OFFICE OF INSPECTOR GENERAL
UNITED STATES POSTAL SERVICE

The "First and Last Mile" Strategy: A Critical Assessment

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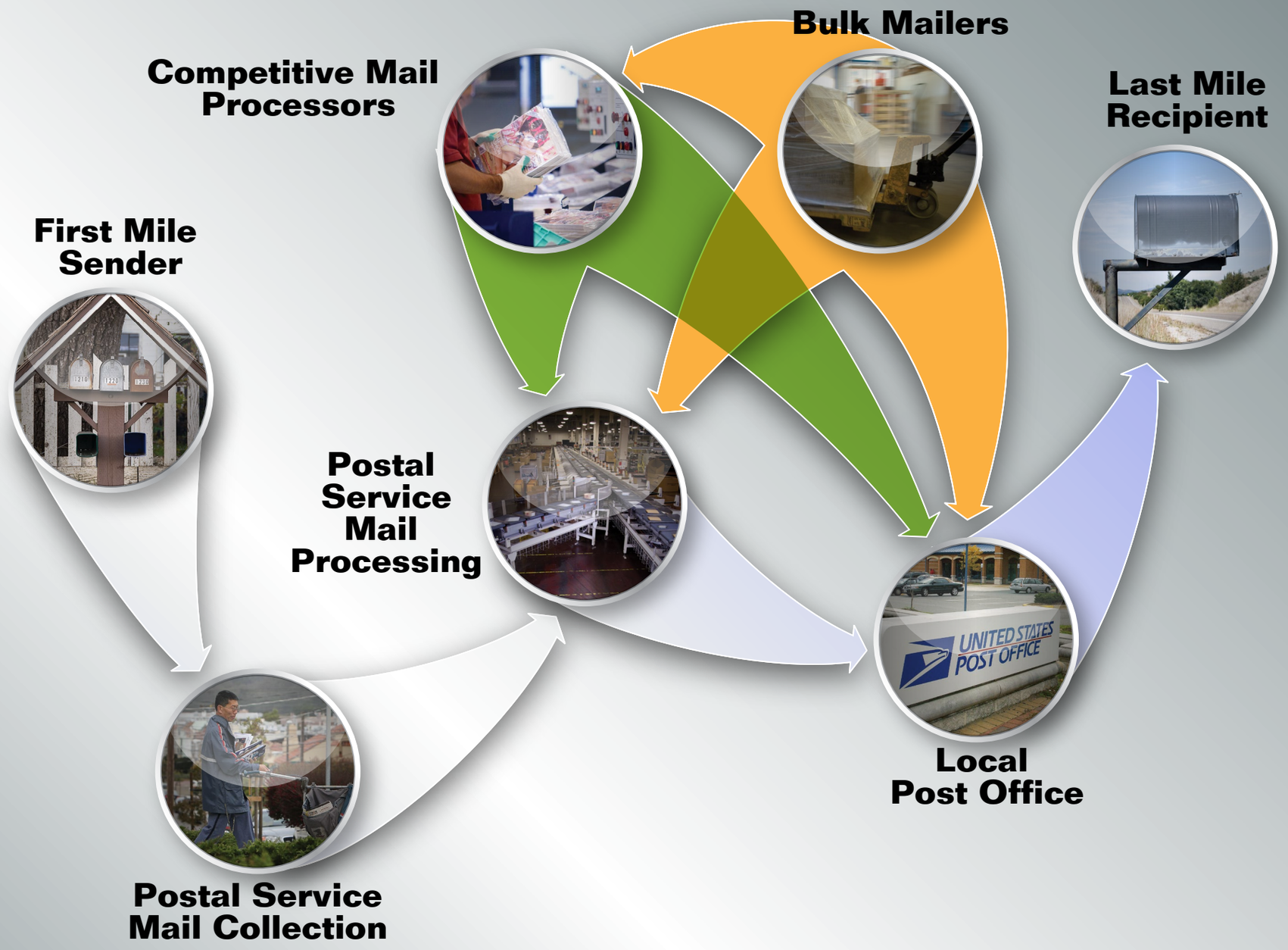

OFFICE OF INSPECTOR GENERAL
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Executive Summary

The concept of allowing the private sector to take over all mail processing is a more radical idea that warrants close examination.

As the U.S. Postal Service (Postal Service) continues to address its difficult financial situation, some have argued that overall efficiency would be improved if the Postal Service were to focus exclusively on the first and last mile and allow private industry to take over mail processing. While there exists many terms to describe this idea, including unbundling, focusing only on the first and last mile, or making the Postal Service a "collection and delivery" only company, the general argument is the same. That is, costs would decline and mailers would be better off if the private sector took over the mail processing and transportation of all mail, the so-called middle mile.[1] One such recent article is "Restructuring the U.S. Postal Service, The Case for a Hybrid Public-Private Partnership."[2]

Encouraging private industry to process the mail is not a novel concept. There has been some de facto unbundling through the introduction of workshare discounts — where the Postal Service offers a discount for mailers, or third parties, whose mail avoids some portion of mail handling, typically part of the sortation and/or transportation. The current prices for workshared letters and flats are based on a concept called efficient component pricing (ECP), which means setting the discount equal to the amount of costs the Postal Service avoids as a result of not having to process the workshared mail. Under ECP, the discount for mail presorted to the destination Post Office should be equal to the cost of that sort, since that is the cost the Postal Service avoids. However, the concept of allowing the private sector to take over all mail processing is a more radical idea that warrants close examination. The U.S. Postal Service Office of the Inspector General (OIG) asked Dr. John Panzar, an expert in postal economics, to look at the economic implications of the Postal Service abandoning mail processing completely and focusing exclusively on the first and last mile for the letters and flats market.

Highlights

Some postal commentators have argued the Postal Service should "unbundle" and focus its activities exclusively on the first and last mile.

The OIG asked Professor Panzar, a renowned expert on postal economics, to weigh in on this important issue.

Dr. Panzar developed a theoretical model that shows that if the Postal Service would abandon completely mail processing of letters and flats, there will be an overall loss in efficiency.

The Postal Service is made worse off through a loss in profits, and the mailers are made worse off through having to pay higher prices.

In fact, the only parties that benefit are the private providers of mail processing, and their benefit is less than the combined loss to the Postal Service and mailers.

This paper focuses on letters and flats; a similar analysis for the different parcel market will be released in a future white paper.

1 While this paper explicitly discusses mail processing, it should be understood that this also includes any transportation related to the middle mile.

2 Ed Gleiman, George Gould, Ed Hudgins, John Nolan, "Restructuring the U.S. Postal Service, the Case for a Hybrid Public-Private Partnership" (January 2013), http://www.napawash.org/wp-content/uploads/2013/01/Hybrid-Public-Private-Postal-Service-1-2-13-3.pdf.

If the Postal Service abandons all mail processing of letters and flats, there will be an overall loss in efficiency.

Dr. Panzar develops a theoretical model for letters and flats that assumes the Postal Service can choose the amount of mail processing it can pass on to the private sector. What Dr. Panzar finds is that when combined with efficient component pricing for workshare discounts, the Postal Service's mail processing plays a vital role in ensuring the productive and allocative efficiency of the postal sector, even in the absence of economies of scale in mail processing. In other words, if the Postal Service abandons all mail processing of letters and flats, there will be an overall loss in efficiency. The Postal Service is made worse off through a loss in profits, and the mailers are made worse off through having to pay higher prices. In fact, the only parties that benefit are the private providers of mail processing, and their benefit is less than the combined loss to the Postal Service and mailers. This result is a byproduct of how the current workshare discounts are set. If the discounts are based on efficient component pricing, they will encourage private companies to perform the sorting activity whenever, but only whenever, they do it more efficiently than the Postal Service. If the Postal Service is to abandon mail processing altogether, it will be forced to give that business to a less efficient operator. Therefore, the very nature of setting discounts equal to cost avoided results in having the most efficient entity performing the mail processing. Simply put, the Postal Service's participation in mail processing is necessary for overall efficiency.

This paper lays out a sound foundation for understanding the economics of pricing components of the postal value chain. While it provides some very valuable insights, we do not mean to imply that it alone answers the debate surrounding focusing on the first and last mile. Much more thought and empirical evidence are warranted. The models developed by Dr. Panzar rely heavily on assumptions, as do all theoretical models. His letter model assumes that the Postal Service has constant returns to scale, which means that it has the same productivity regardless of volume. Dr. Panzar's model also assumes the appropriate use of efficient component pricing for setting workshare discounts. Both of these assumptions are consistent with conventional wisdom and the regulator's policy. However, both are ultimately empirical questions that should be examined before accepting the conclusions in this paper.

