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Analysing the prospects for transactional Mail using a sender-recipient framework*

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1. Introduction

Letter volumes in countries with advanced postal networks have been in decline since the early to mid 2000s. A rich econometrics literature exists on the demand for mail. A key conclusion of this body of work is that letter volumes are positively correlated with economic activity but advances in technology, in particular the increasing use of e-communications, are impacting negatively letter volumes to a greater extent[1]. The impact of e-communications on mail volumes in such studies are mainly estimated using proxy variables reflecting the availability of new technology. However the econometric models do not tend to explain why such substitution takes place and, in general, cannot explain the extent to which letter volume declines differ so markedly between countries. For example, the rates of letter volume decline in Denmark, Norway and Sweden are considerably greater than in other countries with similar penetration rates of internet enabled technology.

The aim of this paper is to advance the postal economics literature on the demand for mail by constructing a theoretical model that is based on sender and recipient preferences. In particular, the paper presents an analytical model studying the decision by senders and recipients of transactional mail to use electronic forms of communications (e-substitutes) rather than paper mail. The model framework has been constructed to be able to take explicit account of the characteristics of different types of transactional mail (e.g. statements, bills/invoices, general correspondence and official documents) that are relevant for this decision. More precisely, we build a model with a generic type of transactional mail, where a representative business sender (for example, private sector organizations, such as banks and insurance companies, or not for profit organizations, such as government departments and charities or clubs) sells a final good to its customers, with each unit of final good necessitating one unit of communication with its customers. This communication can take the form of either paper mail, or of an electronic substitute. The choice between modes of communication is modeled as a classical horizontal differentiation problem *à la* Hotelling, with two modifications. First, there exists a fraction of individuals who do not have access to the e-substitute technology (because they are not connected to the Internet, or do not have a computer for instance). Second, the communications strategy of the business impacts on the

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[1] Econometric estimates of the impact of economic activity and e-substitution are provided by: Boldron et al. (2010), Jarosik et al. (2012), Meschi et al. (2011) and Nikali (2008).

demand for its final product. Sending letter mail may be preferred for some types of communications, on the grounds that it could increase overall demand (e.g. information on high value added services such as financial investments, potentially acting as trans-promotional mail or ensuring people turn up for hospital appointments and operations,…). The key point to note is that transactional mail communications are highly heterogeneous and different types of senders and recipients will differ in their willingness to e-substitute. In the model this is represented by the distribution of preferences over the Hotelling line.

Mail, in our model, is an input into the production function of the representative business[2]. The representative business is assumed to choose the price of its final product taking into account the communication method (paper or electronic) in order to maximize consumer surplus and profit, with a weight attached to each depending on the objective of the different individual sender and the market structure they operate within.

We describe analytically the equilibrium allocation as a function of the objective of the representative firm, and then calibrate the model under two alternative sets of assumptions to provide insights on the extent to which the interactions of sender and recipient preferences can impact e-substitution. The calibrations differ in that in one case transactional mail is considered to have no impact on the demand for the final product of the representative firm and in the other it is considered to have a positive impact on demand for the final product. The two calibrations provide a number of important insights. First, they show how differences in assumptions concerning the extent to which letter mail affects demand impacts the estimated distribution of the willingness to use letter mail as opposed to the e-substitute. Second, we examine the sensitivity of the equilibrium allocation of letter mail versus e-communications to the objective of the representative firm–i.e., of the weight it puts on its profit compared to consumer surplus. Third, we show how the prices for the two communication strategies, and their market shares, are affected when the firm cares more for profit. Finally, we draw out some general conclusions for postal operators and policy makers from the results obtained from our analytical model and provide a number of recommendations on how further insights could be derived from our model framework.

2. The Model

Businesses send many different types of transactional mail (such as general correspondence, statements, bills/invoices and official documents), corresponding to different markets (such as banking, utilities and government services).[3] To simplify notation, we model a generic market in this section. We then calibrate the model and show how results are impacted as a function of the characteristics of the type of mail studied.

