PO Box Access:

Competition Issues in a Two-Sided Postal Market

PRELIMINARY DRAFT

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I. Introduction and Summary

The role of "essential facilities" has been a controversial feature of the process of liberalizing postal markets. Some have argued that the absence of substantial sunk costs means that there is no need to transfer policies designed to deal with "monopoly

bottlenecks" in sectors such as telecommunications or electricity.[1] Others have argued that requiring incumbents to grant downstream assess is essential for the development of significant competition, at least in the short to medium run. I will not try to resolve this question here. However, all parties to the debate seem to agree that the entrant must be granted access to the incumbent's PO Box subscribers.

Incumbent posts tend to argue that the Efficient Component Pricing Rule (ECPR) is the appropriate methodology. Regulatory commissions tend to argue that the appropriate standard should be cost-based: i.e., "bill and keep" when the costs of receiving mail at a PO Box location are zero. The incumbent post's position is based on the claim that PO Boxes are an integral part of its postal network and that ECPR based pricing of network access is not anticompetitive. The regulatory position is based upon the argument that the likely outcome in workably competitive postal and PO Box markets would be a cost-based access charge.

Thus, this issue of pricing access to the incumbent post's PO Boxes by competitive providers of postal delivery services seems to raise a conflict between two principles of competition policy: the presumption that access prices based upon ECPR are

[1] See, for example, de Bilj et. al. (2006), Crew and Kleindorfer (2002), and Panzar (2002).

not anticompetitive and the "obvious" conclusion that the incumbent post is "making use" of its dominant position in the PO Box market to impede competition in markets for delivery services.

It turns out that this debate ignores an important aspect of the market for PO Box services and postal markets generally: they are 2-sided markets. As the emerging literature on this topic has indicated, simple cost-based rules rarely suffice to characterize either desirable or equilibrium characteristics of the marketplace.

The remainder of this paper is organized as follows. In Section II presents attempts to apply a traditional "use" of dominant position or "leveraging of monopoly power" analysis to the case of PO Box access. I identify five potentially distinct markets for postal and PO Box services relevant for this analysis. Section III discusses an alternative benchmark scenario: a PO Box monopolist facing a competitive postal sector. Section IV presents a rather general model of postal and PO Box services as interrelated 2-sided markets. Section V simplifies the model by eliminating one dimension of consumer heterogeneity and derives some basic results. Section VI shifts attention to the case of a hypothetical specialized PO Box monopolist serving PO Box customers and selling access to competitive postal service providers. I derive some limited "equivalence" results that demonstrate how such a monopolist can replicate the welfare maximizing prices achieved by an integrated service provider. Section VII proposes

some potentially interesting regulatory scenarios for further analysis. Section VIII offers some (very) tentative conclusions.

II. "Traditional" Market Dominance Analysis

A. Market definitions issues:

As usual, the market definition exercise involves determination of both relevant product or services markets and relevant geographic markets. For purposes of this section, I will focus on two retail markets for postal services, one wholesale (or service component) market for postal service, and the market for PO Box services. The geographical market definition for all markets considered is *local/ regional*, because it is my understanding that this is the business model of most delivery competitors. The retail markets are those for locally originating mail addressed to street addresses (*street addressed mail*) and locally originating mail addressed to PO Boxes (*PB addressed mail*). Separating these two markets greatly clarifies the analysis. This distinction is also based upon the assumption that entrants are able to "pass through" any PB access charge by charging customers a premium price for PB addressed mail. The wholesale markets discussed are the complementary components *access to PO Boxes* and that portion of the value chain that is "upstream" of the PO Box in the retail PB addressed mail market. That is, it involves all the steps of local mail processing *except* the actual placement of the piece in the secure PO Box. The market for PO Box services involves the rental of

locked facilities to subscribers (mail recipients) for a fee. I assume that the incumbent post has a dominant position in all of these markets.

To summarize, my analysis is conducted with respect to the following markets:

- Locally originating retail street addressed mail
- Locally originating retail PB addressed mail
- Locally originating wholesale PB addressed mail
- Access to local PO Boxes
- Local PO Box reception services

B. "Making use" of dominance

This breakdown helps clarify the issue at hand, namely would an above cost price for access to the incumbent post's PO Boxes adversely affect competition in any of the above mail markets. I shall analyze each, in turn.

1. The retail market for street addressed mail

Consider an entrant that provides end-to-end service in this market, entirely bypassing the incumbent post's network. Nothing the incumbent post does in the access market will have any direct effect on competition in this market. Nonetheless, there is an

important interrelationship between the market for PO Box services and the associated wholesale market involving collection, sortation, and partial delivery. In order for an entrant to successfully compete in this wholesale market, it must be granted access to the incumbent post's PO Box addresses. Similarly, the connection between this wholesale market and the retail market for street addressed mail in the same region is also very close. It is difficult (but not impossible) to envision an entrant competing successfully in the market for street addressed mail without being granted access to the incumbent post's PO Box addresses. However, as long as access is granted at some price, entrants can limit the impact on its ability to compete in the street addressed mail market by passing through some portion of the PB access charge by charging a higher price for PB addressed mail.

One might argue that, by forcing entrants to charge different prices for street addressed and PB addressed mail, the incumbent post is "raising its rivals' transaction costs." There may be something to this, but I treat this as a "second order" for purposes of this paper.

2. The retail market for PB addressed mail

As long as the incumbent post has an overwhelming dominance in the market for PO Box *service*, its dominance in end-to-end provision of service for PB addressed mail

is largely a matter of definition. In any event, competition in this market cannot be significantly impacted by PB access pricing.

3. The wholesale market for PB addressed mail

This is where the ECPR methodology is traditionally applied. As long as ECPR principles are followed, no equally efficient competitor will be excluded from this market by a PB access price above cost. Therefore, it seems that the ability of the incumbent post to charge ECPR access prices for PO Box addressed mail has the effect of limiting the inefficient bypass of its local delivery network to street addressed mail. This does not exclude an equally efficient competitor from the delivery market for PO Box addressed mail. Rather, it prevents the expansion of an arguably less efficient competitor into that market as well.

