Economics Bulletin

Volume 32, Issue 4

Optimal pricing of postal services under endogenously determined entry

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Abstract

Postal reform (liberalization) is occurring rapidly around the world, perhaps most notably in the EU where January 1, 2011 was the date of Full Market Opening (FMO). As a strategy for maintaining the Universal Service Obligation (USO) under FMO, several authors suggest that the sale of access to competitive entrants may provide the universal service provider with significant opportunities to enhance revenues. In a single postal product context, Crew and Kleindorfer (2011) provide conditions under which competitive entry via access is welfare superior to entry via bypass (the Theorem on the Superiority of Access). In this paper, we show that in the single product context, the Laspeyres price cap-based regulatory adjustment process of Vogelsang and Finsinger (1979) may be adapted to determine optimal access-inducing prices, thereby fulfilling the USO efficiently. We also discuss a number of potential problems associated with extending the Theorem on the Superiority of Access and the Vogelsang-Finsinger price capping procedure to a multiproduct context.

I would like to thank two anonymous referees for several useful comments and suggestions
Citation: Kevin M. Currier, (2012) "Optimal pricing of postal services under endogenously determined entry", *Economics Bulletin*, Vol. 32 No. 4 pp. 3503-3511.
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Submitted: January 09, 2012. **Published:** December 28, 2012.

1. Introduction

Postal reform (liberalization) is occurring rapidly around the world, perhaps most notably in the European Union. Indeed, since the early 1990s, reforms in the EU postal sector have been implemented with the intent of ultimately establishing fully competitive markets with January 1, 2011 being the date of Full Market Opening (FMO) (Crew et al., 2008; WIK Consulting, 2009).[1]

The Universal Service Obligation (USO) typically requires the incumbent universal service provider (USP) to maintain a delivery network. Historically, USOs have been financed by monopoly profits generated via "reserved areas" in which competitive entry was prohibited. With January 1, 2013 being the deadline for the complete phasing out of reserved areas in the EU, the future sustainability of the USO is called into question (Crew and Kleindorfer, 2002, 2011; Bloch and Gautier, 2008).

In general, competitive entry may occur via bypass or access. Under access, the entrant employs the USP's delivery network. Under bypass, the entrant establishes and maintains its own delivery network. As a strategy for maintaining the USO under FMO, several authors note that the sale of access may provide significant opportunities for the USP to enhance revenues (Crew and Kleindorfer, 2006; Bloch and Gautier, 2008). For example, "competitor collaboration" was discussed by Smith and Vogel (2010) within the context of the competitive/cooperative relationship between the USPS and UPS. Most recently, Crew and Kleindorfer (2011) demonstrate that for a single-product incumbent USP, when an entrant's average delivery cost exceeds the unit delivery cost of the USP, bypass can never be an efficient solution relative to access (Theorem on the Superiority of Access). This result derives from the essential fact that in passing from a situation of bypass to one of access, the channeling of the entrant's demands into the USP's delivery network coupled with economies of scale in delivery for the incumbent USP reduces average delivery cost, thereby increasing welfare. However, when the delivery method is endogenous, i.e., the regulator cannot choose the entrant's delivery method, private and social incentives for entry may diverge, in which case entrants may have an incentive to select bypass when access is socially optimal (Armstrong, 2008). Thus, under endogenous entry, the impact of end-to-end (E2E) and access prices on the delivery method (access versus bypass) must be incorporated into the design of optimal prices so as to preserve incentives for entry via access.

Price caps have been shown to provide strong incentives for a profit-motivated regulated firm to pursue cost reduction and welfare enhancing "rate rebalancing" (Sappington and Weisman, 2010; Crew and Kleindorfer, 1996; Braeutigam and Panzar, 1993; Brennan, 1989). Price caps are now widely applied around the world in telecommunications, natural gas, electricity, and airports. In addition, price cap regulation has been applied in the postal sector in many EU member countries, including Germany, Belgium, Denmark, Italy, and the U.K. As of 2009, member states employing price cap regulation in the postal sector accounted for 62% of the postal market (WIK Consulting, 2009)

In this paper, following Crew and Kleindorfer (2011) and Bloch and Gautier (2008), we assume a single-product USP facing competitive entry by an entrant offering an imperfect substitute. We show that under the hypothesis of the Theorem on the Superiority of Access, the well-known Laspeyres price cap-based regulatory adjustment of Vogelsang and Finsinger (VF) (1979) may be adapted to determine socially optimal *access-inducing* prices. Since the USP breaks even

[1] An anonymous referee has pointed out that a number of obstacles to postal reform in the EU remain, due to country variation, public ownership and unionization issues etc.

under these prices, the USO is fulfilled. We conclude with a discussion of the need for and the potential difficulties associated with generalizing the Theorem on the Superiority of Access and the modified VF procedure to a multiproduct/service context.

