The Effect of Regulation on Innovation in the Postal Sector

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1   Introduction

Postal regulators around the world are currently confronted with the question which regulatory regime maximizes social welfare. Economists have developed theoretical models to compare the welfare effects of different regulatory scenarios (De Donder et al. 2005, Panzar 2002, Billette de Villemeur et al. 2003, Dietl and Waller 2002, Dietl et al. 2005). Although innovation is regarded as the driving force of social progress, economic development and welfare gains, relatively little is known about the effect of regulation on innovation in the postal sector. Proponents of market liberalization often cite more innovations as the major benefit when confronted with arguments such as the graveyard spiral and delivery economies of scale.

To date, economists have not explicitly modelled the effect of market liberalization, work sharing and other forms of postal regulation on innovation. We try to fill this gap by presenting a game-theoretic model that predicts the effect of regulatory decisions on innovation incentives in letter markets. Our model focuses on process innovations which are by large the major innovations within the postal sector.

We compare four different regulatory scenarios: postal monopoly, end-to-end competition, and access regulation with and without bypass. These regulatory regimes represent the current and/or planned regulatory environment of developed countries. Quantitative results based on model parametrization will allow us to compare the innovation incentives, and the effects of innovation on welfare.

The paper is organized as follows. In the next section we present our model for each of the different regulatory scenarios. In section 3 we calibrate the model with Swiss data. Section 4 contains the main results, which

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are subjected to some sensitivity analysis in Section 5. In Section 6, we examine how the results change when we introduce spillover effects. Section 7 concludes.

2   Model

We develop a model to analyze the impact of postal regulation on innovation. We introduce the model by presenting the reference case, i.e. the regulated monopoly. Afterwards, we adapt the model to allow for multiple service providers and we consider three alternative regulatory scenarios: end-to-end competition, work sharing without bypass and work sharing with bypass.

2.1   Reference Case: Regulated Monopoly

For the demand side, we assume a representative customer (or sender) whose utility depends on the quantity of letters sent, which in turn depends on prices. We assume quasilinear preferences with respect to money and a quadratic utility function over quantities. Furthermore, we divide the market into two different regions $r = \{h,l\}$, where h denotes the highly populated region (or urban region) and l the less populated region (or rural region). We also assume that there are no information asymmetries. Our model builds on Dietl et al. (2005). The representative sender has the utility function

$$U\left(q^h, q^l, y\right) = \sum_r \left(a^r q^r - \frac{1}{2} b^r \left(q^r\right)^2 \right) + y$$

where $a, b > 0$. Variables q^h and q^l refer to the amount of mail sent to each region, and y is the amount of money spent on other goods. Parameter a influences market size, while b varies with regards to the price elasticity of demand. The representative sender has to satisfy the budget constraint $y + p \sum_r q^r \leq m$, where p represents the monopolist's uniform price for both regions and m describes the initial wealth endowment. Utility maximization implies that the budget constraint holds with equality. The demand functions for each region are therefore given by

$$q^r(p) = \frac{1}{b^r} \left(a^r - p \right)$$

Activities along the postal value chain are divided into two segments $s = \{u, d\}$. The activities of collection, transportation and sorting are regarded as a composite upstream activity denoted by u. Delivery, the downstream

activity, is denoted by d. We assume that the costs for the composite upstream activity are fully variable, and denote these marginal costs by c_u^r. In contrast, part of the monopolist's downstream costs are considered to be fixed, since the universal service obligation requires the monopolist to maintain its delivery network irrespective of market demand. We denote these fixed costs by F_d, and the variable downstream costs by c_d^r. Process innovations are introduced into the model by an option to reduce the initial marginal costs by an amount equal to k_s^r. To achieve this reduction the service provider must invest an amount of $I_s^r = \frac{1}{2} z (k_s^r)^2$, where $z > 0$. Profit is therefore given by the function

$$\Pi = \sum_r \left[\left(p - \sum_s (c_s^r - k_s^r) \right) q^r - \sum_s I_s^r \right] - F_d$$

Given the uniform price set by the regulating authority, the monopolist maximizes profit by choice of k_s^r, leading in the equilibrium to marginal cost reductions through process innovations equal to

$$k_s^r = \frac{1}{zb^r} (a^r - p)$$

Thus, in the case of a single monopolistic service provider, the incentives to innovate increase linearly with demand in the respective region.