III. Analysis of an alternative counterfactual benchmark

The above discussion indicates that if one interprets that the incumbent post's PO Box services are an integral part of its postal network, ECPR pricing of access is appropriate. It is hard to argue that competition in any relevant market is being adversely affected. Yet, if one takes as a benchmark the outcome of hypothetical competitive postal and PO Box markets, an access price of zero seems the appropriate starting point.

From that perspective, the insistence of the incumbent post on an ECPR level access charge is not consistent with what would result in a competitive market place.

But, is an ECPR based access charge by a dominant firm a violation of the law? That is a more complicated question. It is my understanding that the incumbent post's dominant position in the PO Box market is *not* a violation of the law. Therefore, an alternative counterfactual benchmark to use in evaluating its access pricing policy is that of a hypothetical PO Box *monopolist* facing a workably competitive postal delivery market. I shall refer to this hypothetical firm as PBM. PBM would have two sources of revenue: the rental fees it charged its subscribers and the revenues from any access charges it collected from postal operators. Then, the relevant theoretical issue is whether or not PBM would choose to charge an access fee above cost to postal operators.

I shall analyze this issue in the context of a highly stylized model. Assume that PBM faces a perfectly competitive postal delivery market (in which it may or may not participate). Assume also that a large enough percentage of mail was addressed to PO Boxes that no postal operator could remain viable if it refused to deliver to them. In that case, any access price it might charge postal operators would be passed through to mailers through an increase in the equilibrium stamp price(s). It is my understanding that entrants charge premium rates for mail addressed to the incumbent post's PO Boxes. Therefore, it seems likely that the outcome in this hypothetical competitive postal market

would also involve dual prices. Furthermore, the price for mail addressed to PBM would be increased by the amount of the access charge. This means that PBM would be in a position to use its access price extract the monopoly profits associated with a vertically integrated end-to-end PO Box operator! Here, I am ignoring any "feedback effect" between the access price and the optimal monopoly rental rate. If this were taken into account it would somewhat alter this Chicago-style "one monopoly rent" result. I have not attempted to work through such a model in detail. However, it seems clear that PBM would have an incentive to set an access fee substantially above its cost of handling incoming mail.

Would such a fee be illegal under competition law? Obviously, others are better placed than I to render such a judgment. However, by charging an access price in excess of cost, PBM is clearly *not* "restricting entry . . . preventing or deterring . . . competitive conduct . . . or eliminating a person from . . . any . . . market." All that it would be doing is charging monopoly prices on "both sides" of its market. The next sections attempt a formal analysis of this type of scenario.

IV. A "General" Model of Integrated Markets for Postal and PO Box Services

Operators of PO Boxes have two sets of customers: mail receivers and mail originators. Mail receivers typically pay a monthly rental fee for the convenience of a

private and secure facility for receiving their mail. In principle, but rarely in practice, receivers might also be subject to a (positive or negative) payment based upon the volume of mail that they receive. The demand of mail originators is for delivery to mail receivers. This demand is typically effectuated through the market for postal delivery services: i.e., through the stamp price. I assume that the demand by senders for delivery to mailer recipients is a function of price and a type characteristic $s \in [0,1]$: i.e., $v(p,s)$ with $v_p < 0$ and $v_s > 0$. Mailers may or may not pay a surcharge for mail addressed to PO Boxes, p_B, instead of "street" addresses, p_S. I assume that the demand for mail results from the maximization of a quasi-linear mailer utility function so that consumers' surplus, $S(p,s)$, is an appropriate measure of mailer net benefits. Under this assumption, $\partial S/\partial p = -v(p,s)$.

Mail receivers are also indexed a type parameter, $t \in [0,T]$, that reflects the intensity of their preferences to receive their mail in a secure PO Box. I assume that these characteristics are distributed according to the strictly positive density function $f(s,t)$. The quasi-linear utility function of a mail recipient of type (s,t) that subscribes to a PO Box is assumed to be given by $U_B = y + u[v(p_B, s), t]$, where, y is the amount of a composite commodity. The sub utility function, u, is assumed to be concave in v. The utility of that same recipient if he does not subscribe is assumed to be given by $U_0 = y + u^S[v(p_S, s)]$, with u^S also assumed to be concave. Next, let m denote the

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monthly subscription fee charged for a PO Box and let r denote any per piece reception fee that Box holders pay[2] for receiving mail. Then, *for given value of the volume characteristic s,* the recipient whose security preference t^* makes him just indifferent between renting and not renting a PO Box is given by:

$$u[v(p_B, s), t^*] - m - rv(p_B, s) = u^S[v(p_S, s)]. \quad (1)$$

Assuming that $u_t > 0$, Equation (1) defines an implicit function $t^*(p_S,p_B,m,r;s)$ such that recipients of type $t \in [0,t^*)$ prefer not to rent a PO Box, while recipients of type $t \in (t^*,1]$ prefer to rent one.[3]

It is now possible to express the demand for PO Box subscriptions as

$$B(p_S, p_B, m, r) = \int_0^1 \int_{t^*}^T f(s,t)dtds. \quad (2)$$

Equation (2) is interpreted as follows. For any volume type level s, a certain fraction of mail recipients will find subscription desirable: those for whom $t > t^*(p_S,p_B,m,r;s)$. This

[2] Note that r could be negative; i.e., recipients may receive a payment for each piece of mail they receive.

