fully distributed costs are always above the relevant incremental costs, so it might be argued that their use could provide a built-in "margin for error" for the evaluation process. However, my analysis shows that using FDC to create such a extra margin, or "contribution hurdle," is clearly inferior to using a hurdle based upon a fixed dollar amount. Indeed, I present a simple example that illustrates the likelihood that the use of FDC in evaluating NSAs will lead to biased selections of projects.

The paper is organized as follows. Section 2 briefly presents an overview of the theory of multiproduct cost functions. The discussion builds upon a careful definition of the cost of an increment of output. Section 3 provides a general definition of cost allocation processes. It also presents simple examples useful for the analysis. Section 4 describes the Postal Service's costing methodology as implemented in the CRA. Section 5 demonstrates that incremental

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evaluation of any given NSA, but rather as a term describing a way the Postal Service can make a change in the service and price available to a specific customer.

costs are the theoretically correct basis for evaluating NSAs or other new offerings. It also illustrates the extent to which CRA and FDC-based estimates overstate the costs of such projects. Section 6 analyzes situations in which there are "opportunity costs" associated with implementing an NSA, so that not all profitable NSAs can be implemented. I show that, in this case, a "profit hurdle" may be desirable. However, the built-in hurdle created by the use of FDC may lead to selection bias. Section 7 restates my main findings.

2. Multiproduct Cost Functions

To an economist, there is a *causal relationship* between the quantities of various economic goods and services provided and the expenditures incurred by the entity producing those goods and services. In economic textbooks, this relationship is usually defined as the solution to an explicit optimization problem: i.e., it is assumed that the amount of inputs chosen by the firm, $\mathbf{x} = (x_1, x_2, \ldots, x_m)$, are chosen so as to minimize the total expenditures required to produce a vector of specified output levels, $\mathbf{q} = (q_1, q_2, \ldots, q_n)$.[5] However, for purposes of the present discussion, it is only necessary that there exists a relatively stable relationship between inputs, outputs, and factor prices so that one can assume that there exists a multiproduct Postal Service *behavioral cost function*, $C: \mathbb{R}^n_+ \times \mathbb{R}^m_{++} \rightarrow \mathbb{R}_+$, relating the levels of services provided and the resulting amount of costs incurred. In what follows, I will assume that the factor prices

[5] More formally, let the vectors $\mathbf{q} \in \mathbb{R}^n_+$ and $\mathbf{x} \in \mathbb{R}^m_+$, respectively, denote output levels of the various goods and services offered by the firm and the quantities of the inputs used to produce them and let $\mathbf{w} \in \mathbb{R}^m_{++}$ denote the vector of positive input prices facing the firm. Then, the solution to the firm's cost minimization problem defines the minimum cost function $\tilde{C}: \mathbb{R}^n_+ \times \mathbb{R}^m_{++} \rightarrow \mathbb{R}_+$ as $\tilde{C}(\mathbf{q}, \mathbf{w}) = \min_{\mathbf{x}}\{\mathbf{wx} : \mathbf{q} \text{ can be produced from } \mathbf{x}\}$. See, for example, the treatments in an advanced microeconomic textbook such as Mas-Colell, Whinston, and Green.

facing the postal service are exogenously fixed, so that the relationships of interest can be summarized by the function $C(\mathbf{q})$.

This cost function is assumed to be defined for *any* non negative output vector $\mathbf{q} \geq \mathbf{0}$. However, it is customary to use a special designation for the costs associated with output vectors in which one or more output levels are equal to zero. The *stand-alone costs* of any product set $S \subset N$ is defined as follows. Given any reference output vector $\mathbf{q} > \mathbf{0}$ in which all n products are produced in strictly positive quantity, let $\mathbf{q}_S$ denote that vector whose ith component is equal to that of the reference vector $\mathbf{q}$ for $i \in S$ and equal to 0 for $i \notin S$. Thus, $\mathbf{q} = \mathbf{q}_S + \mathbf{q}_{N/S}$, where the set $N/S \equiv \{i \in N \mid i \notin S\}$ is the *complement* of S in N. Using this notation, the *stand-alone costs* of the product sets S and its complement are given by $C(\mathbf{q}_S)$ and $C(\mathbf{q}_{N/S})$, respectively.