2.2 Multiple Service Providers

We now add the possibility of market entry by an additional service provider. As in the case of a monopoly, the incumbent I must serve both regions at a uniform price p_I. The entrant E may enter one or both regions, and is free to maximize profits by choice of different prices p_E^r for each region. The customers' utility function assumes the form

$$U \left(q_I^h, q_I^l, q_E^h, q_E^l, y \right) = \sum_r \left(a_I^r q_I^r - \frac{b^r}{2} (q_I^r)^2 + a_E^r q_E^r - \frac{b^r}{2} (q_E^r)^2 - e b^r q_I^r q_E^r \right) + y$$

where $a, b > 0$ and $0 < e < 1$. The parameter e allows for differentiated products. The restriction imposed on this parameter means that the service providers' products are imperfect substitutes. Given the budget constraint $y + \sum_r (p_I q_I^r + p_E^r q_E^r) \leq m$, the representative customers' utility maximization problem results in the demand functions

$$q_I^r(p_I, p_E^r) = \frac{1}{b^r(1-e^2)} \left(a_I^r - ea_E^r - p_I + ep_E^r\right)$$

$$q_E^r(p_E^r, p_I) = \frac{1}{b^r(1-e^2)} \left(a_E^r - ea_I^r - p_E^r + ep_I\right)$$

As in the reference case, we assume that the incumbent's upstream costs are variable, while its downstream costs are partly fixed. In contrast, the entrant is free of any universal service obligation. Thus, we consider the entrant's costs over the whole value chain to be entirely variable. We denote the entrant's initial marginal costs for the composite upstream activity by c_{Eu}^r and for delivery by c_{Ed}^r. The entrant can reduce initial marginal costs by an amount equal to k_{Es}^r. The corresponding investments into process innovations are equal to $I_{Es}^r = \frac{1}{2}z\left(k_{Es}^r\right)^2$.

2.2.1 End-to-End Competition

In the case of end-to-end competition, the entrant must compete with the incumbent over the whole value chain. Profits are determined by the functions

$$\Pi_I = \sum_r \left[\left(p_I - \sum_s \left(c_{Is}^r - k_{Is}^r\right)\right) q_I^r - \sum_s I_{Is}^r \right] - F_{Id}$$

$$\Pi_E = \sum_r \left[\left(p_E^r - \sum_s \left(c_{Es}^r - k_{Es}^r\right)\right) q_E^r - \sum_s I_{Es}^r \right]$$

The first term of each operator's profit function describes the profit margin in each region. It results from the price per unit of mail, subtracted by the marginal costs after reduction by process innovations. The second term contains the investment into process innovation. For the incumbent, this investment concerns expenditures into the up- and downstream segment of both urban and rural areas. Depending on where the entrant is active, the entrant's investment concerns either one or both regions, or none at all.

Assuming a uniform price p_I set by the regulator, the incumbent maximizes profits by choice of k_{Is}^r, while the entrant is free to choose different prices and therefore maximizes simultaneously for p_E^r and k_{Es}^r. Depending on the parameters, the entrant may choose prices p_E^r such that the demand function $q_E^r(p_E^r, p_I)$ gives a negative value. In this case, we set $q_E^r = 0$ and assume that the entrant does not enter region r. In particular, the entrant may not be able to set prices in the rural region that are sufficiently high to compensate the entrant's marginal costs, yet sufficiently low to be competitive with the incumbent's uniform price p_I.

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2.2.2 Work Sharing without Bypass

In the case of work sharing without bypass, the incumbent receives competition concerning the upstream activities. The incumbent retains the monopoly regarding delivery, but is required to grant the entrant access and to deliver the entrant's mail at a uniform access price α per unit of mail. We assume that the access price is determined by the regulatory authority and treat it as an exogenous variable. Profit functions are now given by

$$
\begin{aligned}
\Pi_I &= \sum_r \left[\left(p_I - \sum_s \left(c_{Is}^r - k_{Is}^r \right) \right) q_I^r - \sum_s I_{Is}^r + \left(\alpha - c_{Is}^r + k_{Is}^r \right) q_E^r \right] - F_{Id} \\
\Pi_E &= \sum_r \left[\left(p_E^r - \left(c_{Eu}^r - k_{Eu}^r + \alpha \right) \right) q_E^r - I_{Eu}^r \right]
\end{aligned}
$$

For the incumbent's profit function, the first term refers to the margin resulting from mail collected, sorted, transported and delivered by the incumbent. The second term contains the investment into up- and downstream process innovations in both urban and rural markets. The third term describes the additional revenues from the transfer fee, subtracted by the incumbent's marginal costs for delivery. Comparing the entrant's profit function in the case of work sharing with the entrant's profit function under end-to-end competition shows that the profit function takes a similar form. The difference is that in the case of work sharing without bypass, the entrant's marginal costs for delivery are replaced by the access fee per unit of mail the entrant must transfer to the incumbent. Furthermore, the entrant has no incentives to innovate in the downstream segment. Given the incumbent's uniform price p_I, the incumbent maximizes profit for k_{Is}^r, while the entrant maximizes for p_E^r and k_{Eu}^r. Depending on whether the resulting prices p_E^r result in a positive demand for the entrant's services, the entrant enters one or both regions.

