Worksharing : a calibrated model[1]

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1 Introduction

The practice of worksharing has been introducing a measure of competition in the postal sector, even when the industry was otherwise monopolistic. Processing workshared mail at a discounted rate is effectively like providing the client with access to one or several segments of the postal network. Like in the case of downstream access, the postal operator sells some products which use only part of its network, while other products use the entire network. Put differently, the postal sector has the specific feature that access is a relevant issue even when there are no competing operators in the market. This feature raises the question how the workshared product ought to be priced and more generally, how the possibility of worksharing ought to affect the operators pricing structure. The underlying *theoretical* issues raised by this subject have been extensively studied in the literature see Billette de Villemeur et al. (2002, 2003).[1]

The structure of prices has to be reconsidered when the market opens. Competition may take two different forms. First, once entry has occurred, the demand for workshared mail may in part emanate from the competing operators. Specifically, the entrant may have all or part of its mail delivered by the incumbent (for an access charge) rather then build its own delivery network. In that case competition is limited to the upstream segments (mail preparation, etc.). Second, the entrant may find it optimal to "bypass" the incumbent's network in some areas by setting up its own delivery network. Now competition affects all segments and the ability of the incumbent to cover its fixed costs may be more seriously undermined. The possibility of bypass limits the possibility to have the entrant's product contribute towards universal service costs and pricing rules will have to be amended. The incumbent's pricing policy will be modified accordingly and one can expect a rather significant impact. The determination of the structure and the levels of pricing in settings that combine worksharing, access and bypass has been studied by Panzar (2005) as well as in our earlier papers (see Billette de Villemeur et al. (2004, 2005)).

All these studies are essentially of theoretical nature.[2] They provide optimal pricing

[1]See also Crew and Kleindorfer (1995), Mitchel (1999), Sherman (2001) and Panzar (2002).
[2]Exception Crew and Kleindorfer ? some numbers.

rules and many qualitative arguments that are useful in the regulatory debate and lead to valuable policy recommendations. However, such studies are not suitable to address a number of more specific and quantitative questions. For instance, they do not tell as what would be the order of magnitude of price adjustments and welfare changes across scenarios and policies. They do tell us that optimal prices usually differ from those stipulated by ECPR;[3] they do not tell us by how much nor do they quantify the welfare loss (and the impact on the operator's profit) associated with such an ad hoc rule. The theoretical investigations show that the financial viability "may" be challenged in some case but they fail to determine how serious a threat this would represent.

To address such quantitative issues an empirical implementation of the theoretical model is required. This paper represents a first step in that direction. We present a calibrated specification of Billette de Villemeur et al. (2002, 2003) based on real (albeit normalized) data from the French postal sector. For the time being we study only the monopoly scenarios while leaving the empirical study of competitive settings presented in Billette de Villemeur et al. (2004, 2005) for future research. In addition to the scenarios considered in Billette de Villemeur et al. (2002, 2003) we consider a number of other regulatory scenarios: ECPR, price of single piece mail fixed at an exogenous ("affordable") level, profit maximization, etc. The most interesting question associated with these scenarios are of quantitative nature; they have therefore be neglected in the earlier theoretical models but can be now addressed in our calibrated model.

One of the most original feature of our earlier investigations was the specification of the "demand model". We have explicitly modeled the heterogeneity between business customers that differ in the characteristics of their demand (level and elasticity) and in their preparation cost. Our current study involves the estimation of the distribution of preparation cost and this turned out to be a most challenging exercise. This demand model will be an important ingredient in future studies of additional regulatory scenarios.

[3] "Efficient Component Pricing Rule"; see Section ?? for details.

2 Model

The basic model is closely inspired by Billette de Villemeur et al. (2002, 2003) with some generalizations. To make the paper self-contained and to avoid cumbersome cross referencing we have to repeat some of the features of the original model. The stylized postal network we consider consists of two segments. Segment 1 corresponds to a composite activity including collecting, sorting and transportation. This activity implies a constant marginal cost of c_1. Segment 2 is delivery with marginal cost of c_2. In addition, there is a fixed cost of F. Throughout the paper we assume that there is a single operator.

There are two types of customers and two goods. The n_h customers of type h (households) consume good x which uses both segments. The marginal cost of x is thus given by $c_1 + c_2$. The n_f customers of type f (firms) may or may not use segment 1 of the operator's network. If they do not use segment 1 they consume good z which implies a marginal cost of $k + c_2$, where k is distributed over $\left[\underline{k}, \bar{k}\right]$ according to the cumulative distribution $G(k)$ with density $g(k)$. Observe that c_2 is the operator's cost, while k is directly born by the client. Alternatively, they can consume good x for which they pay the same price as households.[4]

Let $S_h(\cdot)$ and $S_f^k(\cdot)$ denote the (gross) surplus of the two types of clients as a function of their consumption level.[5] Observe that households are assumed identical for simplicity. Firms on the other hand, may differ not only in the cost of preparing mail but also in their willingness to pay. The variable k thus plays two roles: it is the cost of segment 1 and also a parameter which determines willingness to pay (surplus). Throughout the paper we assume that a lower k implies lower cost and higher willingness to pay. Net surplus is obtained by subtracting total cost: payment to the operator plus

[4] Except for the cost difference x and z are considered as perfect substitutes.