2. The Model

Pearsall and Trozzo (2008) show that only one potential competitor to the USP is likely to exist in any single contestable postal delivery market since economies of scope and scale in delivery will either provide powerful incentives for the competitors to combine or make entry by more than one of them unprofitable .We therefore assume there are two postal operators: an incumbent, denoted by I, and an entrant, denoted by E. A USO is imposed on the incumbent, thus requiring firm I to maintain a delivery network. For simplicity, we assume a single delivery zone. As in Crew and Kleindorfer (2011) and Bloch and Gautier (2008), each operator offers an E2E product to consumers. We let p^i denote the price charged by firm *i*, $i \in \{I, E\}$. The E2E product offered by firm E is an imperfect substitute for the E2E product offered by I.

We assume throughout that all functions are twice continuously differentiable. Consumer surplus is $v(p^I, p^E)$, which is convex. Market demands are $x^I(p^I, p^E)$ and $x^E(p^I, p^E)$. Consumer surplus satisfies Roy's Identity $\frac{\partial v}{\partial p^i} = -x^I(p^I, p^E), i \in \{I, E\}$. Furthermore, $\frac{\partial x^I}{\partial p^I} < 0$; $\frac{\partial x^E}{\partial p^E} < 0$; and, since x^I and x^E are substitutes, $\frac{\partial x^I}{\partial p^E} = \frac{\partial x^E}{\partial p^I} > 0$. Inverse demands are $p^I(x^I, x^E)$ and $p^E(x^I, x^E)$.

The unit cost of collection, sorting, and transport (i.e., "upstream" costs) is c^i, $i \in \{I, E\}$. Unit costs of delivery ("downstream" costs) are d^i, $i \in \{I, E\}$. The fixed cost of establishing and maintaining a delivery network is F^i, $i \in \{I, E\}$. Thus, as in Bloch and Gautier (2008) and Crew and Kleindorfer (2011), F^I may be regarded as USP's cost of fulfilling the USO. The assumption that $F^i > 0$, $i \in \{I, E\}$ implies that downstream activities exhibit economies of scale for the entrant as well as the incumbent USP .[2]

Since the demand for the entrant's product is independent of the access/bypass decision, the entrant chooses access (using I's delivery network) or bypass (using its own delivery network) based solely on cost considerations. The unit price of access set by I is *a*. Under bypass, the entrant's profit is $\pi^E = (p^E - c^E - d^E)x^E(p^I, p^E) - F^E$. We assume π^E is strictly concave in p^E for all p^I. The market for downstream activities (delivery) is assumed to be contestable, implying that the threat of entry forces p^E down to its average cost. We thus have

$$p^E = \min\left\{c^E + a, c^E + d^E + \frac{F^E}{x^E(p^I, p^E)}\right\}.$$

It should be noted that contestability implies that $\pi^E = 0$ under both access and bypass.

As noted above, the entrant's choice of access versus bypass will depend on the size of the average delivery cost $AC^E = d^E + \frac{F^E}{x^E(p^I, p^E)}$ relative to the unit cost of purchasing access *a*.

[2] It should be noted that we are assuming that the products/services of the USP and the entrant are homogeneous in the delivery function with all product differentiation occurring "upstream."

We assume that an inducement to enter via bypass exists if and only if $AC^E < a$. Define now $\hat{p}^E(p^I) = \min\{p^E \mid p^E \geq c^E + AC^E\}$ and let $\hat{a}(p^I) = \hat{p}^E(p^I) - c^E$, the maximum value at which access is induced at p^I. Consider now $\pi_+^E = \{(p^I, p^E) \mid p^E \geq c^E + AC^E\}$. From the assumed concavity of π^E, a vertical translation down by c^E units yields the Access-Bypass Separation Line (ABSL) (Crew and Kleindorfer, 2011), shown in Figure 1.

