Worksharing: A Calibrated Model

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Abstract

This paper studies the price structure in a postal sector with a monopolistic operator when customers can engage in worksharing. It presents simulation results obtained from an empirical model that is calibrated on data from the French postal sector. The optimal worksharing discount is significantly larger than the avoided costs. Consequently, the appropriate pricing structure differs markedly from the often recommended *ECPR* policy.

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

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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 than 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. They provide optimal pricing 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 us 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*;² 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 questions associated with these scenarios are of quantitative nature. They have therefore been neglected in the earlier theoretical models but can be now addressed in our calibrated model.

One of the most original features 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.

¹ See also Crew and Kleindorfer (1995), Mitchel (1999), Sherman (2001) and Panzar (2002).

² “Efficient Component Pricing Rule”; see Section 5.2 and 6.2 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 $[\underline{k}, \bar{k}]$ according to the cumulative distribution $G(k)$ with density $g(k)$. We assume that $c_1 \in [\underline{k}, \bar{k}]$. This says that there are both, clients that have lower collecting, sorting and transportation costs than the operator; and clients that are less efficient than the operator in preparing their mail. Observe that k is directly born by the client while c_2 is the operator's cost. Alternatively, firms can consume good x for which they pay the same price as households.³

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.⁴ 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 a lower cost and a higher willingness to pay. In other words, bigger clients are also relatively more efficient in preparing their mail than small firms.

Net surplus is obtained by subtracting total cost: payment to the operator plus cost of activity 1, if applicable. We can then define the following demand functions:

$$(1a) \quad x_f^k(p) = \arg \max \{S_f^k(x) - px\},$$

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

$$(1c) \quad z^k(p+k) = \arg \max \{S_f^k(z) - (p+k)z\}$$

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:

$$(2a) \quad V_h(p_x) = S_h[x_h(p_x)] - p_x x_h(p_x),$$

³ Except for the cost difference, ξ and ζ are considered as perfect substitutes.

⁴ For simplicity, we use surplus as a welfare measure for firms. This can be understood as representing the surplus of the consumers who buy the goods produced by firms ϕ 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 (that is, all firms who consume mail sell their products in competitive markets).

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

where p_x and p_z denote prices. To understand (2b), note that all users of type f for which $p_z + k \leq p_x$ (that is, 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 $\tilde{k} = p_x - p_z$.

2.1 Pricing policies

2.1.1 First-best

Not surprisingly, first-best optimal prices equal marginal costs; see Billette de Villemeur *et al* (2003). Consequently, the prices that would implement the first-best allocation are given by

$$(3) \quad p_x^{FB} = c_1 + c_2 \quad \text{and} \quad p_z^{FB} = c_2.$$

This pricing policy is equivalent to offering a rebate $\tilde{k} = c_1$ to firms that engage in worksharing. This induces efficient worksharing (production efficiency) in the sense that only customers with $k \geq c_1$ use segment 1 of the operator's network; those with $k < c_1$ engage in worksharing. However, the first-best policy does not allow the operator to break-even. This explains why most of the literature focuses on alternative policies.

2.1.2 Second-best

The policy that maximizes social welfare subject to the operators' break-even constraint is defined by

$$(4) \quad \frac{p_x^{SB} - (c_1 + c_2)}{p_x^{SB}} = \frac{\lambda}{1 + \lambda} \frac{1}{\hat{\varepsilon}_x},$$

$$(5) \quad \frac{p_z^{SB} - c_2}{p_z^{SB}} = \frac{\lambda}{1 + \lambda} \frac{1}{\hat{\varepsilon}_z},$$

where $\hat{\varepsilon}_x$ and $\hat{\varepsilon}_z$ are the "superelasticities" of the demand for goods x and z . These "superelasticities" are modified price elasticities of demand which account for substitution between the two goods. It can be shown that $\hat{\varepsilon}_x < \varepsilon_x$ and $\hat{\varepsilon}_z < \varepsilon_z$, that is that the superelasticities are smaller than the respective ordinary elasticity.

