Strategic bypass deterrence*

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February 29, 2008

Abstract

Keywords: Postal sector, access, bypass, investment incentives.
JEL Classification: L51, L87

1 Introduction

In the European Union, Full Market Opening (FMO) of postal markets is now scheduled for January 1st, 2011. FMO allows competitors of the incumbent postal operator to enter all the segments of postal markets including mail delivery. FMO might be a threat for the financing of the Universal Service Obligation (USO) imposed on the incumbent postal operator, particularly if the entrant bypasses the incumbent's delivery network.

In the postal sector, competition has started long before FMO. However, with a few exceptions, competition was limited to the upstream segments of the market (collection and sorting) through the use of worksharing agreements. Worksharing or access means that a competitor can perform all the upstream operations of the postal value chain and buy access to the incumbent's PO delivery network at a discounted price (compared to the letter price). FMO means that in addition to the access solution that will continue to be available, the competitors also have the option to deliver mail with their own delivery network (bypass).

*This paper is prepared for the Fifth Conference On Regulation, Competition and Universal Service in the Postal Sector, Toulouse, France, 13-14 mars 2008.

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In this paper, we are interested in the consequences of FMO on the behavior of the incumbent PO. As mentioned, FMO means that the entrant can bypass the incumbent's delivery network and build up its own. Bypass can be detrimental for both the incumbent's profit with a negative impact on its ability to finance the USO and welfare (Crew and Kleindorfer 2005, De Donder 2006, and Bloch and Gautier 2006). Our interest lies in the strategies that the incumbent can develop to prevent (inefficient) bypass by the entrant. In particular, we concentrate on the pricing and on the investment strategies undertaken by the incumbent to deter bypass.

Prices, and in particular worksharing discounts and access prices, should provide the right signals to clients and rival firms. Prices should be designed to promote technical efficiency and the development of competition. Worksharing discount, for example, should give incentives to mailers to undertake upstream activities themselves whenever they are more efficient than the incumbent.[1] In a fully liberalized postal market, the prices should not only give right signals for undertaking (or not) upstream activities but also for undertaking (or not) delivery activities. That is prices should give the right incentives to bypass the incumbent's postal delivery network.[2] This means that prices play a central role in the choice of a delivery technology by an entrant.

Increasing the productivity of the delivery network is a key challenge for postal operators in the perspective of FMO. Following the gradual introduction of competition in the European postal sector, incumbent postal operators have launched ambitious restructuring programs to diversify their operations (banking, logistic) and to improve their efficiency.[3] The cost effectiveness of the delivery network does not itself enter in the choice of a delivery method by the entrant. But, a more cost effective incumbent sells its products, including access, at a lower price and this in turn affects the incentives to bypass or not the incumbent's postal delivery network.

So prices and investments can both be used to deter inefficient bypass by an entrant. In this paper, we compare these two instruments. More precisely, we compare, from a

[1] Billette de Villemeur et al. (2003) determine the optimal worksharing discount when mailers are heterogeneous. Many other papers concentrate on optimal worksharing discounts.

[2] Delivery Area Access Pricing (DAP) introduced by Crew and Kleindorfer (2002) is one approach to access pricing that takes explicitly into account the possibility of bypass by the entrant. Bloch and Gautier (2006) define optimal prices that prevent bypass.

[3] Austria Post for example took the following measures to improve the distribution process: reduction and automation of the sorting centres, reduction of the number of delivery centres, redesign of distribution routes and introduction of innovative delivery services (PWC, 2006).

welfare point of view, the effectiveness of price distortions and investment to deter bypass by a competitive entrant. We show that these instruments are substitutes: either prices are distorted or the firm over-invests to deter bypass.

This work is closely related to Bloch and Gautier (2006) and Bloch and Gautier (2008). In these two related papers, we study the price distortions necessary to induce a competitive or a profit-maximizing entrant to choose access instead of bypass when it is efficient to do so. In addition, Bloch and Gautier (2008) introduce the possibility for the incumbent to make an investment to improve the cost-effectiveness of its postal delivery network, like in this paper, but it mainly concentrates on the incentives to invest at the (intensive) margin i.e. taking the access vs. bypass decision of the entrant as given. In this paper, we look at the incentives to invest at the extensive margin, that is an investment that modifies the entrant's decision.