When firm I's price p^I is below $\bar{p}^I$, the entrant will always select access because break-even operation under bypass will never be possible. The heavily shaded downward-sloping curve is the ABSL. Above $\bar{p}^I$, the entrant will select access if (p^I, a) lies on or below the ABSL and bypass if (p^I, a) lies above the ABSL. Following Crew and Kleindorfer (2011), we assume throughout that $AC^E > d^I$, in which case the Theorem on the Superiority of Access implies that bypass can never be an efficient solution relative to access. As noted previously, this important result stems from the fact that on or below the ABSL, the entrant's demands j are serviced via firm I's delivery system, thereby decreasing I's average cost and increasing welfare.[3]

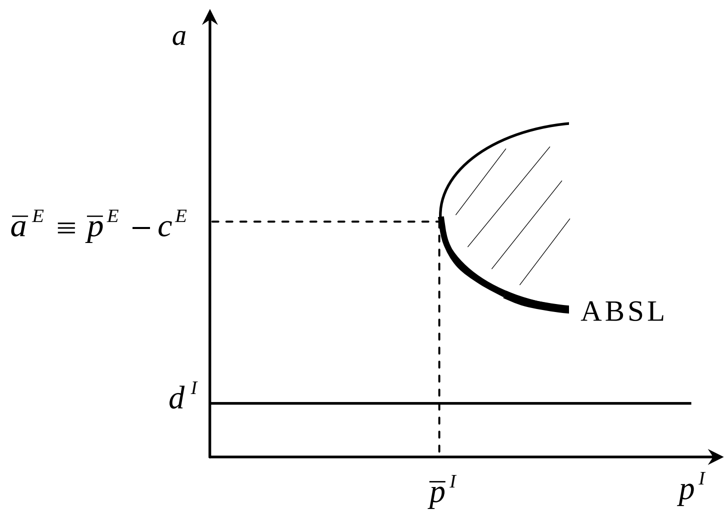

Figure 1

When the entrant selects access, the incumbent USP's profit is $\pi^I = (p^I - c^I - d^I)x^I(p^I, a + c^E) + (a - d^I)x^E(p^I, a + c^E) - F^I$, which equals E2E profits plus profits from selling access. We assume π^I is strictly concave in (p^I, a) and attains a unique global maximum. Finally, social welfare is defined to be $W = v + \pi^I + \pi^E = v + \pi^I$ since delivery markets are assumed contestable.

[3] Equivalently, the Theorem on the Superiority of Access implies that a lower E2E price could be implemented under access than under bypass while still permitting firm I to break even.

3. A Modified Vogelsang-Finsinger Procedure for Optimal E2E/Access Pricing

When the regulator cannot select the delivery method of the entrant, the effect of p^I and a on the entrant's delivery method choice must be incorporated into the optimal pricing problem. In this section, we present an iterative price capping procedure that solves the optimal E2E/access pricing problem while incentivizing socially desirable entry via access.

The regulator wishes to determine an E2E/access price vector $\left(p^I, a\right)$ that maximizes welfare subject to the constraint that the USP breaks even. However, this price vector could lie above the ABSL, in which case, paradoxically, socially undesirable bypass would be induced.[4] To ensure that the entrant selects access, the regulator must solve:

$$\underset{\left(p^I,\, a\right)}{\text{Maximize}}\ v\left(p^I, a + c^E\right)$$

subject to

$$\left(p^I - c^I - d^I\right)x^I\left(p, a^I + c^E\right) + \left(a - d^I\right)x^E\left(p^I, a + c^E\right) - F^I = 0 \tag{1}$$

$$a \le \hat{a}\left(p^I\right). \tag{2}$$

Constraint (1) ensures that firm I breaks even. Constraints (2) ensure that the solution to the entrant's delivery cost minimization problem is consistent with the socially optimally choice.

To this end, let $\left(p_t^I, a_t\right)$ denote firm I's E2E/access price vector in time period t. In addition, assume that $\left(p_0^I, a_0\right)$ prevails in time period 0 with $\pi_0^I = \pi^I\left(p_0^I, a_0\right) > 0$ and $a_0 \le \hat{a}\left(p_0^I\right)$. Hence in time period 0, access is induced and firm I's profit is strictly positive. Now define $L_{t+1} = \dfrac{p_{t+1}^I x_t^I + a_{t+1} x_t^E}{p_t^I x_t^I + a_t x_t^E}$ where $x_t^i \equiv x^i\left(p_t^I, a_t + c^E\right), i \in \{I, E\}$. In addition, let $\upsilon_t = p_t^I x_t^I + a_t x_t^E$, firm I's period t revenues from E2E operations and the sale of access. Finally recall that under access, $\pi^I = \left(p^I - c^I - d^I\right)x^I\left(p^I, a + c^E\right) + \left(a - d^I\right)x^E\left(p^I, a + c^E\right) - F^I$.