[3] It is not, in general, possible to normalize the utility of non PO Box holders to zero, because they will typically receive differing volumes of mail if $p_B > p_S$.

fraction is then summed over all volume types. The total volume of PO Box addressed mail is given by:

$$(3) \qquad V(p_S, p_B, m, r) = \int_0^1 \int_{t^*}^T v(p_B, s) f(s,t) dtds .$$

Similarly, the total volume of street addressed mail is given by:

$$(4) \qquad V^S(p_S, p_B, m, r) = \int_0^1 \int_0^{t^*} v(p_S, s) f(s,t) dtds .$$

Equations (1)-(4) can be used to derive the partial derivatives of the number of PO Box subscribers and the volumes of PO Box and Street Addressed mail with respect to the relevant prices. The formulae for these partial derivatives will clearly depend upon the behavior of the threshold value t^* with respect to the parameters of interest. The somewhat lengthy derivation of the properties of this demand system is relegated to the Appendix. The analysis there reveals that the demand system exhibits characteristics typical of participation and quantity choices made in the absence of income effects. Various special properties of the demand functions will come up in the analysis that follows.

Total consumer benefits consist of the sum of the (net) maximized utilities of mail recipients and the consumers' surplus of mail senders. The total net utility of mail recipients includes that of both PO Box subscribers and non subscribers: i.e.,

$$(5) \qquad R = \int_0^1 \int_0^{t^*} u^S f(s,t)dtds + \int_0^1 \int_{t^*}^T [u - m - rv(p_B, s)] f(s,t)dtds$$

Mailers' consumers' surplus is given by

$$(6) \qquad M = \int_0^1 \int_0^{t^*} S(p_S, s) f(s,t)dtds + \int_0^1 \int_{t^*}^T S(p_B, s) f(s,t)dtds$$

For future reference, it is useful to derive the formulae for the partial derivatives of these surplus measures with respect to prices.

Differentiating the expression for the net economic benefits accruing to mail recipients with respect to *x*, *m* and *r* yields:

$$(7) \qquad \frac{\partial R}{\partial m} \equiv R_m = -\int_0^1 \int_{t^*}^T f(s,t)dtds = -B$$

$$(8) \qquad \frac{\partial R}{\partial r} \equiv R_r = -\int_0^1 \int_{t^*}^T v(p_B, s) f(s,t)dtds = -V$$

Differentiating receiver net benefits with respect to mailing rates yields:

$$(9) \qquad \frac{\partial R}{\partial p_B} \equiv R_B = \int_0^1 \int_{t^*}^T (u_v - r) v_p(p_B, s) f(s,t)dtds$$

$$(10) \qquad \frac{\partial R}{\partial p_S} \equiv R_S = \int_0^1 \int_0^{t^*} u_v^S v_p(p_S, s) f(s,t)dtds$$

A bit of explanation is in order. All of the expressions have been simplified using the characterization of t^* derived in equation (1). The use of this substitution makes possible the cancellation of the terms multiplying the derivatives of t^*. The right most equalities in equations (9) and (10) make use of the partial derivatives of the demand system derived in the Appendix.

Differentiating the expression for mailer consumers' surplus with respect to *m* and *r* yields:

$$(11) \qquad \frac{\partial M}{\partial m} \equiv M_m = \int_0^1 [S(p_S, s) - S(p_B, s)] \frac{\partial t^*}{\partial m} f(s, t^*) ds \geq 0$$

$$(12) \qquad \frac{\partial M}{\partial r} \equiv M_r = \int_0^1 [S(p_S, s) - S(p_B, s)] \frac{\partial t^*}{\partial r} f(s, t^*) ds \geq 0$$

Equations (11) and (12) reveal a potential externality. An increase in the subscription charge or reception fee will decrease the number of PO Box subscribers. The resulting shift in mail volumes will *increase* the surplus of mailers if the price of street addressed mail is below that of PO Box addressed mail. For notational convenience, let $X(p_S,p_B,s) = S(p_S,s) - S(p_B,s)$ denote the magnitude of this potential externality for mail recipients of type *s*. Note that $X(p,p,s) = 0$; i.e., there is no externality when the prices of PO Box addressed and street addressed mail are equal.

Differentiating mailer surplus with respect to mail rates yields:

$$(13) \qquad \frac{\partial M}{\partial p_B} \equiv M_B = \int_0^1 X(p_S, p_B, s)\frac{\partial t^*}{\partial p_B} f(s,t^*)ds - \int_0^1 \int_{t^*}^T v(p_B, s) f(s,t)dtds \equiv X_B - V$$

$$(14) \qquad \frac{\partial M}{\partial p_S} \equiv M_S = \int_0^1 X(p_S, p_B, s)\frac{\partial t^*}{\partial p_S} f(s,t^*)ds - \int_0^1 \int_0^{t^*} v(p_S, s) f(s,t)dtds \equiv X_S - V^S$$

The last terms in equations (13) and (14) are, as expected, the (negative) volumes of, respectively, PO Box addressed and street addressed mail. The first term in each equation again reflects a potential externality resulting from the switch of mail volumes between differently priced PO Box addresses and street addresses.

The next step is to characterize the profits of a fully integrated, traditional monopoly provider of delivery and PO Box services. For simplicity, assume that the sector operates under constant costs. That is, the total cost of collecting, sorting, transporting, and delivering a piece of street addressed mail is assumed to be c_S, whereas the total cost of collecting, sorting, transporting, and delivering a piece of PO Box addressed mail is assumed to be c_B. Assume also that the firm incurs a constant cost b for each PO Box provided and a cost c for each piece of mail accepted by the PO Box. Thus, any difference between c_B and c_S reflect differences in the *network costs* of collecting, sorting, transporting, and delivering the mail to a PO Box rather than a street address.

Depending on the network configuration, it is possible (and plausible) that c_B may be greater than, less than, or equal to c_S.