2 The Model

There are two types of postal products: single piece mail and commercial (or bulk) mail. Firm 1, the incumbent postal operator, is the sole supplier of the single piece mail product. In addition, firm 1 offers a bulk mail product. A competitor of firm 1, the entrant (or firm 2), offers an alternative commercial mail product. Consumers view the two bulk mail products as imperfect substitutes. For example, the competitor may choose to deliver mail with a lower frequency (twice a week instead of five/six times a week) and/or to have a limited geographical coverage, with both strategies actually used by competing postal operators in Europe. The single piece mail product is sold at unit price p_0, the bulk mail product of firm i, $i = 1, 2$ is sold at price p_i.

There is one representative consumer who patronizes the two operators for its bulk mails and who uses the incumbent for its single piece mails. Denote by x_0 the number of single piece letters and by x_1 and x_2 the amount of commercial mail proceeded by firm 1 and firm 2. The net consumer surplus generated by these products is:

$$U(x_0) - p_0 x_0 + V(x_1, x_2) - p_1 x_1 - p_2 x_2. \tag{2.1}$$

Demand for product x_j at prices (p_0, p_1, p_2), $j = 0, 1, 2$ is obtained by maximizing (2.1) with respect to x_j. We assume that the demand for single-piece mail is independent of the prices of commercial mails i.e. the surplus function in (2.1) is additively separable.

We decompose the postal value chain into two composite operations: upstream opera-

tions (collection, transport and sorting) and downstream operations (delivery). Upstream operations are operated under constant returns to scale. Upstream operations have a constant unit cost c_j per product $j = 0, 1, 2$. Upstream costs are higher for single piece mail: $c_0 > c_1, c_2$.

The incumbent uses its postal delivery network for distributing single piece mails and bulk mails to mailboxes. The incumbent delivery network has a fixed cost F_1 and a cost d_1 per mail delivered. The entrant has two option for mail delivery: it can either use the incumbent's network, this is the access option, or it can develop its own delivery network, the bypass option. If the entrant chooses the access option, it pays an access price of a to the incumbent and all the mails are delivered by firm 1. In this case, the total delivery cost for firm 1 is

$$C_1(x_0, x_1, x_2) = d_1(x_0 + x_1 + x_2) + F_1.$$

If the entrant chooses the bypass option, establishing an alternative distribution network has a cost d_2 per mail distributed but no fixed cost.[4] The total delivery costs for firms 1 and 2 are respectively:

$$\begin{aligned} C_1(x_0, x_1) &= d_1(x_0 + x_1) + F_1 \\ C_2(x_2) &= d_2 x_2 \end{aligned}$$

If the entrant chooses to buy access, the firms have profits equal to:

$$\pi_1^A = (p_0 - c_0 - d_1)x_0 + (p_1 - c_1 - d_1)x_1 + (a - d_1)x_2 - F_1 \tag{2.2}$$

$$\pi_2^A = (p_2 - c_2 - a)x_2 \tag{2.3}$$

If the entrant chooses to bypass the incumbent's network, profits are:

$$\pi_1^B = (p_0 - c_0 - d_1)x_0 + (p_1 - c_1 - d_1)x_1 - F_1 \tag{2.4}$$

$$\pi_2^B = (p_2 - c_2 - d_2)x_2 \tag{2.5}$$

[4]Panzar (1991) and de Bijl et al (2005) among others argue that, unlike other network industries, a postal delivery network requires little sunk costs, since the main costs are workers, vehicles and buildings. Therefore, we consider that all the long run costs of the entrant are variable. Things might be different for the incumbent because of the, usually imposed, universal service obligations. If the incumbent must deliver nationwide at a given frequency (say five times a week) and/or maintain services (delivery, post offices) in remote areas, it can generate substantial fixed costs, even in the long run. USO can therefore justify the existence of a fixed cost for the delivery activity. Panzar (1991) and de Bijl et al (2005) also document significant economies of scale in the delivery activity. By taking a constant delivery cost for the entrant, we implicitly assume that the entrant manages to capture a sufficiently large fraction of the mail volume to exploit these economies of scale.

The total welfare is the sum of the net consumer surplus and the firms' profit.

There is a postal regulator who has the power to set the incumbent's letter prices p_0, p_1 and its access price a. The regulator chooses the prices that maximize the total welfare subject to a non-negative profit constraint for the incumbent. The entrant is not regulated and decides freely on its price p_2 and on its delivery method. We suppose that decisions are sequential: the regulator decides first on p_0, p_1 and a. Then, the entrant decides on its delivery method, access or bypass, and on its bulk mail price p_2. We consider that the entrant behaves like a competitive fringe and sells its bulk mail at marginal cost. This assumptions are common in the analysis of postal markets (see for example De Donder, 2006).