Thus far, the Postal Service cost function, C, that I have described is a purely theoretical construct. Nonetheless, it is a useful, indeed essential, tool for establishing economically sensible postal pricing policies. In particular, the economic implications of C are contained in a complete description of how costs change in response to a change in the levels of the services provided. Economists refer to these cost changes as *incremental cost*. The incremental cost of any vector of changes in postal volumes, $\Delta\mathbf{q} = (\Delta q_1, \Delta q_2, \ldots, \Delta q_n)$, relative to a base vector $\mathbf{q}$ is the increase or decrease in total costs resulting from the specified changes: i.e., $IC(\mathbf{q}; \Delta\mathbf{q}) = C(\mathbf{q}+\Delta\mathbf{q}) - C(\mathbf{q})$.

Other familiar cost concepts can be constructed from this definition through artful choices of the base vector, $\mathbf{q}$, and increment, $\Delta\mathbf{q}$. For example, the *marginal cost of service i*, $MC_i(\mathbf{q})$, results from choosing $\Delta\mathbf{q} = (0, 0, \Delta q_i, \ldots, 0)$ and taking the limit of $IC/\Delta q_i$ as Δq_i goes to zero. Similarly, the incremental cost of a set of services $S \subset N$ results from setting the base vector $\mathbf{q} = \mathbf{q}_{N/S}$ and the increment $\Delta\mathbf{q} = \mathbf{q}_S$. Thus, $IC_S(\mathbf{q}) = C(\mathbf{q}) - C(\mathbf{q}_{N/S}) = C(\mathbf{q}_S + \mathbf{q}_{N/S}) - C(\mathbf{q}_{N/S})$.

3. Fully Distributed Costs

It is obvious that the costs incurred in producing the services provided by the Postal Service (or any other organization) must, somehow, be "fully covered." This is true even if the services are provided to its customers without charge. The inputs employed must be paid for, either by the enterprise itself through the revenues it receives and/or through public subsidy. Since the Postal Reorganization Act of 1970, the Postal Service has been a government-owned entity that is required to cover its costs through revenues. This balance between revenues and costs is one of the defining characteristics of a private enterprise economy. And, the associated condition of *zero economic profits* is one of the standard benchmarks of industrial and regulatory economics.

However, this close relationship between revenues and costs masks an important difference between the two quantities. Revenues can be unambiguously *distributed* over the individual products of the firm, but costs cannot. The firm's total revenues can be expressed as the simple sum of the individual revenues resulting from the sales of each of the firm's products. Usually, the revenue associated with each product is just the quantity produced and sold of that product times its price, p_i. That is,

$$R = \sum_{i=1}^{n} R_i = \sum_{i=1}^{n} p_i q_i$$

Unfortunately, such simple decompositions are not typically available for multiproduct cost functions. In general, multiproduct cost functions are neither *linear* nor *additively separable*.

Nonetheless, the desire to "balance" costs and revenues on a product-by-product basis has led regulators to seek to develop methods to *allocate*, or *fully distribute,* the total costs of the enterprise in order to determine an unambiguous *unit cost*, u_i, for each service with the property that, at least hypothetically, prices set equal to such unit costs would exactly cover the total costs of the enterprise: i.e.,

$$C(\mathbf{q}) = \mathbf{u}\cdot\mathbf{q} = \sum_{i=1}^{n} u_i q_i$$

Obviously, there are many allocation schemes that are capable of satisfying the above equality.[6] Most allocation schemes used by regulatory authorities were developed constructively.[7]

To illustrate, suppose the total costs of the enterprise consist of costs that are unambiguously "caused" by the quantities of individual products as well as fixed costs that are insensitive to volume. That is,

$$C(\mathbf{q}) = F + \sum_{i=1}^{n} C_i(q_{\mathrm{i}})$$

Then, the cost distribution process involves choosing an *allocator function*,

$$f(\mathbf{q}) = (f_1(\mathbf{q}), f_2(\mathbf{q}), \ldots, f_n(\mathbf{q})),$$

[6] Formally, what is required is to construct a vector valued "unit cost" function, $\mathbf{u}(\mathbf{q},C)$, that has as its arguments a quantity vector **q** and a cost function, *C*, such that the sum, over all products, of unit price times quantity exactly equals total costs. Thus, the problem is to define a mapping $\mathbf{u}\colon \mathbb{R}_+^n \times \aleph \rightarrow \mathbb{R}_+^n$ such that $\mathbf{u}(\mathbf{q};C(\cdot)) \cdot \mathbf{q} = C(\mathbf{q})$, where $C(\cdot) \in \aleph$, the set of continuously differentiable functions from $\mathbb{R}_+^n \rightarrow \mathbb{R}_+$.