The integrated postal provider may receive revenue from both mailers and mail recipients. As noted above, he may charge PO Box subscribers a monthly subscription fee *m* and a per piece handling fee *r*. Street addressed mail and mail addressed to PO Boxes are priced at p_S and p_B, respectively. The profits of the integrated postal provider are then given by:

$$\pi^I = (m-b)\,B + (p_B + r - c_B - c)V + (p_S - c_S)V^S \tag{15}$$

Next, it is useful to also explicitly set out the partial derivatives of the postal monopolist's profits with respect to *m*, *r*, p_B, and p_S. These formulae are given by:

$$\pi_m^I \equiv \frac{\partial \pi^I}{\partial m} = (m-b)\,B_m + B + (p_B + r - c_B - c)V_m + (p_S - c_S)V_m^S \tag{16}$$

$$\pi_r^I \equiv \frac{\partial \pi^I}{\partial r} = (m-b)\,B_r + (p_B + r - c_B - c)V_r + V + (p_S - c_S)V_r^S \tag{17}$$

$$\pi_B^I \equiv \frac{\partial \pi^I}{\partial p_B} = (m-b)\,B_B + (p_B + r - c_B - c)V_B + V + (p_S - c_S)V_B^S \tag{18}$$

$$\pi_S^I \equiv \frac{\partial \pi^I}{\partial p_S} = (m-b)\,B_S + (p_B + r - c_B - c)V_S + (p_S - c_S)V_S^S + V^S \tag{19}$$

Next, I set forth the pricing conditions for total surplus maximization in this model. Total surplus is given by the sum of the surplus of the integrated postal provider plus the surplus of mailers and mail recipients: i.e.,

(20) $$W = \pi^I + R + M \, .$$

Differentiating with respect to r, m, p_B, and p_S yields the following First Order Necessary Conditions:

$$W_m \equiv \frac{\partial W}{\partial m} = \pi^I_m + R_m + M_m = 0$$
$$W_r \equiv \frac{\partial W}{\partial r} = \pi^I_r + R_r + M_r = 0$$
$$W_B \equiv \frac{\partial W}{\partial p_B} = \pi^I_B + R_B + M_B = 0$$
$$W_S \equiv \frac{\partial W}{\partial p_S} = \pi^I_S + R_S + M_S = 0$$

Upon substitution and simplification, these become:

(21) $$W_m = (m-b)B_m + (p_B + r - c_B - c)V_m + (p_S - c_S)V^S_m + M_m = 0$$

(22) $$W_r = (m-b)B_r + (p_B + r - c_B - c)V_r + (p_S - c_S)V^S_r + M_r = 0$$

(23) $$W_B = (m-b)B_B + (p_B + r - c_B - c)V_B + (p_S - c_S)V^S_B + R_B + X_B = 0$$

(24) $W_S = (m-b)B_S + (p_B + r - c_B - c)V_S + (p_S - c_S)V_S^S + R_S + X_S = 0$

One can gain some insight by approaching the above system of FONCs somewhat simplistically. A first cut at "marginal cost pricing" would involve setting equal to zero each of the three terms in parentheses that recur in all four equations. Next, recall that $M_r = M_m = X_B = X_S = 0$ when $p_B = p_S$. This establishes a candidate marginal cost pricing price vector of $(m^*, r^*, p_B^*, p_S^*) = (b, c_B - c_S + c, c_S, c_S)$. Intuitively, one might expect that the unconstrained surplus maximization would be solved by marginal cost pricing. However, evaluating the above partial derivatives at (m^*, r^*, p_B^*, p_S^*), one discovers that such is not the case. The derivates of total surplus with respect to the PO Box rental rate and the per unit mail reception charge vanish at the candidate marginal cost pricing vector: i.e., $W_m(m^*, r^*, p_B^*, p_S^*) = W_r(m^*, r^*, p_B^*, p_S^*) = 0$. But the derivatives with respect to mailing rates do not:

(25) $W_B(m^*, r^*, p_B^*, p_S^*) = R_B = \int_0^1 \int_{t^*}^T (u_v - r^*) v_p(p_B^*, s) f(s,t) dt ds$

(26) $W_S(m^*, r^*, p_B^*, p_S^*) = R_S = \int_0^1 u_v^S v_p(p_S^*, s) \int_{t^*}^T f(s,t) dt ds$

The sign of W_S is negative as long as receivers of street addressed mail value additional pieces. This means that, *at marginal cost prices*, total surplus would be increased by reducing p_S *below* its unit cost of c_S. The sign of W_B can be positive or negative

depending whether or not the average value of another letter received by PO Box subscribers is less than or greater than $r^* = c_B - c_S + c$.

The failure of marginal cost pricing to yield a surplus maximum should not be too surprising. The above, "general" model is simply "too rich." There are *two* two-sided markets involved that are interdependent. That is, pricing decisions in one market have an impact, not only on the "other side" of the same market, but also on both sides of the "other" market. In addition, a price of zero is exogenously assumed for receivers of street addressed mail. Thus, a combination of external effects and "too few prices" makes deriving even 1st best pricing rules somewhat complicated.

V. A Benchmark Model of Integrated Markets for Postal and PO Box Services

Therefore, in order to proceed, I drop the assumption that mail recipients are heterogeneous in the eyes of mailers: i.e., I assume that $v(p,s) = v(p)$ and that $f(s,t) = f(t)$. This change runs the risk of oversimplifying the model, but it greatly simplifies the analysis and makes the framework more comparable with the literature on two-sided markets.[4] I also assume that mail recipient's utility is linear in the number of letters

[4] See, for example, Armstrong (2004), Rochet and Tirole (2004), and Roson (2005).

received: i.e., $u[v(p_B,t)] = t + \alpha v_B$ and $u^S[v(p_S)] = \alpha_S v_S$. This is also consistent with the literature, and is more of a notational convenience that a substantive simplification.

This homogeneity assumption greatly simplifies the properties of the demand system derived earlier. These properties are summarized in the Appendix. Here, it is useful to state the simplified measures of consumers' surplus. Mail recipients' surplus becomes

$$(27) \qquad R = \alpha_S v(p_S)(P - B) + \int_{t^*}^{T} \left[t + (\alpha - r)v(p_B) - m\right] f(t)dt$$

Mailers' consumers' surplus is given by

$$(28) \qquad M = S(p_S)(P - B) + S(p_B)B$$

In equations (27) and (28), P represents the (exogenously fixed) total population of mail recipients.

