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POSTAL SERVICES: LEGAL MONOPOLY, ENTRY AND EFFICIENCY

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Postal services: legal monopoly, entry and efficiency*

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Abstract

In this paper we derive efficiency conditions for the determination of an optimal reserved area in a model of postal services' tariffs with potential entry. Current European regulatory schemes are critically discussed within the above mentioned framework. Following a recent innovative approach of Crew and Kleindorfer (2000) in this paper we present a model that illustrates the welfare costs of the exogenous determination of the reserved area (even as an upper limit) and the efficient conditions to be respected for its efficient determination alongside the determination of optimal Ramsey and *peak-load* pricing. In this latter respect the paper is an extension of recent Crew and Kleindorfer's results.

JEL classification: D2, L5

1 Introduction

Post offices are traditionally considered as a (*sui generis*) natural monopoly (Crew and Kleindorfer, 1992: 15) because of the network structure that characterizes part of their activities. As such, post offices have been regulated all over the world in order to ensure welfare compatible outcomes of their behaviour even at the cost of allowing legal monopoly protection for a part of the services they provide. Nonetheless, in recent times we have witnessed new regulation policy aiming at reducing the protected area and permitting competitive entry. A recent example of this new attitude towards postal services is the UE Directive 67/97. The welfare foundations of this new policy can be easily understood in terms of the desire to create conditions for competitive pressure on the incumbent firms' cost in order to improve productive efficiency. What is more difficult to understand is how this policy

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can be reconciled with another traditional welfare element of postal regulation, namely the maintenance of the so-called Universal Service Obligation (*USO*) in a regime of unique price. Indeed, competitive entry may jeopardize the possibility of making cross subsidization among different services belonging to *USO* which, under uniform tariff, permits the incumbent to cover excess cost (over revenue) for some services with excess revenue (over cost) for others and so implement the above mentioned cross-subsidiazation policy.

According to Crew and Kleindorfer (1998), *USO* exists if, on the whole (national) market, the supply of services is characterized by ubiquity, tariff uniformity and quality uniformity. Tariff uniformity allows the above mentioned cross subsidization among services and eliminates the transaction costs associated to the search of the lowest price if different suppliers are present in different segments of the market. Ubiquity and quality uniformity are essential to *USO* since they contribute to define its very and most basic nature (Crew and Kleindorfer, 2000: 5). Given the above three elements of *USO* one has to recognize that competitive entry might impinge upon *USO* obligations of the incumbent if the regulator does not take measures sufficient to avoid *cream skimming* policy on the part of entrants. To prevent this outcome the institution of a reserved area is generally recommended (Kolin and Smith, 1999; Rodriguez et al., 1999). The reserved area should consist of a subset of *USO* services for which competition in supply is not allowed. Since in this subset costs are generally lower that revenues this provides the incumbent with sufficient resources to meet its obligation to provide the rest of *USO* services (produced at higher costs) at the same uniform price charged for the services belonging to the reserved area. Profits made in the reserved area will finance the supply of non reserved *USO* services sold at the same price. Given this cross-subsidization scheme, the dimension of the reserved area should, in turn, be endogenously determined alongside the optimal (uniform) tariff. A reserved area exogenously determined by the regulator without reference to tariffs might not be efficient. The UE Directive 67/97 operates a sort of intermediate choice since it fixed an upper limit to the number of services to be included in the reserved area. Even this solution, however, is open to criticisms when tariff uniformity is maintained. The extent of the upper limit might not be sufficient to guarantee the incumbent the fulfillment of break-even conditions for the all *USO* services when government specific subsidies are not allowed. If the incumbent encountered herself in such a condition how could she react? In such a condition the negotiation of lower quality standards for the entire set of *USO* services might be a measure the incumbent can resort to in order to reduce costs and have no budget losses. In this case, the ultimate result of the regulation policy aiming at easing entry by compressing the legally reserved area of *USO* could be the opposite to the intended one: i.e. the incumbent might respond to the regulatory policy of easing entry with quality reduction rather than with more internal efficiency.

Following a recent innovative approach of Crew and Kleindorfer (1988; 2000) in this paper we present a model that illustrates the welfare costs of the exogenous determination of the reserved area (even as a upper limit) when this is fixed independently of prices and the conditions to be respected for its efficient determination alongside the determination of an optimal either Ramsey or *peak-load* pricing. In this latter respect the paper is an extension of previous Crew and Kleindorfer's results since it offers arguments against restrictions of the reserved area even in the case of no tariff uniformity. The paper is organized as follows. In section 2 a brief summary of the main aspects of *USO* is presented in order to make subsequent discussion clearer. In section 3 the endogenous determination of the limits of the reserved area is obtained in welfare maximization model that maintains tariff uniformity. The trade-off between easing competitive pressure and preserving *USO* is analytically discussed. Section 4 shows that even discarding tariff uniformity the imposition of exogenous limits to the reserved area still produces costly inefficiencies. Section 5 summarizes the main results.