A representative firm is assumed to sell a final good to consumers. Selling this final good requires communication between the seller (the firm) and the buyer (the final consumer). We make three assumptions regarding this communication: *(i)* each unit of final good sold requires one unit of communication, *(ii)* communication can take place either through paper mail or through an electronic substitute, and *(iii)* the communication channel used is part of the firm's overall business and marketing strategy and can potentially have an impact on the

[2] The term business or firm in this paper refers to all types of senders of transactional mail, including private and public sector organisations.

[3] We assume for simplicity that each type of transactional mail corresponds to a market. In reality, each market probably requires a different combination of the different types of mail. This simplification is without loss of generality.

demand for the final product. Final consumers are then assumed to choose individually whether they prefer to purchase the good with the communication with the representative firm to take place via mail or an electronic substitute, depending on their (exogenous) ability to use this e-substitute and on their willingness to do so, which in turn depends on the characteristics (including price) of the two communication channels. In other words, the demand for transactional mail is a derived demand in our model, and the final consumers of the firm are the recipients of mail, while the representative firm is the mail sender.

We first describe the demand side of our model, before turning to the supply side.

2.1. Demand side

An exogenous fraction α of the general population (final consumers) has access to the e-substitute technology (i.e., they own a computer, tablet or mobile phone and have access to Internet). The remaining fraction of final consumers, $1-\alpha$, always uses paper mail rather than e-substitutes.

We model the willingness of the fraction α of final consumers to use the e-substitute rather than receive paper mail by a classical horizontal differentiation model *à la* Hotelling. To represent these taste differences, we assume that consumers are distributed over a Hotelling line, with $z \in [0,1]$, according to distribution function $G(z)$ and density $g(z)$. Point 0 corresponds to paper mail while point 1 corresponds to the electronic substitute. Each customer is characterised by a "location" on this interval, denoting her relative preference for the two modes of communication. The distribution of individuals on this line represents the distribution of the willingness to e-substitute among those who are able to do so.

The unit price of the final good sold by the representative firm may depend on the communication channel used. We denote by q_0 the unit price when the consumer chooses to use paper mail, and by q_1 the unit price when the consumer opts for the electronic substitute in her dealings with the representative firm. A final consumer located at $z \in [0,1]$ and buying the quantity x of the good is assumed to have utility

$$\theta u(x) - q_0 x - tz^2 \text{ if she buys paper mail,}$$

$$u(x) - q_1 x - t(1-z)^2 \text{ if she prefers the e-substitute,}$$

where t denotes the usual psychological, or convenience, cost borne by a customer who has to use a communication method that differs from the intermediate method (located at z) that she most prefers. Observe that this utility cost, t times the distance between used and most-preferred communication methods, is independent of the quantity x of final good bought. This in turn means, as we shall see shortly, that all consumers who choose a specific communication channel (either paper mail or the electronic substitute) buy the same amount of final good (and thus use the same quantity of communication) at the prevailing price for the good.

The parameter $\theta \geq 1$ embodies the assumption that the use of paper mail in the communications between the firm and its clients may allow it to engage more fully with customers and thus increase their utility. The provision of information by mail may impact on consumer utility directly; for example, where a firm's good has complex terms and conditions (say an insurance policy) receiving it in paper form rather than electronically may be of positive value to consumers. Paper mail may also provide the firm with a more effective channel to communicate with consumers for the promotion and sale of its set of products (for

example, through the use of trans-promotional mail) which may allow consumers to increase their utility through the better matching of their preferences to products. As we shall see shortly, a larger value of the parameter θ increases the amount of good sold using the paper mail communication method (thereby increasing the amount of transactional mail), both because more consumers choose this communication method and because all those who do so buy a larger quantity of the final good, thus requiring more communication with the firm.

