Network Externalities and the Digital Divide[1]

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[1] The views expressed in this paper are solely those of the authors and should not be construed to represent the views of George Washington University, Howard University, the USPS Office of the Inspector General, or any other institution.

1. Introduction

Some exciting work has emerged from economists studying the postal sector on the relation between external effects in networks and the universal service obligations (USO) borne by incumbent posts, In particular, Boldron, *et al* (2009) and Cremer, *et al* (2008) have introduced the possibility that there are efficiency improvements associated with the USO constraint. Heretofore, analyses of postal USO requirements have taken them to be set down by governments acting in the interest of general welfare, possibly for reasons of equity or social cohesion, but this new analysis uses the concept of network externalities to specify in a much more precise manner the impact of intervention on social welfare. In this paper, we extend some of the notions put forward in this literature to investigate the question of the impact of electronic access on the value of the postal network the implications for the USO.

The new approach characterizes postal markets as consisting of a platform that intermediates between agents on each of two-sides of the market. The notion of a two-sided market stems from analyses of credit cards and of game developers and is surveyed in Armstrong (2006) and also in Rochet and Tirole (2006). Most importantly, the usage and/or membership on one side of the market have an impact on the benefits enjoyed on the other side. In the application of this model made in Boldron (2009), which inspires the work in this paper, the two sides of the market are senders and receivers of mail, with a postal operator functioning as the platform. Senders derive benefits from the number of receivers (at high quality delivery frequency) and receivers get utility from the mail they receive. The authors show that a profit maximizing operator will not set prices so as stimulate the welfare optimal volume and participation in high quality delivery. Hence, the conclusion suggests a justification for the USO.

This result is particularly important in the current postal environment in which secularly declining volume has made the cost of the universal service obligation relatively more onerous. In fact, continuing volume reduction has placed pressure on governments to reduce the scope of the USO.

At the same time, the approach highlights some interesting difficulties concerning the growth in electronic information and communication technologies (ICT), since the size of the USO would depend explicitly on the value of the network to its participants. The growth in ICTs tends, in some respects, to reduce the social benefit attached to a postal universal service obligation. In particular, the value of the network may decline as the number of people who choose to access it declines.

Yet, at least in the United States, access to electronic alternatives is not anywhere near universal and significant parts of the population (the poor, the elderly, rural residents, technologically challenged, etc.) will continue to be extremely dependent upon postal operators for important communications. As a result, there is a continuing demand for physical postal services, the benefits of which are actually enhanced to the very extent that essential communications (government, finance) are digitized. Perkins (2001), Heitzler (2010), and Jaag and Trinkner (2011) have argued, following this train of thought, that the purely postal USO should be incorporated into a broader mandate addressing the wider communications market.

Hence, the combination of declining volume and lack of access to electronic alternatives raises a question as to just what is the social benefit associated with a postal USO when a material number of households choose to no longer participate in the postal network?

This paper seeks to understand the implications of the fact that the benefits, whether we speak of the network externality (a senders' benefit) or the call externality (external effects

flowing from senders' decision to send mail to receivers of mail), depend crucially upon whether the recipients have access to ICT alternatives to mail and whether receivers place a high (or low) value on the information conveyed by the mail. For instance, some receivers clearly read ad mail and respond to it by making purchases. Others complain about 'junk mail' and incur disposal costs.

It turns out that the external effects approach to the USO provides a useful framework for investigating these issues. Essentially, we differentiate between the external effects from serving high-value recipients, who place a high value on mail either because they have no alternative to the information it provides (no access to ICT) or they respond positively to mail that informs them about product decisions, or both, and from serving low-value recipients who place lower value on the mail (possibly because they enjoy an ICT alternative).

We proceed to analyze the implications for the foundation of the USO by comparing equilibrium market results, given the utility specifications described above, to welfare optimal results (achievable by a social planner), and to study the impact on the value of the network of continued growth in ICT mail alternatives. We introduce the possibility of an access fee charged to mail recipients to allow them to self-select participation in mail delivery. Because such an alternative permits recipients to signal senders regarding their interest in reading and responding to mail, it has a significant impact on the sender externality.