[5] For simplicity we use surplus as a welfare measure for firms. From a strict welfare economics point of view, this can be understood as representing the surplus of the consumers who buy the goods produced by firms f which use postal services as inputs. One can easily show that our shortcut does not involve any loss of generality in the case where all downstream markets are competitive (i.e., all firms who consume mail sell their products in competitive markets).

cost of activity 1, if applicable. We can then define the following demand functions:

$$x_h(p) = \arg\max\{S_h(x) - px\}, \tag{1a}$$

$$x_f^k(p) = \arg\max\left\{S_f^k(x) - px\right\} \tag{1b}$$

$$z^k(p+k) = \arg\max\left\{S_f^k(z) - (p+k)z\right\}. \tag{1c}$$

Observe that we have two classes of demand functions for x: one for households and one for each type of firms. Substituting demand functions into net surplus yields the following indirect utility functions:

$$V_h(p_x) = S_h[x_h(p_x)] - p_x.x_h(p_x), \tag{2a}$$

$$V_f^k(p_z, p_x, k) = \begin{cases} S_f^k\left[z^k(p_z+k)\right] - (p_z+k)\ z^k(p_z+k) & \text{if } \ p_z + k \leq p_x, \\ S_f^k\left[x_f^k(p_x)\right] - p_x.\,x_f^k(p_x) & \text{if } \ p_z + k > p_x. \end{cases} \tag{2b}$$

where p_x and p_z denote prices. To understand (2b) note that all users of type f for which $p_z + k \leq p_x$ (i.e., when $k \leq p_x - p_z$) find it profitable to buy good z at a level $z^k(p_z + k)$. Observe that overall per-unit cost of z is equal to $p_z + k$; it is this overall cost rather than just p_z which determines demand. On the other hand, when $p_z + k > p_x$, it is cheaper to consume x (which is otherwise a perfect substitute) and demand is $x_f^k(p_x)$. The index of the marginal firm is denoted by $\widetilde{k} = p_x - p_z$.

3 Regulatory scenarios

Our model can be used to study the market equilibrium in a monopolistic market under a variety of assumptions regarding the consumer characteristics, the production costs and the regulatory environment. In this paper, we consider two broad classes of regulatory environments. In the first one, the price p_x for single-piece mail is considered as exogenously given (for instance because of political economy constraints). The regulator sets p_z according to a welfare objective, possibly subject to a number of constraints. In the first part, we shall assume that p_x is exogenous and set at its (normalized) current value p_x^o. In the second class of problems, both p_x and p_z are endogenous. For each of these two settings, we consider the *four* alternative scenarios. In the first one, which is (with some abuse) labelled FB for "first-best", the relevant problem is to maximize welfare (total surplus) without imposing a break even constraint for the operator. In other words, we suppose that a possible deficit can be covered by a subsidy from the government (that is financed by a lump-sum tax and involves no "cost of public funds"). Observe that, while FB is effectively the first-best allocation when both p_x and p_y are endogenous, it is of course not in general first-best efficient when p_x is arbitrarily fixed. The second scenario, which is labelled $ECPR$ for "Efficient Component Pricing Rule", is obtained by imposing the constraint that the "worksharing discount" (i.e., the price differential between single-piece and industrial mail $p_x - p_z$) is restricted to be exactly equal to the avoided cost c_1. Since it is not sufficient to define a uniquel solution when p_x and p_z are endogenous, we impose the operator's break even constraint in that case.[6] Because of this feature, the comparison between $ECPR$ and the third scenario is particularly interesting. This scenario, which is labeled SB for "Second-best", is a Ramsey type solution. It is obtained by maximizing welfare subject to the operator's break-even constraint. Finally we consider a scenario, labeled $\max \Pi$, under which the operator maximizes profits; there are no regulatory constraint except possibly the restriction imposed on the price of single-piece mail, p_x.