What is appropriate for letters and flats may not be appropriate for parcels. The parcel market is different and requires its own focused attention and stylized model. This will be addressed in a future white paper.

Table of Contents

Cover
Executive Summary 1
Observations 4
1. Introduction and Summary 4
2. A Stylized Postal Network 6
2.1 Structural Assumptions on Demand, Supply, Profits and Surplus 9
2.2 “Competitive” Equilibrium in Mail Processing 12
2.3 *Equilibrium* Profit and Welfare Functions 18
3. Normative Benchmarks 18
3.1 Ramsey Pricing 22
3.2 “Bottom Up” Pricing 23
4. The Postal Sector Following the Establishment of a C&D Postal Service 25
4.1 C&D Scenario 1: Capped Single-Piece Rate and “Cost Based” Delivery Rate 26
4.2 C&D Scenario 2: PAEA-Style Global Price Caps 30
4.3 C&D Assessment: Ending Mail Processing Would Likely Have Significant Costs to the Postal Service and Lead to Higher Prices 32
5. Conclusions 34
References 35
Appendices 37
A1: Equilibrium Comparative Statics 38
A2: Ramsey Pricing for a C&D Postal Service 39
Contact Information 40

The "First and Last Mile" Strategy: A Critical Assessment

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United States Postal Service
Office of Inspector General

1. Introduction and Summary

The financial difficulties of the Postal Service following the Great Recession of 2008 have prompted extensive discussions about its future. There have been many proposals regarding how its business plan should be changed. Perhaps the most numerous and persistent suggestions have been those that argue for an increased focus on the "first and last mile" of postal operations.[1] Conventional wisdom has long held that it is this part of the postal value chain in which economies of scale are concentrated.[2] And, this conclusion has received substantial support from empirical studies over the past two decades.[3] On the other hand, there is much less consensus about the extent of scale economies in the "middle" portions of the postal value chain. The Postal Regulatory Commission (PRC), and its predecessor, the Postal Rate Commission, has

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[1] I must confess that I contributed to this body of literature in Panzar (2012).

[2] See, for example, Owen and Willig (1983) and Panzar (1991).

[3] The empirical literature has grown to be quite extensive. See, for example, Bradley *et. al.* (2007), Cazals *et. al.* (2005), Cazals *et. al.* (1997) and Cohen and Chu (1997).

consistently treated mail processing costs as exhibiting constant returns to scale.[4] Indeed, ever since the Postal Reform Act of 1971, the development of a competitive mail processing sector has been encouraged by the offering of work-sharing discounts to mailers and consolidators who partially processed their mail before lodging it with the Postal Service. This would hardly be a rational policy if the Postal Service enjoyed increasing returns to scale in mail processing. In that case, it would increase total postal sector costs to divert mail processing activity from the Postal Service by encouraging work-sharing.

In addition, the system of work-sharing discounts implemented by the Postal Service and the PRC functions as an access pricing regime for the Postal Service's delivery monopoly bottleneck. That is, mailers or consolidators that receive a work-sharing discount as a result of bypassing the transportation and mail processing functions of the Postal Service are essentially purchasing unbundled delivery services. As in other industries, the pricing of downstream access to competitors can be a contentious issue.[5] Therefore, it is tempting to conclude that eliminating the Postal Service's mail processing activities might greatly simplify regulatory and antitrust policy without paying a significant penalty in terms of economic efficiency. My analysis reveals that this view is in error. It turns out that, *when combined with avoided-cost* (*ECP*) *work-sharing discounts*, the mail processing activities of the Postal Service play a vital role in ensuring the productive and allocative efficiency of the postal sector, *even in the absence of economies of scale* in mail processing.

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[4] In postal parlance, the terminology refers to mail processing costs as "100% volume variable:" i.e., such costs increase proportionately with mail volume.

[5] See, for example, de Bijl *et. al.* (2006), Bradley *et. al.* (2008) and Panzar (2008).

The mail processing activities of the Postal Service play a vital role in ensuring the productive and allocative efficiency of the postal sector.

The remainder of this White Paper is organized as follows. Section 2 presents a model of a simple postal network consisting of collection, mail processing and delivery components. The model is formulated so that it is possible to easily compare the current situation, which features a mix of end-to-end delivery and competitive sorting via work-sharing discounts, with an hypothetical "collection and delivery only" (C&D) Postal Service. Section 3 presents normative standards to use in evaluating the economic efficiency of a postal sector with a C&D Postal Service. Section 4 analyzes various scenarios for regulating an hypothetical C&D Postal Service and discusses the likely results.

2. A Stylized Postal Network

The setting analyzed is quite simple. Figure 1 depicts a simplified version of a (unidirectional) postal network as currently structured. Single piece mailers utilize the collection network of the Postal Service, which processes (i.e., transports and sorts) their mail and advances it to the Postal Service's delivery network for delivery to mail recipients.[6] In this stylized version of the current system, large, "bulk" mailers have three options. They can lodge their mail with the Postal Service at the Postal Service Mail Processing Center, bypassing the Postal Service collection network and receive a work-sharing discount off the single-piece rate. They can also lodge their mail volumes "deeper" in the postal network, at a Local Delivery Office, for which they are rewarded with an even larger work-sharing discount. Alternatively, bulk mailers can lodge their volumes directly with competitive mail processing firms at the bulk mail rate.

[6] Of course, the actual postal network is bi-directional and most (i.e., 66%) local post offices combine the collection and delivery functions. See USPS OIG (2011).

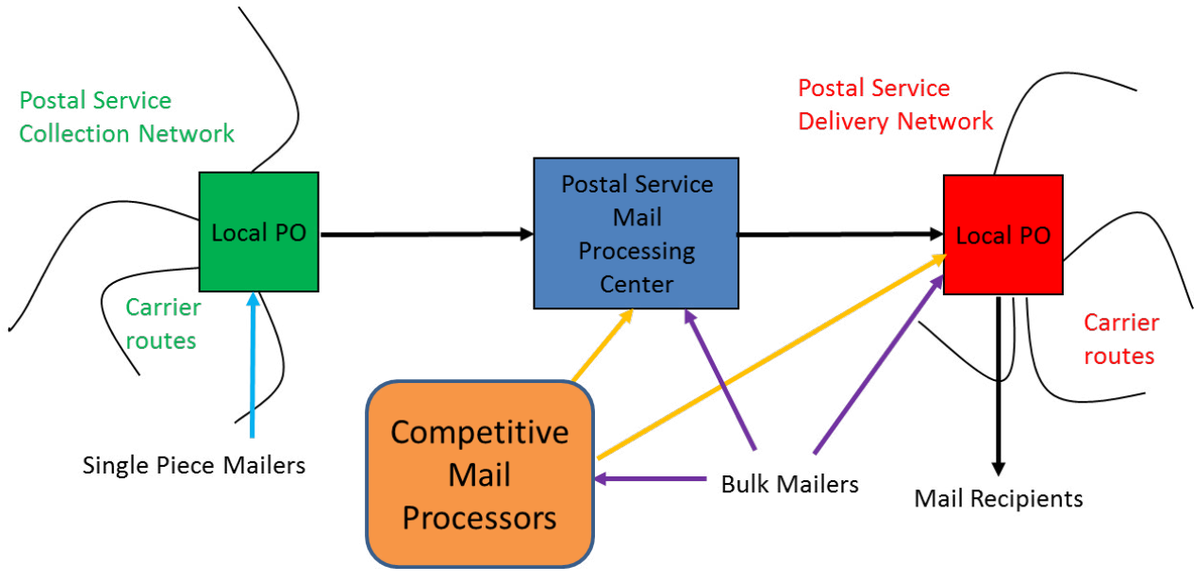

Figure 1

I further simplify this model of the postal network in order to more easily focus on the case in which the Postal Service is limited to operating *only* a collection and delivery (C&D) network. The Postal Service operates its local collection and delivery networks. Initially, it also is the dominant firm in the mail processing market, competing with a fringe of (perfectly) competitive operators. Thus the Postal Service collects "single piece," retail mail from the public and small businesses. It then sorts and transports these volumes to its local delivery locations. The analytical framework I develop also will allow the Postal Service the option of "outsourcing" a portion of the sortation and transportation function to a competitive mail processing sector. These firms sort the mail and transport it to the Postal Service's delivery sortation facility. (This could be the local delivery office or a mail processing center that performs route-walk sorting for a number of delivery units.) In addition to the mail originating with the Postal Service, large mailers may lodge their volumes directly with mail processors. I do not allow for small mailers to "bypass" the Postal Service by patronizing competitive collection offices. I also assume that there is no bypass of the Postal Service delivery function. It is

straightforward to allow for the presence of a "competitive fringe" in one or both markets without materially affecting the analysis.