In section 2 we describe the basic model. In the section following that we derive the optimal mail volumes delivered to high- and low-value recipients. Section 4 presents a market solution and discusses its differences from the optimal result. In section 5 we calibrate the model and present numerical simulations of the solutions of sections 3 and 4. We also develop some interesting modifications to the solutions of the earlier sections to bring the analysis slightly

closer to the reality of present-day postal regulation. We look at the impact of electronic divergence on welfare and examine the effects of delivery charges levied on recipients. Conclusions are presented in section 6.

2. A Two-Sided Model with Participation Option

In this model, which has a basic structure similar to Boldron, *et al* (2009) and Cremer, *et al* (2008), a postal monopolist operates a platform intermediating between senders (firms) and recipients (households). The N total households are of two types. There are ρN high-value recipients, who might be considered as those having no access to electronic alternatives, and there are $(1 - \rho)N$ low-value recipients. Recipients are characterized as high-value (or low) in two senses: (1) they place a high value on the mail they receive, either because they have no ICT alternative to physical mail or because they derive utility from reading and responding to mail, or both, and (2) they are highly valued by senders because of their response behavior. It is presumed that senders (here represented by a single representative sender) enjoy positive benefits from reaching more high value recipients, but that no external benefits flow from low value recipients to senders, as such recipients can be reached by other means. In addition, recipients can to choose to opt in or out of the postal system. As for recipient (call) externalities, we assume there is a recipient externality greater than 0 for high-value households and negative for low-value households (unwanted mail is worse in large quantities).[2] The proportion of recipients opting in is denoted μ_h for high value recipients and μ_l for low value recipients. This means that $\rho(1 - \mu_h)N + (1- \rho)(1 - \mu_l)N$ recipients are electing not to participate.

[2] Refinements of this approach might include low-value external effects initially taking on a positive value but turning negative at a certain volume level.

Recipient participation in the postal market is modeled here as a function of an 'access price', P_A, recipients would pay to receive mail. In a broader sense, however, P_A could also serve to represent recipients' time and expense.

The sender's surplus can be expressed as:

$$S^S = \rho\mu_h(P_A)N\left[ax_h - \frac{\alpha}{2}x_h^2\right]\lambda(\rho) + (1-\rho)\mu_l(P_A)N\left[ax_l - \frac{\alpha}{2}x_l^2\right] + Z^s$$

where:

$$Z^s = R^s - P_{x_h}\rho\,\mu_h(P_A)Nx_h - P_{x_l}(1-\rho)\,\mu_l(P_A)Nx_l$$

Note that x_i denotes the volume of mail delivered to recipient i (i is of type h or l), the composite commodity and R^s refers to the sender's income and the sender's utility function is of the quasi-linear form familiar to readers of this literature. Note that the externality, $\lambda(\rho)$, is a function of the proportion of high-value recipients.

The utility enjoyed by a high- and low-value recipient, respectively, is

$$\Gamma^h = dx_h + \frac{\delta}{2}x_h^2$$

and

$$\Gamma^l = gx_l - \frac{\gamma}{2}x_l^2$$

so that total recipient surplus is the sum of the benefits going to high- and low-value addresses:

$$S^R = \rho\mu_h(P_A)N\left[dx_h + \frac{\delta}{2}x_h^2\right] + (1-\rho)\mu_l(P_A)N\left[gx_l - \frac{\gamma}{2}x_l^2\right] + Z^{Rh} + Z^{Rl}$$

where:

$$Z^{Rh} = R^{Rh} - P_A\,\rho\,\mu_h(P_A)N$$

$$Z^{Rl} = R^{Rl} - P_A(1-\rho)\,\mu_l(P_A)N$$

Note that R^{Ri} is the income of recipients.