We now determine the (individual and market) demand for the final good and for each type of communication method. We define the indirect utility (consumer surplus) of a final consumer buying the quantity x of final good at price q (with $\theta \geq 1$ if paper mail is used to communicate with the firm, and $\theta = 1$ otherwise) as

$$v(\theta, q) = \max_x \theta u(x) - qx. \tag{1}$$

Note that, by the envelope theorem,

$$\frac{\partial v}{\partial \theta} = u(x),$$
$$\frac{\partial v}{\partial q} = -x.$$

The solution to problem (1) gives a consumer's demand function $x(\theta, q)$, which does not depend on location, as explained above.

The marginal consumer $\hat{z}(\theta, q_0, q_1)$ is defined by

$$v(\theta, q_0) - t\hat{z}^2 = v(1, q_1) - t(1-\hat{z})^2.$$

In words, this consumer is indifferent between receiving paper mail (when each unit of the final good is sold at price q_0 when paper mail is used) and using the e-substitute (when each unit of the good is sold at price q_1 when the e-substitute is used). All consumers to the left of $\hat{z}$ (with locations in $[0, \hat{z}]$) will opt for paper mail communication while those to the right (in $[\hat{z}, 1]$) will choose the electronic substitute. These two intervals then determine the market shares (in terms of proportion of customers able to use the e-substitute) of the two communication modes which will be given by $G(\hat{z})$ for paper mail and $1 - G(\hat{z})$ for the e-substitute respectively. Solving for $\hat{z}$ yields

$$\hat{z}(\theta, q_0, q_1) = \frac{1}{2} + \frac{v(\theta, q_0) - v(1, q_1)}{2t}. \tag{2}$$

This expression is quite intuitive. When $q_0 = q_1$ and $\theta = 1$ the marginal consumer is located at $1/2$. Note that (unless the distribution of consumers is symmetrical) this does *not* imply that the market share of the two communication modes are equal. When $\theta > 1$ we have $\hat{z} > 1/2$ when $q_0 = q_1$; for a given price the better consumer experience allowed for by paper mail implies a higher market share of paper mail communication. We have

$$\frac{\partial \hat{z}}{\partial q_0} = -\frac{x_0}{2t},$$
$$\frac{\partial \hat{z}}{\partial q_1} = \frac{x_1}{2t},$$
$$\frac{\partial \hat{z}}{\partial \theta} = \frac{u(x_0)}{2t},$$

where $x_0 = x(\theta, q_0)$ and $x_1 = x(1, q_1)$ represent, respectively, the individual demand for both the final good when paper mail is used and for paper mail itself[4] (respectively, for the final good when the e-substitute is used and for the e-substitute itself).

Taking into account the existence of a fraction $1-\alpha$ of individuals who are unable to use the electronic substitute, aggregate (market) demand for the two final products and the two communication methods is given by

$$X_0(\theta, q_0, q_1) = x(\theta, q_0)\left[1-\alpha+\alpha G\left(\hat{z}(\theta, q_0, q_1)\right)\right],$$
$$X_1(\theta, q_0, q_1) = x(\theta, q_1)\left[\alpha(1-G\left(\hat{z}(\theta, q_0, q_1)\right))\right].$$

We now turn to the supply side of the economy.

2.2. Supply side

The cost function of the representative firm selling the quantities X_0 of final goods using paper mail and X_1 of final good using the e-substitute is

$$C(X_0, X_1) = F + (p + c_0)X_0 + (p + c_1)X_1,$$

where F denotes the fixed cost of running the firm, including the fixed cost of using both communication technologies, and where the variable cost when using communication technology $i \in \{0,1\}$ is divided into the price for the firm of one unit of final good, p, deemed to be independent of the communication method used, and of the variable cost c_i per unit of communication method i.