The partial derivatives of recipients' surplus with respect to m and r remain unchanged from the end results in equations (7) and (8). However, the partial derivatives of receiver net benefits with respect to mailing rates simplify substantially:

$$(29) \qquad R_B = \int_{t^*}^{T} (\alpha - r)v'(p_B) f(t)dt = (\alpha - r)v'(p_B)B$$

(30) $$R_S = \int_0^{t^*} \alpha_S v'(p_S) f(t) dt = \alpha_S v'(p_S)(P - B)$$

The partial derivatives of mailers consumers' surplus are also simplified:

(31) $$M_m = -[S(p_S) - S(p_B)]B_m = [S(p_S) - S(p_B)] f(t^*) \equiv x(p_S, p_B) f(t^*)$$

(32) $$M_r = -[S(p_S) - S(p_B)]B_r = x(p_S, p_B) v(p_B) f(t^*)$$

(33) $$M_B = -[S(p_S) - S(p_B)]B_B - Bv(p_B) = x(p_S, p_B)(\alpha - r)v'(p_B) f(t^*) - V$$

(34) $$M_S = -[S(p_S) - S(p_B)]B_S - (P - B)v(p_S) = x(p_S, p_B)\alpha_S v'(p_S) f(t^*) - V_S$$

Equations (31) - (34) again reveal the potential externality discussed above. In this case, the external effect can be expressed using a term that depends only upon mailing rates. Thus, the above equations employ the definition $x(p_S,p_B) = S(p_S) - S(p_B)$.

Next, I restate the FONCs for unconstrained surplus maximization for under the assumptions of the Benchmark Model. Equation (21) becomes

$$W_m = -(m - b) f^* - (p_B + r - c_B - c) v_B f^* + (p_S - c_S) v_S f^* + x f^* = 0,$$

where $f^* = f(t^*)$, $v_B = v(p_B)$, and $v_S = v(p_S)$. Upon rearrangement, this becomes

(35) $$x = (m - b) + (p_B + r - c_B - c) v_B - (p_S - c_S) v_S .$$

Similarly, equation (22) simplifies to

$$W_r = -(m-b)v_B f^* - (p_B + r - c_B - c)v_B{}^2 f^* + (p_S - c_S)v_S v_B f^* + x v_B f^* = 0 .$$

Upon rearrangement this condition also reduces to equation (35). Thus, because of the removal of one dimension of heterogeneity, conditions for welfare maximization in the Benchmark Model cannot determine unique optimal values for *r* and *m*. Given mail volumes, all that matters for the PO Box subscription decision is the total bill associated with receiving the common volume of mail: i.e., the value of $m + r\, v_B$.

Turning to the optimality conditions for mail rates, equation (23) becomes

$$W_B = (m-b)B_B + (p_B + r - c_B - c)[Bv'_B + v_B B_B] - (p_S - c_S)v_S B_B + (\alpha - r)v'_B B - xB_B = 0 ,$$

or,

$$B_B[(m-b) + (p_B + r - c_B - c)v_B - (p_S - c_S)v_S - x] + [(p_B + r - c_B - c) + (\alpha - r)]v'_B B = 0$$

where $v'_B = v'(p_B)$. Upon substituting in the formula for *x* from equation (35), this reduces to a simple formula for the optimal rate for mail addressed to PO Boxes:

(36) $$p_B^* = c_B + c - \alpha .$$

This is a familiar 2-sided market result: the 1st best price for one side of the market equals marginal cost *less* the external benefit to the other side. Similarly, equation (24), the condition for the optimal price of street addressed mail becomes

$$W_S = (m-b)B_S + (p_B + r - c_B - c)v_B B_S + (p_S - c_S)(Nv_S' - v_S B_S) + \alpha_S v_S' N - xB_S = 0,$$

where $N = P - B$ is the number of customers that do not subscribe to a PO Box. Upon rearrangement this becomes

$$B_S[(m-b) + (p_B + r - c_B - c)v_B - (p_S - c_S)v_S - x] + (p_S - c_S + \alpha_S)v_S' N = 0.$$

Substituting in the value of *x* from equation (35) again yields a simple formula for the optimal price of street addressed mail in an integrated postal system:

(37) $$p_S^* = c_S - \alpha_S.$$

The mailing rate for street addressed mail is equal to its marginal cost less the value it confers on the receiver.

Since both types of mail are optimally priced below cost in the Benchmark Model, it is interesting see whether or not the integrated postal operator covers its costs at the 1st best prices. (Recall that I have assumed that the sector operates under constant returns to scale, so there are not any overhead or institutional costs that must be

recovered.) Rewriting equation (15) to reflect the assumptions of the Benchmark Model and imposing the optimal restrictions on *m* and *r* reflected in equation (35), one obtains:

$$\pi^I = [(m-b) + (p_B + r - c_B - c)v_B - (p_S - c_S)v_S]B + (p_S - c_S)P = xB + (p_S - c_S)v_S P$$

Substituting in the optimal mail pricing conditions from equations (35) and (36) yields:

(38) $$\pi^{I*} = x(c_S - \alpha_S, c_B - \alpha + c)B - \alpha_S v_S P$$

Depending on parameter values, the profit level in equation (38) may be positive, negative, or zero. However, it is easy to see that 1st best profits must be zero when (i) there are no net costs associated PO Box delivery ($c_S = c_B + c$) and (ii) the reception benefits are equal ($\alpha = \alpha_S$). In that case, $x = 0$ and $\pi^{I*} = -\alpha_S P \leq 0$.

While not uncommon in 2-sided market models, it is somewhat disturbing that 1st best prices may involve losses, even under constant returns to scale. Because I am ultimately interested in deriving pricing rules that can be applied to competitive PO Box and/or postal services markets, it is desirable to limit such "2nd Best" problems as much as possible. Therefore, from now on, I will also assume that only the PO Box market is 2-sided in the usual sense. That is, I assume that there are no reception externalities for recipients that do not purchase PO Box services: i.e., $\alpha_S = 0$.

VI. Pricing by "PO Box specialists"

In this section, I analyze the pricing policies of a PO Box monopolist. First, it is necessary to specify a mechanism for the delivery firms to "pass through" such access charges to mailers. That is, it is necessary to define functions $p_S(a)$ and $p_B(a)$ that relate how the prices paid by mailers for street addressed and PO Box addressed mail are affected by the per unit access charge, a, set by the PO Box monopolist.