The regulatory procedure is defined as follows. As in VF, in time period $t + 1$ the regulator observes period t market prices and outputs etc. Then, the regulator defines the set of allowed prices for period $t + 1$ to be the set of E2E/access price vectors $\left(p_{t+1}^I, a_{t+1}\right)$ satisfying

$$L_{t+1} \le 1 - \frac{\pi_t^I}{\upsilon_t} \tag{3}$$

and

$$a_{t+1} \le \hat{a}\left(p_t^I\right). \tag{4}$$

Constraint (3) is a "global" price cap constraint based on a chained Laspeyres index. Constraint (4) requires that the access price not exceed the maximum allowable access price at the previous period's E2E price. We assume that firm I behaves myopically in each time period, selecting $\left(p_{t+1}^I, a_{t+1}\right)$ to maximize π_{t+1}^I subject to constraints (3) and (4). At each step of the procedure, (3) ensures that consumer surplus increases (as long as the previous period's profit is positive) and (4) ensures that the least-cost delivery method for the entrant is access. As in the original VF procedure, convergence depends critically on firm I's ability to find a constrained price vector in each time period that yields non-negative profit. However, our application also requires that this

[4] Strictly speaking, under endogenously determined entry, firm I's zero-profit locus does not actually extend above the ABSL since for E2E/access price combinations in that region, bypass is chosen by the entrant.

price vector satisfy the access pricing constraint $a \le \hat{a}\left(p^I\right)$ in each time period. The following lemmas allow us to establish convergence of the procedure described by (3) and (4) above.

Recall now the inverse demands for $p^E\left(x^I, x^E\right)$ and $p^I\left(x^I, x^E\right)$ where $a\left(x^I, x^E\right) \equiv p^E\left(x^I, x^E\right) - c^E$. Let $p^I(r) \equiv p^I\left(rx^I, rx^E\right)$, $p^E(r) \equiv p^E\left(rx^I, rx^E\right)$ with $a(r) \equiv p^E(r) - c^E$. We make two additional assumptions. Convexity of v ensures that its Hessian matrix H_v is positive semidefinite. We shall adopt a slightly stronger assumption.

A1: H_v is positive definite for p^I, $p^E > 0$.

This assumption implies that v is strictly convex.

We also assume:

A2: There exists $r^0 > 1$ such that $R^I \equiv p^I\left(rx^I, rx^E\right)x^I + a\left(rx^I, rx^E\right)x^E \to 0$ as $r \to r^0$, where $a\left(x^I, x^E\right) \equiv p^E\left(x^I, x^E\right) - c^E$.

Lemma 1: $\dfrac{da}{dr} < 0$.

Proof: The inverse demands satisfy

$$x^I\left[p^I\left(rx^I, rx^E\right), p^E\left(rx^I, rx^E\right)\right] \equiv rx^I$$

and

$$x^E\left[p^I\left(rx^I, rx^E\right), p^E\left(rx^I, rx^E\right)\right] \equiv rx^E .$$

Using the definitions of $p^i(r)$, $i \in \{\mathrm{I}, \mathrm{E}\}$ and differentiating with respect to r yields

$$\frac{\partial x^I}{\partial p^I}\left(\frac{dp^I}{dr}\right) + \frac{\partial x^I}{\partial p^E}\left(\frac{dp^E}{dr}\right) = x^I$$

$$\frac{\partial x^E}{\partial p^I}\left(\frac{dp^I}{dr}\right) + \frac{\partial x^E}{\partial p^E}\left(\frac{dp^E}{dr}\right) = x^E ,$$

implying that

$$\frac{dp^E}{dr} = \frac{x^E \dfrac{\partial x^I}{\partial p^I} - x^I \dfrac{\partial x^E}{\partial p^I}}{\dfrac{\partial x^I}{\partial p^I}\dfrac{\partial x^E}{\partial p^E} - \dfrac{\partial x^I}{\partial p^E}\dfrac{\partial x^E}{\partial p^I}} .$$

The denominator is the determinant of the Hessian of v, which by A1 is positive. Furthermore, the numerator is negative since x^I and x^E are substitutes. Hence, $\dfrac{dp^E}{dr} < 0$, implying that $\dfrac{da}{dr} < 0$ since $a(r) = p^E(r) - c^E$.