2.3. Equilibrium allocation

The representative firm chooses its prices for the final good it sells according to the communication method (q_0 and q_1) in order to maximise a weighted sum of consumer surplus and of profit

$$\max_{q_0, q_1} W(q_0, q_1) + \lambda\Pi(q_0, q_1),$$

with $\lambda \geq 1$ is the (exogenous) weight put on the firm's profit, and where

$$\Pi(q_0, q_1) = q_0 X_0 + q_1 X_1 - C(X_0, X_1),$$

is the representative firm's profit, and $W(q_0, q_1)$ is the consumer surplus,

$$\begin{aligned} W(q_0, q_1) = {} & (1-\alpha)v(\theta, q_0) \\ & + \alpha\int_0^{\hat{z}} [v(\theta, q_0) - tz^2]g(z)dz + \alpha\int_{\hat{z}}^1 [v(1, q_1) - t(1-z)^2]g(z)dz \\ & - q_0 X_0 - q_1 X_1. \end{aligned}$$

A weight $\lambda = 1$ corresponds to the first-best allocation, while a weight λ tending towards infinity models the profit-maximisation scenario. The value of λ can then be taken as a proxy of the competition intensity in the representative firm's market (with a lower value of λ for a more competitive industry, and the polar cases of $\lambda = 1$ for a competitive fringe and $\lambda \to \infty$ for a profit-maximising monopoly), and/or a depiction of its stated objective (such as profit-

[4] Keep in mind that each unit of final good sold requires one unit of communication, either paper mail or an e-substitute.

maximisation for a private firm or welfare maximisation for a non profit entity). The Ramsey solution (maximisation of welfare under a break-even constraint) corresponds to the (endogenous) value of λ that is such that $\Pi = 0$ at the optimal allocation using this value of λ. The optimal prices $q_0^*(\lambda)$ and $q_1^*(\lambda)$ are traditional Ramsey formulas (but with the value of λ being exogenous, except for the Ramsey case).[5] They can be simplified into *(i)* marginal cost pricing when $\lambda = 1$ and *(ii)* profit-maximizing prices when $\lambda \to \infty$.
We now turn to the calibration of the model.

3. Calibration

There are in reality many different types of transactional mail segments. They differ in the willingness of senders to e-substitute (as summarised by the density function $g(z)$), by the value added by paper mail as opposed to the e-substitute (the parameter θ) and by the objective and/or the competition intensity in the representative firm's market (the value of λ). We provide here two different calibrations of the density function, each corresponding to a specific value of θ. For each of these two calibrations, we compute the equilibrium allocation for several values of λ. The two calibrations are based on the same set of assumptions presented in the following subsection. We then turn in the next two subsections to the assumptions specific to a particular calibration and to the results obtained with this calibration.

3.1. Assumptions common to the two calibrations

We set exogenously the cost of the final good sold by the firm (excluding communication), p, at 100. Both a macro and a micro approach based on UK data (computations available from the authors) suggest a cost of letter communication of around 0.5% of the output price (so that $c_0 = 0.5$) and we assume a cost of electronic communications as a low fraction (2%) of the letter communication costs, so that $c_1 = 0.01$. Hence, the marginal cost prices are $q_0 = 100.5$ and $q_1 = 100.01$.

We assume that the utility function $u(x)$ is quadratic, so that individual demands for final goods $x(\theta, q)$ are linear in q (although not in θ). Utility functions and individual demands are then determined by two parameters, which are calibrated so that (1) the direct demand price elasticity for the final good is -1, and (2) the individual quantity demanded at the marginal cost price with letter communication of 100.5 is 1000 (an arbitrary round number).
Data provided by the UK Office for National Statistics (ONS) shows that in the latter part of 2013 84% of adults had "ever used the internet" and of these users 97% state they had used it over the past 3 months.[6] We then set $\alpha = 0.85$.

Based on market research commissioned by Royal Mail on consumer preferences for letter versus e-communications if charges were explicitly introduced for paper items, we have obtained the following four estimations of the letter market shares as a function of the prices of final good according to the communication method used, q_0 and q_1.

[5] They are available upon request.