2 The universal service

The idea of a universal service (*USO*) has been traditionally used to justify the presence of a (generally public) monopoly in the postal sector. The most frequently encountered elements of *USO* are service ubiquity and price uniformity. As for the former, a recent approach taken by the European Union (U.E. Directive 67/97) implies that uniformity must be obtained over the entire European territory by means of the imposition to member states of uniform minimum standards. As for price uniformity it is recognized that this historical element of *USO* allows the exploitation of the advantages of a prepaid tariff and permits the minimization of transaction search costs, i.e. costs incurred by users to obtain information about tariffs for each service and for each route as well as the corresponding marketing costs for the postal enterprise. Since these costs are generally considered as non negligible, price uniformity is normally regarded as a constituent part of *USO*. However, one should consider that the advantages of uniform pricing implies an allocative distortion induced by the application of non marginal cost pricing, which is in turn justified by the need to ensure cross-subsidization among services belonging to *USO*. More specifically, since it is possible to define each postal service on the basis of its product specificity (ordinary mail, registered mail, package, etc.), of each couple of points of collection and delivery (route serviced) and on the basis of the combination of weight-volume characteristics of each processed item the marginal cost of the service changes according to each particular combination of product, route, weight and volume that is realized. In turn this implies that some services/routes combinations are profitable whereas others are not. Therefore, uniform pricing, i. e. a policy of a same price charged for any service irrespective of the service-route combination, implies the existence of cross subsidies among different products and different routes. Policy aimed at opening the sector to competitive entry should, therefore, take the above cross-subsidization problem into account. If appropriate measures are not taken competitive entry might result in *cream skimming* on the part of the entrants and this may jeopardize cross-subsidization and the very possibility of meeting *USO* commitments for the incumbent. For this reason the regulation of the limits of the reserved area and the pricing policy should be strictly coordinated.

3 The efficient dimension of the reserved area with efficient uniform tariffs

Let A be the set of the existing postal products (letters, postcards, parcels, etc.). Each $a \in A$ is characterized by a "route" dimension t which indicates the distance between the point of collection and the point of delivery. Call T the set of all possible routes and assume that both A and T are normalized subsets of the set of the real numbers, i.e. put $A = [0,1]$ and $T = [0,1]$. Let us indicate $A = R \cup U \cup C$ where $R = [0,r]$ is the set of the services belonging to the reserved area, $U = [0,u] \supset R$ is the set of *USO* services for the incumbent (reserved or not) and C is the set of services open to competition. Then, the incumbent is a *legal monopolist* compelled to *USO* on $R \subset U$; she is a *competitor* compelled to *USO* on $U \backslash R$ where she may be challenged by fringe competitors not compelled to *USO*; and finally she is a *competitor* not compelled to *USO* in $C = A \backslash U$. As one can see, the entire set A is partitioned into subsets in such a way that the values of each a in each interval reflects the belonging of each service to: i) a reserved area; ii) an *USO* sector existing outside the reserved area; iii) a pure competitive sector. Accordingly, we can define the following inequality $0 < r < u \leq 1$ where each letter defines the upper limit of each relevant interval where a may fall.

The quantity of each service provided by the incumbent is specified by the two characteristics, a and t, and it will be indicated as $x(a,t,\cdot)$. We assume, following Crew and Kleindorfer (1998), that for each subset of services there is a marginal willingness to pay of the consumers[1]:

$$\begin{aligned} V(x_R(a,t),0) \text{ when } a &\in (0,r) \\ V(x_U(a,t),y(a,t)) \text{ when } a &\in (r+\varepsilon,u) \\ V(x_C(a,t),y(a,t)) \text{ when } a &\in (u+\varepsilon,1) \end{aligned}$$

[1] Following Crew and Kleindorfen (1998) we assume also quasi-linear preferences and separability of willingness to pay across services.

where $y(a,t)$ is the quantity offered by the competitors. For $a \in (0,r)$, we have $y(a,t) = 0$ because the services belong to the reserved area and $x(a,t;R) = x_R(p_m(a),t)$ as the quantity sold by the incumbent at a price $p_m(a)$ in the reserved area R. Notice that because of the uniform price rule within the USO area t is not an argument of $p(.)$. For $a \in [r+\epsilon, u]$, that is in the area still subject to USO but open to competition, quantity sold by the incumbent is $x(a,t;U) = x_U(p_m(a),t,p_f)$, where p_f is the competitors' price and $p_m(.)$ is once again independent of t because of the tariff uniformity rule. Quantity sold by competitors is $y(a,t;U) = y_U(p_f(a,t),p_m(a),t)$. Finally, outside the USO area, quantities are $x(a,t;C) = x_C(p_m(a,t),t,p_f)$ and $y(a,t;C) = y_C(p_f(a,t),p_m(a,t),t)$, respectively. Notice that in this latter case the incumbent's prices too depend upon t. In this case we are outside the USO area and the incumbent may behave in a profit maximizing way.