Two approaches suggest themselves for modeling this pass through effect. The relative realism of the two depends upon market circumstances. First, suppose that delivery firms are able to charge mailers a different rate for PO Box addressed mail, passing through the higher costs directly to mailers. In that case, the stamp price for street addressed mail remains unaffected by the access charge, while the price of PO Box addressed mail increases penny for penny: i.e., $p_B = p_S + a$. This assumption seems reasonable in the context of a highly competitive postal delivery market in which mailer transactions costs are low. The second approach assumes that it is too costly for delivery firms to charge different rates for street addressed and PO Box addressed mail. Rather, the access charges levied by the PO Box monopolist are spread over all mail on an averaged basis: i.e., $p_B = p_S = p(a)$, with $p'(a) \in (0,1)$. This assumption seems appropriate when delivery is provided by a franchised monopolist whose prices are determined on a "cost plus" basis. The focus of my analysis is on the impact of PO Box access pricing

policies on competition in postal services. Therefore, I shall usually assume that delivery operators "pass through" any access charges they may face to mailers, so that the price of street addressed mail is unaffected. That is, $p_B = p_S + a$, $p_S'(a) = 0$, and $p_B'(a) = 1$.

Making use of the dependency of mailing rates on the PO Box access fee charged to mailers allows me to write the profits of a PO Box monopolist as:

$$(39) \qquad \pi^B(m,r,a) = (m-b)B(m,r,p_B(a)) + (a+r-c)v(p_B(a))B(m,r,p_B(a)) .$$

Equation (39) reflects the fact that the number of PO Box subscribers does not depend upon p_S when there are no reception externalities for street addressed mail.[5] The partial derivatives of PO Box monopoly profits are given by:

$$(40) \qquad \pi_m^B \equiv \frac{\partial \pi^B}{\partial m} = (m-b)\,B_m + B + (a+r-c)v_B B_m$$

$$(41) \qquad \pi_r^B \equiv \frac{\partial \pi^B}{\partial r} = (m-b)\,B_r + (a+r-c)v_B B_r + v_B B$$

$$(42) \qquad \pi_a^B \equiv \frac{\partial \pi^B}{\partial a} = (m-b)\,B_B + (a+r-c)[v_B B_B + B v_B'] + v_B B$$

[5] Because, in that case, α_S, $\partial t^*/\partial p_S$, and B_S are all equal to zero.

I begin by considering the case in which the PO Box monopolist faces competitive providers of postal delivery services for PO Box and street addressed mail, so that $p_S = c_S$ and $p_B = c_B + a$. In addition, I assume that the PO Box monopolist sets rates to maximize total surplus. Since the postal delivery markets are assumed to be competitive, total surplus is given by:

(43) $$W = \pi^B + R + M$$

The FONCs for an optimum with respect to *r* and *m* are:

(44) $$W_m = \pi_m^B + R_m + M_m = -(m-b)f^* - (a+r-c)v_B f^* + xf^* = 0$$

(45) $$W_r = \pi_r^B + R_r + M_r = -(m-b)v_B f^* - (a+r-c)v_B{}^2 f^* + xv_B f^* = 0$$

Upon cancellation and rearrangement, both of these equations reduce to:

(46) $$x = (m-b) + (a+r-c)v_B .$$

Again, the lack of heterogeneity in mail volumes makes the decision maker indifferent between combinations of *m* and *r* that leave PO Box subscribers' total bills constant. The FONC for an optimum with respect to the access charge is given by

(47) $$W_B = \pi_m^B + R_m + M_m = (m-b)B_B + (a+r-c)[Bv'_B + v_B B_B] + (\alpha - r)v'_B B - xB_B = 0,$$

or,

$$B_B[(m-b)+(a+r-c)v_B - x]+[(a+r-c)+(\alpha-r)]v_B'B = 0\,.$$

Upon substituting in the formula for *x* from equation (46), this reduces to a simple formula for the optimal access for mail addressed to PO Boxes:

(48) $$a = c - \alpha\,.$$

Under the assumption that the postal delivery markets are competitive, the equilibrium price paid by the sender for delivery to a PO Box is given by

(49) $$p_B = c_B + a = c_B + c - \alpha$$

Equation (49) reveals that a surplus maximizing PO Box monopolist can, through suitable choice of access charge, achieve the same outcome as a surplus maximizing integrated postal and PO Box provider. However, binding non negativity constraints may break this equivalence. Let me explain. I have not imposed non negativity constraints thus far in the analysis. As mentioned earlier, it is not unreasonable, in general for *r* to be negative. And, in the homogeneous volumes case, *m* can be negative if *r* is sufficiently greater than *c*. While it does not make sense for mail rates to be negative, I merely assumed that the FONCs resulted in strictly positive prices. In the current disintegrated model: (i) access price must be constrained to be non negative in order to prevent

arbitrage; and (ii) plausible parameter values might lead to a negative solution to equation (48). Therefore, the results in equations (48) and (49) must be restated as follows:

(50) $$a^{**} = \min\{0, c - \alpha\}.$$

(51) $$p_B^{**} = c_B + a = \min\{c_B, c_B + c - \alpha\}$$

Thus, in cases in which the reception benefit, α, exceeds the marginal cost, c, of PO Box reception, the optimal access charge would be zero and the resulting postal price would be c_B. For the same parameter values, the planner in the integrated situation would do better by setting a PO Box mail rate such that $0 < p_B = c_B + c - \alpha < c_B$.

What about the profits of a surplus maximizing PO Box monopolist? Examining equation (46) reveals that, at the values of m and r consistent with surplus maximization, firm profits are always exactly equal to x, the difference in mailer surplus from sending items to PO Box subscribers and non subscribers. Substituting in the optimal values of a and the resulting mail rates, we have

(52) $$\pi^{B**} = \max\{x(c_S, c_B + c - \alpha)v(c_B + c - \alpha), x(c_S, c_B)v(c_B)\}$$

Equation (52) reflects the possibility that the non negativity constraint on the access charge may be binding. For example, when $c_B = c_S$, profits at the optimum are positive if

c is greater than α, but zero if *c* is less than α. In general, profits at the optimum can be either positive or negative.