4 Calibration

4.1 SP: Nature of the calibration exercise

The result presented in this paper are obtained from simulations of a calibrated version of our model. The calibrations are based on *real* data from "La Poste" (that we combine with some stylized facts). However, for obvious confidentiality reasons, the reported numbers have been normalized and the "starting point" SP *completely modified.* More precisely, prices and costs are expressed as a function of the single piece price p_x which is set to 1. The number of worksharing firms is set to 500. The traffic flows are such that the total volume of mail amounts to 10000 (millions of objects) at SP; their relative share reflects the arbitrary choice of the prices p_x^o and p_z^o but entail no relationship with the actual situation. Finally, the impact of the various changes in prices on the operator's profit are expressed as a rate of change. By contrast, consumer surplus associated with

[6] The $ECPR$ rule does not prevent the operator from realizing strictly positive profits.

the various segments and social welfare are expressed in terms of their actual units, namely in millions of euros.

The advantage of adopting such an approach is that, despite the numerous normalizations, the qualitative outcomes of the various *scenarios* are absolutely unchanged. In particular, all the relative changes are exactly preserved. In other words, while avoiding the disclosure of confidential information, we are nevertheless able to go beyond the purely fictitious exercise and deliver a clear and precise assessment of the implications of different policies.

4.2 Demand and Elasticity of the different market segments

The aggregate demand function of the households is assumed to be linear and given by

$$X_h(p_x) = A_x - B_x p_x. \tag{3}$$

Depending on the prices p_x and p_z of both goods and on their *own* preparation cost k, the firms buy the commodity x or z. The firm's demand functions are assumed to be linear in prices:

$$x_f^k(p_x) = A_k - B_k p_x, \tag{4}$$

$$z^k(p_z + k) = A_k - B_k(p_z + k). \tag{5}$$

Note that the parameters of these functions (like their counterparts in the general model (1b) and (1c)) are indexed by k; consequently, demand function are firm (or rather type) specific. More precisely, we shall assume that a firm's demand and its demand elasticity (in absolute value) are inversely related to its level of k. In other word, customers with a low preparation cost are those with the highest and most elastic demands.

Calibrations are made by using both traffic flows and elasticity estimates of the different market segments, *i.e.* households, (small) firms that consume the commodity x and (large) firms that consume commodity z. The aggregate demand functions for both goods are given by:

$$X(p_x, p_z) = X_h(p_x) + X_f(p_x, p_z) = X_h(p_x) + \int_{p_x - p_z}^{\overline{k}} x_f^k(p_x)\, g(k)\, dk, \tag{6}$$

$$Z(p_x, p_z) = \int_{\underline{k}}^{p_x - p_z} z^k(p_z + k)\, g(k)\, dk. \tag{7}$$

The price elasticity of the firms' aggregate demand for x and z are given by

$$\varepsilon_X^f = \frac{p_x}{X_f(p_x,p_z)} \int_{p_x-p_z}^{\overline{k}} \frac{-\partial x_f^k(p_x)}{\partial p_x} g(k)\,dk = \int_{p_x-p_z}^{\overline{k}} \frac{x_f^k(p_x)}{X_f(p_x,p_z)} \varepsilon_k g(k)\,dk, \quad (8)$$

$$\varepsilon_Z^f = \frac{p_z}{Z(p_x,p_z)} \int_{\underline{k}}^{p_x-p_z} \frac{-\partial z^k(p_z+k)}{\partial p_z} g(k)\,dk = \int_{\underline{k}}^{p_x-p_z} \frac{z_k(p_z+k)}{Z(p_x,p_z)} \varepsilon_k g(k)\,dk. \quad (9)$$

Observe that in equation (8) and (9), firms with a low level of k tend to be given a higher weight. This explains that aggregate (market segment) demand elasticities are larger than the average (individual) demand elasticities.

4.3 Distribution of Costs

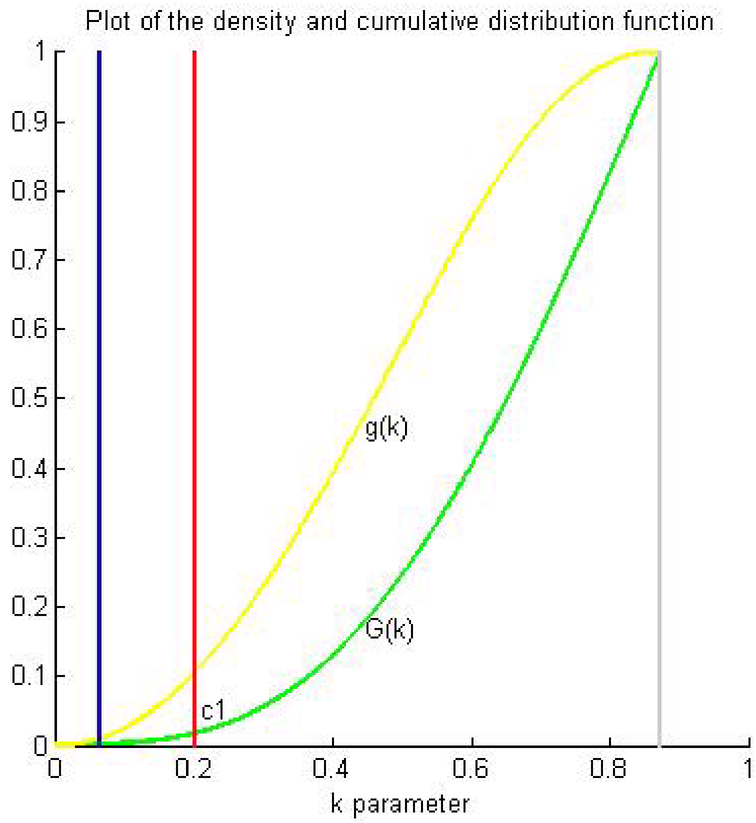
Equations (6)–(7) and (8)–(9) like most other subsequent expressions depend on the density function $g(k)$. We adopt the following specification for the distribution function $G(k)$ from which the density is derived:

$$G(k) = \frac{1-\gamma \exp(-\sigma k^\rho)}{1-\gamma \exp\left(-\sigma \overline{k}^\rho\right)}, \quad (10)$$

where $\overline{k}$ is the upper-bound of the cost parameter k; in other words, the support of the distribution is $[0,\overline{k}]$.[7] The parameters γ, σ and ρ are adjusted to match simultaneously *(i)* the expected profile of the cost k distribution, *(ii)* the actual number of worksharing firms, *(iii)* the anticipated number of worksharing firms if the discount where equal to the avoided costs and *(iv)* the data for the different market segments as given by aggregate demand and price-elasticity. As shown in Figure 1, the sorting costs k are asymmetrically distributed. More precisely, $g(k)$ is an increasing function which means that the lower is k, the smaller is number of firms that are able to prepare their mail at that specific cost. The total number of firms is fixed to $N = 250,000$. The number of worksharing firms $NG\left(p_x^0 - p_z^0\right)$ for the actual discount $\widetilde{k} = p_x^0 - p_z^0$ (represented by the vertical blue line) is arbitrarily set at 500, that is 0.2% of the total number of firms. We also assume that, if the discount were four times larger, so as to equate avoided costs (as represented by the vertical red line), the number of worksharing firms $NG(c_1)$

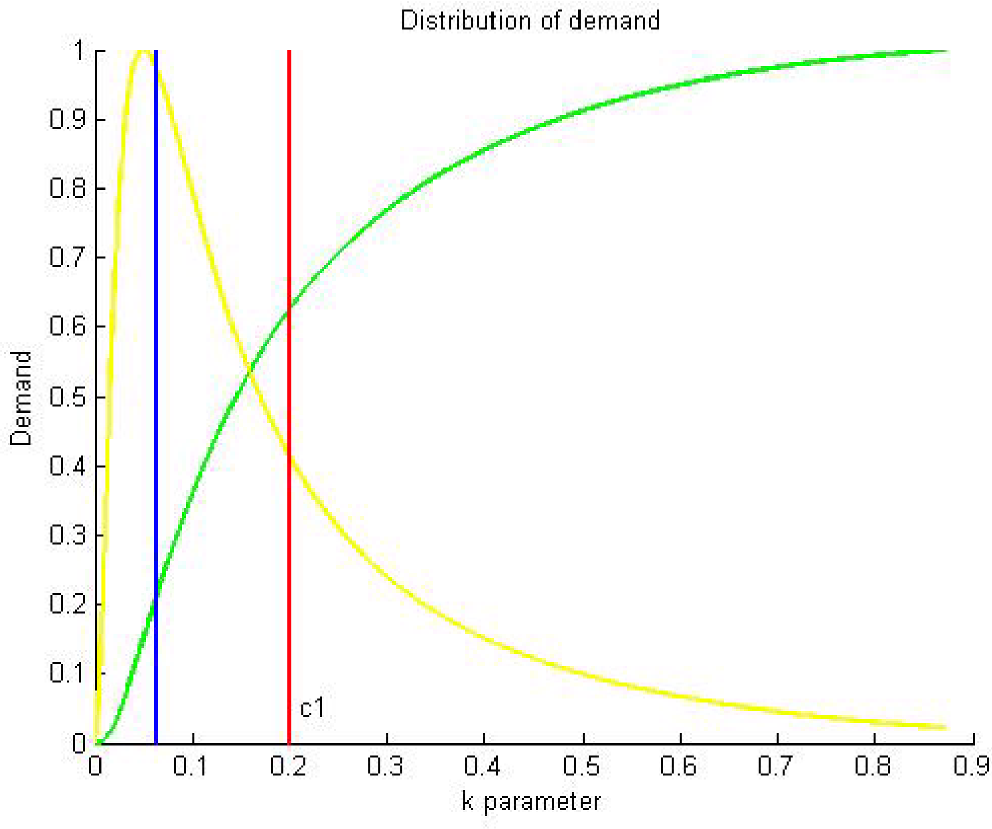
[7] In the theoretical model we have previously assume that $\overline{k} = \infty$. For practical purposes we have truncated the estimated distribution. This has no impact on the result.

would be ten times larger (but yet represents only 2% of the total number of firms).