3 Pricing under access and bypass

In this section, we derive the optimal prices that apply under access and bypass. This exercise has been done elsewhere by Bloch and Gautier (2006), Billette de Villemeur *et al.* (2006) and Laffont and Tirole (1993). For the moment, we consider that the prices charged by the incumbent do not affect the choice of a delivery method by the entrant. We will relax this assumption latter on.

3.1 Access

Suppose that the entrant has chosen to use the incumbent's delivery network. Under access, the price charged by the entrant is

$$p_2 = a + c_2. \tag{3.6}$$

The objective of the regulator is

$$\max_{p_0,p_1,a} U(x_0) + V(x_1, x_2) - c_0 x_0 - c_1 x_1 - c_2 x_2 - d_1(x_0 + x_1 + x_2) - F_1 \tag{3.7}$$

subject to $\pi_1^A \geq 0$ and (3.6).

Denote by η_0, the price elasticity of x_0, by $\hat{\eta}_j$, the super-elasticity of product $j = 1, 2$ and by λ is the Lagrange multiplier of the zero profit constraint for the incumbent, this problem gives rise to standard Ramsey prices[5]:

$$\frac{p_0 - c_0 - d_1}{p_0} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_0} \tag{3.8}$$

[5]See Laffont and Tirole (1993).

$$\frac{p_1 - c_1 - d_1}{p_1} = \frac{\lambda}{1+\lambda}\frac{1}{\hat{\eta}_1} \tag{3.9}$$

$$\frac{p_2 - c_2 - d_1}{p_2} = \frac{\lambda}{1+\lambda}\frac{1}{\hat{\eta}_2} \tag{3.10}$$

At optimal prices, the regulator charges a mark-up on all products (including the bulk mail of firm 2) to finance the fixed delivery cost F_1. These mark-ups are proportional to the product's elasticity (single-piece mail) or super-elasticity (bulk mails).

3.2 Bypass

Suppose that the entrant chooses to bypass the incumbent's delivery network. Under bypass, the price charged by the entrant is

$$p_2 = d_2 + c_2. \tag{3.11}$$

In the bypass case, the access price is irrelevant since we not allow for consumer direct access in this model. The objective of the regulator is then:

$$\max_{p_0,p_1} U(x_0) + V(x_1, x_2) - c_0x_0 - c_1x_1 - c_2x_2 - d_1(x_0 + x_1) - d_2x_2 - F_1 \tag{3.12}$$

subject to $\pi_1^B \geq 0$ and (3.11).

Again, prices are standard Ramsey prices:

$$\frac{p_0 - c_0 - d_1}{p_0} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_0} \tag{3.13}$$

$$\frac{p_1 - c_1 - d_1}{p_1} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_1} \tag{3.14}$$

Optimal prices under bypass are such that the incumbent charges a mark-up above marginal cost on its two products to cover the fixed cost F_1. Again, mark-ups are proportional to the elasticities. Under bypass, there is no mark-up on the bulk mail of firm 2 and this products does not contribute to the financing of the fixed cost.

Notice that, except for the single piece mail, the structure of prices changes (compare (3.9) with (3.14) and (3.6) with (3.11)). And, for all products, the level of prices changes. The Lagrange multiplier captures this effect. λ determines the importance of the mark-up on each imposed on each product and it is endogenously determined in this model.[6] Therefore, when firm 1 looses access receipts because firm 2 bypasses, both the structure and the level of prices are modified.

[6]Alternatively, we can assume that the regulator does not impose a break-even constraint on the incumbent and finances its losses with public subsidies. In this alternative interpretation, λ is the shadow cost of public funds and it is exogenously given.

4 Delivery choices

In this section, we first derive the welfare-maximizing delivery method for the entrant. We then compare this efficient choice with the actual choice made by the entrant.

4.1 Efficient delivery choice

Denote by $\hat{W}^A$ and $\hat{W}^B$ the value of the objective function under access and bypass when the efficient prices of section 3 are applied. Our objective is to determine if and when $\hat{W}^B \geq \hat{W}^A$ i.e. when it is efficient to allow downstream bypass.

Critical factors to determine the efficient delivery method are obviously the delivery costs of firms 1 and 2. In this paper, we will assume that d_2 and F_1 are given and we will make comparative static analysis with respect to the incumbent's marginal cost of delivery d_1 and we express $\hat{W}^A$ and $\hat{W}^B$ as a function of this parameter.