[6] Further details can be found in the Internet Access Quarterly Update Q3 2013 available at http://www.ons.gov.uk/ons/dcp171778_336739.pdf

q_0	q_1	Letter market share
100.5	100.01	50%
101.0	100.01	35%
102.5	100.01	24%
103.5	100.01	22%

Table 1: Letter market shares assumptions

Note that the letter market shares are expressed in terms of fractions of consumers, as given by

$$1-\alpha+\alpha G(\hat{z}(\theta,q_0,q_1)),$$

rather than in terms of volumes, which would correspond to

$$\frac{X_0(\theta,q_0,q_1)}{X_0(\theta,q_0,q_1)+X_1(\theta,q_0,q_1)}.$$

The two market share measures differ from each other because individuals buy different quantities of the final product (and thus use different quantities of communications) depending on the type of communication method used ($x(\theta,q_0)\neq x(1,q_1)$ both because $q_0\neq q_1$ and in the case where $\theta>1$).

We assume a density function $g(z)$ as $h(1-z)$ where $h(.)$ is a Pareto function indexed by a single parameter, γ.

There remain three parameters to calibrate: γ (the skewness of the distribution of consumers on the Hotelling line), t (the disutility incurred by consumers when they do not consume their most-preferred type of communication technology) and θ (the extent to which using letter mail boosts the demand for the final good). It is difficult to obtain direct evidence for these three parameters. At the same time, we are especially interested in how results are affected by assumptions related to the value of θ. We cover two distinct possibilities in the next two subsections.

3.2. Calibration with $\theta=1$

We first calibrate our model by assuming that the final demand for the representative firm's good is not impacted by its choice of paper versus electronic communication channel , which can be represented by assuming that $\theta=1$. In Table 2, we report the market shares for the four pairs of prices using $\theta=1$. Since we only have two degrees of freedom (the setting of γ and of t) and four calibration points, we use the two most extreme calibration points (the first and last rows in Table 1) and we report the letter market shares (in fractions of consumers and in volumes) we obtain in Table 2. Observe first that the market shares obtained for the two intermediate rows are larger than, but close to those in Table 1 (45.1% vs 35% for $q_0=101$, and 31% vs 24% for $q_0=102.5$). Also, letter market shares in volumes are lower than (since $q_0>q_1$ so that $x_0<x_1$), but close to, those measured in fractions of consumers.

		Letter market share of	
q_0	q_1	consumers	volumes
100.50	100.01	**50.0%**	49.9%
101.00	100.01	45.1%	44.8%
102.50	100.01	31.0%	30.4%
103.50	100.01	**22.0%**	21.3%

Table 2: Calibrated market shares with $\theta = 1$

The resulting density (dashed line) and distribution (solid line) functions are depicted in Figure 1.

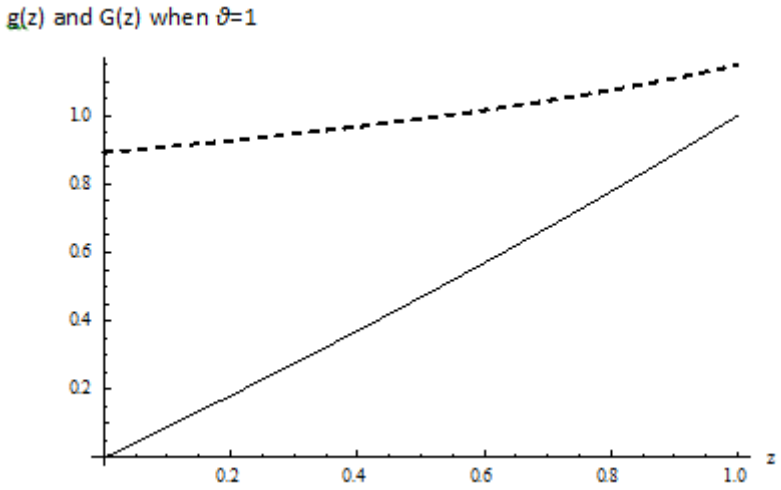

Figure 1: Calibrated density (dashed line) and distribution (solid line) functions when θ=1