Distribution of the sorting costs k

It is a well-known feature of the industry that, although the customers who potentially workshare their mail constitute only a small fraction of firms, their demand represents a significant share of total mail volume. The distribution of demand is depicted in Figure 2. Colors are chosen as in Figure 1 so that the yellow curve represents the density function while the green curve represents the distribution function. Figure 2 makes it clear that roughly one third of the total demand originates from the 500 firms that currently workshare their mail. The share of total mail that is sent by the 5000 firms with the lowest preparation costs is estimated to be twice as large.



Demand by firms of type k

Further details on the specification of the parameters of the model are given in Appendix. We now turn to the presentation of the results.

5 Scenarios with an exogenously fixed price for single-piece mail

We first consider the case where the regulatory policy takes the form of an exogenously fixed price for single-piece mail. Furthermore we assume that the price p_x remains at its initial level : $p_x = p_x^o$. The price p_z that will prevail at equilibrium depends on the considered scenario. A full characterization of the market equilibria is reported in Table 1, where SP (for starting point) refers to the initial situation, while FB, $ECPR$, SB, and $\max \Pi$ refer to the different regulatory scenarios just described.

Sc. $p_x = 1$ fixed	SP	FB	SB $\lambda = 1.79$	ECPR	$max\Pi$
p_x	1	1	1	1	1
p_z	0.950	0.477	0.883	0.800	0.907
Discount	0.050	0.523	0.117	0.200	0.093
Avoided Cost	0.200	0.200	0.200	0.200	0.200
Nb Worksharing Firms	500	81140	1396	5279	907
Z Trafic	2778	8773	5078	6433	4452
$X(MA)$ Trafic	4651	264	2534	1451	3088
X (Households) Trafic	2571	2571	2571	2571	2571
Z Elasticity	0.77	0.23	0.56	0.45	0.61
$X(MA)$ Elasticity	0.32	0.16	0.25	0.21	0.27
X (Households) Elasticity	0.20	0.20	0.20	0.20	0.20
$\Delta\Pi$ Profit Variation	0	-0.26	0	-0.03	0.01
Z Surplus	1211	7572	2978	4390	2426
X(MA) Surplus	4858	496	3258	2142	3738
X (Households) Surplus	3938	3938	3938	3938	3938
Social Welfare	11215	11669	11436	11549	11380

5.1 FB: Social welfare maximization without budget constraint

In the FB case, price p_z that prevails is 36% above the marginal cost of delivering industrial mail, namely $c_2 = 0.350$. As observed in Billette de Villemeur *et al.* (2005), the distortion imposed by the constraint $p_x = p_x^o$ spills over into the other market and induces the regulator to set a price of z that is above marginal cost. This positive margin is *not* set to raise revenue (no break-even constraint being imposed) but to reduce inefficient worksharing. To see this, recall the customers of type f engage in worksharing whenever $k \leq p_x - p_z$. When p_x is required to equal p_x^o setting p_z at c_2 implies a "very large" discount (of 0.650) so that many firms would prefer to prepare their mail even though their preparation cost exceeds the operators avoided cost $c_1 = 0.200$. The price p_z is increased above the marginal cost c_2 in order to reduce this *productive* inefficiency. This efficiency-enhancing effect of an increase in p_z has to be balanced with the (standard) *pricing* inefficiency that follows from having the price above the marginal cost. Thus p_z will be lower than the price level $p_z = p_x^o - c_1$ that would restore efficient worksharing. Specifically, the optimal value of p_z implies that about 32% of the firms do workshare while productive efficiency would reduce this share to 2%.

5.2 ECPR: Efficient component pricing rule

$ECPR$, though not second-best optimal, is very commonly recommended by policy makers. According to this rule, the difference between single-piece mail and industrial mail is exactly equal to the avoided cost ($p_x - p_z = c_1$). Given the costs and the imposed price $p_x^o = 1$, the resulting price for industrial mail is exactly 80% of the single-piece rate. In other words, the actual discount of 5% is well below the value that would follow from adopting $ECPR$. Observe however that, imposing both $ECPR$ and $p_x = p_x^o$ would result in negative profits for the operator. Finally recall that, by definition, $ECPR$ induces efficient worksharing. The comparison with the current situation shows that the proportion of firms that effectively engage in worksharing (namely 0.2%) is too low (lower than required by production efficiency). In other words, the same volume of mail could be processed at a lower total cost if more firms were incited to engage in worksharing.