A direct consequence of equations (4) and (5) is that, the worksharing decision is no longer (production) efficient. This is because the worksharing discount $\tilde{k} = p_x - p_z$ is likely to differ from c_1 . More precisely, we have

$$(6) \quad p_x^{SB} - p_z^{SB} - c_1 = \frac{\lambda}{1 + \lambda} \left\{ \frac{p_x^{SB}}{\hat{\varepsilon}_X} - \frac{p_z^{SB}}{\hat{\varepsilon}_Z} \right\}.$$

Intuitively we expect $\hat{\varepsilon}_Z > \hat{\varepsilon}_X$, so that $p_x^{SB} - p_z^{SB} > c_1$. In words, the demand for z being more elastic, we should obtain a worksharing discount that exceeds the marginal cost of access. In our empirically application, we can test the relevance of this theoretical prediction.

2.1.3 Efficient component pricing rule

In contrast to the second-best policy, the *ECPR* doctrine requires productive efficiency hence a worksharing discount that equals the operators marginal cost ($\tilde{k} = p_x - p_z = c_1$). The original rule, however, does not specify the levels of prices. For the sake of comparison with the second-best policy, we will define *ECPR* by both (i) $p_x - p_z = c_1$ and (ii) zero profits for the operator. Condition (i) implies that the operator realizes the same markup on all products:

$$p_x - (c_1 + c_2) = p_z - c_2.$$

Condition (ii) requires these margins to add up exactly to total costs. Maximizing surplus subject to *ECPR* and a break-even constraint yields a Ramsey type formulation⁵:

$$p_x - (c_1 + c_2) = \frac{\lambda}{1 + \lambda} \frac{p_x}{\tilde{\varepsilon}_{X+Z}},$$

where $\tilde{\varepsilon}_{X+Z}$ is an “aggregate” demand elasticity, defined over the entire postal market:

$$\tilde{\varepsilon}_{X+Z} = \frac{X}{X+Z} \varepsilon_X + \frac{p_x}{p_z} \frac{Z}{X+Z} \varepsilon_Z.$$

Observe that, while *ECPR* policy guarantees efficient worksharing, it ignores “allocative inefficiencies” that arise when prices are set above marginal costs. Since it precludes exploiting the trade-offs between the two sources inefficiencies (productive and allocative), there are potential benefits from relaxing the “Efficient Cost Pricing Rule”. In other words, *ECPR* is not in general second-best efficient.

⁵ This is an artificial problem with no degree of freedom left to maximize. However, it will give us a level of the Lagrange multiplier λ to make the solution comparable to the second-best allocation.

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). It is set at its (normalized) current value p_x^o . The regulator sets p_z according to a welfare objective, possibly subject to a number of constraints. In the second class of problems, both p_x and p_z are endogenous. For each of these two settings, we consider four alternative scenarios. In the first one, which is (with some abuse) labeled *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 labeled *ECPR* for “Efficient Component Pricing Rule”, is obtained as explained in Subsection 2.1.3: the worksharing discount ($p_x - p_z$) equals avoided cost c_1 and the operator must break even. The third 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. Observe that the scenarios *ECPR* and *SB* both imply break-even so that their comparison is particularly interesting. 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 results 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*) suitably 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 10,000 (millions of items) at *SP*; their relative share reflects the arbitrary choice of the prices p_x^o and p_z^o but entails no precise relationship with the current situation. On the other hand, the variations of the operator’s profit induced by the various changes in prices are expressed in terms of their actual units, namely in millions of euros. This is also the case of variations in consumer surplus and social welfare.

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. Moreover, the results in terms of profits and welfare variations are the exact outcomes of the model. 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

Before turning to the main figures on the French postal market, let us briefly present the demand model that is underlying the calibration exercise. Since the focus of the paper is worksharing, households (who, anyway, do not workshare) are represented in the simplest possible way. More precisely, there is a representative household whose (aggregate) demand function is assumed to be linear and given by

$$(7) \quad X_h(p_x) = A_x - B_x p_x.$$

By contrast, the underlying model for firms' demand for mail is much more sophisticated. Depending on the prices p_x and p_z of both goods and on its own preparation cost k , each firm buys the commodity x or z . Each of the firm's demand functions is assumed to be linear in price:

$$(8) \quad x_f^k(p_x) = A_k - B_k p_x,$$

$$(9) \quad z^k(p_z + k) = A_k - B_k (p_z + k)$$

However, since the decision to buy either x or z depends on the comparison between p_x and $p_z + k$ the firm's behavior is highly non-linear.