[7] See Braeutigam (1980) for a thorough discussion and critique of widespread regulatory practice at the time of his writing.

that distributes the fixed costs over the various products.[8] In this case, the fully distributed costs of service i are given by $FDC_i(\mathbf{q}) = f_i(\mathbf{q})F + C_i(\mathbf{q})$. Then, per unit fully distributed costs are given by $u_i(\mathbf{q}) = FDC_i/q_i$.

4. Postal Service Costing (CRA)

The Postal Service employs a product costing methodology to generate cost information, both for internal decision making and to satisfy the cost reporting requirements of the Postal Rate Commission (PRC). This costing system is referred to as the Cost and Revenue Analysis (CRA).[9]

The CRA models total costs by dividing the incurred expenses of the enterprise into some number of *cost components*, $j = 1, \ldots, J$. The dollar cost present in any component, C_j, is assumed to be caused by the level of the *cost driver*, D_j, associated with that activity: i.e., $C_j = C_j(D_j)$. The level of the cost driver is assumed to be determined by the volumes of individual mail products; i.e., $D_j = D_j(\mathbf{q})$. Cost drivers are typically defined in such a way that the functions D_j are *linearly homogeneous*, so that a proportional increase in all volumes leads to an increase of driver activity of the same proportion: i.e., $D_j(t\mathbf{q}) = tD_j(\mathbf{q})$ for any constant $t > 0$. Often, the relationship is assumed to be linear, so that $D_j(\mathbf{q}) = \mathbf{aq} = \sum_i a_i q_i$ for some vector of product weights $\mathbf{a} = (a_1, \ldots, a_n)$. For example, suppose that cubic inches are recognized as the cost driver for the transportation cost component and that there are two services "letters" and

[8] That is, define $f\colon \mathbb{R}_+^n \rightarrow S^n \equiv \{f_i \in [0,1] | \sum f_i = 1\}$

[9] See Bradley, Colvin, and Smith (1993) for a detailed description of Postal Service costing methodology, as reflected in its Cost and Revenue Analysis (CRA) reports. Here, I present only a basic description of the CRA in order to illustrate the issues at hand.

"parcels." If each letter occupies a_l cubic inches and each parcel a_p cubic inches, the total amount of the cubic inches cost driver is given by: $D_{cube} = a_l q_l + a_p q_p$.

The CRA analysis begins by determining the proportion of component costs that are "volume variable" with respect to the level of the cost driver. This is done by multiplying total component costs by the estimated elasticity, e_j, of those costs with respect to component activity: i.e.,

$$VVC_j = C_j e_j = C_j \left[\frac{D_j}{C_j}\frac{\partial C_j}{\partial D_j}\right] = D_j \frac{\partial C_j}{\partial D_j}$$

Next, the volume variable costs of each component are *attributed* to individual services on the basis of that service's share of driver activity. When possible, this share, σ_{ij}, is determined on the basis of an estimated elasticity: i.e.,

$$VVC_{ij} = VVC_j \sigma_{ij} = C_j e_j \sigma_{ij} = D_j \frac{\partial C_j}{\partial D_j}\left[\frac{q_i}{D_j}\frac{\partial D_j}{\partial q_i}\right] = q_i \frac{\partial C_j}{\partial D_j}\frac{\partial D_j}{\partial q_i}$$

Then, the total amount of volume variable cost attributed to any product i is determined by summing over cost components:

$$VVC_i = \sum_j VVC_{ij} = q_i \sum_j \frac{\partial C_j}{\partial D_j}\frac{\partial D_j}{\partial q_i}$$

Finally, the CRA expresses the volume variable costs attributed to service i on a per unit basis by dividing VVC_i by the volume of service i. That is,

$$v_i(\boldsymbol{q}) = \frac{VVC_i}{q_i} = \sum_j \frac{\partial C_j}{\partial D_j}\frac{\partial D_j}{\partial q_i} = \frac{\partial\left[\sum_j C_j[D_j(\boldsymbol{q})]\right]}{\partial q_i} = MC_i(\mathbf{q})$$

The well-known[10] outcome of the CRA's volume variability analysis is the surprising result that the unit volume variable costs of a service are equal to the marginal cost of that service. As we shall see, the unit volume variable costs of a service can be used to provide a conservative, but reasonably accurate measure of the costs of implementing an NSA.