Lemma 2: At each step of the procedure defined by (3) and (4), firm I can find an E2E/access price pair for which profit is non-negative and the access pricing constraint is satisfied.

Proof: We have assumed that the procedure is initiated at a point where $\pi_0^I \ge 0$ and $a_0 \le \hat{a}\left(p_0^I\right)$. So without loss of generality, assume

$$\pi_t^I = p^I\left(x_t^I, x_t^E\right)x_t^I + a\left(x_t^I, x_t^E\right)x_t^E - \left(c^I + d^I\right)x_t^I - d^I x_t^E - F^I \ge 0$$

and $a_t \le \hat{a}\left(p_t^I\right)$. The existence of an E2E/access price vector $\left(p^I\left(\bar{r}x_t^I, \bar{r}x_t^E\right), a\left(\bar{r}x_t^I, \bar{r}x_t^E\right)\right)$, $\bar{r} > 1$ satisfying (3) for which profit is non-negative follows from A2 using the same argument as that of Vogelsang and Finsinger (1979). To see that the access pricing constraint is satisfied, note that $a_t = a(1)$ and recall that $a_t \le \hat{a}\left(p_t^I\right)$. By Lemma 1, $a\left(\bar{r}x_t^I, \bar{r}x_t^E\right) \equiv a(\bar{r}) \le a(1) = a_t \le \hat{a}\left(p_t^I\right)$ since

$\bar{r} > 1$ and the ABSL is downward sloping. Thus, $a\left(\bar{r}x_t^I, \bar{r}x_t^E\right)$ also satisfies the period t + 1 access pricing constraint.

Figure 2 provides an illustration. In Figure 2 and the following, we let $T^+ = \left\{\left(p^I, a\right) \mid \pi^I\left(p^I, a\right) \geq 0\right\}$ and the zero-profit locus $T = \left\{\left(p^I, a\right) \mid \pi^I\left(p^I, a\right) = 0\right\}$. Furthermore, we let $A = \left\{\left(p^I, a\right) \mid a \leq \hat{a}\left(p^I\right)\right\}$.