5.3 SB: Second-best

It is well known that when (second-best) welfare rather than just cost efficiency is considered, optimal prices differ (in general) from those stipulated by the $ECPR$ rule. This is also the case in our simulations. In the SB case, the price for industrial mail is $p_z = 0.883$ so that the worksharing discount equals 0.117. Here the optimal discount is thus less than 60% of the avoided cost. This result is dues to the fact that p_x is exogenously given and the intuition is the same as in Subsection 5.1 (tradeoff between production and demand inefficiencies). If p_x were also endogenous, the optimal discount associated to the SB case would *exceed* the avoided costs (See Subsection 6.3 and Billette de Villemeur et al. (2003)). Our results also have other interesting implications. In particular, they show that it would be possible to maintain the price p_x at its current level while decreasing the price p_z by about 7% from its current level *without endangering the operator's financial viability.* To be more precise, such a decrease in the price p_z would increase the industrial mail volume by 2.5% and this would more than compensate for the decrease in price. Consequently, the lower price would actually result in higher profits in the industrial mail segment. Note, however, that such a decrease of p_z implies a worksharing discount *more than twice as large as its current level.* This makes worksharing more attractive so that the number of firms that sort their mail more than doubles, but continues to represent yet a very small fraction (less than 1%) of the total number of firms. As a result, firms' demand for X drops by 45% and the profits in this market segment will decrease. Overall, this change of the price structure would not modify the profitability of the operator but result in an increase in consumer surplus of 2%, which given the size of the industry represent a non-negligible welfare gain of about 221 million euros.

Finally, observe that the multiplier associated with the operator's break even cosntraint of the firm is $\lambda = 1.79$ under this scenario. In other words, an additional euro raised by the firm imposes a welfare costs of $1 + \lambda = 2.79$ euros on the consumer. This yields a deadweight loss that is well above a the usual estimates for the "marginal cost of public fund" that are in the range of $0.2 - 0.3$. Consequently, it would be efficient to pay a lump sum subsidy to the operator as compensation for the imposed low level of p_x. We shall return to this issue in Subsection 6.3.

5.4 $\max \Pi$: Profit-maximization

If the regulatory policy is limited to guaranteeing an "affordable" price to households, (*i.e.* the only constraint imposed on the firm is $p_x \leq p_x^o$), a (profit maximizing) operator will set the price for industrial mail to $p_z = 0.907$. This means that it would effectively be profitable for the firm to decrease its price p_z by 4.5%. This corresponds to an increase of about 86 % in the worksharing discount (that would nevertheless remain below the avoided cost). As a result the number of worksharing firms would increase by 81%, while the workshared mail would increase by 60%. Of course, this increase in cash-flow from the industrial market segment is mitigated by a decrease of revenues from the single-piece market by 22%. Overall, the net increase on profits is positive but represents an increase of only 1%. However, the corresponding variation in total welfare would amount to 165 million euros. In other words, a less rigid pricing policy (giving the freedom to the operator to decrease its price and to increase the worksharing discount) would yet boost social welfare by more than half of the total potential gains (i.e., the gains achieved by switching from the current prices to the second-best solution).

6 Flexible price scenarios

We now reconsider the same four scenarios for the case where both prices, p_x and p_z can be adjusted. The numerical results are reported in Table 2.

	SP	FB	SB $\lambda = 0.24$	$ECPR$ $\lambda = 0.25$	$max\Pi$
p_x	1	0.550	1.070	1.036	2.998
p_z	0.950	0.350	0.814	0.836	1.670
Discount	0.050	0.200	0.256	0.200	1.328
Avoided Cost	0.200	0.200	0.200	0.200	0.200
Nb Worksharing Firms	500	5279	10504	5279	250000
Z Trafic	2778	7962	6774	6312	4610
$X(MA)$ Trafic	4651	1590	1043	1440	0
X (Households) Trafic	2571	2802	2535	2552	1543
Z Elasticity	0.77	0.17	0.45	0.48	1.40
$X(MA)$ Elasticity	0.32	0.11	0.22	0.22	NaN
X (Households) Elasticity	0.20	0.10	0.22	0.21	1.00
$\Delta\Pi$ Profit Variation	0	-0.51	0	0	0.49
Z Surplus	1211	6375	4805	4251	3061
X(MA) Surplus	4858	2562	1618	2111	0
X (Households) Surplus	3938	4679	3829	3882	1419
Social Welfare	11215	11811	11513	11506	8720