Note also that the parameters of these functions (like their counterparts in the general model (1b) and (1c) are indexed by k ; consequently, demand functions 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 words, 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, that is, households, (small) firms that consume the commodity x and (large) firms that consume commodity z . More precisely, in our model the aggregate demand functions are given by

$$(10) \quad X(p_x, p_z) = X_h(p_x) + X_f(p_x, p_z) = X_h(p_x) + \int_{p_x - p_z}^{\bar{k}} x_f^k(p_x) g(k) dk,$$

$$(11) \quad Z(p_x, p_z) = \int_{\underline{k}}^{p_x - p_z} z^k(p_z + k) g(k) dk,$$

where the density function $g(k)$ can be interpreted as the number of firms of type k . We have a very flexible model that can potentially give rise to a very refined representation of demand. In particular, given that worksharing is contractual, the demand for mail by each

of the firms of type $k \in [\underline{k}, p_x - p_z]$ is precisely known. It is thus possible to have an exact estimate of the function $g(k)$ over this segment. As explained below, for the current paper, we adopt a specific functional form for $g(k)$, that nevertheless matches all essential characteristics of observed patterns. Similarly, although it would be possible to equalize the demand $z^k(p_z + k)$ by firms of type $k \in [\underline{k}, p_x - p_z]$ to their actual level, we adopt a functional form for the parameters A_k and B_k . Their values are nevertheless (simultaneously) adjusted to reflect both the actual aggregate flows and the aggregate price elasticities that we posit for the different market segments.

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

$$(12) \quad \varepsilon_X^f = \frac{p_x}{X_f(p_x, p_z)} \int_{p_x - p_z}^{\bar{k}} \frac{-\partial x_f^k(p_x)}{\partial p_x} g(k) dk = \int_{p_x - p_z}^{\bar{k}} \frac{x_f^k(p_x)}{X_f(p_x, p_z)} \varepsilon_k g(k) dk,$$

$$(13) \quad \varepsilon_Z^f = \frac{p_z}{Z(p_x, p_z)} \int_{\underline{k}}^{p_x - p_z} \frac{-\partial z^k(p_z + k)}{\partial p_z} g(k) dk = \int_{\underline{k}}^{p_x - p_z} \frac{z^k(p_z + k)}{Z(p_x, p_z)} \varepsilon_k g(k) dk.$$

While precise information on demand levels is available, there is no information on price elasticities at the firms' level (even for firms of type $k \in [\underline{k}, p_x - p_z]$). We thus have to set a priori a distribution of elasticities ε_k that verifies the system of equations (12) and (13). This lack of information for firms' elasticities is at the origin of our choice to rely on functional forms for the demand functions and for the density $g(k)$.

We, however, impose more constraints on the distribution ε_k (that is ultimately on the two distributions of parameters A_k and B_k) than “the sole” equations (12) and (13) that define the aggregate elasticities ε_X^f and ε_Z^f . In particular, the distribution of firms' elasticities ε_k is constrained to be monotonous decreasing in k . In other words, we voluntarily restrict our attention to distributions of ε_k that guarantee, at the firms level, the larger clients are also the more sensitive to price changes. The range of elasticities $[\underline{\varepsilon}, \bar{\varepsilon}] = [\varepsilon_{\bar{k}}, \varepsilon_{\underline{k}}]$ is also imposed from the outset.

Finally, observe that in both equations (12) and (13), firms with a low level of k tend to be given a higher weight. This explains why aggregate (market segment) demand elasticities will be larger than the average (individual) demand elasticities. It is worth keeping this observation in mind when discussing the values of elasticities that we adopt for this calibration.

4.3 Costs and market share distribution

Equations (10)–(11) and (12)–(13) 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:

$$(14) \quad G(k) = \frac{1 - \gamma \exp(-\sigma k^\rho)}{1 - \gamma \exp(-\sigma \bar{k}^\rho)},$$

where $\bar{k}$ is the upper-bound of the cost parameter k ; in other words, the support of the distribution is $[0, \bar{k}]$ ⁶. 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 were equal to the avoided costs and (iv) the data for the different market segments as given by aggregate demands and price-elasticities. 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 the number of firms that are able to prepare their mail at that specific cost. The total number of firms is fixed at $N = 250,000$. The number of worksharing firms $NG(p_x^0 - p_z^0)$ for the current discount $\tilde{k} = p_x^0 - p_z^0$ (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 $NG(c_1)$ would be ten times larger (but yet represents only 2% of the total number of firms).