5. The Theoretical Standard for Evaluating NSAs

In terms of our theoretical framework, any NSA can be evaluated in terms of the associated (expected) change in revenues, ΔR, and change in service levels, $\Delta\mathbf{q}$. Thus an NSA generates an increase in net profit for the Postal Service whenever

$$\Delta R \geq IC(\mathbf{q};\Delta\mathbf{q}) = C(\mathbf{q}+\Delta\mathbf{q}) - C(\mathbf{q}) \equiv IC_{true}(\Delta\mathbf{q}).$$

That is, it does so when the incremental revenues of the NSA are greater than the incremental costs associated with the forecast change in volume. The cost calculation required here is, in principle, quite straightforward for it involves relatively small changes in postal operations. In particular, services are not being added or eliminated. Therefore the incremental cost in the above equation is "interior" in that it is driven by volume changes expected to result from the NSA.

In theory, it is as simple as that. For practical application, it is necessary to relate this result to estimates based upon the Postal Service's costing methodologies. An *estimate* of the change in cost associated with an NSA can be readily obtained using CRA unit volume variable

[10] See, for example, Bradley, Colvin, and Smith (1993) and Bradley, Colvin and Panzar (1999).

costs. All that is required is to multiply the forecast change in the quantity of each service by the total marginal cost of that service: i.e.,

$$IC_{CRA}(\Delta\mathbf{q}) \equiv \mathbf{v}(\mathbf{q})\cdot\Delta\mathbf{q} = \sum_{i=1}^{n} v_i \Delta q_i$$

Similarly, it is straightforward to construct an FDC – based estimate of NSA costs by multiplying the vector of quantity changes by the vector of FDC unit costs: i.e.,

$$IC_{FDC}(\Delta\mathbf{q}) \equiv \mathbf{u}(\mathbf{q})\cdot\Delta\mathbf{q} = \sum_{i=1}^{n} u_i \Delta q_i$$

How do these cost accounting estimates compare to the "true" NSA costs that, ideally, should be compared to projected NSA revenues? For the CRA measure, this is easily accomplished by means of Figure 1, which is built upon Figure 7 in *A Primer on Postal Costing Issues*.[11] The diagram reflects the falling marginal costs associated with most postal operations. At a specified initial output level q^0, the level of unit attributable cost is given by $MC(q^0)$. Associated with this point of operation are volume variable costs and institutional costs, as indicated in the diagram. It is clear that volume variable costs understate the full incremental costs of the service in question. Bradley, Colvin, and Panzar (1999) explain how these biases can be systematically dealt with in using Postal Service cost attribution data to test for cross-subsidization. This suggests the possibility that volume variable costs will typically *understate* relevant cost magnitudes.

[11] Office of Inspector General, Risk Analysis and Research Center, *A Primer on Postal Costing Issues*, Report No. RARC-WP-12-008, March 20, 2012, p. 21. http://www.uspsoig.gov/foia_files/RARC-WP-12-008.pdf.