Take the total differential of the objective function evaluated at optimal prices with respect to d_1, we have (by the envelope theorem):

$$\frac{\partial \hat{W}^A}{\partial d_1} = -(1+\lambda)(x_0 + x_1 + x_2) \tag{4.15}$$

$$\frac{\partial \hat{W}^B}{\partial d_1} = -(1+\lambda)(x_0 + x_1) \tag{4.16}$$

Keeping the other costs constant, the welfare declines with the marginal cost d_1 at a rate which is given by the total mail volume distributed by the incumbent. Postal demands are characterized by a relatively low elasticity[7] and a high displacement ratio[8]. In light of that, we can reasonably assume that: $\frac{\partial \hat{W}^A}{\partial d_1} \geq \frac{\partial \hat{W}^B}{\partial d_1}$.

As the unit delivery cost increases, prices increases and the welfare decreases. At a point, it might be impossible to find prices compatible with the zero profit constraint for the incumbent, particularly if the entrant bypasses the incumbent's network. This problem is known as the graveyard spiral (Crew and Kleindorfer, 2005). In the case of a graveyard spiral, $\hat{W}^B$ is not well-defined. In this paper, we restrict our attention to values of d_1 such that the functions $\hat{W}^A$ and $\hat{W}^B$ are both well defined. That is we concentrate

[7]De Donder et al (2006) use price elasticity of -0.2 for the single piece mail product and -0.4 for the bulk mail; Fève et al (2006) estimate a price elasticity of -0.36 for Mailsort, a service for large volume of pre-sorted mails offered by Royal Mail in the UK.

[8]The displacement ratio (Armstrong Doyle and Vickers, 1996) measures the business stealing effect of the competitor on the incumbent's mailing volume. A displacement ratio of 0.9 is commonly accepted for the postal sector. This means that 90% of the mail carried by the entrant are 'stolen' from the incumbent.

on values of the delivery cost such that the financial viability of the entrant is no threated by full market opening.

We will assume that there exists a cut-off value d_1^* such that $\hat{W}^A \geq \hat{W}^B$ for $d_1 \leq d_1^*$ and $\hat{W}^A \leq \hat{W}^B$ for $d_1 \geq d_1^*$. We can show that bypass is efficient only if the unit delivery cost of firm 1 is strictly higher than the unit cost of firm 2.

PROPOSITION 4.1 $d_1^* > d_2$.

Proof: For $d_1 \leq d_2$, the regulator can replicate the bypass solution under access by setting $a = d_2$. Therefore it implies that $\hat{W}^A > \hat{W}^B$ for all $d_1 \leq d_2$. By continuity of the objective function, $d_1^* > d_2$. ■

This proposition implies that when firms have identical marginal cost of delivery (and therefore, firm 1 has a higher average delivery cost), prohibiting downstream bypass is efficient. With identical costs or a higher cost d_2, the regulator can replicate the bypass prices under access and leave a non negative profit to firm 1. The fact that the regulator selects different price structures under access and bypass means that the access solution strictly dominates the bypass one for $d_1 \leq d_2$. By continuity of the objective function, access also dominates for $d_1 > d_2 + \epsilon$.

Without bypass, the regulator imposes a mark-up on all the three products to finance the fixed cost F_1 while, with bypass, the fixed cost is recovered by a higher mark-up on two products only. Therefore, access may dominate bypass even when firm has a higher unit delivery cost. Bypass is efficient only when the entrant has a sufficiently large cost advantage over firm 1. In this case, a lower price for good 2 more than compensate a higher price for the incumbent's products.[9]

4.2 Delivery choice by the entrant

Access is efficient as long as the cost d_1 is smaller than the threshold value d_1^*. In a fully liberalized postal market, the entrant can freely bypass the incumbent's delivery network and will do so whenever it is profitable.

In this model, the entrant behaves as a competitive fringe and, therefore, realizes a zero profit whatever its mail delivery option. We consider then that the entrant chooses the cheapest option for mail delivery.[10]

[9] In this paper, we neglect the possibility for the incumbent to contract-out delivery to the entrant.

[10] Alternatively and equivalently, the entrant chooses the delivery method that maximizes its mailing volume.