2.2.3 Work Sharing with Bypass

The case of work sharing with bypass can be seen as a combination of the previous cases. The entrant is given a choice to enter one or both regions, and to either compete with the incumbent over the whole value chain, or to provide only the upstream activities and use the incumbent's delivery network. This choice does not have to be the same in the two regions. In particular, it may be desirable for the entrant to use the distribution network of the incumbent in the rural region and to provide distribution only in the urban region. The entrant's choice on whether or not to compete

over the whole value chain depends on how the entrant's marginal costs after reduction by process innovations compare to the access price to the incumbent's delivery network. If $\alpha > c_{Ed}^r - k_{Ed}^r$, the entrant chooses end-to-end competition in region r, assuming he decides to enter, and if $\alpha < c_{Ed}^r - k_{Ed}^r$ the entrant uses the incumbent's delivery network in the case of entry.

If $\alpha > c_{Ed}^r - k_{Ed}^r \forall r$, profit functions are the same as in the case of end-to-end competition. If $\alpha < c_{Ed}^r - k_{Ed}^r \forall r$, profits are equal to the profits in the case of work sharing without bypass. In the case where the entrant takes advantage of the incumbent's delivery network only in the less populated region, that is for $\alpha > c_{Ed}^h - k_{Ed}^h$ and $\alpha < c_{Ed}^l - k_{Ed}^l$, profits are given by

$$
\begin{aligned}
\Pi_I &= \sum_r \left[\left(p_I - \sum_s \left(c_{Is}^r - k_{Is}^r \right) \right) q_I^r - \sum_s I_{Is}^r \right] + \left(\alpha - c_{Is}^l + k_{Is}^l \right) q_E^l - F_{Id} \\
\Pi_E &= \left(p_E^h - \sum_s \left(c_{Es}^h - k_{Es}^h \right) \right) q_E^h - \sum_s I_{Es}^h \\
&\quad + \left(p_E^l - \left(c_{Eu}^l - k_{Eu}^l + \alpha \right) \right) q_E^l - I_{Eu}^l
\end{aligned}
$$

The incumbent's profit function is the same as under work sharing without bypass, except that the incumbent only receives transfers resulting from the delivery of the entrant's mail to the rural regions. The first line of the entrant's profit function describes the part of the profit resulting from competing end-to-end in the highly populated region. The second line concerns the revenue from the less populated region, subtracted by the entrant's corresponding upstream costs and the access charge transferred to the incumbent. The choice variables are the same as in the previous cases.

3   Parametrization with Swiss Data

In order to obtain quantitative results, we calibrated our model for the reference case, i.e. regulated monopoly, with data of the Swiss letter market. Then, we modify the parameters accordingly so as to predict the outcomes for multiple service providers. Our method of parametrization relates to the one used in Dietl et al. (2005). We used simplified assumptions for the values of the parameters whenever we felt that it did not critically affect the results. To calculate the parameters of the demand function in the case of a regulated monopoly, we assumed a uniform price equal to $p_{RM} = €0.5$, and a corresponding total demand of $q_{RM} = 3$ billion. Furthermore, we assumed that a quarter of the total amount was sent to the less populated region l,

thus $q_{RM}^h = 2.25$ billion and $q_{RM}^l = 750$ million. Concerning price elasticity of demand, we used $\eta = -0.5$. By substituting p_{RM}, q_{RM} and $\eta = -0.5$ into

$$q_{RM}^r(p_{RM}) = \frac{a_{RM}^r - p_{RM}}{b_{RM}^r} \text{ and } \eta = -\frac{1}{b_{RM}^r} \frac{p_{RM}}{q_{RM}^r}$$

we can calculate the parameters determining the demand function of each region in the reference case.