It will be assumed that for each a costs increase with t. This implies that if the tariff of each service $a \in U$ is imposed to be uniform irrespective of the route, the following problem emerges: if the level of r is exogenous the incumbent may not make sufficient profits on the low cost routes in order to finance the services provided on the high cost routes. It is clear that according to the costs levels there are many values of r and $p(.)$ that can guarantee an overall break-even result for the services between 0 and u, if the possibility of using for this purpose the profits made in the pure competitive area is legally prohibited. Therefore, in the presence of a legal reserve regime $p(.)$ and r should be chosen simultaneously. To illustrate this let us define the incumbent's costs as follows:

$$C_m = F_m + c_m(a,t)\,x(.)$$

where F_m is the fix cost and the competitors' costs as

$$C_f = c_f(a,t)\,y(.)$$

We assume fringe behaviour on the part of competitors for any service $a \in [r+\varepsilon, 1]$. Then $p_f(.) = c_f(a,t) + c_h(a)$, where $c_h(a)$ indicates transaction costs existing only outside the reserved area[2].

Under the above assumptions the social planner's problem is to maximize w.r.t. p and r the following welfare function:

$$W = \sum_{a=0}^{r}\sum_{t=0}^{1}\left[V\left(x_R\left(p_m(a),t\right)\right) - c_m(a,t)\,x_R\left(p_m(a),t\right)\right] - F_m +$$

$$+\sum_{a=r+\varepsilon}^{u}\sum_{t=0}^{1}\left[V\left(x_U\left(p_m(a),t,p_f(a,t)\right), y_U\left(p_f(a,t),p_m(a),t\right)\right)\right] +$$

[2] Following Crew and Kleindorfer (1998) we assume a complete shifting of transaction costs on prices.

$$+\sum_{a=u+\varepsilon}^{1}\sum_{t=0}^{1}\left[V\left(x_C\left(p_m\left(a,t\right),t,p_f\left(a,t\right)\right),y_C\left(p_f\left(a,t\right),p_m\left(a,t\right),t\right)\right)\right]+$$

$$-\sum_{a=r+\varepsilon}^{u}\sum_{t=0}^{1}[c_m\left(a,t\right)x_U\left(p_m\left(a\right),t,p_f\left(a,t\right)\right)+\left(c_f\left(a,t\right)+c_h\left(a\right)\right)\times$$

$$y_U\left(p_f\left(a,t\right),p_m\left(a\right),t\right)]+$$

$$-\sum_{a=u+\varepsilon}^{1}\sum_{t=0}^{1}[\left(c_m\left(a,t\right)+c_h\left(a\right)\right)x_C\left(p_m\left(a,t\right),t,p_f\left(a,t\right)\right)+$$

$$\left(c_f\left(a,t\right)+c_h\left(a\right)\right)y_C\left(p_f\left(a,t\right),p_m\left(a,t\right),t\right)] \qquad (1)$$

under the following participation constraint for the incumbent:

$$\sum_{a=0}^{r}\sum_{t=0}^{1}\left[p_m\left(a\right)x_R(a,t)-c_m\left(a,t\right)x_R(a,t)\right]+$$

$$\sum_{a=r+\varepsilon}^{u}\sum_{t=0}^{1}\left[p_m\left(a\right)x_U(a,t)-c_m\left(a,t\right)x_U(a,t)\right]+$$

$$\sum_{a=u+\varepsilon}^{1}\sum_{t=0}^{1}\left[p_m\left(a,t\right)x_C(a,t)-c_m\left(a,t\right)x_C(a,t)\right]-F_m\geq 0 \qquad (2)$$

The first term in (1) is the net *surplus* evaluated with respect to the consumption of the services belonging to the reserved area whereas the other terms indicate net surplus realized outside the reserved area.

First order conditions with respect to $p(.)$ for $\forall a\in[0,u]$, are:

$$\sum_{t=0}^{1}\left[\left(p_m\left(a\right)-c_m\left(a,t\right)\right)\frac{\partial x_R\left(.\right)}{\partial p_m\left(a\right)}\right]+ \qquad (3)$$

$$\sum_{t=0}^{1}\left[p_m\left(a\right)\frac{\partial x_U\left(.\right)}{\partial p_m\left(a\right)}+p_f\left(a,t\right)\frac{\partial y_U\left(.\right)}{\partial p_m\left(a\right)}\right]+$$

$$-\sum_{t=0}^{1}\left[c_m\left(a,t\right)\frac{\partial x_U\left(.\right)}{\partial p_m\left(a\right)}+\left(c_f\left(p,t\right)+c_h\left(a\right)\right)\frac{\partial y_U\left(.\right)}{\partial p_m\left(a\right)}\right]+$$