Suppose that the incumbent charges the optimal prices anticipating access by the entrant given by equations (3.8), (3.9), (3.10)). At these prices, the entrant bypasses whenever its unit delivery cost is smaller than a. That is when:

$$d_2 \leq a \Leftrightarrow d_2 \leq d_1 + \frac{\lambda}{1+\lambda}\frac{p_2}{\hat{\eta}_2} \tag{4.17}$$

So bypass occurs whenever the cost d_1 is higher than a threshold value $\tilde{d}_1$ given by $\tilde{d}_1 = d_2 - \frac{\lambda}{1+\lambda}\frac{p_2}{\hat{\eta}_2}$. It is clear from this equation that bypass occurs too often at the optimal prices. In other words, $\tilde{d}_1 < d_1^*$ and so for a delivery cost $d_1 \in [\tilde{d}_1, d_1^*]$, access is efficient but the entrant chooses to bypass. The following proposition summarizes that point:

PROPOSITION 4.2 *There exists a cut-off value $\tilde{d}_1$ such that the entrant bypasses the incumbent when $d_1 \geq \tilde{d}_1$ and chooses access otherwise. $\tilde{d}_1 < d_2 < d_1^*$ and for $d_1 \in [\tilde{d}_1, d_1^*]$, there is inefficient bypass. That is the entrant chooses to bypass while access leads to a higher welfare.*

The reason for this inefficient bypass is the mark-up on good 2, proportional to the super-elasticity of the product. This makes access relatively more expensive and distorts the access vs. bypass decision of the entrant. Consequently, bypass occurs too often.[11]

Finally notice that excessive access is not possible. Suppose that the incumbent charges the optimal prices anticipating bypass by the entrant (given by (3.13) and (3.14)). At these prices, it is always possible to induce bypass by setting the access price sufficiently high.

5 Strategic bypass deterrence I: prices

Bypass occurs too often at optimal prices. The regulator must then take this into account in its price design. By distorting prices appropriately, the regulator can strategically deter bypass.

For $d_1 \geq \tilde{d}_1$, if the regulator wishes to prevent bypass, it must choose the prices a, p_0 and p_1 to maximize the welfare subject to $\pi^A \geq 0$, $p_2 = a + c_2$ and the no-bypass

[11] Armstrong (2001) suggests to price access at marginal cost and to impose an input tax on the entrant that must be paid irrespectively of the chosen delivery method. With such a scheme, an entrant chooses the bypass option only if it is more cost effective than the incumbent. However, in the postal sector, compensation funds have not worked very well (e.g. Italy) and have potentially many practical difficulties (definition of the taxable base, distortion of competition, adequate tax level, monitoring,...).

constraint: $a \leq d_2$. That is, to constraint the entrant to choose the access option, this should be the cheapest option for the entrant. This leads to the following modified prices:

$$\frac{p_0 - c_0 - d_1}{p_0} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_0} \tag{5.18}$$

$$\frac{p_1 - c_1 - d_1}{p_1} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_1} + (d_2 - d_1)\frac{\eta_{21}}{\eta_1}\frac{x_2}{p_1 x_1} \tag{5.19}$$

To make access the preferred option for the entrant, the regulator reduces the access price to d_2. This has consequences on the level and the structure of the other prices of the incumbent. Since a decreases, the regulator reduces the access receipts and, to compensate, the price level increases i.e. λ increases. In addition, the structure of p_1 is modified.[12]

When the regulator applies modified prices to deter bypass, the value of the objective function is no longer $\hat{W}^A$ but it is lower (call it $\tilde{W}^A$). Hence, it might not be always efficient to deter bypass by modifying the prices. The following proposition summarizes that:

PROPOSITION 5.3 *It is efficient to deter bypass for* $d_1 \in [\tilde{d}_1, d_2]$.

Proof: ■

Consequently, for $d_1 \in [d_2, d_1^*]$, the highest welfare would be achieved if downstream bypass was prohibited but, in a fully liberalized market, it is efficient to allow bypass.

To summarize, our model is similar to the classical model of entry barriers, where the incumbent chooses a price in order to block, deter or accommodate entry of a competitor (Tirole (1988), Chapter 8). The model differs from the classical model in two respects: (i) the choice of the entrant is not whether to enter or not, but whether to bypass or use the delivery technology of the incumbent, and (ii) accordingly, all prices are modified when the regulator deters bypass. By analogy with the model of entry barriers, we can distinguish three regimes:

1. **Blocked bypass:** For $d_1 \leq \tilde{d}_1$, by setting its optimal delivery and access prices, the incumbent prevents bypass.

2. **Deterred bypass:** For $d_1 \in [\tilde{d}_1, d_2]$, the incumbent distorts its delivery and access prices in order to force the entrant to choose access.