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 cumulative distribution function. Figure 2 makes it clear that roughly one fourth 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.

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

⁶ In the theoretical model, we have previously assumed that $\bar{k} = \infty$. For practical purposes, we have truncated the estimated distributions. This has no impact on the results.

Figure 1: Distribution of the sorting costs k

Figure 2: Demand by firms of type k

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	<i>SP</i>	<i>FB</i>	<i>ECPR</i> $\lambda = 0.68$	<i>SB</i>	Max Π
p_x	1.000	1.000	1.000	1.000	1.000
p_z	0.950	0.477	0.800	0.850	0.907
Discount	0.050	0.523	0.200	0.150	0.093
Avoided Cost	0.200	0.200	0.200	0.200	0.200
Nb Worksharing Firms	500	81140	5279	2465	906
Z Traffic	2778	8773	6433	5718	4452
$X(f)$ Traffic	4651	264	1451	1998	3088
$X(h)$ Traffic	2571	2571	2571	2571	2571
Z Elasticity	0.77	0.23	0.45	0.51	0.61
$X(f)$ Elasticity	0.32	0.16	0.21	0.23	0.27
$X(h)$ Elasticity	0.20	0.20	0.20	0.20	0.20
$\Delta \Pi$	--	-1546	-130	0	68
ΔSZ	1211	6361	3180	2396	1215
$\Delta SX(f)$	4858	-4362	-2716	-2119	-1119
$\Delta SX(h)$	3938	0	0	0	0
ΔSW	10007	454	334	276	165

Table 1: Results with an exogenously fixed price for single-piece mail

5.1 *FB*: Social welfare maximization without budget constraint

In the *FB* case, the 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 operator’s 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 or allocative inefficiency that follows from having the price p_z above the marginal cost c_2 . Thus, p_z will be lower than the price level $p_z = p_x^o - c_1$ that would restore efficient worksharing and higher than the marginal cost c_2 . Specifically, the optimal value of p_z implies that the worksharing discount is more than 2.5 times the avoided cost and the operator makes a margin $p_z - c_2 = 0.127$ per unit of Z . As a result, about 32% of the firms do workshare while productive efficiency would reduce this share to 2%. Yet, consumption per worksharing firm Z/N is reduced to 0.1 (to be compared to 1.5 at the “true” first-best, that is, when $p_1 = c_1 + c_2$ and $p_2 = c_2$). Overall, this allocation would allow to improve upon *SP* in terms of welfare by about 450 million euros, which is 142 million less than what would allow shifting to the *FB* with endogenous p_x . Recall, however, that both situations would yield a deficit for the operator.

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 current discount of 5% is well below its *ECPR* level. 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 lower than required by productive 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. Observe however that, since *ECPR* does not account for pricing or allocative inefficiency, this does not provide any indication as to whether or not worksharing discount should be increased or not from its current level. Overall, this allocation would yield a welfare improvement with respect to *SP* of about 330 million euros. However, imposing both *ECPR* along with $p_x = p_x^o$ would again result in negative profits for the operator.

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 $p_z = 0.850$ so that the worksharing discount equals 0.150. Here, the optimal discount is thus 75% of the avoided cost. This result is due to the fact that p_x is exogenously given and the intuition for it is the same as in Subsection 5.1: there is a trade-off between productive and allocative inefficiencies. If p_x were also endogenous, the optimal discount associated to the *SB* case would exceed the avoided costs (See Billette de Villemeur *et al* (2003)). Here, the worksharing discount is lower than the avoided cost because p_x is exogenously fixed below the “true second-best” level (as defined in Subsection 6.3). This also explains why p_z is higher than the level it takes in Subsection 6.3.

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 10% from its current level without endangering the operator's financial viability. To be more precise, such a decrease in the price p_z would double the industrial mail volume and this would more than compensate for the decrease in price. Consequently, the lower price would effectively result in higher profits in the industrial mail segment. Note, however, that such a decrease of p_z implies a worksharing discount three times larger than its current level. This makes worksharing more attractive so that the number of firms that sort their mail is more than four times higher than its current level. It nevertheless continues to represent a very small fraction (less than 1%) of the total number of firms. As a result, firms' demand for X drops by 57% and the profits in this market segment decrease accordingly. Overall, this adjustment of the price structure would not modify the profitability of the operator but result in an increase in consumer surplus of 2.75%, which represents a sizeable welfare gain of about 276 million euros. This is 58 million less than the gains that would follow from applying "constrained *ECPR*" allocation presented at the previous section. However, the later result came at a cost of 130 million deficit for the operator.