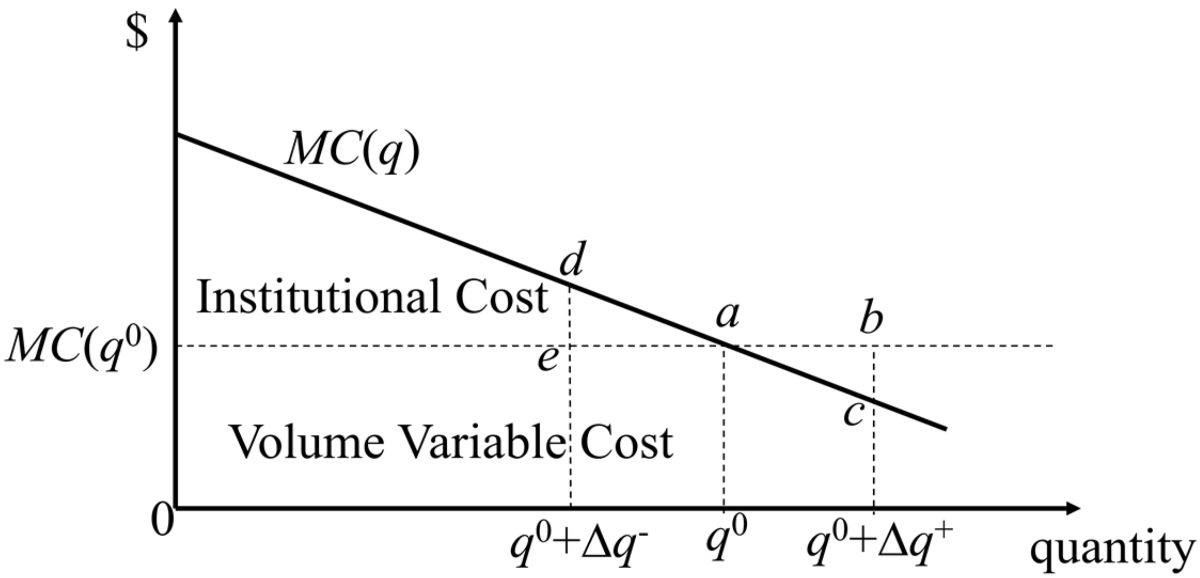

Figure 1

Now consider an NSA with projected increment $\Delta q^{+} > 0$. The true additional cost of this increment is given by the area of the trapezoid $q^{0}ac(q^{0}+\Delta q^{+})$. This is the theoretically correct amount to compare with the ΔR of this NSA. However, as a practical matter assume that the analyst approximates this cost increase by simply multiplying the increase in volume by the observed unit attributable cost at the initial volume level. It is clear from the diagram that this "naïve" use of unit attributable costs would overstate the cost increases due to the NSA by the area of triangle *abc*. It follows immediately that any NSA whose ΔR exceeds the naïve cost estimate will also exceed the "true" added costs of the increased volume. While volume increases are likely the goal of most NSAs, it is also possible to carry out the argument in reverse. Suppose an NSA involves a proposed volume change (reduction) of $\Delta q^{-} < 0$. Then, theoretically, the NSA should be accepted as long as the reduction in revenues received was no larger than the area of trapezoid $q^0ade(q^0+\Delta q^-)$. Use of the naïve attributable cost estimate would be more conservative by an amount equal to area *dae*.

It is not possible to reach any *general* conclusions regarding the relationship between IC_{FDC} and IC_{true}. This is because there are an infinite variety of possible FDC schemes and, so far, the only requirement we have placed upon them is the "adding up property" that the *sum* of FDC unit costs multiplied by base quantities exactly equals total base costs; i.e., $\mathbf{u}\cdot\mathbf{q} = C(\mathbf{q})$. However, for any particular increment vector it may be the case that u_i is very low precisely when Δq_i is very high, so that IC_{FDC} is very low. Fortunately, the simple single product example analyzed above can be used to examine the *average* properties of an FDC–based NSA cost measure. This follows from the fact that, with only one product, it must be the case that $u = AC$.