The distribution (or density) function is close to the uniform distribution but slightly increasing in z, meaning that slightly more customers locate themselves close to the electronic substitute than to letter mail (i.e., $G(0.5) < 0.5$). Observe first that, for the first row of Table 2, letter mail has only a 41% market share among consumers who have access to the e-substitution technology (since 0.15+0.85*0.41=0.50). At the same time, this row corresponds to $q_0 > q_1$. As q_0 increases, we can see from Table 2 that the letter market share decreases at a roughly constant rate. But, with concave utilities, the location of the marginal consumer $\hat{z}$ (as given by equation 2) increases by a slightly smaller amount as q_0 increases. This in turn means that more and more people are located close to the right-hand extreme of the Hotelling line–i.e., that $g(z)$ is slightly increasing in z. This is then the first thing we learn from this calibration: if $\theta = 1$, then the letter mail assumptions imply that, although the distribution of intrinsic tastes for letter mail vs e-substitute is close to uniform, slightly more consumers would actually prefer the electronic substitute to letter mail. We will see in the next section how the distribution function is impacted if we assume that $\theta > 1$.

We are now in a position to report in Table 3 the equilibrium allocation as a function of the value of λ.

λ	q_0	q_1	$G(\hat{z})$	X_0	X_1	$X_0/(X_0+X_1)$	π	C. surplus	Welfare
1	100.5	100.01	0.4118	500.	502.44	0.4988	0	50 186	50 186
1.2	114.9	114.36	0.4109	427.55	431.69	0.4976	12 366	36 790	49 156
1.5	125.8	125.09	0.4073	371.31	380.54	0.4939	18 936	28 095	47 031

Table 3: Equilibrium allocations as a function of λ when $\theta = 1$

The first row of Table 3 reports the first-best allocation, attained when the representative firm maximises unweighted welfare (either because this is the objective of this non-profit organisation or because it faces a competitive fringe) and thus sets prices equal to marginal costs. The letter market share corresponds to the first row of Table 2, with 44% --that is, $G(\hat{z})$ of Internet connected consumers preferring letter mail when the price difference with the e-substitute is 0.49, for a total market share of 50% when adding the fraction $1-\alpha$ of consumers unable to use the e-substitute because of lack of access to the Internet. Profit in this case is zero, absent any fixed cost (i.e., assuming that $F = 0$), and the totality of welfare is made of consumer surplus.

As λ increases, the representative firm puts more weight on profit, as opposed to consumer surplus (for instance because the degree of competition in its industry decreases, allowing it to set a mark-up over marginal costs). We obtain that the representative firm increases both prices. Note that it is not possible to disentangle the margin made on selling the final good and the one made on selling one or the other communication method, since good and communication method are bundled into a single package. Also, the extent to which the firm increases its prices is in large part driven by our assumption on the direct price elasticity of the demand for the final good (numerical results available upon request show very intuitively a larger increase in prices with a lower demand price elasticity). More interestingly, the firm increases both prices in a similar way, with the relative price barely changed. More precisely, q_0 remains larger than q_1, and the difference between the two increases slightly. This results in a very slight decrease in the letter market share, both in fraction of consumers and in volumes. Consumer surplus decreases more than the increase in profit, so that total welfare decreases.

Finally, the Ramsey solution (i.e., the allocation maximising welfare subject to the representative firm breaking even) depends on the value of the fixed cost F. In other terms, the Ramsey allocation corresponds to the second row of Table 3 if $F = 12366$, and to the last row if $F = 18936$. A reasonable value for λ in numerical studies often lies between 1.2 and 1.3 so that the second row seems a good approximation of the Ramsey solution.