This model is similar to others I have used[7] to analyze vertically integrated postal networks. However, there are some important modifications. Theoretical models usually limit attention to two vertical stages: a delivery stage and a composite, "mail processing" stage in which collection, inward and outward sortation and transportation are all lumped together. I follow standard practice by assuming that mail processing can be performed by the Postal Service at an essentially constant cost per unit, while the delivery function exhibits significantly increasing returns to scale. For obvious reasons, I have added a third, collection stage. I modeled the partially competitive mail processing stage somewhat differently. Rather than casting the Postal Service as a traditional dominant firm price leader, I have modeled its participation in the market as a quantity choice. Thus, instead of directly setting a bulk mail rate (or a work-sharing discount), the Postal Service chooses how much, if any, of its collected mail to "hand off" to the competitive mail processing market. In the end, the economic content of the model is the same. The Postal Service can *indirectly* determine the competitive mail processing price through its choice of quantity. However, the current formulation allows me to move directly to a C&D only scenario by simply not *allowing* the Postal Service to engage in mail processing. Figure 2 provides a schematic of the postal sector analyzed in the theoretical model. The newly introduced variables indicate quantity flows and are defined below.

[7] See, for example, Panzar (2008), (2010), (2011) and USPS OIG (2010).

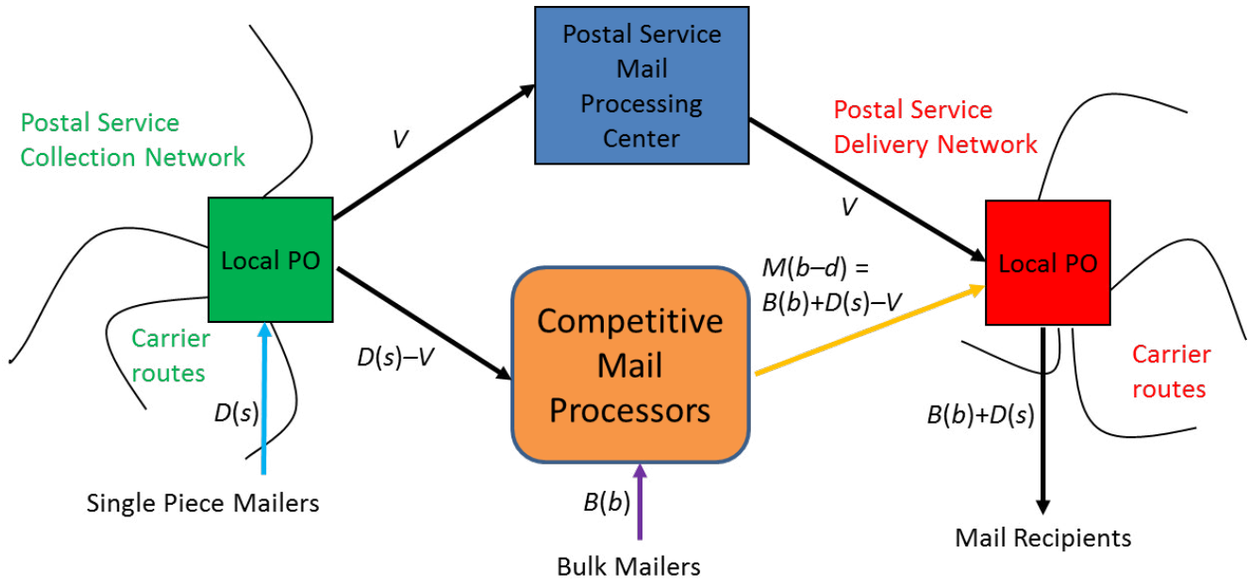

Figure 2

2.1 Structural Assumptions on Demand, Supply, Profits and Surplus

The demand function for large mailers is given by $B(b)$, where b is the price paid by such mailers for the delivery of their "bulk" mail. For simplicity, I assume that these bulk mailers deal only with competitive mail processors and *not* directly with the Postal Service. The demand of individual and small business mailers is given by $D(s)$, where s is the end-to-end price established by the Postal Service for such "single piece" mail. Again, these small mailers have no option but to lodge their mail using the collection network of the Postal Service. Firms in the competitive mail processing sector receive mail from bulk mailers and a portion of that collected by the Postal Service. Both bulk mailers and the Postal Service pay mail processors the prevailing competitive bulk mail rate b when they transfer their mail. The bulk mailers are paying for processing and delivery. The Postal Service pays b when it relinquishes its mail to processing firms, but receives a delivery fee of d for each piece when the processed mail is

returned to it for delivery. Thus, the Postal Service actually pays a net fee of $b–d$ for mail processing services.

Similarly, the supply curve of the competitive mail processing industry is also based on this *net margin*, $m = b–d$. Let $M(m) = M(b–d)$ denote this upward sloping supply function. The economic profit[8] P of the competitive mail processing sector at any bulk mail price b and delivery price d is given by the area between the supply curve and the price line: i.e.,

$$P(m) = P(b-d) = \int_0^m M(z)dz = \int_0^{b-d} M(z)dz \qquad (1)$$

From the Fundamental Theorem of the Calculus, it follows that the derivative of processing industry profits with respect to the processing margin $m = b–d$, is just the market supply: i.e.,

$$P'(m) = M(m) = M(b-d) \qquad (2)$$

The costs incurred by the Postal Service, $C(V_c,V_d,V,N)$, are a function of the volume it collects, V_c; the volume it delivers, V_d; the volumes (if any) of mail that it processes V; and the number of its collection and delivery installations, N. For simplicity, I assume that the collection, mail processing and delivery activities of the Postal Service are carried out at constant marginal cost, where c, t and r represent the marginal cost of each respectively.[9] I will make use of the following *affine* cost function in my analysis:

$$C(V_c,V_d,V,N) = F(N) + cV_c + rV_d + tV \qquad (3)$$

---

[8] Economic profit, in contrast to accounting profit, is measured *net* of a normal return on capital.

[9] This is largely for notational convenience. It is much easier to refer to marginal costs as parameters rather than as a function evaluated at particular output levels. For purposes of the present analysis, little of substance is lost through such a simplification. For postal costing issues, it is important to recognize the nonlinearities in the system. See the discussions in Bradley, Colvin and Smith (1993), Bradley, Colvin and Panzar (1999) and USPS OIG (2012).

In this simple model, the fixed costs of the Postal Service are determined by the size of its collection and delivery network.

Thus, in this simple model, the fixed costs, $F(N)$, of the Postal Service are determined by the size of its collection and delivery network.[10] The volume of single-piece mail collected by the Postal Service is equal to the market demand:

$$V_c = D(s) \tag{4}$$

Since the Postal Service ultimately delivers *all* mail volumes, it must be the case that:

$$V_d = D(s) + B(b) \tag{5}$$

Using equation (3), Postal Service profits can be written as

$$\pi = (s - c)V_c - b(V_c - V) - tV + d(V_d - V) - rV_d - F \tag{6}$$

That is, for each unit of mail it collects, the Postal Service receives the single piece rate and incurs collection costs. For mail it chooses to process itself, it incurs processing costs based on its unit costs; for the remaining collected mail, the Postal Service *pays* the bulk rate to competitive suppliers to have the mail processed and transported. In addition, the Postal Service receives a delivery charge for all mail in the system *except* those volumes processed internally. However, *all* volumes incur the marginal delivery cost r. Substituting in the demand identities of equations (4) and (5), the expression for Postal Service profits becomes:

$$\pi = (s - c - b)D(s) + (b - t - d)V + (d - r)[D(s) + B(b)] - F \tag{7}$$

This specification includes an option for the Postal Service to process a portion, V, of its volumes rather than transfer them to the competitive mail processing industry. Obviously, $V = 0$ in a

[10] The number of collection and delivery points is held constant in the remainder of the analysis and the variable N is dropped from the equations.

This specification includes an option for the Postal Service to process a portion of its volumes rather than transfer them to the competitive mail processing industry.

C&D only Postal Service. It will become clear below how considering the possibility of a nonzero V can yield important insights.