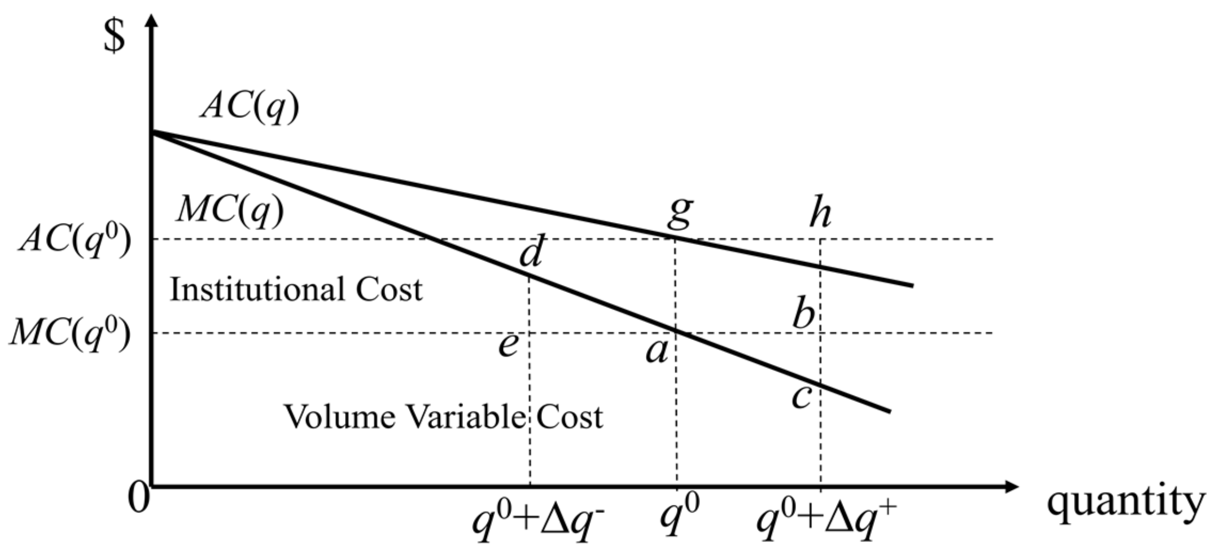

Figure 2

Figure 2 augments Figure 1 by adding the average cost curve associated with the marginal cost curve depicted there.[12] Again, consider an NSA with projected increment $\Delta q^+ > 0$. As above, the true additional cost of this increment is given by the area of the trapezoid $q^0ac(q^0+\Delta q^+)$. Because $u = AC(q^0)$, we have $IC_{FDC} = \Delta q^+ AC(q^0)$, which is the area of the rectangle $q^0gh(q^0+\Delta q^+)$. This estimate overstates IC_{true} by the area of the trapezoid *aghbc* and also exceeds (the conservative measure) IC_{CRA} by the area of the rectangle *aghb*.

These results are very important. They demonstrate that, for cost elasticities less than one, using CRA–based *total marginal cost*[13] estimates to calculate NSA costs leads to a conservative overestimate of total costs, therefore, an underestimate of the true net profitability of undertaking the NSA in question. Any attempt to "inflate" the cost estimates by adding an FDC–based share of institutional costs can only make the bias more severe. A simple algebraic example can be used to illustrate the *quantitative* significance of my analysis.

The general point can be made using an example involving a single product firm with a single cost driver. Then, the level of driver activity and output can be measured in the same units, *V*. Assume that costs as a function of volume are given by $C(V) = AV^e$, where A is a positive constant and $e \in (0,1)$ is the cost elasticity of the firm's operations. That is, a 1 percent increase in volume leads to an $e < 1$ percent increase in costs. In the context of this example, the

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[12] For simplicity, I have assumed that there are no fixed costs. Therefore, the vertical intercepts of the *MC* and *AC* curves are the same and *AC* remains above *MC* throughout.

[13] The term "total marginal cost" is used by the Postal Service to refer to the sum (taken over all cost components) of per unit volume variable costs.

Postal Service's CRA methodology would lead to a total amount of attributable (volume variable) costs given by

$$VVC(V) = V = \ (V)(eAV^{e-1}) = eC(V)$$

Thus, if the cost elasticity were 0.6, the Postal Service would end up attributing 60 percent of its total costs. Note that, in this single output situation, FDC costing would lead to unit costs exactly equal to average cost, $u(V) = AC(V) = \frac{C(V)}{V} = AV^{e-1}$.

Now suppose that a proposed NSA will generate estimated incremental revenues of ΔR and increased volumes of $\Delta V = zV$. The "true" cost of the added volume is given by

$$IC_{true} = C(V + \Delta V) - C(V) = \int_{V}^{(1+z)V} AQ^{e} dQ = AV^{e}[(1+z)^{e} - 1] = C(V)[(1+z)^{e} - 1]$$

Using the Postal Service's CRA methodology would produce an estimate of

$$IC_{CRA} = \Delta VMC(V) = (zV)(eAV^{e-1}) = C(V)ez.$$

And, of course, using an FDC–based approach would yield an estimate of

$$IC_{FDC} = \Delta Vu(V) = \Delta VAC(V) = (zV)(AV^{e-1}) = C(V)z.$$

The following tables illustrate the differences between the "true" cost change and the CRA and FDC estimates of NSA cost changes for plausible parameter values.[14] In line with experience over various cost components, the cost elasticity (and the extent of cost attribution) ranges from 0.5 to 1.0. On the other hand, the percentage volume increase associated with any

[14] In this constant elasticity example, the FDC value always overstates the CRA value by the factor 1/*e*.