Since the profits of a welfare maximizing PO Box specialist need not be zero, it is interesting to examine the behaviour of a "perfectly competitive" PO Box sector. Following Armstrong and Vickers (2001), I assume that, at equilibrium, firms act "as if" they were maximizing the surplus of the representative customer subject to a break even constraint. That is, assume that the representative firm chooses *m*, *r*, and *a* to maximize $(\alpha - r)v(p_B(a)) - m$ subject to $(m - b) + (a + r - \alpha)v(p_B(a)) = 0$. Upon solving the constraint for *m* and substituting, it turns out that *r* and *m* drop out, so that one is left with a single variable, unconstrained maximization problem with respect to the access price:

$$(53) \qquad a^c = \arg\max\{(a+\alpha-c)v(a+c_B)\} \Rightarrow a^c = c-\alpha-\frac{v(c_B+a^c)}{v'(c_B+a^c)} > c-\alpha$$

Again, this result is familiar from the 2-sided market literature. As in the case of fixed to mobile termination charges, a "competitive bottleneck" results: firms charge mailers a

monopoly rate and compete away the profits by offering low prices to PO Box customers.[6]

VII. Regulatory Examples

Consider the situation of an incumbent post offering integrated postal and PO services at regulated postal rates. Assume that, because of Universal Service requirements, there is no rate differential between street addressed mail and mail destined for PO Boxes. Assume that the PO Box operation yields exactly zero profits. Under the assumption that $p_B = p_S = p$, this means that the condition embodied in equation (35) is also satisfied:

$$(54) \qquad 0 = x(p, p) = (m - b) + (p + r - c_B - c)v - (p - c_S)v = (m - b) + (r + c_S - c_B - c)v$$

Therefore, those *combinations* of m and r values are also consistent with surplus maximization *given* mail rates. For concreteness and simplicity, I further assume that $m = b$, so that $r = c_B + c - c_S$. Of course, while m and r are optimally set, the system of rates as a whole is not likely to be at an optimum. For example, equations (36) and (37) show that mailing rates will optimally be equal only for one particular configuration of

[6] See Armstrong and Wright (2004). It is easily shown that a profit maximizing PO Box monopolist would set the same access price.

parameter values. In addition, the averaged mail rate *p* may be marked up in order to cover overhead costs.

Now suppose that a competitive fringe supplying postal delivery services enters, the market, but that the PO Box market remains monopolized. Assume that the Postal Regulatory Commission decrees that competitors must be granted access to the incumbent's PO Box addresses. How the PRC determine the appropriate access rate? Obviously, the answer to this question depends on the extent of the market adjustments envisioned by the PRC.

Scenario 1: The PRC is content with the established mail and PO Box rates. Therefore, it attempts to establish the surplus maximizing *a*, taking the other rates as fixed.

Scenario 2: The PRC keeps the mail rates fixed, but declares PO Boxes a "non core service" and allows the post to set profit maximizing *m* and *r*, *given p* and *a*.

Scenario 3: The PRC keeps mail rates fixed, but seeks to set *m* and *r* in addition to *a*.

Scenario 4: The PRC declares a general rate investigation in order to set the optimal mail and PO Box rates as well as *a*.

VIII. Conclusions

Unfortunately, I have not been able to make much headway with any of these Scenarios, even for the Benchmark Model. However, a few points suggest themselves:

- Any but the simplest, most limited regulatory agenda is unlikely to lead to simple access pricing rules such as marginal cost (e.g., $a = c$) or ECPR (e.g., $a = p_B - c_B$).

- In most regulatory settings, optimal access prices for PO Boxes will depend upon the magnitude of the "reception externalities" for various categories of mail (e.g., α and α_S).

- The "irrelevance" of the mix of subscription charge (m) and per unit PO Box charge (r) may not persist in a competitive environment in the Benchmark Model.

Appendix

The "General" Model: I begin the characterization of the demand system by analyzing response of the threshold value t^* to changes in relevant parameters. Performing standard comparative statics analysis on equation (1) yields the following intuitive results:

(A1) $$\frac{\partial t^*}{\partial m} = \frac{1}{u_t} > 0$$

(A2) $$\frac{\partial t^*}{\partial r} = \frac{v(p_B, s)}{u_t} = v(p_B, s)\frac{\partial t^*}{\partial m} > 0$$

(A3) $$\frac{\partial t^*}{\partial p_B} = -\frac{(u_v - r)v_p(p_B, s)}{u_t} = -(u_v - r)v_p(p_B, s)\frac{\partial t^*}{\partial m}$$

(A4) $$\frac{\partial t^*}{\partial p_S} = \frac{u_v^S v_p(p_S, s)}{u_t} = u_v^S v_p(p_S, s)\frac{\partial t^*}{\partial m}$$

Equations (A1) and (A2) establish that the threshold value t^* is increasing in the monthly subscription fee and the per unit reception price. In addition, they reveal that the two partial derivatives are proportional to one another, with the factor of proportionality given by the volume of the user's PO Box addressed mail. Equations (A3) and (A4) derive the effects on t^* of changes in mailing rates. An increase in the price of street addressed mail has the expected effect of make PO Box subscription more attractive. However, the

effect of a change in the price of PO Box addressed mail is ambiguous. This is due to the fact that a large and positive reception charge may offset the increase in utility normally associated with an increase mail volume.