To determine the parameters of the cost side, we set the monopolist's profit under the regulated price equal to zero ($\Pi_{RM} = 0$), which reflects the fact that Swiss post approximately breaks even in the letter market. Total delivery costs amount for approximately half of total costs, which equals half the total revenue under the assumption that there is no profit. It is estimated that approximately 60% of the monopolist's delivery costs are fixed, that is $F_d = €$ 450 million. Given the proportion between marginal costs in the urban and rural regions, as well as the observed prices, quantities, profits and fixed costs in the reference case, we can derive the marginal costs for each activity. Under the assumption that $c_u^l = 2c_u^h$, we get $c_u^h = €$ 0.20 and $c_u^l = €$ 0.40 for the composite upstream activity, and $c_d^h = €$ 0.08 and $c_d^l = €$ 0.16 for delivery.

The final parameter necessary to complete the parametrization of the reference case is z, which determines the relationship between innovation incentives reflected by marginal cost reductions k and the necessary investment $I(k)$. We chose a sufficiently high value for z so that the cost reductions k_s^r chosen by the monopolist in the equilibrium are at all times smaller than the marginal costs c_s^r without the need to impose any additional restrictions. At the same time, the calculated incentives should be significant, yet not unreasonably high. By doing sensitivity analysis, we decided on the value $z = 6 \cdot 10^{10}$.

The values chosen for the parameters are not exact, therefore the absolute values of our results can only serve as a rough approximation. The values are however sufficiently realistic to allow for an ordinal comparison of results between the different regulatory scenarios.

In order to adapt our calibrated model to accommodate multiple service providers, we used the method outlined in Dietl et al. (2005). We set the parameter determining the degree of product differentiation to be equal to $e = 0.75$. We further assumed the percentage of total demand the incumbent receives, in case the entrant offers the same price, to be equal to $x = 70\%$. This value reflects the incumbent's advantage resulting from switching costs and similar considerations. By substituting prices p_I and p_E^r for p_{RM} and using the relationship describing the incumbent's advantage $q_I^r/(q_I^r + q_E^r) =$

x, we can solve the demand functions of each region for a_E^r given parameters a_I^r.

To determine the access price to the incumbent's delivery network in the case of work sharing we assumed a "naive" regulator that tries to set the access price to be equal to the incumbent's average costs of delivery per unit[1]. Thus, the regulator divides the observed total downstream costs by the total amount of mail delivered, and sets

$$\alpha = \frac{\sum\limits_{r}\left(c_{Id}^r q_I^r\right) + F_{Id}}{\sum\limits_{r} q_I^r} = \text{€ } 0.25.$$

4 Results & Discussion

In this section we present the main results of the simulation. The amount of money invested in innovation can be seen in Table 1.

	Incumbent					Entrant		
	I_{Iu}^h	I_{Id}^h	I_{Iu}^l	I_{Id}^l	$\sum$	I_{Eu}^h	I_{Ed}^h	$\sum$
Monopoly	42.27	42.27	4.69	4.69	93.92			
End-to-end	25.39	25.39	4.69	4.69	60.16	3.81	3.81	7.62
WS without B	29.11	47.2	4.69	4.69	85.69	2.18		2.18
WS with B	25.39	25.39	4.69	4.69	60.16	3.81	3.81	7.62

Table 1: Investments in Innovation [in millions of Euro]

On the left are the incumbent's investments into the urban and rural region, followed by the entrant's investments into up- and downstream activities in the urban area. The entrant has no incentives to innovate in the rural region because he does not enter this market. The underlying reason is that the incumbent's uniform price lies below the marginal costs in the rural market. Therefore, the entrant is not able to set a competitive price above marginal costs in the rural market. According to our results, the case of work sharing with bypass equals the scenario of end-to-end competition. This happens because the access price is higher than the entrant's marginal downstream costs, and therefore the entrant does not ask for access to the incumbent's network.

The biggest incentives to innovate can be observed in the case of a regulated monopoly. The intuition is tied to economics of scale - the total

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[1]The determination of the access price is in itself a major subject of research. De Donder 2004 is a recent work that explores the question of socially optimal access prices.

savings resulting from optimized processes due to innovation are higher in the case of only one service provider, since investment in innovation reduces costs of each letter sent in the economy. Comparing the cases with multiple service providers, we can see that the incumbent's incentives to innovate are greater in the case of work sharing without bypass than under end-to-end competition or work sharing with bypass. This happens because the access price is higher than the entrant's marginal costs for delivery and therefore the entrant is forced to raise his price(s) in the work sharing scenario. Since the incumbent's demand is positively related to the entrant's price, the incumbent's incentives to innovate increase in the case of work sharing. For the entrant, the opposite holds true. The entrant's incentives to innovate are greater under end-to-end competition or work sharing with bypass than under work sharing without bypass. As already mentioned, the reason is that the entrant has a smaller demand in the end-to-end competition scenario due to the higher price the entrant has to practice. Additionally, the entrant only has incentives to invest into optimized delivery processes if operating in the downstream segment.