Finally, observe that the multiplier associated with the operator's break even constraint of the firm is $\lambda = 0.68$ under this scenario. In other words, an additional euro raised by the firm imposes a welfare cost of $1 + \lambda = 1.68$ euros on the consumer. This yields a deadweight loss that is well above the usual estimates for the "marginal cost of public fund" that is, for France, in the range of 0.2–0.3. Consequently, it would be efficient to pay a lump sum subsidy to the operator (financed through the general budget) as compensation for the imposed low level of p_x . We shall return to this issue in Subsection 6.3.

5.4 Profit-maximization

If the regulatory policy is limited to guaranteeing an "affordable" price to households, (that is, 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 only 2% of the fixed costs. However, the corresponding variation in total welfare would amount to 165 million euros. In other words, a less rigid pricing policy (giving the operator the option to decrease its price and to increase the worksharing discount) would boost social welfare by more than half of the total potential gains (that is, 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.

	<i>SP</i>	<i>FB</i>	<i>ECPR</i> $\lambda = 0.24$	<i>SB</i> $\lambda = 0.23$	Max Π
p_x	1.000	0.550	1.025	1.058	3.275
p_z	0.950	0.350	0.825	0.805	1.632
Discount	0.050	0.200	0.200	0.253	1.643
Avoided Cost	0.200	0.200	0.200	0.200	0.200
Nb Worksharing Firms	500	5279	5279	10263	250000
Z Traffic	2778	7962	6348	6796	4752
$X(f)$ Traffic	4651	1590	1443	1057	0
$X(h)$ Traffic	2571	2802	2558	2541	1401
Z Elasticity	0.77	0.17	0.47	0.44	1.33
$X(f)$ Elasticity	0.32	0.11	0.22	0.21	NaN
$X(h)$ Elasticity	0.20	0.10	0.21	0.21	1.20
$\Delta\Pi$	--	-3013	0	0	3060
ΔSZ	1211	5165	3081	3620	1960
$\Delta SX(f)$	4858	-2296	-2738	-3218	-4858
$\Delta SX(h)$	3938	741	-40	-91	-2769
ΔSW	10007	596	304	311	-2606

Table 2: Results with flexible prices

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 that is 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 about 2% of the firms would prepare their mail. As compared to the current situation, mail volumes would increase by 29% for customers of type f (firms) and by 9% for customers of type h (households). As a result, there would be a social welfare improvement of about 600 million 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 $p_x = 1.025$ and $p_z = 0.825$. In other words, the price for single-piece mail should be slightly increased (+2.5%) while pre-sorted mail should become much cheaper (−13%) so that its price would be about 82% of the single-piece rate (as compared to a current ratio of 95%). In other words, it appears that the current discount is equal to 25% of its *ECPR* level. Recall that by definition, the *ECPR* implies efficient worksharing. As compared to the current situation, the mail volume is almost unchanged. It would increase by about 5% for firms and would slightly decrease for households (less than 1%). By contrast, the structure of traffic is completely modified. The workshared volume more than doubles while firms' demand for single-piece mail is divided by more than three. Recall that, if p_x is exogenously fixed to $p_x^0 = 1$, the *ECPR* allocation bring the operator to make losses, that is, less profits than what is obtained in the *SB* case with exogenously fixed price $p_x = p_x^0$ (See Subsection 5.3). Such a comparison no longer makes sense here, because when p_x is endogenous we impose zero-profits in both cases. Our results also show the welfare impact of imposing the *ECPR* constraint $p_x - p_z = c_1$. Overall, shifting to the *ECPR* prices would result in a gain of 304 million euros in social welfare, which is substantial yet smaller than what can be obtained with second-best prices.

6.3 SB: Second-best

The *SB* scenario we consider is in the Ramsey tradition: prices are set to maximize social welfare subject to the operator's break-even constraint. Interestingly, the optimal *SB* prices, namely $p_x = 1.058$ and $p_z = 0.805$, 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 +6% while pre-sorted mail should be reduced by about 15% 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 almost 2.5, while firms' demand for X would drop by more than 75%. Overall, the switch to the *SB* prices would increase consumer surplus by 3% which corresponds again to a total variation of about 300 million euros.