We assume the postal operator has the same cost for delivery to high- and low-value households and thus charges the same price. Importantly, neither the operator nor the sender knows which type of household is receiving mail until the recipient self-selects by reacting to P_A. Hence the operator's fixed and per unit variable cost, F and c respectively, are given by:

$$C = F[(\rho\mu_h(P_A) + (1-\rho)\mu_l(P_A))N] + c\,N\,[\rho\mu_h(P_A)x_h + (1-\rho)\mu_l(P_A)x_l]$$

and the operator's profit by:

$$\Pi = P_{x_h}\rho\,\mu_h(P_A)Nx_h - P_{x_l}(1-\rho)\,\mu_l(P_A)Nx_l + P_A\rho\mu_h(P_A)N + P_A(1-\rho)\mu_l(P_A)N$$
$$- F[(\rho\mu_h(P_A) + (1-\rho)\mu_l(P_A))N] - c\,N\,[\rho\mu_h(P_A)x_h + (1-\rho)\mu_l(P_A)x_l]$$

3. The Social Planner Solution

We first find the solution that would be derived by an omniscient altruistic social planner. The welfare maximizing quantities are found by choosing X_h and X_l so as to maximize W, the sum of sender surplus, recipient surplus, and profit.

$$\begin{aligned} W = {} & \rho\mu_h(P_A)N\left[ax_h - \frac{\alpha}{2}x_h^2\right]\lambda(\rho) + (1-\rho)\mu_l(P_A)N\left[ax_l - \frac{\alpha}{2}x_l^2\right] + R^s \\ & + \rho\mu_h(P_A)N\left[dx_h + \frac{\delta}{2}x_h^2\right] + (1-\rho)\mu_l(P_A)N\left[gx_l - \frac{\gamma}{2}x_l^2\right] + R^{Rh} + R^{Rl} \\ & - F[(\rho\mu_h(P_A) + (1-\rho)\mu_l(P_A))N] - c\,N\,[\rho\mu_h(P_A)x_h - (1-\rho)\mu_l(P_A)x_l] \end{aligned}$$

The first order conditions for finding the optimal volumes are:

$$\frac{\partial W}{\partial x_h} = \rho\mu_h(P_A)N[a - \alpha x_h]\lambda(\rho) + \rho\mu_h(P_A)N[d + \delta x_h] - c\,\mu_h(P_A)N\rho = 0$$

$$\frac{\partial W}{\partial x_l} = (1-\rho)\mu_l(P_A)N[a - \alpha x_l] + (1-\rho)\mu_l(P_A)N[g + \gamma x_l] - c\,\mu_l(P_A)N(1-\rho) = 0$$

Solving yields:

$$x_h = \frac{\lambda(\rho)a + d - c}{\lambda(\rho)\alpha - \delta}$$

and

$$x_l = \frac{a + g - c}{\alpha + \gamma}$$

This result shows how the network externality enjoyed by the sender, λ, and the high-value recipient externality, δ, serve to increase the volume going to high-value households.

The optimal volume can then be used to calculate the welfare for the senders and recipients as well as the profit for the operator in the optimal social planner solution. These expressions are provided below. The sender's surplus is derived from the sums of the differences between the utility gain from sending mail and the prices paid to do so:

$$\begin{aligned}\tilde{S}^S = \; & \rho\mu_h(P_A)N\lambda(\rho)\left[a\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right)-\frac{\alpha}{2}\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right)^2\right] \\ & + \; (1-\rho)\mu_l(P_A)N\left[a\left(\frac{a+g-c}{\alpha+\gamma}\right)-\frac{\alpha}{2}\left(\frac{a+g-c}{\alpha+\gamma}\right)^2\right] + \; R^s \\ & - P_{x_h}\,\rho\mu_h(P_A)N\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right) - P_{x_l}(1-\;\rho)\mu_l(P_A)N\left(\frac{a+g-c}{\alpha+\gamma}\right)\end{aligned}$$

The recipient's surplus includes just the utility from receiving mail and the flat access price (which could be zero) because recipients do not pay on unit basis for mail receipt:

$$\begin{aligned}\tilde{S}^R = \; & \rho\mu_h(P_A)N\lambda(\rho)\left[d\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right)+\frac{\delta}{2}\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right)^2\right] \\ & + \; (1-\rho)\mu_l(P_A)N\left[g\left(\frac{a+g-c}{\alpha+\gamma}\right)-\frac{\gamma}{2}\left(\frac{a+g-c}{\alpha+\gamma}\right)^2\right] + \; R^{Rh} \\ & + \; R^{Rl} - P_A\rho\mu_h(P_A) - P_A(1-\rho)\mu_l(P_A)N\end{aligned}$$