6.1 FB: Social welfare maximization without budget constraint

The unrestricted first-best solution yields of course marginal cost pricing so that $p_x = 0.550$ and $p_z = 0.350$. While the numbers we report are obtained from simulation, this specific result can of course also be established analytically (see Billette de Villemeur *et al.* (2003)). These authors also point out that the solution implies efficient worksharing *i.e.* customers of type f engage in worksharing whenever $k \leq p_x - p_z = c_1$. Our simulations are (fortunately) also consistent with this result. This level of worksharing discount implies that $2,1\%$ of the firms would prepare their mail. As compared to the current situation, mail volumes would increase by 29% for clients of type f (firms) and by 9% for clients of type h (households). As a result, there would be a social welfare improvement of more than *half a billion* euros. However, operator's revenues cover only marginal costs so that there is a deficit that corresponds to the level of fixed cost F. Consequently to reestablish the operators current profit level a government subsidy that represents about 50% of the current cash-flow would be required.

6.2 ECPR: Efficient component pricing rule

When both prices p_x and p_z are endogenous the $ECPR$ does not provide a unique solution. Recall that according to this rule the difference between the price of single-piece mail and that of industrial mail is set equal to the avoided cost ($p_x - p_z = c_1$). This imposes a (linear) restriction on pricing rules, but leaves one degree of freedom. To remove this ambiguity, we assume that the operator is requested to adopt the $ECPR$ price structure *and* to make zero-profits. The resulting prices are $p_x = 1.036$ and $p_z = 0.836$. In other words, the price for single piece mail should be slightly increased (+3.6%) while pre-sorted mail should become much cheaper (-12%) so that its price would amount to about 80% of the single-piece rate (as compared to the current ratio of 95%). In other words, it appears that the current discount is equal to 25% of its $ECPR$ level. By definition of the $ECPR$, there is again efficient worksharing. As compared to the current situation, the mail volumes are almost unchanged. It would increase by about 4% for firms and would slightly decrease for households (less than 1%). By contrast, the structure of trafic is completly modified. The workshared volume more than doubles while firms' demand for single-piece mail is divided by more than three. Overall, these adjustments would result in a gain of 291 million euros in social welfare.

6.3 SB: Second-best

First-best efficient prices are equal to marginal costs. However, when there are fixed costs (that reflect economies of scale and scope), marginal cost pricing implies a deficit for the operator. This explains why the FB solution is usually not considered as a "realistic" scenario. The SB scenario we consider is in the the Ramsey tradition: prices are set to maximizes social welfare subject to the operator's break-even constraint.

Interestingly, the optimal SB prices, namely $p_x = 1.070$ and $p_z = 0.814$, differ from those obtained under $ECPR$. This is so even though we have defined the $ECPR$ to yield the same level of profits (namely zero). The SB solution implies that the price for single-piece mail should be increased by +7% while pre-sorted mail should be reduced by about 14% with respect to SP prices. Observe that SB prices are further away from current prices than are the $ECPR$ prices. Consequently a switch from SP to SB on the one hand and a switch from SP to $ECPR$ on the other hand yield price variations along the same directions but of different magnitude. Specifically, the adjustment is more significant for a switch to SB. Furthermore, the results show that the worksharing discount would be multiplied by 5 if SB were adopted. As a result, the number of firms that sort their mail would be multiplied by 20, the industrial mail volume be multiplied by about 2.5, while firms' demand for X would drop by almost 80%. Overall, the switch a the SB prices would increase consumer surplus by 2.6% which corresponds to a total variation of almost 300 million euros.

Shifting from $ECPR$ to SB may appear to induce only minor price changes. Nevertheless, there are quite significant difference between the two scenarios. First, in the SB scenario, the worksharing decision would no longer be (production) efficient. As shown by Billette de Villemeur *et al.* (2003), the worksharing discount now *exceeds* the avoided cost. Our numerical results are consistent with this property and furthermore show the number of worksharing firms is about *twice* as large under SB than under $ECPR$. Second, the traffic in Z would increase by 7% while firms' demand for X would drop by 28%. Finally, losses in terms of production efficiency (as a result of a too high number of worksharing firms) are offset by gains in (gross) surplus (associated with the more suitable pricing structure). The effect of prices on demand is typically neglected by $ECPR$ that focus on the sole cost dimension. However, by taking them into account, *i.e.* by shifting from $ECPR$ to SB, the regulator could enhance social welfare by 7 million euros.

Finally, observe that the multiplier of the break even constraint, λ, is now equal to 0.24 a level that is within the range of conventional estimates for the overal marginal cost of public funds. Consequently, the case for a subsidy from the general budget can no longer be made when all prices are endogenous. Put differently, the subsidy discussed in Subsection 5.3 is effectively a "compensation" for the cap on the price of single-piece mail.