Shifting from *ECPR* to *SB* may appear to induce only minor price changes. Nevertheless, there are quite significant differences 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 27%. 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 (that better fits the differences in elasticities across consumers). The effect of prices on demand is typically neglected by *ECPR* that focus on the sole cost dimension. However, by taking them into account, that is, 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 0.23, a level that is within the range of conventional estimates for the overall 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 Profit-maximization

A profit-maximizing (monopolistic) operator will set the price for industrial mail at $p_z = 1.632$. This means that it would effectively be profitable for the firm to increase this price by 71%. Moreover, the optimal price for single-piece mail would be multiplied by more than 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 36% for firms and 45% for households. Those changes would lead to a loss of 2.6 billion euros in social welfare. These results are quite extreme but do not come as a surprise. It is well known that a profit-maximizing monopolistic 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 services 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 an 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 times) 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 311 million 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 otherwise set prices to 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 million 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 10%) 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 welfare to improve by about 275 million euros. Consequently the cost of maintaining p_x at its current level implies a welfare (efficiency) cost of about 35 million euros. Recall, however, that capping the price of single piece mail can be justified on “redistributive” grounds (See, for example, Billette de Villemeur *et al* 2002). Finally, in that scenario, given the usual estimates for the “marginal cost of public fund”, there is a case to subsidize the operator.

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9 Appendix

9.1 Calibration of the “demand model”

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.

9.1.1 Preferences and Demand

Households

Households have a quasi-linear quadratic utility function where the utility of mail is specified as:

$$U_h(X_h) = \left(A_x - \frac{X_h}{2} \right) \frac{X_h}{B_x}.$$

Consequently, the demand function is linear in price and given by:

$$X_h(p_x) = A_x - B_x p_x.$$

With the observed (normalized) demand $X_h = 2571$ at the current price $p_x^o = 1$ and an assumed price elasticity of $\varepsilon_x^h = -0.2$ we obtain:

$$A_x = 3085.2 \quad \text{and} \quad B_x = 514.2.$$

Firms

Like for households, we specify a quasi-linear quadratic utility function so that firm's demand functions are linear in prices. Apart from the cost dimension, workshared mail Z is a perfect substitute to single-piece mail X . Consequently, preferences are represented by a single utility function for both goods. If single-piece mail X is purchased, the price to be considered is simply p_x . If product Z is consumed, the "price" to be considered is the sum of p_z and the sorting cost k for the firm. Formally,

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

Recall that commodity X is preferred to commodity Z if and only if $p_x \leq p_z + k$. For a given firm (a given value of the parameter k), demand for mail appears to be piecewise linear. Since the value of the sorting cost k may vary from one firm to another, the aggregate behavior of this market segment may however display very rich patterns, including highly non-linear response to price changes.

Consistently with stylized facts from the postal industry, we 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:

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

Unlike for households, calibration of firms' demand cannot be conceived independently from costs aspects.

9.2 Costs

9.2.1 Operator's costs

The costs of the operator are assumed to be linear:

$$C(X, Z) = F + (c_1 + c_2)X + c_2Z.$$

Given the price normalization, cost accounting data are correctly reflected by the following parameter values:

$$\begin{aligned} F &= 4916.7, \\ c_1 &= 0.200, \\ c_2 &= 0.350. \end{aligned}$$

Although the value of c_1 and c_2 has been rounded in order not to unveil their exact ratio, model outcomes shall mirror quite faithfully the exact consequences of the various scenarios. This is because the calibration of “the demand model” is not affected by changes in the operator's costs. In contrast, the collection and sorting costs k , as supported by worksharing firms, do impact the demand by firms. To obtain a faithful representation of demand characteristics, we did not adjust the customers' costs.

9.2.2 Distribution of sorting costs

As mentioned above in Section 4, we use the following cumulative distribution of sorting costs $k \in [0, \bar{k}]$:

$$G(k) = \frac{1 - \gamma \exp(-\sigma k^\rho)}{1 - \gamma \exp(-\sigma \bar{k}^\rho)}.$$

This functional form allows us to match all essential characteristics of the postal sector. In particular, the density function appears to be increasing, reflecting high market concentration.