Total economic surplus ("welfare") in the postal sector in this model is the sum of the consumers' surplus[11] of single-piece and bulk mailers and the profits of industry participants, including the Postal Service. Let $S_s(s)$ denote the consumers' surplus of single-piece mailers and $S_b(b)$ the consumers' surplus of bulk mailers. As usual, these consumers' surplus functions decrease when price increases. We will also have occasion to appeal to *Antonelli's Lemma*, the fact that the derivative of consumers' surplus with respect to price is equal to the negative of the quantity demanded: i.e., $S_s'(s) = -D(s) < 0$ and $S_b'(b) = -B(b) < 0$. The formula for the profits of the Postal Service, $\pi(s,d,b,V)$, is given in equation (7). Finally, equation (1) defines the profits of competitive mail processors. Thus the social welfare function used in the analysis is given by:

$$W(s,d,b,V) = S_s(s) + S_b(b) + \pi(s,d,b,V) + P(b-d) \qquad (8)$$

2.2 "Competitive" Equilibrium in Mail Processing

I begin by characterizing the market equilibrium that results when the Postal Service, or the Postal Regulatory Commission (PRC), establishes rates for single piece mail (s) and delivery services (d). The equilibrium bulk mail price is determined by supply and demand conditions in the mail processing market. The equilibrium price results when the total quantity presented for

[11] *Consumers' surplus* is a standard economic term that refers to the amount by which the value consumers place on a service exceeds the amount that they are required to pay for it. In the standard economic textbook diagram, it is measured as the area between the market demand curve and the horizontal line given by the market price.

Since all mail must be processed, this aggregate demand for mail processing depends on both the single piece rate and the bulk mail rate.

processing by large mailers and the Postal Service is equal to the competitive supply of mail processing services:

$$D(s) - \mathrm{V} + B(b) = M(b - d) \qquad (9)$$

This equation reveals how the equilibrium bulk mail price is indirectly determined by the specification of the Postal Service's prices for single-piece mail and delivery services. For ease of exposition, henceforth let $b(s,d,V)$ denote the equilibrium bulk mail price, and let b_s, b_d, and b_V denote the relevant partial derivatives with respect to, respectively, changes in the single-piece rate, the bulk mail rate, and the quantity of Postal Service mail processing. Thus, the function $b(s,d,V)$ is defined implicitly by the following equation:

$$D(s) - V + B[b(s,d,V)] = M[b(s,d,V) - d] \qquad (10)$$

Figure 3 illustrates the operation of supply and demand in the mail processing market. The total demand for mail is the single piece demand, $D(s)$, plus the demand of bulk mailers, $B(b)$. Since all mail must be processed, this aggregate demand for mail processing depends on both the single piece rate and the bulk mail rate. However, for a given single-piece rate, it is a downward sloping function of the bulk delivery charge rate. As noted above, the supply curve of competitive mail processors, $M(m)$, is an upward sloping function of the margin the firms receive, $m = b - d$. For any given delivery price, this curve is an increasing function of the bulk mail rate. Total postal sector mail processing supply is the sum of the amount supplied by competitors and the amount, V, that the Postal Service chooses to process itself. In Figure 3 consider the price $b_1 = b(s,d,V)$. The intersection of the supply curve of competitive mail processors with this price is the amount $M(b_1–d)$. The total demand for mail at the price b_1 is given by the aggregate demand curve and is equal to the quantity $B(b_1) + D(s)$. This is greater

than the amount supplied, but greater by exactly the amount of mail processing, V, that the Postal Service has chosen to do itself. Therefore, b_1 is the equilibrium price in the market. If the Postal Service chose to provide less mail processing, there would be a shortfall of processing supply, and the equilibrium price would rise. In the C&D only case, $V = 0$ and the equilibrium price would be determined, as usual, by the intersection of the mail processing supply and demand curves: i.e., at b_0 in the diagram.[12]

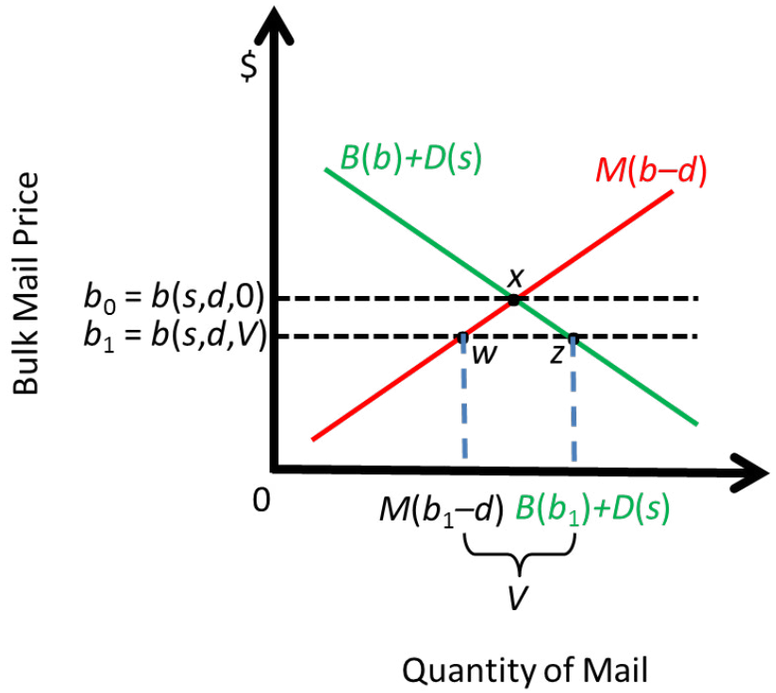

Figure 3

[12] Figure 3 illustrates what would happen if the Postal Service were to eliminate its internal mail processing activities. The market price would rise because V units of relatively inexpensive Postal Service processing (at constant unit cost t) are replaced with increasingly expensive processing by outside firms. However, this begs the question of *why* the Postal Service has this capability. Suppose that the Postal Service were to "spin off" its mail processing facilities and labor into a private company. Why would it not be possible for this "new" competitive mail processing firm to process the former internal volumes V at the same constant unit cost of t? If it could, the equilibrium competitive price would not rise at all. The explanation for the Postal Service mail processing cost advantage must somehow lie in the integration of the Postal Service's mail processing operation with the rest of its network. This important issue is not analyzed here.

It is important to understand how the prices established by the Postal Service (or the PRC) impact the competitive bulk mail price. These standard *Comparative Statics* results are obtained by differentiating the equilibrium condition in equation (10) with respect to the parameters of interest. The mathematical derivations are presented in Appendix A1. A diagrammatic presentation of the results follows.

The effect on the equilibrium bulk mail rate of an increase is given by:

$$b_s = \frac{D'(s)}{M'(b-d)-B'(b)} < 0 \qquad (11)$$

Thus, an increase in the single-piece rate will result in a decrease in the equilibrium bulk mail rate. Figure 4 provides the intuition for this result. Suppose the initial single-piece stamp price is at s_2 and the equilibrium process described above yields an equilibrium price of b_2. The aggregate demand curve intersects that price at point y, which is exactly V units more than the intersection of the supply of competitive mail processors at point x. Now suppose that the single-piece prices *rises* to s_1. This will reduce the quantity of single-piece mail demanded and shift the aggregate demand curve back to the left. Demand now falls short of the available supply at the price b_2, so the price must fall. Equilibrium is re-established at the lower price b_1.

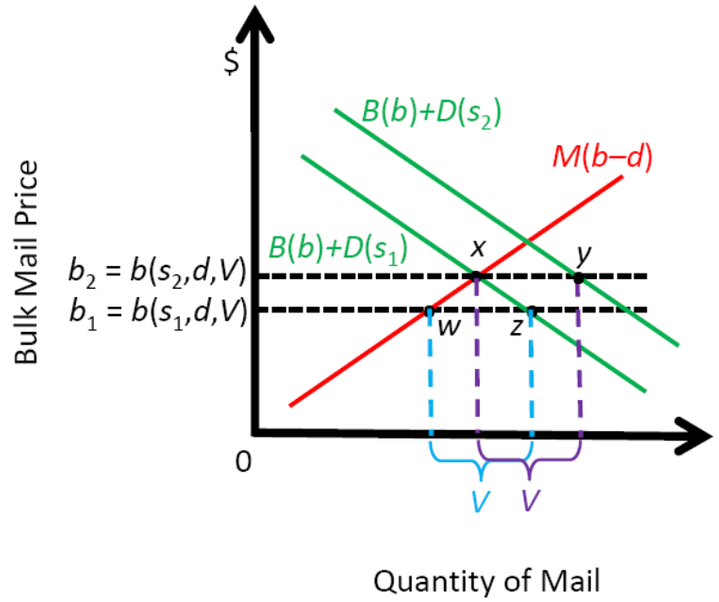

Figure 4

Similarly, the effect on the equilibrium bulk mail rate of an increase in the delivery price is given by:

$$b_d = \frac{M'(b-d)}{M'(b-d)-B'(b)} > 0 \qquad (12)$$

Not surprisingly, an increase in the delivery charge shifts the mail processing supply curve to the left, resulting in a higher equilibrium mail processing price. This result is illustrated in Figure 5.