3.3 Calibration with $\theta = 1.05$

We now calibrate our model by considering the case where the final demand for the representative firm's good would be positively impacted by sending letter mail (possibly due to paper based trans-promotional communications being more effective than e-communications) by assuming $\theta > 1$. In particular, we set $\theta = 1.05$ and, to ease comparison with the previous calibration, we keep all other assumptions (including the first and last rows of Table 1) unchanged. We calibrate the values of γ and t in order to replicate these first and last rows. Table 4 reports the letter market shares (in fraction of consumers and in volumes) we obtain for the four pairs (q_0, q_1) proposed in Table 1. Observe that the market shares in

consumers obtained for the two intermediate rows are even closer to those reported in Table 1 than with the previous calibration. Letter market shares are now a little higher in volumes than in consumers, because the impact of $\theta > 1$ on volume is larger than the impact of the larger letter price (i.e., $x(\theta, q_0) > x(1, q_1)$ when $\theta = 1.05$, even though $q_0 > q_1$).

		Letter market share in	
q_0	q_1	consumers	volumes
100.50	100.01	**50%**	51.2%
101.00	100.01	41.2%	42.2%
102.50	100.01	26.6%	27.1%
103.50	100.01	**22%**	22.3%

Table 4: Calibrated market shares with $\theta = 1.05$

The resulting density (dashed) and distribution (solid) functions are depicted on Figure 2.

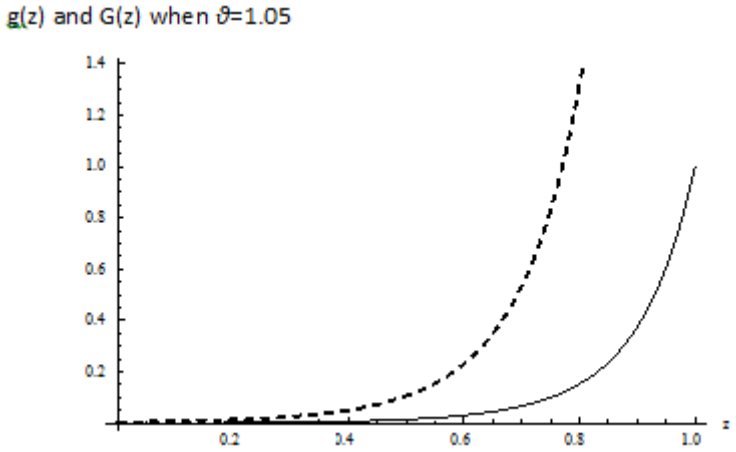

Figure 2: Calibrated density (dashed line) and distribution (solid line) functions when θ=1.05.

We obtain a density function which is much more increasing and convex than when $\theta = 1$. The intuition for this result runs as follows. Market shares are assumed to be the same, at marginal cost prices, when $\theta = 1$ and when $\theta = 1.05$. At the same time, equation (2) shows that the value of $\hat{z}$ increases with θ. From Figures 1 and 2, and concentrating on the first row of Table 1, we obtain that $\hat{z}$ is slightly lower than one half when $\theta = 1$ while it is close to 0.9 with $\theta = 1.05$. To maintain the market share $G(\hat{z})$ at the same value of 0.41 in both cases, we thus need that the distribution of preferences be more skewed in favor of e-substitutes when $\theta = 1.05$. As q_0 increases from 100.5 to 103.5 (while $q_1 = 100.01$), the value of $\hat{z}$ increases more slowly with $\theta = 1.05$ than with $\theta = 1$, which implies that the density function is increasing and convex–much more more so when $\theta = 1.05$.

The comparison between Figures 1 and 2 is striking, since we have increased θ by only 5%. This shows the high sensitivity of the density function $g(z)$ to the value of θ, and the importance of the latter for our results.

We now report in Table 5 the equilibrium allocations for various values of λ when $\theta = 1.05$.