Finally, the operator's profit is calculated in the normal way:

$$\Pi = P_{x_h}\rho\,\mu_h(P_A)N\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right) - P_{x_l}(1-\rho)\,\mu_l(P_A)N\left(\frac{a+g-c}{\alpha+\gamma}\right) + P_A\rho\mu_h(P_A)N$$

$$+ P_A(1-\rho)\mu_l(P_A)N - F[(\rho\mu_h(P_A)+(1-\rho)\mu_l(P_A))N]$$

$$- c\,N\left[\rho\mu_h(P_A)\left(\frac{\lambda(\rho)a+d-c}{\alpha\lambda(\rho)-\delta}\right) - (1-\rho)\mu_l(P_A)\left(\frac{a+g-c}{\alpha+\gamma}\right)\right]$$

4. A Market Solution

We develop an expression for a market outcome, to be compared to the optimal solution described above, by recognizing that the sender, having no ability to differentiate between high- and low-value recipients, sends the same quantity of mail to each. For this reason, $x_h = x_l = x$ and $P_{xh} = P_{xl} = P_x$. Senders choose the volume to send to maximize their own utility, the operator maximizes profit and recipients determine whether or not to participate in the postal system based on the access price.

To find the sender surplus, recipient surplus, and operator profit in this market solution, we first derive the sender's demand equation through maximizing sender utility. We then find the profit maximizing price by substituting this demand curve into the operator's profit function. In combination with the demand curve, this provides the equilibrium volume per household. Finally, these equilibrium values can be used to find the sender surplus, the recipient surplus and the operator profit in the market case. In the case of the sender surplus we see that the market solution volume is below the social planner volume because the market solution does not incorporate the positive sender externality. In addition, the fact that recipients receive utility from getting mail is not incorporated in the solution for volume because there is no mechanism for senders to share costs with the recipients that receive mail:

$$\hat{S}^S = \rho\mu_h(P_A)N\lambda(\rho)\left[a\left(\frac{a-c}{2\alpha}\right)-\frac{\alpha}{2}\left(\frac{a-c}{2\alpha}\right)^2\right]+(1-\rho)\mu_l(P_A)N\left[a\left(\frac{a-c}{2\alpha}\right)-\frac{\alpha}{2}\left(\frac{a-c}{2\alpha}\right)^2\right]$$
$$+ R^s - P_x\left(\rho\mu_h(P_A)N\left(\frac{a-c}{2\alpha}\right)+(1-\rho)\mu_l(P_A)N\left(\frac{a-c}{2\alpha}\right)\right)$$

The surplus for recipients is also lower as a result of the reduced volume:

$$\hat{S}^R = \rho\mu_h(P_A)N\lambda(\rho)\left[d\left(\frac{a-c}{2\alpha}\right)+\frac{\delta}{2}\left(\frac{a-c}{2\alpha}\right)^2\right]+(1-\rho)\mu_l(P_A)N\left[g\left(\frac{a-c}{2\alpha}\right)-\frac{\gamma}{2}\left(\frac{a-c}{2\alpha}\right)^2\right]$$
$$+ R^{Rh} + R^{Rl} - P_A\rho\mu_h(P_A) - P_A(1-\rho)\mu_l(P_A)$$

Finally, operator profit is likely to be enhanced because it can now charge the profit maximizing price. This also serves to reduce volume and reduce sender and recipient utility. In the market solution operator profit is given by:

$$\Pi = P_x\left[\rho\,\mu_h(P_A)N\left(\frac{a-c}{2\alpha}\right)-(1-\rho)\,\mu_l(P_A)N\left(\frac{a-c}{2\alpha}\right)\right]+P_A\,[\rho\mu_h(P_A)+(1-\rho)\mu_l(P_A)]N$$
$$- F[(\rho\mu_h(P_A)+(1-\rho)\mu_l(P_A))N]$$
$$- c\,N\left[\rho\mu_h(P_A)\left(\frac{a-c}{2\alpha}\right)-(1-\rho)\mu_l(P_A)\left(\frac{a-c}{2\alpha}\right)\right]$$

As expected, the volumes, prices, utilities and profits are different from the welfare maximum solution. The direction and extent of the difference is studied in the numerical simulations.