6.4 $\max \Pi$: Profit-maximization

A profit-maximizing (monopolistic) operator will set the price for industrial mail at $p_z = 1.670$. This means that it would actually be profitable for the firm to increase this price by 70%. Moreover, the optimal price for single-piece mail would be multiplied by three. The worksharing discount is higher than the avoided cost and we end up with a situation where all firms engage in worksharing. As a result, firms' demand for X disappears. Compared to the current situation, the mail volumes would decrease by about 40% both for firms as for households. Those changes would lead to a loss of 2545 millions euros in social welfare. These results are quite extreme but do not come as a surprise. It is well know that a profit-maximizing operator who is not subject to the appropriate regulatory constraints would tend to set prices that are higher than socially optimal. The added feature we get from the numerical results is that in the postal sector this would lead to very significant adjustments. Also observe that the monopoly setting is crucial here. Under competition, we can expect the profit maximizing solution to perform "much better".

7 Conclusion

We have studied the price structure that would prevail in the postal sector under a number of alternative regulatory scenarios. There is a single operator that provides service to households (single piece, end to end mail) and to business customers (who may have the option of worksharing their mail). We have determined the optimal prices and studied the implications of various policies in terms of (mail) volumes, profits and welfare. The results were obtained from simulations based on a empirical model. This model is a calibrated version of the setting introduced by Billette de Villemeur et al. (2002, 2003); calibrations were based on real (albeit normalized) data from the French postal sector.

The (socially) optimal worksharing discount was shown to be significantly larger than the avoided costs (more than 25%). Consequently the number of firms that effectively engage in worksharing firms is larger (about five time) than the (production) efficient level. The welfare gain (over and above the reference scenario) that would result from the implementation of such a policy was estimated at approximately 300 millions euros. Interestingly, this "Ramsey pricing" scenario has been shown to differ significantly from the often recommended ECPR policy. If the operator were to offer a discount exactly equal to its avoided costs and just break-even the number of worksharing firms would be about half of that prevailing with the socially optimal policy. The structure of mail volumes, as distributed over the different products would also be significantly different. However, in term of social welfare, the difference did not appear to be very significant (7 millions euros).

We have also shown that an application of ECPR combined with the current price of single piece mail p_x^o does not appear to be feasible as the operator would not break-even. However, it would be possible to maintain p_x at its current level and decrease the price of p_z (by about 7%) without changing the operator profits. This result was explained by the fact that the induced increase in demand would totally compensate for the reduced margin over the commodity z. Such a change would allow to improve on welfare by about 200 millions euros. Consequently the cost of maintaining p_x at its current level implies a welfare (efficiency) cost of about 100 millions. Recall, however, that capping the price of single piece mail can be justified on "redistributive" grounds (See e.g., Billette de Villemeur et al. 2002).

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The values of the demand parameters and the costs functions are not derived from an econometric analysis. We have selected the values of the parameters in order to reproduce some stylized facts of the French postal sector.

A Preferences and Demand

We set the total demand $X_h + X_f + Z$ to $100,000$ objects.

A.1 Households

We assume demand to be linear with a price elasticity of $\varepsilon_x^h = -0.2$. Given the price p_x^o and the observed demand $X^o(p_x^o)$ we obtain the following demand function:

$$X_h(p_x) = 3085.2 - 514.2p_x.$$

A.2 Firms

As mentioned above, the firm's demand functions are assumed to be linear in prices:

$$\begin{aligned} x_f^k(p_x) &= A_k - B_k p_x \\ z^k(p_x + k) &= A_k - B_k(p_z + k) \end{aligned}$$

We furthermore assume that both the firm's demand and (the absolute value of) price elasticity are decreasing with their collection and sorting cost k. For the purpose of the calibration we adopt the following functional form:

$$\begin{aligned} A_k &= a_z(k_0 + k)^{-\alpha}, \\ B_k &= A_k b_z(k_{00} + k)^{-\beta}. \end{aligned}$$

Given the market data as made available by *La Poste*, the values of k_0, k_{00}, α, β, a_z and b_z are set to the following levels:

$$\begin{aligned} k_0 &= 2.1260 \times 10^{-2} \qquad k_{00} = 4.8450 \times 10^{-4} \\ \alpha &= 0.9993 \qquad \beta = 7.6531 \\ a_z &= 45.420 \qquad b_z = 26.547 \end{aligned}$$

A.3 Costs distribution

The functional form of the cumulative distribution is

$$G\left(k\right)=\frac{1-\gamma\exp\left(-\sigma k^{\rho}\right)}{1-\gamma\exp\left(-\sigma\overline{k}^{\rho}\right)}$$

The parameter γ, σ ,ρ and $\overline{k}$ are set to the following values:

$$\begin{aligned}\gamma &= 0.9993 \quad \sigma=1.0514 \quad \rho=3\\ \overline{k} &= 0.87229\end{aligned}$$