Table 2 shows the effects of the observed levels of investment in innovation on profits. Delta refers to the added profits resulting from the

	Incumbent		Entrant	
	Investment	Profit	Investment	Profit
Monopoly	93.92	$\Delta = 93.92$ (94.41)		
End-to-end competition	60.16	$\Delta = 50.59$ (-50.86)	7.62	$\Delta = 6.96$ (81.09)
Work sharing without bypass	85.69	$\Delta = 85.8$ (88.73)	2.18	$\Delta = 2.08$ (48.54)
Work sharing with bypass	60.16	$\Delta = 50.59$ (-50.86)	7.62	$\Delta = 6.96$ (81.09)

Table 2: Effects on Profits [in millions of Euro]

possibility of innovation. The respective service providers' total profits are listed in parentheses. The biggest difference in profits is observed in the case of a regulated monopoly. One reason is that as shown above, the incumbent's incentives to innovate are highest in the monopolistic scenario, resulting in the biggest total gains from innovation. The other reason is that the monopolist's investments into process innovation are fully added to the monopolist's own profits, that is, neither competitors nor consumers benefit

from the monopolist's innovation activity.

Comparing only the scenarios with multiple service providers, we can see that the incumbent's added profits due to innovation are much larger under work sharing without bypass than under end-to-end competition or work sharing with bypass. There are two reasons for this. One is that the incumbent invests more in the work sharing without bypass scenario than under end-to-end competition or work sharing with bypass, thus reaching a higher level of innovation and larger cost savings. The other reason is that the incumbent benefits from the entrant's innovation activity in the work sharing without bypass scenario, but not under end-to-end competition or work sharing with bypass. A reduction in the entrant's costs and price(s) due to innovation is translated into a higher demand for the entrant's good. Since in the work sharing without bypass the entrant uses the incumbent's delivery network, the entrant must pay a greater total access fee to the incumbent.

Table 3 presents the effects of innovation on welfare. The highest in-

	Total Investment	Producer Surplus	Consumer Surplus	Social Surplus
Monopoly	93.92	$\Delta = 93.92$ (94.41)	$\Delta = 0$ (1501.22)	$\Delta = 93.92$ (1595.63)
End-to-end competition	67.77	$\Delta = 57.54$ (30.23)	$\Delta = 7.28$ (1545.56)	$\Delta = 64.83$ (1575.8)
Work sharing without bypass	87.87	$\Delta = 87.88$ (137.28)	$\Delta = 2.13$ (1526.58)	$\Delta = 90.01$ (1663.85)
Work sharing with bypass	67.77	$\Delta = 57.54$ (30.23)	$\Delta = 7.28$ (1545.56)	$\Delta = 64.83$ (1575.8)

Table 3: Effects on Welfare [in millions of Euro]

crease in social surplus is observed in the case of a regulated monopoly. The intuition is that the monopolist is able to make the best use of more efficient processes, since he covers the entire market. It should be noted however that the total welfare gains go to the monopolist, i.e. consumers do not get any benefit from innovation in the case of the regulated monopoly. In contrast to this, consumers do benefit from innovation whenever there are multiple service providers, though the service providers get the lion's share in all cases. By comparing only the scenarios with multiple service providers, we notice that the total gain in welfare in the case of work sharing without bypass exceeds the gain in welfare under end-to-end competition and work

sharing with bypass.

5   Sensitivity Analysis

As already mentioned before we calibrated our model using data from the Swiss letter market. In order to evaluate the impact of a change in the parameters on our results we performed some sensitivity analysis. In particular, the access price and the incumbent's uniform price are important parameters that we assumed were set by the regulatory authority. Thus, we present the variations in consumer's surplus and total surplus due to innovation for different values of α and p_I in the analysis that follows.