We also present, in section 5, a numerical examination of the case where P_A is raised. Note there are three critical ranges for the access price. The first range is defined by an access price sufficiently low price so that both low-and high-value households participate:

$$0 \leq P_A < gx_l - \frac{\gamma}{2}x_l^2 \quad \rightarrow \quad \mu_h = 1, \quad \mu_l = 1$$

In the second range, the access price is high enough so that low-value households opt out but high-value households continue to receive mail:

$$gx_l - \frac{\gamma}{2}x_l^2 \leq P_A < dx_h - \frac{\delta}{2}x_h^2 \quad \rightarrow \quad \mu_h = 1, \quad \mu_l = 0$$

In the final range the access price is greater than even the utility of high-value households and no recipients participate:

$$dx_h - \frac{\delta}{2}x_h^2 < P_A \quad \rightarrow \quad \mu_h = 0, \quad \mu_l = 0$$

As this third range leads to degenerate solutions, we examine only the first two in our numerical simulations.

5. Numerical Simulations

Calibration of the Model

There are four sets of economic agents in our model, high value mail recipients, low value mail recipients, mail senders and the postal operator. We set the values for the utility function for the first three groups and the cost function parameters for the operator.

We specify utility parameters for the high-value household and low-value household so that the high-value recipient has a higher level of utility at the same level of volume per recipient. We give both households the same income. Senders are assumed to get a higher utility per pieces than recipients. Finally, the operator has a network of 1,000 recipients to serve and incurs a constant variable cost and a fixed cost in serving that network.

The sender's externality is a positive function of the percentage of high value households. As that proportion rises, for a given amount of volume per household, the sender is able to reach more recipients that will reactive positively to the mailing. To be of interest, the externality should be large enough to be noticeable in the results, but should not be overwhelming. Thus we specify the following relationship between the size of the externality and the proportion of high value households:

$$\lambda = 1 + \frac{2\rho}{10}$$

The values for the utility and cost functions are given below.

Sender		HV Recipient		LV Recipient		Operator	
A	0.3	d	0.005	G	0.0025	C	0.2
A	0.01	Δ	0.00006	Γ	0.000002	F	100
R^S	100	R^{RH}	20	R^{RL}	20	N	1,000

Solutions

We first examine a market solution and compare that with the social planner solution. The primary advantage of the social planner is that he or she is endowed with knowledge of the externalities and can take advantage of the utility derived on both sides of the market, sender and recipient, in setting the optimal volume. In this baseline scenario, we assume 95% of recipients are high value households and $P_A = 0$.

In the market solution, the sender does not know which are high value and low value recipients and thus sends the same volume to both households. The sender determines the demand for the volume per household to be sent by maximizing utility.

Prices are set by the operator to maximize profit. Given this price, volume is determined by the sender and there is no mechanism for the sender to share any of the cost of sending mail with the buyer. Thus, the recipient's utility is not considered in determining the volume level.

In the case of a social planner, the planner sets the optimal volumes and prices to maximize total social welfare. This leads to differential volumes by recipient type. High-value recipients get more mail because this solution takes recipient utility into account as well as the sender's externality. Note that, in this case, the prices are below marginal cost and, as a result, the operator cannot breakeven.