There is very few (direct) evidence in order to determine the distribution of costs $G(k)$. The only information which is directly relevant is the current number of worksharing firms

$$NG(\tilde{k}^o) = NG(p_x^o - p_z^o) = 500.$$

However, since the collecting and sorting cost k is assumed to be monotonically related to the demand levels, we may get some (indirect) evidence by collecting information about individual demands. This explains why the calibration exercise consists in a joint estimation of costs and demand parameters.

9.3 Calibration

We adjust the demand parameters k_0 , k_{00} , α , β , a_z , b_z and the costs parameters γ , σ , $\bar{k}$ so as to satisfy simultaneously the following equations:

$$(15) \int_{p_x^0 - p_z^0}^{\bar{k}} x_f^k(p_x) g(k) dk = X_f^0,$$

$$(16) \int_{\underline{k}}^{p_x^0 - p_z^0} z^k(p_z + k) g(k) dk = Z^0,$$

$$(17) N \int_{\underline{k}}^{p_x^0 - p_z^0} g(k) dk = N_0,$$

as well as

$$(18) \frac{p_x^0}{X_f^0} \int_{p_x^0 - p_z^0}^{\bar{k}} \left(\frac{-\partial x_f^k}{\partial p_x} \right) g(k) dk = \varepsilon_{X_f}^0,$$

$$(19) \frac{p_z^0}{Z^0} \int_{\underline{k}}^{p_x^0 - p_z^0} \left(\frac{-\partial z^k}{\partial p_z} \right) g(k) dk = \varepsilon_Z^0,$$

$$(20) N \int_{\underline{k}}^{c_1} g(k) dk = N_1.$$

Three additional constraints are imposed: the range of firm's elasticities (that is, the maximum value $\varepsilon_k = \bar{\varepsilon}$ for $k=0$ and the minimum value $\varepsilon_k = \underline{\varepsilon}$ for $k=\bar{k}$) and an *a priori* relationship⁷ between $\tilde{k}_0 = p_x^0 - p_z^0$, $\tilde{k}_1 = c_1$ and σ :

$$\sigma = \frac{1}{2} \frac{\ln(1 - G(\tilde{k}_0)) - \ln(1 - G(\tilde{k}_1))}{\tilde{k}_1^\rho - \tilde{k}_0^\rho}$$

We posit the following values for the elasticities:

$$\begin{aligned} \underline{\varepsilon} &= 0.2; & \bar{\varepsilon} &= 0.9; \\ \varepsilon_{X_f}^0 &= 0.3; & \varepsilon_Z^0 &= 0.7. \end{aligned}$$

The number of worksharing firms if the worksharing discount were set to be equal to the avoided cost c_1 is set to $N_1 = 5000$, that is 2% of the total number of firms. Given these estimates and the market data X_f^0, Z^0, p_x^0 and p_z^0 provides by La Poste, we obtain the following values for the demand parameters:

⁷ This relationship controls for the spread of the preparation and sorting costs k . In our context, it amounts to assuming that the highest value of the firms' sorting cost $\bar{k}$ is about four-five times the operator's cost c_1 .

$$\begin{array}{ll}
k_0 = 1.7248 \times 10^{-2} & k_{00} = 4.8450 \times 10^{-4} \\
\alpha = 4.0000 & \beta = 0.3375 \\
a_z = 116.73 & b_z = 0.1215
\end{array}$$

The parameters of the cost distribution γ, σ, ρ and $\bar{k}$ are set to the following values:

$$\begin{array}{ll}
\gamma = 0.9993 & \sigma = 1.0514 \\
\bar{k} = 0.8723 & \rho = 3
\end{array}$$

9.4 Normalizations

In order to construct the “Starting Point”, we normalize the price p_x^0 to *one*. The price p_z^0 , as well as the costs c_1, c_2 and F are adjusted accordingly. Demand for all products is computed for this modified price structure and total demand $X_h + X_f + Z$ is normalized to 100,000 objects. As already mentioned, given the highly non-linear behavior of firms’ demand, this means that effective mail volumes cannot be retrieved from the reported *SP* values.

Observe that the accuracy of the various scenarios is not affected by these adjustments. Normalizations occur after the calibration stage. Consequently, they do not impact the outcome of the model. In particular, variations in surplus, profits and welfare are not affected.