For the uniform price of the incumbent we have chosen values between € 0.45 and € 0.6. For the access price we did the simulation for values between € 0.175 and € 0.325. The variation in consumer surplus due to innovation for the different uniform prices p_I is shown in Figure 1.
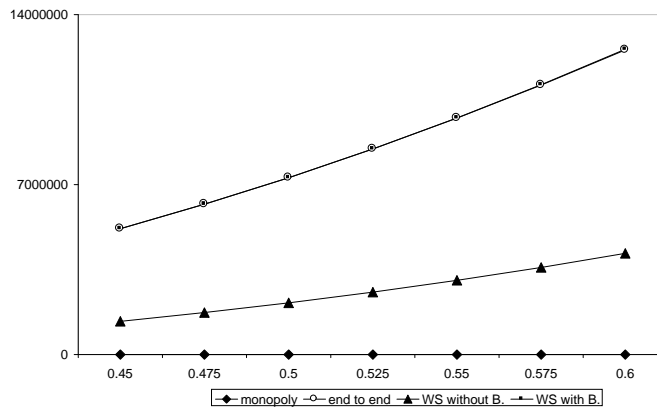
Figure 1: ΔCS for different pI

We observe that the consumers never benefit from innovation in the case of the regulated monopoly. In contrast, we observe that the gain in consumer surplus as a result of innovation increases with a higher uniform price whenever there are multiple service providers. However, the total level of consumer surplus decreases with a higher uniform price. It is important to note that the qualitative results obtained with the initial value of the incumbent's price hold for variations of this parameter. The same happens with the total surplus (Figure 2). As we can observe the total surplus accruing from innovation decreases as the price of the incumbent increases. But again, there are no changes in the relative position of the different
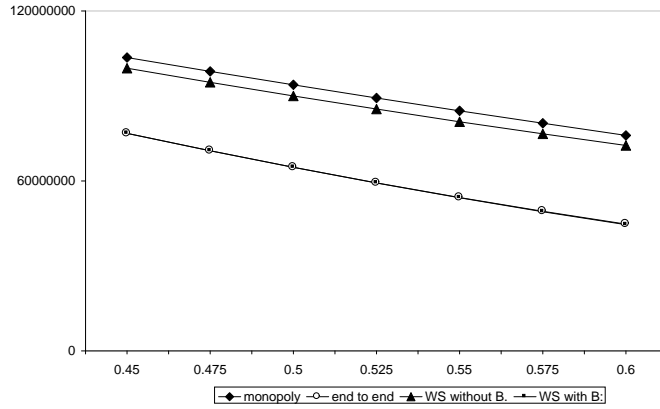
11

Figure 2: ΔTS for different pI

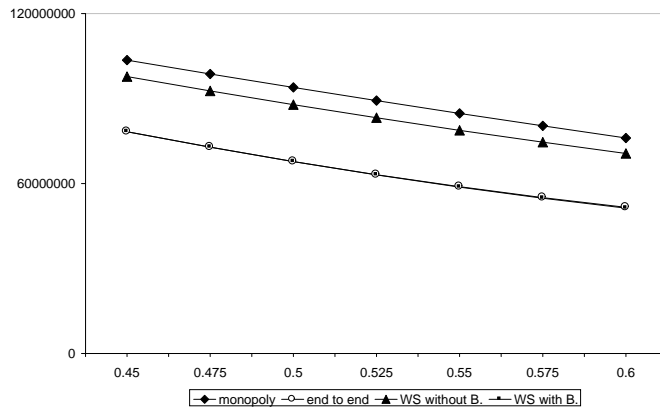scenarios in what concerns variations of the total surplus.

Figure 3: Total investment in innovation for different pI

If we look at the total investment in innovation, we can see that it decreases as the incumbent's price increases (Figure 3). The highest level of investment is observed in the monopoly case independently of p_I. However, for higher prices the decrease in investment in innovation is higher in the monopoly case than under end-to-end competition or work sharing with bypass.

We now consider how the results change with different access prices. Figure 4 shows how consumer surplus is affected by a change in access price. While the results of the monopoly, end-to-end competition and work sharing with bypass cases are unaffected, the results in the work sharing without

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bypass case are very sensible to variations in α. In fact, in this last scenario the gains from innovation in consumer surplus decrease with higher access prices.
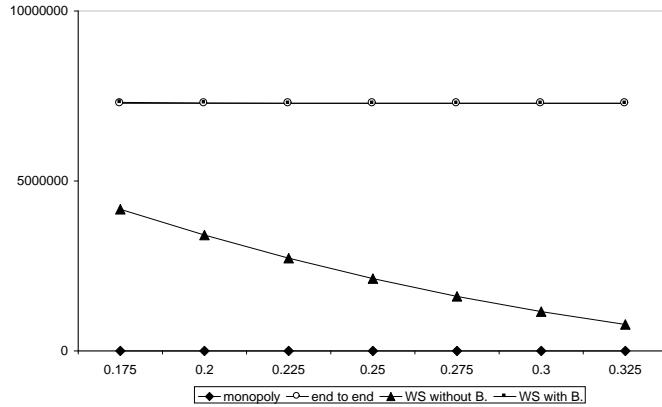