3. **Accommodated bypass:** For $d_1 \geq d_2$, the incumbent prefers to let the entrant set up its own delivery network, and chooses its optimal prices anticipating bypass.

[12] Note that for $d_1 = \tilde{d}_1$, (5.19) is equivalent to (3.9)

6 Strategic bypass deterrence II: Investment

In this previous section, we showed that prices could be used to deter inefficient bypass by a competing entrant. In this section, we look at an alternative way to deter bypass: improving the efficiency of the delivery network.

We therefore introduce the possibility for the incumbent firm to invest in a cost-reducing delivery technology. More precisely, we consider firm 1 can invest to reduces its unit delivery cost d_1. Reducing the unit cost by an amount e costs the firm $\Phi(e)$. The function $\Phi(e)$ satisfies $\Phi'(e) > 0$, $\Phi''(e) > 0$, $\Phi(0) = 0$ and $\Phi'(0) = 0$.

With the investment possibility, the regulator decides on the investment level e and on prices p_0, p_1 and a. Prices must cover all the cost of firm 1, including the cost of the investment $\Phi(e)$, so that the zero profit constraint becomes $\pi^k - \Phi(e) \geq 0$, with $k = A$ (access) or $k = B$ (bypass). Taking the total derivative of the objective function with respect to e, the optimal investment level e^* is given by

$$\frac{\lambda}{1+\lambda}\Phi'(e^*) = X, \tag{6.20}$$

where X is the total volume of mail delivered by firm 1.

The investment size is directly proportional to the mail volume carried by the incumbent, including the mail of the competitor in the access regime. In Bloch and Gautier (2008), firm 1 has additional incentives to invest in the deterred bypass case, because the price distortions necessary to constraint firm 2 to choose the access option, depend on the delivery cost d_1. This is not the case when the entrant behaves like a competitive fringe because the distortion in the access price is a function of the entrant's cost d_2 only.

However, investing can be a substitute to price changes to deter bypass by firm 2. Instead of investing an amount e^*, the firm can invest to switch from the deterred bypass regime to the blocked bypass regime.

A firm with a cost $d_1 \in [\tilde{d}_1, d_2]$ can, instead of investing e^*, invests an amount $d_1 - \tilde{d}_1$ to block bypass. With such an investment, the value of the objective function is $\hat{W}^A(\tilde{d}_1) - \lambda\Phi(d_1 - \tilde{d}_1)$. We can show that

PROPOSITION 6.4 *There exists a cut-off value $\hat{d}_1 > \tilde{d}_1$, such that, for $d_1 \in [\tilde{d}_1, \hat{d}_1]$, it is efficient to deter bypass by investing $d_1 - \tilde{d}_1$.*

Proof: For $d_1 \in [\tilde{d}_1, d_2]$, the regulator can strategicaly deter bypass with either modified price (leading to a welfare of $\tilde{W}^A$) or over-investment (leading to a welfare of $\hat{W}^A(\tilde{d}_1) -$

$\lambda\Phi(d_1 - \tilde{d}_1)$). Since $\Phi'(0) = 0$, for $d_1 = \tilde{d}_1 + \epsilon$, it is more efficient to invest to deter bypass. Moreover, the function $\hat{W}^A(\tilde{d}_1) - \lambda\Phi(d_1 - \tilde{d}_1)$ is concave in d_1 while the function $\tilde{W}^A$ is convex. ■

By investing $d_1 - \tilde{d}_1$, firm 1 switches from a deterred bypass regime where costly price distortions are imposed to a blocked bypass regime where efficient prices are applied.

In this model, there are two options to deter inefficient bypass by a competitive entrant. The firm can either invests an additional amount to improve its delivery network in order to achieve the cut-off level of cost $\tilde{d}_1$ or it can remain with a higher cost but distort its price to make access the cheapest option with both strategies being costly. In the first case, there is an additional cost of effort $\Phi(d_1 - \tilde{d}_1)$, in the second case, prices are not set at their efficient levels. These two strategies to deter bypass are substitutes. That is the firm uses either price distortions or excessive investment to deter bypass.

7 Concluding remarks

We can summarize our research as follow:

- Optimal (or Ramsey) prices do not give the right signal to the entrant, leading to sub-optimal delivery decision.
- By reducing the access prices and consequently modifying the others prices to keep the budget balanced, the incumbent can deter inefficient bypass.
- Alternatively, making a costly investment to reduce the delivery cost is another tool to deter bypass.
- Excessive investment can be motivated by the threat of bypass.
- Excessive investment and price distortions are two substitute tools to deter bypass.

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