Using these results, the partial derivatives of the demand for PO Box subscriptions and of PO Box and Street addressed mail volumes are as follows:

(A5) $$B_m \equiv \frac{\partial B}{\partial m} = -\int_0^1 f(s,t^*)\frac{\partial t^*}{\partial m}ds < 0$$

(A6) $$B_r \equiv \frac{\partial B}{\partial r} = -\int_0^1 f(s,t^*)\frac{\partial t^*}{\partial r}ds = -\int_0^1 f(s,t^*)v(p_B,s)\frac{\partial t^*}{\partial m}ds < 0$$

(A7) $$B_B \equiv \frac{\partial B}{\partial p_B} = -\int_0^1 f(s,t^*)\frac{\partial t^*}{\partial p_B}ds = \int_0^1 f(s,t^*)(u_v - r)v_p(p_B,s)\frac{\partial t^*}{\partial m}ds$$

(A8) $$B_S \equiv \frac{\partial B}{\partial p_S} = -\int_0^1 f(s,t^*)\frac{\partial t^*}{\partial p_S}ds = -\int_0^1 f(s,t^*)u_v v_p(p_S,s)\frac{\partial t^*}{\partial m}ds > 0$$

(A9) $$V_m \equiv \frac{\partial V}{\partial m} = -\int_0^1 v(p_B,s)f(s,t^*)\frac{\partial t^*}{\partial m}ds = B_r < 0$$

(A10) $$V_r \equiv \frac{\partial V}{\partial r} = -\int_0^1 v(p_B,s)f(s,t^*)\frac{\partial t^*}{\partial r}ds = -\int_0^1 v(p_B,s)^2 f(s,t^*)\frac{\partial t^*}{\partial m}ds < 0$$

(A11) $$V_B \equiv \frac{\partial V}{\partial p_B} = \int_0^1 \int_{t^*}^T v_p(p_B, s) f(s,t) dt ds - \int_0^1 v(p_B, s) f(s,t^*) \frac{\partial t^*}{\partial p_B} ds$$

(A12) $$V_S \equiv \frac{\partial V}{\partial p_S} = -\int_0^1 v(p_B, s) f(s,t^*) \frac{\partial t^*}{\partial p_S} ds > 0$$

(A13) $$V_m^S \equiv \frac{\partial V^S}{\partial m} = \int_0^1 v(p_S, s) f(s,t^*) \frac{\partial t^*}{\partial m} ds > 0$$

(A14) $$V_r^S \equiv \frac{\partial V^S}{\partial r} = \int_0^1 v(p_S, s) f(s,t^*) \frac{\partial t^*}{\partial r} ds > 0$$

(A15) $$V_B^S \equiv \frac{\partial V^S}{\partial p_B} = \int_0^1 v(p_S, s) f(s,t^*) \frac{\partial t^*}{\partial p_B} ds$$

(A16) $$V_S^S \equiv \frac{\partial V^S}{\partial p_S} = \int_0^1 \int_0^{t^*} v_p(p_S, s) f(s,t) dt ds + \int_0^1 f(s,t^*) \frac{\partial t^*}{\partial p_S} ds < 0$$

All of the above partial derivatives have the expected signs with the exception those involving p_B, the price of PO Box addressed mail. These effects are of indeterminate sign because of the possibility that the PO Box operator may charge its subscribers a sufficiently high reception fee, r, such that they no longer benefit at the margin from receiving additional mail. However, when $r = 0$, we see that $\partial t^*/\partial p_B$ is positive and the remaining comparative statics results take the intuitively expected signs.

The Benchmark Model: Under the linearity and homogeneity assumptions of the Benchmark Model, i.e., $u[v(p_B,t)] = t + \alpha v_B$ and $u^S[v(p_S)] = \alpha_S v_S$, the threshold value for PO Box subscription can be solved for explicitly:

(A17) $$t^* = m - (\alpha - r)v(p_B) + \alpha_S v(p_S)\,.$$

This greatly simplifies the comparative statics, with the result that the partial derivatives no longer depend upon the type variable t. Thus, we have

(A18) $$\frac{\partial t^*}{\partial m} = 1 > 0$$

(A19) $$\frac{\partial t^*}{\partial r} = v(p_B) > 0$$

(A20) $$\frac{\partial t^*}{\partial p_B} = -(\alpha - r)v'(p_B)$$

(A21) $$\frac{\partial t^*}{\partial p_S} = \alpha_S v'(p_S)$$

The defining demand equations (2), (3), and (4) simplify to

(A22) $$B(p_S, p_B, m, r) = \int_{t^*}^{T} f(t)dt\,.$$

(A23) $$V(p_S, p_B, m, r) = \int_{t^*}^{T} v(p_B) f(t) dt = v(p_B) B .$$

(A24) $$V^S(p_S, p_B, m, r) = \int_{0}^{t^*} v(p_S) f(t) dt = v(p_S)(P - B)$$

In equation (A24), P denotes the (exogenously fixed) total population of mail recipients.

Similarly, the system of own and cross partial derivatives simplify to:

(A25) $$B_m = -f(t^*) < 0$$

(A26) $$B_r = -v(p_B) f(t^*) < 0$$

(A27) $$B_B = (\alpha - r) v'(p_B) f(t^*)$$

(A28) $$B_S = -\alpha_S v'(p_S) f(t^*) \geq 0$$

(A29) $$V_m = -v(p_B) f(t^*) = B_r < 0$$

(A30) $$V_r = -v(p_B)^2 f(t^*) < 0$$

(A31) $$V_B = B v'(p_B) + v(p_B) B_B = \left[B + (\alpha - r) v(p_B) f(t^*)\right] v'(p_B)$$

(A32) $$V_S = v(p_B) B_S = -\alpha_S v(p_B) v'(p_S) f(t^*) \geq 0$$

(A33) $$V_m^S = -v(p_S)B_m = v(p_S)f(t^*) > 0$$

(A34) $$V_r^S = -v(p_S)B_r = v(p_S)v(p_B)f(t^*) > 0$$

(A35) $$V_B^S = -v(p_S)B_B = -v(p_S)(\alpha - r)v'(p_B)f(t^*)$$

(A36) $$V_S^S = (P-B)v'(p_S) - v(p_S)B_S = \left[(P-B) + \alpha_S v(p_S)f(t^*)\right]v'(p_S) < 0$$

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