Figure 4: ΔCS for different α

Still, we observe that the lines do not cross for reasonable variations of the access price. As can be seen in Figure 5, the rung order regarding total surplus added by the possibility of innovation is robust for variations of the access price, though the gap between the case of work sharing without bypass and the monopoly case decreases with an increase in access price. Total
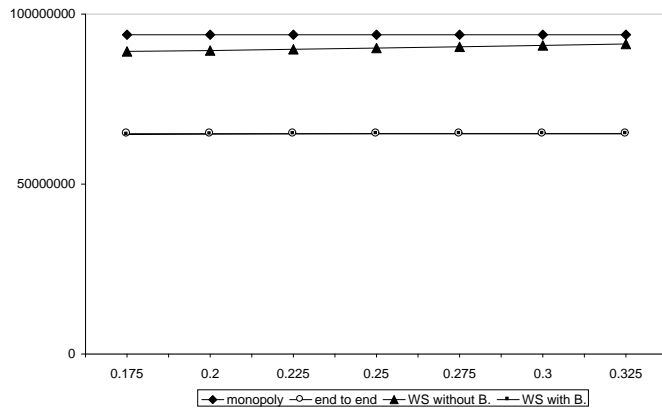

Figure 5: ΔTS for different α

investment, shown in Figure 6, is affected in a similar way by a change in access price. Whereas total investment in the work sharing without bypass case converts to the investment in the monopoly case, investment for end-
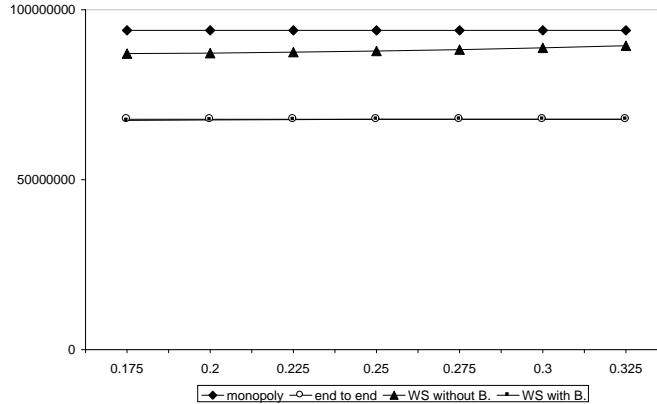
to-end competition remains constant.

Figure 6: Total investment in Innovation for different α

In summary, we observe that if we consider the effects of different access prices, we can see that the work sharing without bypass case converts to the monopoly case for higher access prices. The reason is that the high access price prevents potential competitors from entry.

6 Spillover Effects

Depending on the characteristics of an innovation, it is realistic to assume that an innovation of one service provider has positive external effects on competitors. These spillover effects result from the possibility of firms to imitate a competitor's innovation. In general, the effects of spillovers on innovation incentives are negative. However, as we shall see, this is not necessarily true under the existence of a universal service obligation. We introduce spillover effects into our model by making the following assumption. Besides reducing a service provider's own costs, the investments in innovation by one service provider also reduce the competitor's costs of the same processes by an amount equal to $d * k_{js}^r$, where $0 > d > 1$. The extent of these effects depends largely on whether innovation is tangible or not, and whether or not it can be protected by technical or legal means. Thus, we did not decide on any particular value for the parameter d. Instead, we apply multiple values for d ranging from 0 to 0.9, and observe the effect of spillovers on innovation incentives and welfare. Figure 7 shows the total investments of each service provider for increasingly strong spillover effects.
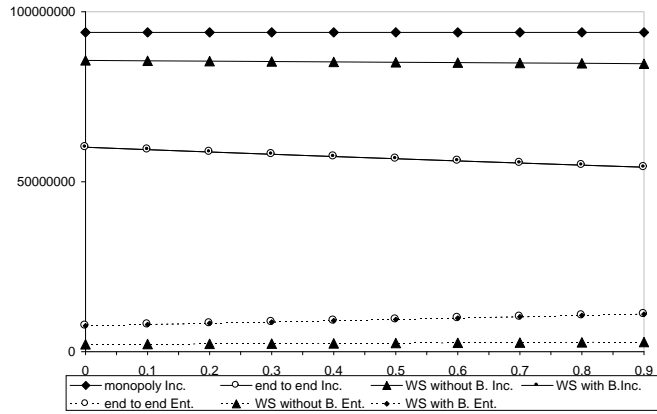
14

Figure 7: Total investment in innovation for different d

From the incumbent's perspective, the effect of spillovers on innovation incentives is purely negative. This is because spillovers reduce the competitor's costs, enabling the entrant to reduce prices. Lower prices result in lower demand for the incumbent, lowering innovation incentives. However, from the entrant's perspective, there are no negative effects from spillovers. This quite remarkable fact is a result of the assumption that the incumbent's uniform price is exogenously given. Thus, the entrant does not mind that the incumbent is able to make use of the entrant's innovations, since the incumbent cannot lower prices and take away additional market share even if costs are lower and profits increase.