$$-\lambda\sum_{t=0}^{1}\left[x_R\left(.\right)+p_m\left(a\right)\frac{\partial x_R\left(.\right)}{\partial p_m\left(a\right)}-c_m\frac{\partial x_R\left(.\right)}{\partial p_m\left(a\right)}\right]+$$

$$-\lambda\sum_{t=0}^{1}\left[x_U\left(.\right)+p_m\left(a\right)\frac{\partial x_U\left(.\right)}{\partial p_m\left(a\right)}-c_m\frac{\partial x_U\left(.\right)}{\partial p_m\left(a\right)}\right]=0$$

where λ is the Lagrangian multiplier associated to the constraint (2). Collecting terms and simplifying, we get, $\forall a \in [0, u]$:

$$\sum_{t=0}^{1} \left[(p_m(a) - c_m(a,t)) \frac{\partial X_{(R+U)}}{\partial p_m} \right] = \frac{\lambda}{1-\lambda} \sum_{t=0}^{1} X_{(R+U)} \tag{4}$$

where

$$X_{(R+U)} = x_R(a, p_m, t) + x_U(a, p_m, t)$$

For any service belonging to the overall *USO* area marginal cost pricing is prevented by $\lambda > 0$.

Expanding (4) one gets

$$\frac{\sum_{t=0}^{1} \left[(p_m(a) - c_m(a,t)) \frac{\partial x_R(a, p_m, t)}{\partial p_m} \right]}{p_m(a) \sum_{t=0}^{1} x_R(a, p_m, t)} = \frac{\sum_{t=0}^{1} \left[(p_m(a) - c_m(a,t)) \frac{\partial x_U(a, p_m, t)}{\partial p_m} \right]}{p_m(a) \sum_{t=0}^{1} x_U(a, p_m, t)} \tag{5}$$

the efficient uniform tariff, i.e. the tariff common to all routes for each service, should be calculated, given the value of r, in such a way that marginal profit over total revenue realized in the reserved area should equal marginal profit over total revenue realized in the rest of *USO* non reserved area. On the one hand, this formalizes the idea of cross subsidization among routes for each services. Since costs vary with distance, low distance routes subsidize long distance routes for each service. On the other hand, equation (5) implies a version of Ramsey pricing where each proportional price-cost variation is weighted by the total variation of the quantity sold in any route serviced. These Ramsey prices are not necessarily applied to each route t, but to the entire set T of routes on which service a might be provided.

Outside the *USO* area, i.e. within the pure competitive area, first order conditions of the problem (1-2) are, $\forall a \in [u + \varepsilon, 1], \forall t \in [0, 1]$:

$$\frac{[p_m(a,t)] - c_m(a,t)}{[p_m(a,t)]} = \frac{\lambda}{(1-\lambda)} \frac{1}{|\eta(p_m(a,t))|} \quad \begin{matrix} \forall a \in [u+\epsilon, 1] \\ \forall t \in [0,1] \end{matrix} \tag{6}$$

where $\eta(p_m(a,t))$ is the demand elasticity to price. The implication of (6) is that Ramsey pricing should be applied to each service and over any route covered by that service.

We have therefore derived two different sets of efficient prices the incumbent should resort to in order to maximize welfare under a balanced budget constraint for any value of r. In the overall *USO* area uniform (over routes) prices should be used to ensure break-even conditions "on the average" i.e. for the entire volume of services sold over the all network of routes. This implies that cross subsidization among routes is possible. Outside the *USO* area, welfare maximization implies that Ramsey prices should be applied service by service and route by route.

To discuss conditions for the efficient dimension of the reserved area we maximize the welfare function (1) under the associated constraint with respect to r. F.o.c. are the following:

$$
\begin{aligned}
&\sum_{t=0}^{1}\left[\left(p_m(r)-c_m(r,t)\right)\frac{\partial x_R(.)}{\partial r}\right]+\sum_{t=0}^{1}\left[p_m(r+\varepsilon)\frac{\partial x_U(.)}{\partial r}\right] \\
&-\lambda\sum_{t=0}^{1}\left[\frac{\partial p_m}{\partial r}x_R(r,t)\right]-\lambda\sum_{t=0}^{1}\left[\left(p_m-c_m(r,t)\right)\frac{\partial x_R(.)}{\partial r}\right]+ \\
&-\lambda\sum_{t=0}^{1}\left[\frac{\partial p_m}{\partial r}x_U(r+\varepsilon,t)\right]-\lambda\sum_{t=0}^{1}\left[\left(p_m(r+\varepsilon)-c_m(r+\varepsilon,t)\right)\frac{\partial x_U(.)}{\partial r}\right] \\
=\;& 0
\end{aligned}
$$

which rewrites as:

$$
\begin{aligned}
&\sum_{t=0}^{1}\frac{\partial V\left(x_R(r,t)\right)}{\partial r}+\sum_{t=0}^{1}\frac{\partial V\left(x_U(r+\varepsilon,t)\right)}{\partial r}+ \\
&\qquad-\sum_{t=0}^{1}c(r,t)\frac{\partial x_R(r,t)}{\partial r}-\sum_{t=0}^{1}c(r+\varepsilon,t)\frac{\partial x_U(r+\varepsilon,t)}{\partial r}= \\
&\qquad\quad\lambda\sum_{t=0}^{1}\left[\frac{\partial p_m}{\partial r}x_R(r,t)+\left(p_m-c_m(r,t)\right)\frac{\partial x_R(.)}{\partial r}\right]+ \\
&\qquad\qquad+\lambda\sum_{t=0}^{1}\left[\frac{\partial p_m}{\partial r}x_U(r+\varepsilon,t)+\left(p_m-c_m(r+\varepsilon,t)\right)\frac{\partial x_U(.)}{\partial r}\right]
\end{aligned}
$$

The L.H.S. is the net consumers' surplus variation induced by the displacement of a service from one area to the contiguous one and the R.H.S. in the net variation of the incumbent's profits weighted by λ.

The point worth stressing is that the enlargement/restriction of the reserved area may affect the price applied to the all *USO* services. Therefore when the regulator fixes the value of the reserved area she should bear in mind that the optimal value of r depends on consumers' evaluation of both reserved and *USO* non reserved services via the unique tariff and that welfare considerations based upon quantity and price changes evaluated only with respect to the reserved area might give a limited if not misleading representation of the effects of a regulation policy consisting in a modification of the extent of the reserved area. To evaluate this we assume that r is exogenously fixed by the regulator and formalize this by imposing a new constraint $(\hat{r} - r) \geq 0$ to the maximization problem where $\hat{r}$ is the maximum limit imposed to the dimension of the reserved area. The last f.o.c. becomes:

$$\sum_{t=0}^{1} \frac{\partial V\left(x_R\left(r,t\right)\right)}{\partial r} + \sum_{t=0}^{1} \frac{\partial V\left(x_U\left(r+\varepsilon,t\right)\right)}{\partial r} +$$
$$- \sum_{t=0}^{1} c\left(r,t\right) \frac{\partial x_R\left(r,t\right)}{\partial r} - \sum_{t=0}^{1} c\left(r+\varepsilon,t\right) \frac{\partial x_U\left(r+\varepsilon,t\right)}{\partial r} =$$
$$\lambda \sum_{t=0}^{1} \left[\frac{\partial p_m}{\partial r} x_R\left(r,t\right) + \left(p_m - c_m\left(r,t\right)\right) \frac{\partial x_R\left(.\right)}{\partial r} \right] +$$
$$+ \lambda \sum_{t=0}^{1} \left[\frac{\partial p_m}{\partial r} x_U\left(r+\varepsilon,t\right) + \left(p_m - c_m\left(r+\varepsilon,t\right)\right) \frac{\partial x_U\left(.\right)}{\partial r} \right] + \mu$$

If $\mu = 0$, the incumbent operates with $r < \hat{r}$. She breaks-even *within* the limit of the reserved area using the price structure given in (5). On the contrary, if the limit binds and $\mu > 0$ the incumbent needs to reach the limit of the reserved area to break-even at the efficient prices. If the reserved area is further reduced the incumbent should increase $(p_m - c_m)$ outside the reserved area in order to cross-subsidize the *USO* services under a uniform pricing regime over routes. This illustrates the existence of a sort of trade-off between the two targets of the regulation policy: the measures aimed at increasing the benefits of competitive entry might imply consumers' sacrifice in the reserved area and even outside it. This point can be further commented upon as follows. From the envelope theorem we know that

$$\frac{\partial W^*}{\partial \hat{r}} = \mu^*$$

where the asterisk indicates evaluation at the maximum value. Then the marginal value of $\hat{r}$ is positive. How far could the regulator go in increasing/reducing $\hat{r}$? To evaluate this we need to know $sig\left(\frac{\partial \mu^*}{\partial \hat{r}}\right)$. In our case this is not indeterminate. Since the objective function is concave and the constraint is linear, μ^* is positive and $\partial \mu^* / \partial \hat{r} > 0$ which implies $\frac{\partial^2 W^*}{\partial \hat{r}^2} < 0$. The policy of increasing/reducing the reserved area increases/reduces welfare at a rate that is decreasing with $\hat{r}$. There exists an optimal value of $\hat{r}$ which is contingent upon the chosen price structure that determines W^*.