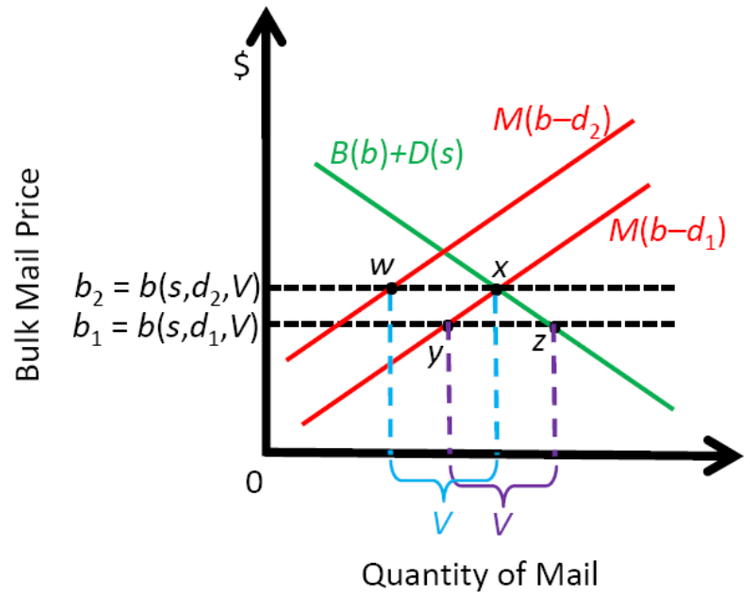

Figure 5

The initial delivery price is at d_1, leading to an equilibrium bulk mail price of b_1 through the process explained earlier. When the delivery price increases to d_2, the effect is to reduce mail processing margins for all levels of the bulk mail price, shifting the competitive supply curve up and to the left. Total supply at the initial price b_1 now falls short of aggregate demand, leading to a rise in price. Equilibrium is re-established at the higher price b_2.

Finally, consider the effect on the equilibrium bulk mail price as the Postal Service changes the amount of mail that it chooses to process. The analysis in Appendix A1 reveals that:

$$b_V = \frac{-1}{M'(b-d)-B'(b)} < 0 \qquad (13)$$

As expected, the effect of withdrawing some processing demand from the market lowers the equilibrium price. This was reflected (in reverse) in Figure 3, which illustrated the price increase that results when the Postal Service eliminates its mail processing activities by setting $V = 0$.

The equilibrium bulk mail rate is determined by competitive forces in the mail processing market.

2.3 *Equilibrium* Profit and Welfare Functions

The equations above reveal that the bulk mail rate is an important determinate of consumers' surplus and firm profits in our stylized postal sector. Yet, as explained above, in the current formulation this variable is not directly chosen by either the Postal Service or the PRC. Rather, the equilibrium bulk mail rate is determined by competitive forces in the mail processing market. The above analysis has explained how this equilibrium price is affected by changes in the single-piece rate, the delivery rate and the quantity of Postal Service mail processing. Next, it is necessary to adapt our profit and welfare functions to reflect the fact that one of their arguments (b) is, in equilibrium, a function of the policy variables s, d and V. Basically, all that is involved is substituting the *equilibrium value function* $b(s,d,V)$ for b wherever it appears in equations (1), (7) and (8). That is, define the following *equilibrium* welfare and profit functions:

$$\varphi(s,d,V) \equiv \pi = [s - c - b(s,d,V)]D + [b(s,d,V) - t - d]V + (d - r)[D + B] - F \quad (14)$$

$$\theta(s,d,V) \equiv P[b(s,d,V) - d] \quad (15)$$

$$\omega(s,d,V) \equiv W[s,d,b(s,d,V),V] = S_s(s) + S_b[b(s,d,V)] + \varphi(s,d,V) + \theta(s,d,V) \quad (16)$$

3. Normative Benchmarks

I assume that the social welfare objective of the policy maker is the maximization of *equilibrium* total surplus in the market.[13] This *social welfare function* is the sum of the total profits of industry participants and the consumers' surplus of all mailers. I begin the analysis by deriving the partial derivatives of the *equilibrium* profits of industry participants with respect to Postal Service prices. For the Postal Service itself, we have:

[13] A plausible alternative objective might be the *minimization* of the single-piece stamp price.

$$\frac{\partial \varphi}{\partial s} = (1 - b_s)D(s) + (s - c - b)D'(s) + Vb_s + (d - r)[D'(s) + b_s B'(b)] \quad (17)$$

$$\frac{\partial \varphi}{\partial d} = -b_d D(s) + B(b) + V(b_d - 1) + (d - r)B'(b)b_d \quad (18)$$

Making use of equation (2) and the Chain Rule, we can readily derive the following:

$$\frac{\partial \theta}{\partial s} = P'(m)b_s = M(m)b_s = M(b - d)b_s \quad (19)$$

$$\frac{\partial \theta}{\partial d} = P'(m)(b_d - 1) = M(m)(b_d - 1) = M(b - d)(b_d - 1) \quad (20)$$

It is now straightforward to derive expressions for the partial derivatives of the equilibrium social welfare function with respect to Postal Service variables:

$$\frac{\partial \omega}{\partial s} = -D - Bb_s + \frac{\partial \varphi}{\partial s} + \frac{\partial \theta}{\partial s} \quad (21)$$

$$\frac{\partial \omega}{\partial d} = \frac{\partial \varphi}{\partial d} + \frac{\partial \theta}{\partial d} \quad (22)$$

The first of these results (twice) makes use of the fact, mentioned above, that the derivative of consumers' surplus with respect to price is equal to the negative of the market quantity demanded. The First Order Necessary Conditions (FONCs) for an (unconstrained) maximum of total surplus are obtained by setting the above partial derivatives equal to zero. Substituting in all the results derived thus far, we have:

$$\frac{\partial \omega}{\partial s} = (s - c - b)D'(s) + (d - r)[D'(s) + b_s B'(b)] = 0 \quad (23)$$

$$\frac{\partial \omega}{\partial d} = (d - r)B'(b)b_d = 0 \quad (24)$$

It is worth examining the welfare foundations of the premise of a C&D Postal Service.

It is clear from the above FONCs that optimal ("First Best") pricing requires a delivery charge equal to delivery marginal cost ($d = r$) and a single-piece rate equal to the sum of Postal Service marginal collection cost plus the *equilibrium* bulk mail rate.

These results are not surprising. The first result just requires the marginal cost pricing of delivery. The stamp price result is a bit more complicated, combining Efficient Component Pricing with competition in the bulk mail/mail processing market. From a "top down pricing" perspective, this just says that the bulk mail rate should equal the single-piece rate less the avoided collection costs of the Postal Service. Of course, the result of such marginal cost pricing is that there are no markups available to cover the fixed costs of the enterprise and the Postal Service earns losses equal to its fixed costs of F.

Before examining "more practical" pricing policies, it is worth examining the welfare foundations of the premise of a C&D Postal Service. The reason the prospect of a Postal Service constrained to outsource all of its sorting is seriously discussed is the belief that the mail processing activities of the Postal Service can be carried out at essentially constant long run marginal costs. In addition, much of this mail processing activity is currently work-shared, and there is some question as to whether Postal Service participation in mail processing is necessary. It is straightforward to examine this issue in the context of the current model, where it is assumed that the Postal Service can provide any desired amount of mail processing activity at the constant long run marginal (and average incremental) cost of t.[14] As we shall see, combined with the assumption of avoided cost work sharing discounts, processing a portion of Postal Service

[14] The analysis becomes considerably more complicated if the Postal Service could also avoid a portion of its fixed costs if it shut down its mail processing function. It would be necessary to deduct such fixed cost savings from the efficiency losses described below. Obviously, if those fixed costs were large enough, it would always be desirable to eliminate Postal Service mail processing.

Processing a portion of Postal Service volumes at constant unit cost will be preferable to shifting those volumes onto the rising supply curve of competitive mail processors.

volumes at constant unit cost will be preferable to shifting those volumes onto the rising supply curve of competitive mail processors.

Begin by supposing that the Postal Service were considering processing a portion of the mail it collects, say a volume V, rather than passing it all on (at a cost of b) to the mail processing sector. The effect on Postal Service profits given a small change in V (*and neglecting any change in bulk mail prices*) is given by:

$$\frac{\partial \pi}{\partial V} = b - t - (d - r) - r = b - t - d \qquad (25)$$

Thus a price-taking, competitive Postal Service would anticipate making a profit by diverting volumes to its own mail processing facilities whenever $b - d = m > t$: i.e., when the competitive margin in the mail processing market was greater than its own unit cost. Conversely, it would anticipate making a loss if said margin is less than its internal unit cost.