In fact, the introduction of spillovers has a positive effect on the entrant's innovation incentives. This effect follows from the incumbent's innovation, which also lower the entrant's marginal costs. Because of reduced marginal costs, the entrant is able to lower prices, thus increasing demand. Therefore, the entrant's innovation incentives increase.

We summarize by saying that under the existence of a USO, spillover effects decrease the incumbent's innovation incentives, but increase the entrant's incentives. It should be noted that this is only true for process innovations, since with regards to product innovation, imitation of the entrant's product can increase the incumbent's market share even if prices remain unchanged.

In Figure 8, we can see the effect of increasingly strong spillover effects on the welfare effects of innovation. Both the difference in consumer surplus resulting from innovation as well as the added total surplus from the possibility of innovation increase with stronger spillovers. Subtracting the
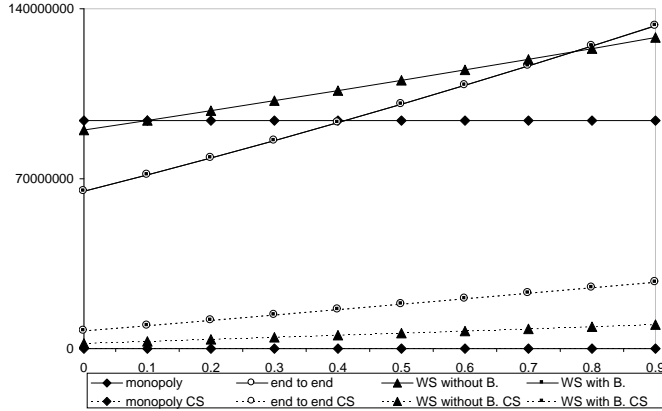
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Figure 8: ΔCS and ΔTS for different α

added consumer surplus from the added total surplus shows that the resulting added industry profits also increase. This result is intuitive. Decreasing investments of the incumbent are largely compensated by increasing investments of the entrant, thus leading to only a slight change in total investment. However, total surplus added by innovation increases since similar expenses for innovation are used in a more efficient way.

The effect of spillovers on welfare is stronger under end-to-end competition and work sharing with bypass than under work sharing without bypass. The reason is that under work sharing without bypass, there are no downstream effects from spillovers. However, in order for end-to-end competition and work sharing with bypass to surpass work sharing without bypass in terms of the effect of innovation on total surplus, very strong spillover effects with $d > 0.75$ are required.

7 Conclusion

In the postal sector, products are quite well-defined. Therefore, we concentrated on process innovations rather than product innovations. We assumed that process innovations lower the service provider's marginal costs. Furthermore, we assumed that the levels of investment and innovation are positively correlated. Taking into account the special characteristics of the postal sector, we applied this structure to the regulatory scenarios currently under discussion.

The calibration of our model allows us to conclude that, contrary to conventional wisdom, a profit-maximizing monopolist has very high innova-

tion incentives. However, the monopolist's behavior does not translate into added benefits for the consumers.

Liberalization does not lead to higher innovation incentives. Instead, dividing demand between two or more service providers decreases the economies of scale related to investment and, consequently, decreases total innovation incentives.

For a sufficiently high access price, the incumbent's incentives to innovate in the work sharing without bypass scenario exceed the incumbent's incentives in the scenarios of end-to-end competition and work sharing with bypass. In contrast, the entrant's incentives to innovate increase with full liberalization of the value chain compared to partial liberalization as done under work sharing.

An interesting result is that innovation is used in a more efficient way under work sharing without bypass than under end-to-end competition or work sharing with bypass. That is, similar levels of investment result in a bigger gain in social surplus under work sharing without bypass than under end-to-end competition or work sharing with bypass.

By examining spillover effects, we observed that although the incumbent's innovation incentives decrease, the entrant's incentives increase. These increasing incentives of the entrant largely compensate for the incumbent's declining incentives.

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