4 The optimal endogenous determination of the reserved area without price uniformity

Does the absence of uniform pricing eliminate the trade-off discussed in the previous section? Using a simple *peak-load* model of postal services modified in order to accommodate the distinction among subsets of services we show that it does not. In other words even if we allow for some form of tariff variation the previous result about endogeneity of the optimal reserved area remains. However, the introduction of more flexible tariff possibilities provides an alternative to possible quantity/quality reduction when the policy of reducing the reserved area is pursued in order to easy entry and improve productive efficiency.

Assume a postal incumbent operated in $n \in N$ periods normalized to $[0,1]$ and over $t \in T$ routes normalized to $[0,1]$ using $h \in H$ plants normalized to $[0,1]$ and that each plant has its production capacity level. Suppose, as above, that unit operating costs $c_{h\,\in\,H}$ are constant for any $x(a,t,h)$ offered in any time period (hours of the day) or for any distance/route (city mail, regional mail, etc.) within the limit of the $h.th$ capacity and that $\beta_{h \in m}$ is the pure capacity cost. With respect to time and routes the capacity limit has different interpretations. Within a same area (say a town) capacity should be mainly referred to time of delivery since plants are subject to different intensity of use in different moment of the day. In terms of routes, capacity should be mainly referred to the volumes of output covering short or long distances. A long distance mail has an higher probability to exhaust capacity since it transits for more network nodes. Symbol a has the same meaning as in previous sections.

Then,$\forall h \in H$ and $\forall a$, we define cost at capacity h as

$$C_h = c_h x(a,t,h) + \beta_h Q_h$$

where Q_h is capacity of level h. Total cost is

$$TC \ \equiv \sum_t \sum_h C_{th} = \sum_t \sum_h c_h x(a,t,h) + \sum_h \beta_h Q_h \quad \forall a$$

Define $X(a,t,h) = \sum_h x(a,t,h)$ as the quantity produced in any period and/or for any distance for capacity h and suppose the willingness to pay that quantity changes with t. To solve a problem analogous to the previous one we measure consumers' surplus in terms of areas under the demand curves defined over the three different subsets of USO. To simplify things we assume zero fixed and transaction costs. Then, optimal tariff can be determined by solving

$$Max\ W = \sum_{a=0}^{r} \sum_{t=1}^{1} \sum_{h=1}^{1} \left[V\left(x_R\left(p_m\left(a,h\right),t,h\right)\right) - c_m\left(a,t\right) x_R\left(p_m\left(a,h\right),t,h\right) \right] +$$

$$\sum_{a=r+\varepsilon}^{u} \sum_{t=1}^{1} \sum_{h=1}^{1} \left[V\left(x_U\left(p_m\left(a,h\right),t,h,p_f\left(a,t\right)\right), y_U\left(p_f\left(a,t\right),p_m\left(a\right),t\right)\right) \right] +$$

$$\sum_{a=u+\varepsilon}^{1}\sum_{t=1}^{1}\sum_{h=1}^{1}\left[V\left(x_C\left(p_m\left(a,t,h\right),t,h,p_f\left(a,t\right)\right),y_C\left(p_f\left(a,t\right),p_m\left(a,t,h\right),t\right)\right)\right]+$$

$$-\sum_{a=0}^{1}\sum_{t=1}^{1}\sum_{h=1}^{1}c_h x(a,t,h)-\sum_{a=0}^{1}\sum_{h=1}^{m}\beta_h Q_h-\sum_{a=r+\varepsilon}^{u}\sum_{t=1}^{1}\left[c_f y_U\left(p_f\left(a\right),p_m\left(.\right),a\right)\right]+$$

$$-\sum_{a=u+\varepsilon}^{1}\sum_{t=1}^{1}\left[c_f y_U\left(p_f\left(a,t\right),p_m\left(a,t,h\right),a,t\right)\right] \tag{7}$$

The last four terms in (7) are the cost for the incumbent (including capacity costs assumed to be present for the all subsets of services) and potential competitors' costs. The latter are assumed to have zero capacity costs. Welfare is maximized subject to

$$\sum\nolimits_{h=1}^{H} x(a,t,h)=X_h \quad \forall t \ \forall a \tag{8}$$

$$Q_h - x(a,t,h)\geq 0 \ \ \forall t \ \forall h \ \ \forall a \tag{9}$$

$$X_h \geq 0 \ \ Q_h \geq 0 \ \ x(a,t,h)\geq 0 \ \ \forall t \ \forall h \ \ \forall a \tag{10}$$

F.o.c. with respect to X_h are

$$p_m(X_h)-\lambda=0 \quad \forall t \ \ \forall a \tag{11}$$

$$-\beta_h+\sum\nolimits_{t=1}^{T}\mu_t=0 \ \forall t \ \ \forall a \tag{12}$$

$$-c_h+\lambda-\sum\nolimits_{t=1}^{T}\mu_t=0 \ \ \forall a \tag{13}$$

where λ and μ are multipliers. By substitution of (13) into (11) we get

$$p_t(X_t)=c_h+\sum\nolimits_{t=1}^{T}\mu_t$$

and using (12):

$$p_m(X_h)=c_h+\beta_h \tag{14}$$

Equation (14) has to be evaluated taking into account the following complementary slackness condition:

$$\mu_t \geq 0 \ \text{ or } \mu_t(Q_h - x(a,t,h))=0$$

Hence if $\mu_t=0$, then $Q_h > x(a,t,h)$ and $p_m(X_h)=c_h$; on the contrary if $\mu_t>0$, then $Q_h = x(a,t,h)$ and $p_m(X_h)=c_h+\beta_h$.