Of course, a decision by the Postal Service to "self-process" some mail volumes *will* affect the equilibrium price in the bulk mail market. Withdrawal of the volume V will shift the aggregate demand curve for mail processing to the left, and lower the equilibrium price. The *equilibrium* profit function defined above is designed to capture this effect. Differentiating it with respect to V yields:

$$\frac{\partial \varphi}{\partial V} = \frac{\partial \pi}{\partial V} + \frac{\partial \pi}{\partial b} b_V = [b(s, d, V) - t - d] - [(D - V) - (d - r)B'(m)]b_V > \frac{\partial \pi}{\partial V} \qquad (26)$$

The difference between equations (25) and (26) is instructive. In addition to the "direct effect," on profitability, $b - t - d$, equation (26) contains additional expressions. We know from equation (13) that the effect on the equilibrium bulk mail rate of an increase in V is negative. It remains to evaluate the bracketed term. The first term, $D - V$, must be nonnegative because the

A way must be found to regulate the C&D Postal Service in such a way that it is able to at least break-even.

Postal Service cannot choose to process more mail than it receives from single-piece mailers. Because bulk mail demand is downward sloping, the second term, $-(d-r)B'$, will also be positive whenever the delivery charge is greater than marginal delivery cost. The effect on Postal Service profits after accounting for the change in the bulk mail price will be larger than the direct effect because a decrease in the bulk mail rate, taken by itself, would increase Postal Service profits.

The *direct* effect on welfare of a change in V is the same as the direct on Postal Service profits, as that is the only place V appears in W. However, taking into account the effects on the equilibrium bulk mail price, we see that:

$$\frac{\partial \omega}{\partial V} = \frac{\partial \pi}{\partial V} + \frac{\partial W}{\partial b} b_V = [b(s,d,V) - t - d] + (d-r)B'(m)b_V = \frac{\partial \varphi}{\partial V} + (D-V)b_v \qquad (27)$$

The key determinant of the desirability of Postal Service self-processing is, as expected, the equilibrium mail processing margin relative to Postal Service processing cost. For any delivery rate greater than marginal delivery cost there is an added, positive term reflecting the welfare effect of a decrease in the equilibrium bulk mail rate resulting from an increase in V. It is important to note that this extra welfare term is always *less* than the analogous term for the profit effect. Thus, although it is desirable from a welfare perspective to maintain Postal Service self-processing, it is even more desirable from the point of view of Postal Service profits.

3.1 Ramsey Pricing

Of course, a way must be found to regulate the C&D Postal Service in such a way that it is able to at least break-even. One well-known (if seldom used) method is *Ramsey Pricing*: prices are set so as to maximize total surplus subject to the constraint that the incumbent firm at least breaks even. Since I see little prospect that Ramsey Pricing will play a significant role in the

future of the C&D Postal Service, the mathematical details of this approach are left to Appendix A2. However, speaking generally, it will be the case that the optimal prices would involve mark-ups over unit costs for both collection and delivery. That is, $s^* > c + b(s^*,d^*,0)$ and $d^* > r$. The relative sizes of the required markups will depend on the elasticities of demand for single-piece and bulk mail and the elasticity of supply in the competitive mail processing market. In a C&D only (i.e., V=0) postal sector the unit processing cost (t) of the Postal Service will *not* play a role in the calculations. Thus, the optimal level of the delivery price, d^*, and the equilibrium level of the bulk mail rate, $b(s^*,d^*,0)$, may or may not create a margin that the Postal Service could profitably (and efficiently) exploit. As a result, a Ramsey Pricing policy is not inherently "self-correcting." That is, the process itself does not determine an optimal amount of mail processing to be done by the Postal Service. Rather, the optimal prices coming out of the Ramsey calculation must be compared to Postal Service unit mail processing costs to determine the desirability of Postal Service participation in that stage of the value chain.[15]

3.2 "Bottom Up" Pricing

The traditional system for determining the relative prices of various products of the Postal Service has been based upon "top down" pricing. In terms of the present model, the appropriate price, b, of bulk mail would be determined by subtracting the Postal Service unit cost of collection, c, from the single piece stamp price, s. Similarly, the suggested price of a "delivery only" service, d, would be found by deducting the unit mail processing cost of the Postal Service from the bulk mail rate $d = b - t = s - c - t$. This "avoided cost" approach to the pricing structure will be difficult to sustain following a move to a C&D only Postal Service. The

[15] Of course, once the Postal Service has been excluded from mail processing, Postal Service cost accounts may no longer produce the data required to estimate the per unit mail processing cost t.

reason is quite simple. If the Postal Service does not offer a bulk mail service, how can the delivery only price be computed as a discount off the bulk mail price? There is little alternative but to directly determine the delivery only price based upon the costs of delivery. How would such a "bottom up" system evolve?

To begin, consider a benchmark "integrated status quo" with the following characteristics (i) the Postal Service earns zero economic operating profits; (ii) the rate structure is based upon avoided costs; and (iii) all of the fixed costs of the network reside in the delivery component. Given these assumptions, $b = s - c$, and $d = b - t = s - c - t$. Substituting these conditions into the expression for Postal Service profits yields:

$$\pi = (d - r)[D(s) + B(b)] - F = (d - r)[D(d + c + t) + B(d + t)] - F = 0 \qquad (28)$$

This equation can be readily solved for the required break-even delivery charge d_0. Once this is determined, the remaining upstream prices are determined by the avoided cost assumption so that $b_0 = d_0 + t$ and $s_0 = b_0 + c = d_0 + t + c$. This procedure has allowed us to transform a three-stage (C&D&MP) Postal Service into a C&D Postal Service. Actually, our benchmark C&D Postal Service is exactly equivalent to a regulated delivery only monopolist serving two upstream competitive industries. This is because we have assumed constant marginal and average collection costs and avoided cost pricing of collection. The collection stage performs "as if" it were a constant cost competitive industry.

The above exercise should convince the reader that there is no fundamental difference between "top down" and bottom up" pricing. Suppose we *start* with the question: What delivery price is required for a *delivery monopolist* to break even, *given* that the upstream markets are allowed (or forced) to act competitively? The delivery charge d_0 is the answer to that

"bottom up" question. The associated upstream prices, b_0 and s_0, will emerge through the competitive process. Alternatively, one could start by asking: What single-piece stamp price is required for the Postal Service to break-even, *given* that successive margins are set on an avoided cost basis? We would find that s_0 is the answer to that question and that b_0 and d_0 emerge through applying avoided cost principles. The important point is that, while bottom up and top down procedures can reach the same answer, the answer depends upon the market behavior at the intermediate stages. This is especially relevant when considering a change in the institutional and regulatory structures of the postal sector.

4. The Postal Sector Following the Establishment of a C&D Postal Service

Now that I have developed a benchmark market model of the postal sector following the establishment of a C&D Postal Service, the important issue becomes: What happens next? That is, how will the postal marketplace function going forward? This depends upon many factors, the most important of which is the nature of the regulatory process facing the Postal Service. Before examining the implications of various regulatory regimes, it is first necessary to discuss the impact of the "abandonment" of mail processing by the Postal Service.

Our benchmark Postal Service offers a delivery only service at a price d_0. The corresponding upstream prices were $s_0 = d_0 + t + c$ and $b_0 = d_0 + t$, implemented by avoided cost pricing rules and the supply of competitive bulk mailers.[16] An important part of that benchmark equilibrium was the decision of the Postal Service to internally process the volume V_0, the difference between the aggregate bulk mail demand and the amount of processing supplied by competitors at the benchmark margin $m_0 = t$. That is,

[16] As noted earlier, one could also model the behavior of a competitive collection fringe in a similar manner.

$$V_0 = D(s_0) + B(b_0) - M(m_0) = D(d_0 + c + t) + B(d_0 + t) - M(t) \quad (29)$$

The first effect of the move to a C&D would be that the competitive mail processing sector would have to "take over" this processing. Of course, the likely result would be an *increase* in the equilibrium mail processing price, *b*. The extent of the increase would depend upon:

(i) Initial Postal Service share of the total mail processing

(ii) Elasticity of the bulk mail demand curve

(iii) Elasticity of the competitive mail processing supply curve

The size of the equilibrium price increase resulting from the Postal Service exit from mail processing will be larger, the larger the initial Postal Service share of mail processing, the less elastic the bulk mail demand and mail processing supply curves. These effects were illustrated in Figure 3, above.

This increase in the mail processing price would occur even if the new C&D Postal Service held its delivery charge and end-to-end stamp price constant. (Let $b_1 > t$ denote the new bulk mail rate after this "first round" of adjustments.) However, the financial situation of the Postal Service would *not* remain constant. The increase in the equilibrium mail processing price would reduce total mail volumes and require the Postal Service to adjust prices in order to again break-even.