given NSA is on the order of a few percent. Table 1 plots the ratio of ΔC_{CRA} to ΔC_{true} for various plausible values of cost elasticity (e) and proportional volume change (z). The result is always above, but very close to, unity. Thus a CRA–based estimate of cost changes closely approximates the "true" cost change for all plausible parameter values.

e\z	0.01	0.02	0.03	0.04	0.05
0.5	1.00	1.00	1.01	1.01	1.01
0.6	1.00	1.00	1.01	1.01	1.01
0.7	1.00	1.00	1.00	1.01	1.01
0.8	1.00	1.00	1.00	1.00	1.00
0.9	1.00	1.00	1.00	1.00	1.00
1.0	1.00	1.00	1.00	1.00	1.00

Table 1: ratio of IC_{CRA} to IC_{true}

In contrast, Table 2, which plots the ratio of ΔC_{FDC} to ΔC_{true}, shows that the use of FDC costing can lead to serious overestimates of the actual costs of serving an NSA's additional volume:

e\z	0.01	0.02	0.03	0.04	0.05
0.5	2.00	2.01	2.01	2.02	2.02
0.6	1.67	1.67	1.68	1.68	1.68
0.7	1.43	1.43	1.43	1.44	1.44
0.8	1.25	1.25	1.25	1.25	1.26
0.9	1.11	1.11	1.11	1.11	1.11
1.0	1.00	1.00	1.00	1.00	1.00

Table 2: ratio of IC_{FDC} to IC_{true}

To conclude, the analysis of this section makes clear that the determination of the net contribution (profitability) of an NSA is entirely determined by a comparison of its incremental revenues to its incremental costs. *The allocation of the non-volume variable costs of the Postal Service plays absolutely no role in this determination.*

6. Choosing among Profitable NSAs

In principle, *every* NSA that satisfies the criteria of the previous section should be implemented. However, the above analysis does not take account of either monetary or opportunity costs associated with implementing an NSA. Monetary costs are easily handled: simply deduct the monetary implementation costs associated with any particular NSA from the net contribution calculated above. However, by their very nature, opportunity costs of implementation are more difficult to incorporate.

Heuristic ("rule of thumb") solutions to this type of problem often utilize *contribution hurdles*. That is, in order to recognize that implementing NSAs places a burden on the scarce resource of managerial "attention," senior management limits consideration to those profitable NSAs whose net contribution exceeds some threshold *X*.[15] Clearly, the use of such a threshold will require that an NSA's projected revenues must exceed its projected incremental costs in

[15] Suppose that each NSA requires an amount *y* of managerial attention and that a total of amount *Y* of senior management time has been allocated to selecting and implementing NSAs. The Postmaster General will know that he can implement only $n_{\mathrm{NSA}} = Y/y$ projects. However, he wishes to design a decentralized process that ensures that only the n_{NSA} most profitable NSAs are implemented. This can be accomplished using a contribution hurdle, *X*. Assume that it is possible to order the net contributions of the universe of potential NSAs from lowest to highest. Let $t \in [0,1]$ index the "types" of NSAs with frequency $g(t)$ and let $\pi(t) \in (-\infty,\infty)$ denote the net contribution of an NSA of type *t*. Then the PG's NSA selection problem is just:

$$\max_s \Pi = \int_s^1 \pi(t)g(t)dt \quad s.t. \quad \int_s^1 g(t)dt = n_{NSA}$$

Suppose s^* solves this problem. Then, the optimal solution (i.e., all NSAs of type $t \geq s^*$ are implemented while the others are not) can be decentralized by requiring managers to recommend NSA whose net contributions meet or exceed a threshold contribution level of $X = \pi(s^*)$.

order to be implemented. Thus, there is some apparent similarity to a policy that requires NSA's projected revenues to exceed their projected fully distributed costs: such a policy also results in implementation of only NSAs with projected revenues strictly greater than their projected incremental costs.

However, the similarity is more apparent than real. As the analysis has revealed, the choice of the optimal threshold *X* is based on the availability of the scarce resource (i.e., managerial attention) relative to the "richness" of the pool of potential NSAs. The level of the Postal Service's institutional costs has nothing to do with this calculation. The following example will serve to illustrate this important point.