Then, with independent demands, we have

$$\sum_{a=0}^{u} p_m(X_h)=\begin{cases}\displaystyle\sum_{a=0}^{u} c_h & \text{with } x(a,t,h)<Q_h\\ \displaystyle\sum_{a=0}^{u}\left[c_h+\beta_h\right] & \text{with } x(a,t,h)=Q_h\end{cases} \tag{15}$$

This defines a particular version of the traditional *peak-load* price result. The interpretation is analogous to (3). The price policy imposed by the presence of capacity limits should guarantee break-even for the entire set u but not necessarily for each service and therefore cross-subsidization is possible among services but not among distances. Given the initial hypothesis this implies that, for example, a letter send to a destination in the same town requires a pre-paid tariff worth c_h regardless of, say, weight or time of delivery, and that the same letter send to a destination in the same region requires a pre-paid tariff worth $c_h + \beta_h$, regardless of weight or time of delivery. This allows the incumbent to break-even without imposing cross-subsidization among routes. The *USO* obligation is therefore sustainable, although in a reduced version (given absence of tariff uniformity over different routes).

Differentiation for r yields, after recasting the results directly in terms of consumers'surplus,

$$\begin{aligned} & \int_0^{X_t(r)} p(x_t(r,R))\frac{\partial x}{\partial r}dy + p(x_t(r,R))\frac{\partial X_t(r,R)}{\partial r} + \\ & \int_0^{X_t(r)} p(x_t(r,U))\frac{\partial x}{\partial r}dy + p(x_t(r,U))\frac{\partial X_t(r,U)}{\partial r} \\ = \; & \lambda_t \frac{\partial X_t}{\partial r} \end{aligned}$$

and summing over all a:

$$\begin{aligned} & \sum_{a=0}^{r}\left[\int_0^{X_t(r)} p(x_t(r,R))\frac{\partial x}{\partial r}dy + p(x_t(r,R))\frac{\partial X_t(r,R)}{\partial r}\right] + \\ & \sum_{a=r+\varepsilon}^{u}\left[\int_0^{X_t(r)} p(x_t(r,U))\frac{\partial x}{\partial r}dy + p(x_t(r,U))\frac{\partial X_t(r,U)}{\partial r}\right] = \\ & \lambda_t \sum_{a=0}^{u} \frac{\partial X_t(a)}{\partial r} \end{aligned} \tag{16}$$

where the two summations on the L.H.S. have contrasting signs. The f.o.c. is evaluated taking into account that

$$\lambda_t > 0 \quad \text{with} \quad \left[\sum\nolimits_h x_{ht} - X_t\right] = 0$$

$$\lambda_t = 0 \quad \text{with} \quad \left[\sum\nolimits_h x_{ht} - X_t\right] > 0$$

Within the limit of capacity for any kind of service offered we have $\lambda_t = 0$ which implies that the R.H.S. of (16) is equal to zero. Then, the optimal value of r is endogenously determined by equating consumers' surplus variations with respect to the quantities consumed in the two subsamples of postal services involved (reserved area and the remaining *USO* services outside the reserved area) given the uniform tariff for any a. If, on the contrary, for any a production is undertaken exactly at the limit of capacity in the whole u area, $\lambda_t > 0$ and therefore the R.H.S. of (16) is positive since the summation is positive. This implies that the difference between the first and the second term on the L.H.S. of (16) must be positive: the welfare gain induced by a change in r more than compensate the welfare reduction brought about by the reduction of the dimension of u. Once again the determination of efficient r is endogenous but in this case it depends on the shadow price of capacity. This result is not counterintuitive. When, for any a, production is undertaken at the limit of capacity, the evaluation of the welfare gain induced by the increase of the range of services offered should take into account the increase in cost associated to the new dimension of capacity required. Indeed, $\lambda_t > 0$ implies that $\lambda_t = c_t + \sum_{t=1}^{n} \mu_{ht}$. Hence, any increment (reduction) in total quantity induced by the increase (decrease) in the number of the elements belonging to the set r brings about an increase (decrease) of cost equal to $c_t + \sum_{t=1}^{n} \mu_{ht}$.