4.1 C&D Scenario 1: Capped Single-Piece Rate and "Cost Based" Delivery Rate

In general, both the single-piece and delivery prices might be adjusted separately. However, in order to simplify the analysis, I will begin with the case in which the single-piece

rate remains at its benchmark level $s^0 = d_0 + c + t$.[17] Now we are basically in the world of a single product monopolist with a falling average cost curve. There is typically one (relevant) price that will allow the enterprise to break-even. We can characterize this price using the Postal Service "equilibrium profit function" derived earlier. (Recall that this function incorporates the fact that b is endogenously determined.) That is, the equilibrium delivery price is obtained by solving:

$$\varphi(s_0, d, 0) = [s_0 - c - b(s_0, d, 0)]D(s_0) + (d - r)\{D(s_0) + B[b(s_0, d, 0)]\} - F = 0 \quad (30)$$

Let d_e denote the delivery price that satisfies this equation. It is intuitively clear that the effect of the volume decrease will result in an increase in the delivery price if the Postal Service is to break-even: i.e., $d_e > d_0$. Basically, the delivery monopolist is forced to "move back up" its falling Average Cost curve.

Let us try to sort out the "winners" and "losers" from the move to a C&D Postal Service under this scenario. First, "Aunt Minnie" is protected by the price cap on the single-piece mail rate. Second, the Postal Service remains at break-even in our benchmark case, so it neither gains nor loses by the change. Third, bulk mailers are clear losers because the new, competitive bulk mail rate has risen above the benchmark rate of $b_0 = t + d_0$. Assessing the impact on competitive mail processors is more complicated because both the price they receive and their unit costs have gone up. The exact calculation depends in a complicated way on demand and supply elasticities and the initial mail processing share of the Postal Service. However, substantial insight can be gained by considering two limiting cases.

[17] Perhaps the single-piece rate was legally "capped and indexed" at this rate as part of the transition process. However, after the increase in the equilibrium bulk mail rate, the initial single-piece rate can no longer be interpreted as being based upon competition and/or avoided cost: i.e., $s_0 = d_0 + c + t < c + b_1$.

There are two changes whose combined effects must be analyzed.

There are two changes whose combined effects must be analyzed. First, there is the increase in the bulk mail price resulting from the replacement of Postal Service volumes V_0 by competitors. Second, the resulting decrease in aggregate volume necessitates an increase in the delivery price charged by the Postal Service. Begin by focusing on the first effect in the extreme case in which the bulk mail demand is essentially price *inelastic*. This situation is illustrated in Figure 6. The Postal Service volumes are replaced by competitors and the bulk mail price rises to b_1. As pointed out earlier, this increases the profits of the mail processing sector, by the area of triangle *wyz* in the diagram. However, aggregate mail volume remains constant, so that there is no need for a delivery price increase. The Postal Service continues to break-even at the delivery price $d_e = d_0$. Without any delivery price increase, mail processing margins increase and the profits of the competitive mail processing sector unambiguously increase. It is not hard to ascertain the source of these gains. Even though their quantity demanded is unchanged, the consumers' surplus of bulk mailers has decreased as a result of the bulk mail price increase; by the rectangular area *wxyz* in the diagram. Notice that the loss of mailers clearly exceeds the gain to mail processors; by the triangular area *wxy* in Figure 4. The source of this *economic deadweight loss* is the replacement of relatively efficient Postal Service mail processing (at a unit cost of *t*) by relatively inefficient mail processing by competitors. Summed over all *V* units of eliminated Postal Service processing, these cost increases equal area *wxy*.

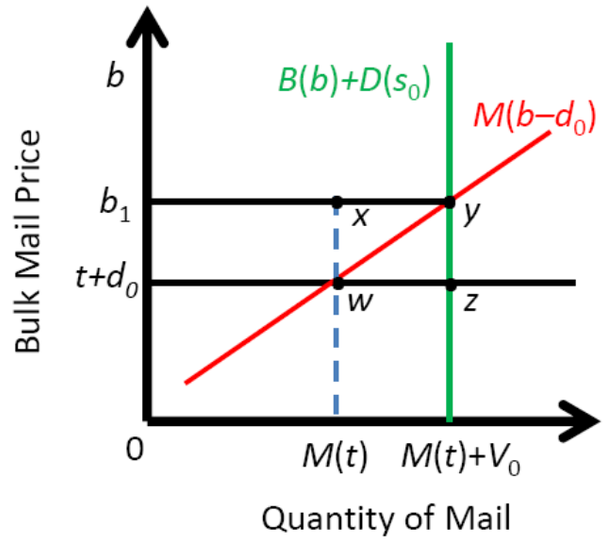

Figure 6

At the other extreme, suppose the bulk mail demand curve is nearly perfectly elastic in the vicinity of the price $b = t + d_0$. This situation is illustrated in Figure 7. When the Postal Service volumes are removed, the amount of bulk mail drops by a (nearly) equal amount, but the equilibrium price barely rises above $t + d_0$. The amount supplied by rival mail processors barely changes, nor do their margins or profits. Now, when the delivery charge rises because of the volume decrease, it reduces their profits. From the point of view of competitive mail processors, the combined effect amounts to only an increase in their unit costs. There is no potentially offsetting increase in their volumes or their selling price.

It is also possible that the C&D Postal Service would be regulated by a price cap regime similar to the one currently in place under PAEA.

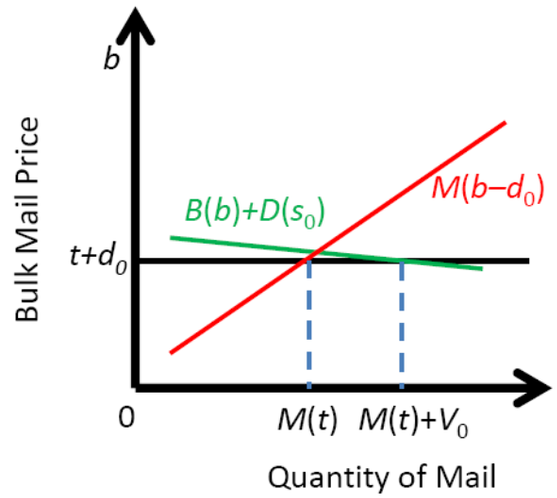

Figure 7

4.2 C&D Scenario 2: PAEA – Style Global Price Caps

It is also possible that the C&D Postal Service would be regulated by a price cap regime similar to the one currently in place under PAEA. I begin by establishing a benchmark from which to analyze this scenario. Suppose that Postal Service mail processing activities had been eliminated as described in the previous section. That is, the C&D transition started from a level of Postal Service mail processing (V_0) single-piece stamp price (s_0) and delivery rate (d_0) such that the Postal Service earned zero profit and avoided cost pricing prevailed at the equilibrium in the bulk mail market: i.e., $\varphi(s_0,d_0,V_0) = 0$ and $b(s_0,d_0,V_0) = d_0 + t$. As discussed above, setting V equal to zero while leaving s and d unchanged would result in losses for the Postal Service. Next, suppose that these losses were initially eliminated by raising *only* the delivery rate to d_e: i.e., $\varphi(s_0,d_e,0) = 0$. I begin the analysis of PAEA – style Global Price Cap regulation starting from this break-even position.

Under global price/revenue cap regulation the Postal Service is free to adjust both its upstream price (s) and its downstream, delivery access price (d) as long as the price combination it chooses would yield the same revenues as obtained in the base period. That is,

$$d\{B[b(s_0, d_e, 0)] + D(s_0)\} + sD(s_0) \equiv d(D_0 + B_e) + sD_0 = s_0 D_0 + d_e(D_0 + B_e) \qquad (31)$$

Rearranging, this becomes:

$$d = d_e + (s_0 - s)\frac{D_0}{D_0 + B_e} \equiv d_e + (s_0 - s)\sigma_e \qquad (32)$$

Here, σ_e is the single-piece share of total mail volume.

What will the Postal Service choose to do with its pricing flexibility? As usual, the answer depends upon complicated expressions involving demand and supply elasticities. However, one would typically expect that the profit increasing alternative would be to raise the single-piece rate, primarily because the demand for this service is likely to be less price elastic. This case situation is illustrated in Figure 8. The curve through point G is the iso (equilibrium) profit curve defined for the benchmark level of Postal Service mail processing V_0. It consists of all the delivery and single-piece price combinations at which the Postal Service just breaks even when it supplies the benchmark level of mail processing services, V_0. By construction, the price combination (s_0,d_0) lies on this curve, at point G. However, from equation (26), we know that the position of the iso profit curve will shift upward and to the right as Postal Service mail processing is reduced (or eliminated). That is, higher combinations of s and d will be required for the Postal Service to cover its costs when $V = 0$. These break-even price combinations are depicted in the curve passing through point H.