	Market Solution	Social Planner
P	0.95	0.95
P_A	0	0
Λ	1.19	1.19
Solutions		
Unit Price	0.25	
Unit Price (High Value)		0.159
Unit Price (Low Value)		0.195
Average Vol. Per Household	5	16.3
High Value Vol. Per Household	5	16.6
Low Value Vol. Per Household	5	10.5
Sender Surplus	225.0	1,691.3
High Value Surplus	59.0	156.9
Low Value Surplus	21.2	22.6
Profit	150	-749.3
Total Volume	5,000	16,325.4
Total Volume (High Value)	4,750	15,801.4
Total Volume (Low Value)	250	524.0
# of High Recipients	950	950.0
# of Low Recipients	50	50.0
Social Welfare	455.2	1,121.4

Comparing the two sets of results shows that both sets of recipients and the sender have increased surplus in the social planner solution. There is just modest gain in utility for low-value households because the increased volumes bring only relatively small gains in utility. In contrast, the higher volumes going to high-value recipients lead to a relatively large increase in surplus. Not only is this from the higher value placed on receiving mail, but as well from the fact that the increase in volume is much larger for high-value recipients. This is because the sender's externality creates a differential in how much mail the sender wishes to send to the two types of recipients. Finally, the sender's utility rises because it can more optimally allocate its resources across high and low value recipients. These results are consistent with those found by Boldron *et*

al (2009) for the case a single recipient type. As those authors note, the difference between the market and the optimal solution may provide a well-grounded justification of the USO.

On the other hand, neither of these scenarios is likely consistent with actual postal regulatory environments. It is first of all unlikely that a monopoly would be allows to set profit maximizing prices in an unfettered manner. But as well, it is unlikely that the operator would be subsidized from general revenues for the sole purpose of increasing utility of participants in the mail market. We thus present two modifications of these alternatives that are perhaps a bit more consistent with regulatory practice.

We modify the market solution by subjecting both the profit-maximizing monopoly operator and the welfare-maximizing social planner to a price cap that ensures the fulfillment of a breakeven constraint. In the market solution, the breakeven constraint is reached through a markup on marginal cost for the single price. In the optimal solution, the social planner maximizes utility subject to a breakeven constraint. In the market solution, the breakeven constraint is reached through a markup on marginal cost for the single price. In the social planner solution, there are two prices and the markup must be allocated across the two. We use a Ramsey approach to determine the relative prices. Note that the markup is much larger for the price of mail being delivered to high value recipients because the sender's externality reduces the elasticity of demand for that product. In fact, high-value recipients subsidize low-value recipients as the latter's price is below marginal cost.

	Market Solution with Breakeven Price Cap	Social Planner with Breakeven Price Cap
P	0.95	0.95
P_A	0	0
Λ	1.19	1.19
Solutions		
Unit Price	0.211	
Unit Price (High Value)		0.207
Unit Price (Low Value)		0.178
Average Vol. Per Household	8.87	16.3
High Value Vol. Per Household	8.87	16.6
Low Value Vol. Per Household	8.87	10.5
Sender Surplus	493.65	941.9
High Value Surplus	90.43	156.9
Low Value Surplus	22.18	22.6
Profit	0.00	0.0
Total Volume	8873.0	16,325.4
Total Volume (High Value)	8429.3	15,801.4
Total Volume (Low Value)	443.6	524.0
# of High Recipients	950	950.0
# of Low Recipients	50	50.0
Social Welfare	606.3	1,121.4

We now turn our attention to an analysis of the effects of electronic diversion. We capture this through a shift of recipients from high value to low value. This occurs because the existence of new electronic alternatives reduces the value of mail to at least some recipients. To model this we assume that the percentage of high-value households falls from 95% to 65%.

We first note that this approach to modeling diversion will have no impact on volume and prices in the market solution with a breakeven price cap. This is because this scenario makes no differentiation between high- and low-value recipients. Total utility does fall as more and more

recipients get less value from the mail. In the face of a recipient access price, this could lead to recipients defecting from the postal systems and thus could have an effect in this way.[3]

We now examine the case of increased diversion in the social planner scenario with a price cap. The results of reducing the proportion of high-value households include reduction in volume per recipient, reductions in total volume, the inability of the operator to break even at current prices and a reduction in welfare for postal market participants.[4]

The decline in the percentage of high-value recipients does not change the optimal volume per household for low-value recipients but it does reduce that volume for high value recipients. That is because of the effect of the sender's externality. As ρ falls, so does λ, reducing the utility maximizing mail per high-value household. In other words, the surplus for high-value households falls but so does the surplus enjoyed by senders.