Suppose there are two potential NSAs under consideration, but the limited availability of senior management attention means that only one can be implemented. Both NSAs have positive contributions based upon the incremental cost standard, with the contribution of NSA_1 greater than that of NSA_2, so that

$$\Delta R_1 - IC_{true}(\Delta \mathbf{q}^1) > \Delta R_2 - IC_{true}(\Delta \mathbf{q}^2) > 0$$

Under what circumstances will the use of FDC costing lead to the choice of the "wrong" NSA? That is, by finding that

$$\Delta R_1 - IC_{FDC}(\Delta \mathbf{q}^1) < \Delta R_2 - IC_{FDC}(\Delta \mathbf{q}^2)$$

Combining these inequalities, yields the condition

$$IC_{FDC}(\Delta \mathbf{q}^1) - IC_{FDC}(\Delta \mathbf{q}^2) > \Delta R_1 - \Delta R_2 > IC_{true}(\Delta \mathbf{q}^1) - IC_{true}(\Delta \mathbf{q}^2)$$

Thus, it becomes possible for the "wrong" NSA to be selected when the difference in the fully distributed costs of the two NSAs is greater than the difference in their respective incremental costs.

The simple single product example of the previous section can be used to show how this situation can easily occur. Recall that there is assumed to be one product and one cost component with both mail volume and the cost driver measured in the same units at the initial quantity V. Total costs are given by $C(V) = AV^e$. Two NSAs are under consideration with forecast revenue increments of ΔR_1 and ΔR_2. The forecast volume changes associated with the two NSAs are $\Delta V_1 = z_1 V$ and $\Delta V_2 = z_2 V$. Using the results from Section 6 yields:

$$IC_{FDC}(\Delta V_1) - IC_{FDC}(\Delta V_2) = C(V)(z_1 - z_2)$$

and

$$IC_{true}(\Delta V_1) - IC_{true}(\Delta V_2) = C(V)[(1 + z_1)^e - (1 + z_2)^e]$$

Then, the above conditions that must be satisfied for the "wrong" NSA to be selected using an FDC costing methodology become:

$$C(V)(z_1 - z_2) > \Delta R_1 - \Delta R_2 > C(V)[(1 + z_1)^e - (1 + z_2)^e] \approx C(V)e(z_1 - z_2)$$

This result is readily interpreted. Suppose that the forecasted revenue increase is greater for NSA_1 than for NSA_2. Then, in order for NSA_1 to yield greater incremental profits than NSA_2 (as hypothesized), it is necessary that this difference in revenue gains exceed the *true* difference in incremental costs between the two proposed NSAs.[16] An evaluation using FDC costs would conclude that NSA_2 would be more desirable if, despite the "true" state of affairs, the FDC–estimated incremental cost disadvantage for NSA_1 *exceeded* its forecasted revenue advantage. This is more likely to occur: (i) the greater the difference in forecasted revenues and volumes; and (ii) the smaller the elasticity of costs with respect to volume. Thus, the "larger" the superior NSA relative to the other, the more likely it is that it will be rejected using an FDC analysis. Intuitively, this is because there is a cost overestimate on each unit that results from using the FDC criteria. The more units involved, the more serious the bias and the more likely the inferior project will be selected.

7. Conclusions

Fully distributed costing has long been discredited as a rate-making methodology. My analysis has demonstrated that it is also poorly suited to use when evaluating the desirability of new projects such as NSAs. This result is especially important for the Postal Service, for my analysis has also demonstrated that the Postal Service costing methodology already in place provides a reasonable, conservative approximation to the "true" incremental costs of an NSA.

In many respects, the use of FDC for project evaluation is even worse than it is for rate-setting. In the rate-setting context (under economies of scale), it is generally recognized that rates must be "marked up" above marginal cost in order for the firm to break even. The difficulty is that an FDC process implements these mark-ups inefficiently, without regard to

[16] If ΔR_1 is greater than ΔR_2 it will presumably be the case that ΔV_1 is greater than ΔV_2. Thus it will be more costly to implement NSA_1 than NSA_2. It is assumed above that the difference in forecasted revenues exceeds this difference in anticipated costs.

important demand considerations. In contrast, when evaluating an incremental project that is small relative to the overall size of the enterprise, it is neither necessary nor desirable to mark up marginal costs at all. They can be used directly to provide an approximate estimate of the costs associated with implementing the project in question.

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