λ	q_0	q_1	$G(\hat{z})$	X_0	X_1	$X_0/(X_0+X_1)$	π	C. surplus	Welfare
1	100.5	100.01	0.4118	500.00	477.56	0.5115	0	45 127	45 127
1.2	113.73	114.20	0.4489	461.59	377.96	0.5498	11 471	32 699	44 169
1.5	124.07	126.54	0.6908	564.32	178.14	0.7601	18 028	23 984	42 012

Table 5: Equilibrium allocations as a function of λ when $\theta = 1.05$

The first row of Table 5 corresponds to the first best allocation. Compared with the first row of Table 3, the letter market share in volumes is now larger than 50% for the reason explained above and the consumer surplus is lower.[7] As we increase the value of λ, both prices posted by the representative firm increase. The prices q_0 and q_1 remain close to each other, but now q_1 increases more than q_0, so that the use of the e-substitute is priced at a higher level than that of letter mail when the representative firm puts enough weight on its profit, even though the e-substitute is less costly to the firm than business mail. This stands in sharp contrast with Table 3. Two factors concur in explaining the differential impact of a larger λ on q_0 and q_1. First, raising q_0 would be especially detrimental for volumes because the impact of a larger price is magnified by $\theta > 1$ (both for individual demand x_0 and for the location of the marginal consumer $\hat{z}$). Second, the density function $g(z)$ represented on Figure 2 shows that in this case a large fraction of consumers would be located close to one –i.e., would have an intrinsic preference for a communication method close to the e-substitute. Raising q_1 then allows more profit to be captured from these consumers. As a consequence, the letter market share increases with λ, in contrast to the results obtained when $\theta = 1$. Finally, profit increases at the expense of both consumer surplus and welfare as λ increases.

4. Conclusions

To conclude, we would like to stress two insights obtained from the way we model e-substitution in the transactional mail market. First, there is a substantial minority of individuals who do not have regular access to the internet (mainly the old and vulnerable) and therefore limit the extent to which shifts to e-communications can take place – although in the very long run this effect is likely to disappear. Second, both recipient and sender preferences matter with regard to the prospects for the demand for transactional mail over the longer term.

In particular, our results indicate that where there is a need to send mail in order to complete a business transaction and the form of that communication (paper or electronic) does not impact the demand for a firm's product (θ=1), then the share of letter versus e-communications is broadly unaffected by the market structure the firm operates within ($\lambda \geq 1$). This is because our analytical model suggests that, while the price of goods and services requiring paper based communications will be higher than those using e-communications under different competitive market structures, their relative price remains broadly unchanged. In such cases

[7] As we calibrate the model so that the one half of consumers who prefer letter mail buy in total (X_0 =) 500 items when the final good is priced at marginal cost with letter mail, the increased market share (in volumes) of letter mail, compared to Table 3, is obtained at the expense of X_1. This also explains why consumer surplus is lower in the first row of Table 5 compared to Table 3.

the key determinant of letter versus e-communications would be recipient preferences.

However, in contrast to this result, our analysis suggests that in cases where the demand for products and services can be positively influenced by communication strategies incorporating an element of paper based communications (such as trans-promotional letter mail resulting in $\theta>1$) then at higher values of λ (that is, where the intensity of competition is lower) profit maximizing firms or cost minimizing public sector bodies with fixed budgets may end up sending more letter mail. The key driver of this result is that to some extent firms have an incentive to offset the relative cost advantage of e-communications via pricing decisions in order to stimulate demand. In such cases a more important determinant of letter versus e-communication would be sender preferences.

The analytical model we have constructed is a useful way to consider the demand for mail and provides a number of valuable insights to postal operators to help limit, or at least slow down, the structural decline in letters, especially if they are applied at a disaggregated level. For example, for specific segments of mail where paper based communications are deemed to have no impact, or very little impact, on the final demand for the product being consumed then postal operators should consider supporting activities that will influence recipients mail preferences and ensuring non-Internet users are not unfairly disadvantaged by business mailer decisions. In contrast, in cases where transactional mail is generated by business activities which are, or could be, positively benefitting from sending paper communications, postal operators should be making the case for mail to senders strongly . The analytical model we have constructed in this paper can be used to assess the equilibrium allocation of letter versus e-communications for many different types of transactional mail and senders. If postal operators were to invest in market research to help identify sender-recipient preferences in different market segments, this model could be a powerful tool for helping assess prospects for transactional letter mail over the longer term.

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