[3] We currently do not model the impact of electronic diversion on the utility that senders get from sending mail. Including this aspect would provide a reduction in volume even in our market scenario.

[4] We note that our analysis does not account for the gain in utility to recipients from additional electronic alternatives. Simply because welfare is falling in the mail market, it does not follow that total social welfare is falling due to electronic diversion.

	Market Solution with Breakeven Price Cap	Social Planner with Breakeven Price Cap
P	0.65	0.65
P_A	0	0
Λ	1.13	1.13
Solutions		
Unit Price	0.211	
Unit Price (High Value)		0.207
Unit Price (Low Value)		0.178
Average Vol. Per Household	8.87	13.3
High Value Vol. Per Household	8.87	14.8
Low Value Vol. Per Household	8.87	10.5
Sender Surplus	493.65	819.8
High Value Surplus	68.19	102.8
Low Value Surplus	35.25	38.0
Profit	0.00	-112.8
Total Volume	8873.0	13,299.7
Total Volume (High Value)	5767.4	9,632.1
Total Volume (Low Value)	3105.5	3,667.7
# of High Recipients	650	650.0
# of Low Recipients	350	350.0
Social Welfare	597.1	847.7

Finally, we address a possible approach to dealing with this aspect of electronic diversion, namely using an access price for recipients. To this point, we have assumed the access price zero. Now we set the access price to be:

$$gx - \frac{\gamma}{2}x^2 \leq P^A < dx + \frac{\delta}{2}x^2$$

This ensures that only high-value recipients participate in the postal market. This has several effects. First, it allows the postal operator to raise revenue to help make the breakeven constraint. Second, it allows senders to identify the high value recipients and take advantage of the externality even in the market solution. This means that the volume per recipient will rise above its market solution of 8.87 pieces. As a result sender surplus will rise relative to the market solution without an access price. Next, because low value recipients are dropping out of the market, total surplus can rise even though volume is declining.

	Market Solution with Breakeven Price Cap
P	0.65
P_A	0.06
Λ	1.13
Solutions	
Unit Price	0.207
Unit Price (High Value)	
Unit Price (Low Value)	
Average Vol. Per Household	12.72
High Value Vol. Per Household	12.72
Low Value Vol. Per Household	12.72
Sender Surplus	730.86
High Value Surplus	51.34
Low Value Surplus	20.00
Profit	0.00
Total Volume	8267.0
Total Volume (High Value)	8267.0
Total Volume (Low Value)	0.0
# of High Recipients	650
# of Low Recipients	0
Social Welfare	802.2

6. Conclusions

In this paper, we build upon the research of Boldron, *et al* (2009) by developing a model of the postal market which features a differentiation of recipients by type and a delivery charge. Given the presence of both a network externality benefitting senders of mail and recipient (call) external effects, it is not surprising that the unregulated market solution produces suboptimal results. We go on to introduce some modifications to the market and social planner solutions, specifically constraining the operator in both scenarios to break even, noting that a welfare maximizing social planner seeking to break even would require high-value recipients to subsidize low-value recipients. We also study the impact of electronic diversion on the value of mail, finding that e-substitution decreases the welfare obtainable from physical mail, reducing volume as well as sender surplus.

Finally, we look at the possibility introducing a delivery charge to allow recipients to opt in or out of the postal market. Such a charge has the somewhat unanticipated impact of raising volume per household and the utility of senders. This result may be surprising as the notion that charging households to receive mail can *benefit* senders of mail runs counter to the basic intuition of the 'senders pay' business model, in which senders subsidize receivers of mail in order to increase the size of the network. However, under the setup presented here, recipients reveal information as to their type, i.e., as to their likelihood of reading and responding to firms' mail. In this case, the reduction of the size of the network consists entirely in reducing the participation of recipients who do not much value the mail. Of course, these results are dependent upon the calibration of the model and future research could focus on determining the sizes of the various effects analyzed in our model.

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