In short, the effects of the imposition of an exogenous upper limit to the reserved area affects welfare in different ways according to whether the incumbent is or is nor operating at the limit of her capacity. In the former case the reduction of the net surplus associated to the imposition of the upper limit implies that the reduction of surplus in the area u more than compensates the gain obtained in the reserved area. This can be seen as follows. Assume again an upper limit $(r_t - \hat{r}_t) \leq 0$ is introduced by the regulator. F.o.c. with respect to r_t are

$$\sum_{a=0}^{r} \left[\int_0^{X_t(r)} p(x_t(r,R)) \frac{\partial x}{\partial r} dy + p(x_t(r,R)) \frac{\partial X_t(r,R)}{\partial r} \right] +$$

$$\sum_{a=r+\varepsilon}^{u} \left[\int_0^{X_t(r)} p(x_t(r,U)) \frac{\partial x}{\partial r} dy + p(x_t(r,U)) \frac{\partial X_t(r,U)}{\partial r} \right] =$$

$$\lambda_t \sum_{a=0}^{u} \frac{\partial X_t(a)}{\partial r} + \theta_t \qquad (17)$$

where θ_t is the multiplier associated to $(r_t - \hat{r}_t) \leq 0$. To satisfy Slater's constraint qualifications for a saddle point with respect to both $x_{ht}(a)$ and r we need to find: *i*) a value $x_{ht}^0(a) > 0$ such that $\sum_h x_{ht}^0 - X_t = 0 \ \forall t \ \forall a$ and *ii*) a value $r_t^0 > 0$ such that $\left(r_t^0 - \hat{r}_t\right) < 0 \ \forall t$. Given the linearity of the constraint for r_t the above value r_t^0 can be assumed to exist. However, $\sum_h x_{ht}^0 - X_t = 0$ implies $\lambda_t(x_{ht}^0) > 0$ which in turn implies $p = c + \beta_h$ at least for some t since $\sum_h x_{ht}^0 - X_t = 0$ for some t implies $\sum_h x_{ht} - X_t > 0$ for some other t. Therefore, for some t, efficient pricing should depend on capacity costs *even within* capacity limits. This means that even the prices of some services provided within capacity limits should include capacity cost in order to ensure total break-even. Moreover, a specific form of cross-subsidization operates: for some t, services provided within capacity limits finance services provided outside capacity limits. However, this in turn implies that the above r_t^0 necessary to satisfy Slater's conditions with respect to the reserved area might not exist if the value of $\hat{r}_t$ is not sufficiently large *in relation to capacity.* In this case the Lagrangian might not achieve a minimum in the θ_t direction whilst it achieves a maximum in the price direction. In short, either we have differentiated (as opposite to uniform) tariffs, whatever the dimension of the reserved area, to allow the incumbent to break-even or we must have a sufficiently large value of r for uniform (over routes) tariff. In the former case we attenuate one of the *USO* requirements whilst in the latter we reduce the possibility of an easy entry. In any case the value of r fixed in order to easy entry and improve productive efficiency should be based upon the capacity limits of the incumbent.

5 Conclusions

In this paper we have discussed some of the issues surrounding the current debate over liberalization of postal services. We employed a welfare maximization model under certainty to analyze what we have called a trade-off between, on the one hand, the potential gains deriving from the imposition of an exogenous limit to the reserved area - justified by the desire to attract new competitors and so to increase productive efficiency - and, on the other hand, the inefficiency costs induced by the above imposition when this policy conflicts with the maintenance of the obligation for the incumbent to a uniform tariff policy for the all *USO* services. The trade-off derives from the fact that the exogenous limit to the reserved area might not be consistent with the need to allow cross-subsidization within the *USO* area by means of the uniform tariff. Cross-subsidization under uniform tariff requires the existence of a sufficient number of profitable services in order to gain a sufficient volume of revenues for some *USO* services to cover deficits realized on other *USO* services. Limiting by law the range of profitable services reserved to the incumbent is therefore potentially in conflict with the logic of *USO* under uniform tariff and balanced budget. Moreover, we have shown that the optimal limit to the reserved area is contingent to an optimal tariff policy even in the case of non uniform tariff when capacity limits are relevant. In such a case decisions about the range of the services to be included into the reserved area should take into account entrants' costs relative to the incumbent as well as capacity limits for any service. We have shown that under reasonable assumptions about technology, entrants' costs advantages might be more that offset by transaction and/or capacity costs.

However, the possibility of allowing for tariff differentiation among routes on the basis of capacity costs provides the regulator with an alternative (or perhaps complementary) regime to the problem of break-even when the reserved area is to be reduced to easy competitive entry and the problem of funding the *USO* emerges. When general or specific (on entrants) taxes are excluded the only regime left is “Funding completely from uniform pricing, with high-cost areas subsidizing low-cost areas and all areas eligible to make contributions to the fixed cost of *USO*” (Crew and Kleindorfen, 2000: 18). The results we obtained in the variant of the model which includes capacity limits represent a possible alternative to this, otherwise ineludible, regime.

6 References

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