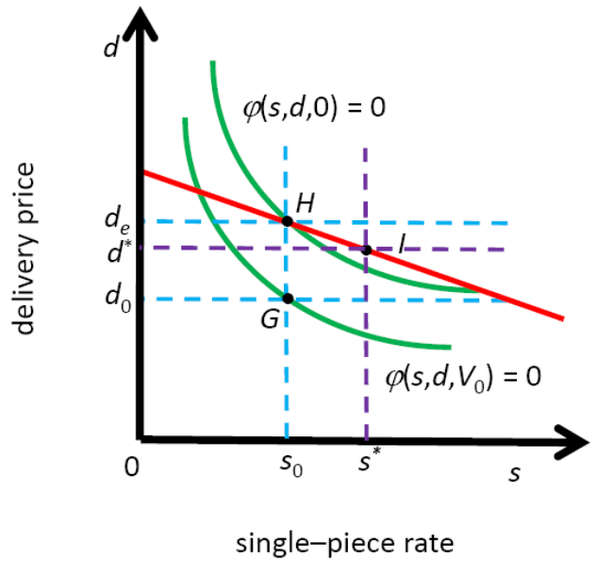

Figure 8

The initial position for our price cap analysis is found by moving up vertically from the benchmark price pair (s_0,d_0) until the $\varphi(s,d,0) = 0$ curve is reached at point *H,* where the single-piece rate remains at s_0, but the delivery price has risen to d_e. Finally, the straight line through point *H* denotes the price combinations that are allowed under price cap regulations. It indicates that, starting from the initial point (s_0,d_e), permissible prices must involve combinations in which at least one price is lower. As drawn, the Postal Service would choose to increase profits by raising the single piece rate to s^* and lowering the delivery charge to d^* at point *I*.

4.3 C&D Assessment: Ending Mail Processing Would Likely Have Significant Costs to the Postal Service and Lead to Higher Prices

More scenarios could be constructed and analyzed. However, the basic message seems reasonably clear. The likely result of the Postal Service ending its mail processing activities would be lower profits for the Postal Service and higher prices for the mailing public. Competitive mail processors are the only likely beneficiaries. Like the analysis, the conclusion

The likely result of the Postal Service ending its mail processing activities would be lower profits for the Postal Service and higher prices for the mailing public.

Competitive mail processors are the only likely beneficiaries.

rests on two important assumptions. First, I have assumed that, regardless of volume, mail processing can be provided by the Postal Service at constant unit costs. Second, the work-sharing discounts established by the Postal Service and the PRC are based upon the unit avoided costs of the Postal Service. Both assumptions are consistent with both conventional wisdom and long standing PRC policy. However, both are ultimately empirical questions that should be examined before accepting my conclusions. And, without empirical study, the theoretical analysis does not provide any sense of the quantitative magnitude of the price and profit effects mentioned above.

First, under PAEA, the Postal Service is no longer required to set work-sharing discounts equal to its per unit avoided costs.[18] Also, the Postal Service may have an incentive to reduce work-sharing discounts below avoided cost under the global price cap regulatory regime implemented by the PRC under PAEA.[19] Therefore, as time goes on, it becomes more difficult to take avoided cost discounts as the relevant benchmark for evaluating the Postal Service's mail processing operations. This is important, because without such ECP pricing, the Postal Service may already be excluding more efficient competitors from mail processing.

Second, while the presumption of constant returns to scale (100% volume variability) in mail processing reflects "postal conventional wisdom," it remains an *assumption* nonetheless. It is true that numerous studies have supported the PRC's consistent determinations that mail processing exhibits constant returns to scale; i.e., "100% volume variability" in postal parlance.[20] However, even if the empirical evidence were completely unambiguous, it could not possibly

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[18] PAEA's provisions do require that such discounts may not *exceed* 100% of avoided cost.

[19] See the analysis presented in USPS OIG (2010).

[20] However, the empirical evidence is not completely unambiguous. See USPS OIG (2012).

provide the final answer regarding the desirability of eliminating *all* of the mail processing done by the Postal Service. This is because the empirical studies are limited to situations in which the Postal Service always supplied a sizable portion of mail processing services. That is, existing studies cannot shed any light on the counterfactual situation in which the Postal Service were to completely eliminate its mail processing activities. They were simply not designed to measure the magnitude of any fixed costs that might be avoided if the Postal Service shut down its mail processing operations completely.

The difficulty this poses can be easily illustrated in the context of the model used in the analysis. In the current formulation, if *all V* units of Postal Service mail processing were eliminated, total Postal Service costs would fall by the amount tV. Now suppose that the fixed costs of the Postal Service network consisted of two components, one due to its delivery activities and the other due to its mail processing activities: i.e., $F = F_D + F_{MP}$. Then, if *all V* units of Postal Service mail processing were eliminated, so would the associated fixed costs F_{MP}. The total costs of the Postal Service would fall by $tV + F_{MP}$. A complete "cost – benefit" analysis of the Postal Service's mail processing activities cannot be done without knowing the magnitude of F_{MP} as well as that of tV.

5. Conclusions

The important advice, "focus on the first and last mile," should not be interpreted as urging the Postal Service to abandon its mail-processing "middle stage." If the Postal Service retains a share of that market when setting work-sharing discounts at avoided cost, then that activity makes a positive contribution to Postal Service operations. In that case, the Postal Service and the mailing public would suffer if the Postal Service ceased its mail processing operations.

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Appendices

Click on the appendix title to the right to navigate to the section content.

Appendices 37
A1: Equilibrium Comparative Statics 38
A2: Ramsey Pricing for a C&D Postal Service 39

A1: Equilibrium Comparative Statics

Appendices

A1: Equilibrium Comparative Statics

By the Implicit Function Theorem, we know that the equilibrium bulk mail price, $b(s,d,V)$, is implicitly determined by the following "supply equals demand" equation:

$$D(s) - V + B[b(s,d,V)] = M[b(s,d,V) - d] \quad (10)$$

Differentiating this with respect to the parameter *s* yields

$$D'(s) + B'[b(s,d,V)]\frac{\partial b}{\partial s} = M'[b(s,d,V) - \mathrm{d}]\frac{\partial b}{\partial s} \quad (A1.1)$$

Solving for the partial derivative of interest, yields

$$\frac{\partial b}{\partial s} \equiv b_s = \frac{D\prime(s)}{M'(b-d)-B'(b)} < 0 \quad (A1.2)$$

Similarly, differentiating equation (10) with respect to *d*, obtaining

$$B'[b(s,d,V)]\frac{\partial b}{\partial d} = M'[b(s,d,V) - \mathrm{d}]\left(\frac{\partial b}{\partial d} - 1\right) \quad (A1.3)$$

Solving yields the desired result

$$\frac{\partial b}{\partial d} \equiv b_d = \frac{M'(b-d)}{M'(b-d)-B'(b)} > 0 \quad (A1.4)$$

Finally, differentiating equation (10) with respect to V yields

$$B'[b(s,d,V)]\frac{\partial b}{\partial V} - 1 = M'[b(s,d,V) - \mathrm{d}]\frac{\partial b}{\partial V} \quad (A1.5)$$

so that

$$\frac{\partial b}{\partial V} \equiv b_V = \frac{-1}{M'(b-d)-B'(b)} < 0 \quad (A1.6)$$

A2: Ramsey Pricing for a C&D Postal Service

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The equilibrium welfare and profit functions developed in the text are valid for any *fixed* value of V. However, since V affects both profits and welfare, the only fixed value of V for which it makes sense to calculate Ramsey prices is $V = 0$, i.e., the case in which the Postal Service is barred from mail processing. The LaGrangian expression for the constrained total surplus maximization problem is given by:

$$L = \omega(s,d,0) + \gamma\varphi(s,d,0) = S_s(s) + S_b[b(s,d,0)] + (1+\gamma)\varphi(s,d,0) + \theta(s,d,0) \quad \text{(A2.1)}$$

where $\gamma \geq 0$ is the LaGrangian multiplier for the Postal Service break-even constraint. The FONCs for an interior (positive price) Ramsey optimum are given by:

$$\frac{\partial L}{\partial s} = \gamma(1-b_s)D + (1+\gamma)[(s-c-b)D' + (d-r)(D' + B'b_s)] = 0 \quad \text{(A2.2)}$$

$$\frac{\partial L}{\partial d} = \gamma B + \gamma(1-b_d)D + (1+\gamma)(d-r)B'b_d = 0 \quad \text{(A2.3)}$$

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