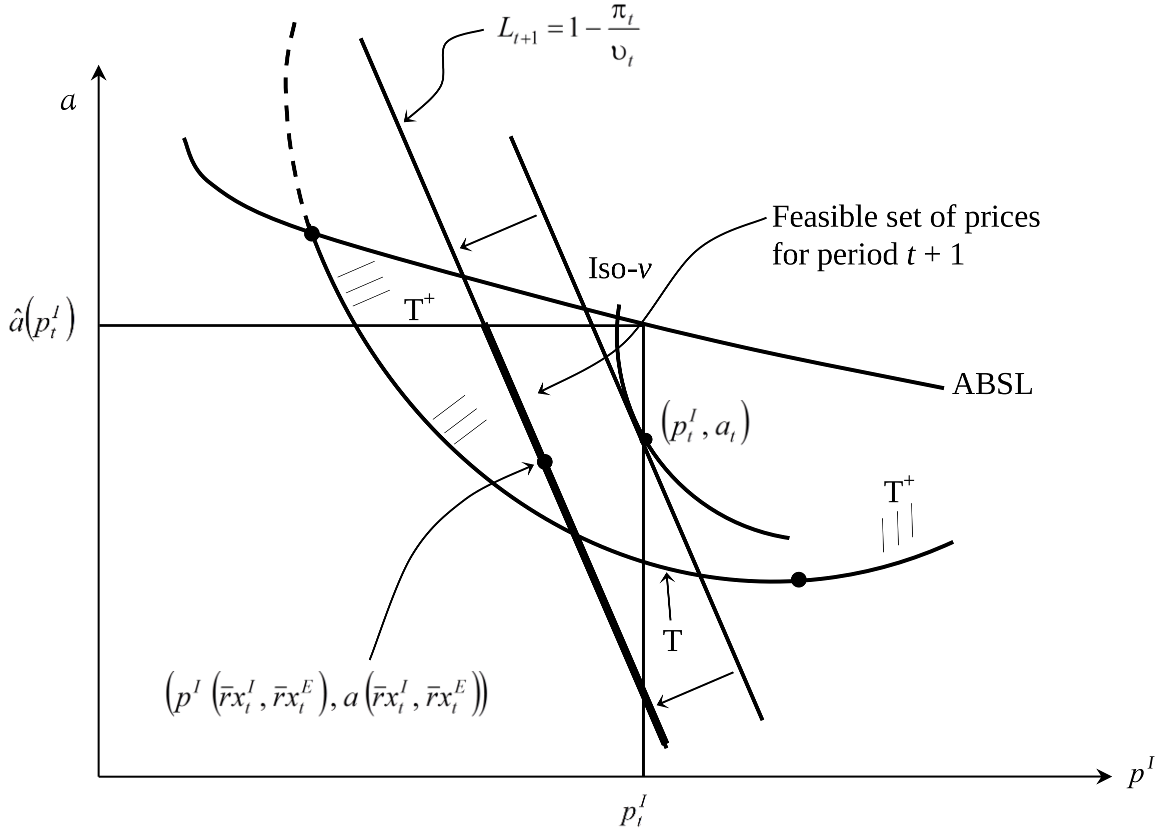

Figure 2

Proposition: Social welfare W increases at each step of the procedure described by (3) and (4). Any convergent subsequence of E2E/access price vectors converges to a critical point of v on $T^+ \cap A$, which is not a welfare minimum.

Proof: Let $\left\{p_t^I, a_t\right\}$ denote the sequence of price vectors generated by (3) and (4). Since $\left\{p_t^I, a_t\right\} \subset T^+ \cap A$, which is compact, $\left\{p_t^I, a_t\right\}$ has at least one convergent subsequence.

Since v is convex, $v_{t+1} \geq v_t + \upsilon_t\left(1 - L_{t+1}\right)$, which implies that consumer surplus is monotonically increasing. Thus $\{v_t\}$ converges (say to $\bar{v}$) since it is bounded above by the global maximum (which exists since $T^+ \cap A$ is compact).

The price cap constraint (3) may be rewritten as $\pi_t^I \leq \upsilon_t(1-L_{t+1})$, so $v_{t+1} \geq v_t + \upsilon_t(1-L_{t+1}) \geq v_t + \pi_t^I \geq 0$ since (maximized) profit is always non-negative. Since $v_{t+1} \to \bar{v}$ and $v_t \to \bar{v}$, $\pi_t^I \to 0$. Thus, if $(\bar{p}^I, \bar{a})$ is a limit point, $\pi^I(\bar{p}^I, \bar{a}) = 0$ and $\bar{a} \leq \hat{a}(\bar{p}^I)$. Furthermore, since $v_{t+1} \geq v_t + \pi_t^I, \pi_t^I \geq 0$ and $\pi_t^E = 0$ for all t, $W_{t+1} = v_{t+1} + \pi_{t+1}^I \geq v_t + \pi_t^I = W_t$. Hence, $(p^I, \bar{a})$ cannot be a welfare minimum.

4. Conclusions and Discussion

Within the context of a single product USP facing competition from a competitive entrant, the Theorem on the Superiority of Access (Crew and Kleindorfer, 2011) implies that from a social welfare standpoint, when the entrant's average delivery cost is greater than the incumbent USP's marginal delivery cost, the incumbent USP should be the provider of delivery services. This result stems from the fact that by channeling the entrant's demands into the USP's delivery network, scale economies in delivery for the USP are exploited. However, when the regulator cannot select the entrant's delivery method, the dependence of the entrant's choice of access versus bypass on E2E/access prices must be accounted for. To promote efficient E2E/access pricing and incentivize socially desirable entry via access within this single-product context, we have demonstrated that the decreasing Laspeyres chain index price capping procedure of Vogelsang and Finsinger (1979) may be adapted in a relatively straightforward manner. Since the USP breaks even at this E2E/access price combination, the USO is fulfilled.

In practice, however, contemporary postal operators offer a wide array of postal products/ services. To yield stronger implications for postal regulatory policy, conditions under which the Theorem on the Superiority of Access (Crew and Kleindorfer, 2011) applies in a multiproduct context must be determined. Under those conditions, a multiproduct analog of our modified VF procedure would be a useful regulatory instrument. However, generalizations of the Theorem on the Superiority of Access and our modified VF procedure to a multiproduct context will be non-trivial. Suppose, for example, that the regulated USP offers a set of n postal products/ services. In this case, a set S consisting of $2^n - 1$ product combinations could be offered by any potential entrant. Several preliminary questions suggest themselves. First, how does an entrant select the set $s \in S$ of product offerings? Second, under what conditions is access welfare superior to bypass for that subset $s \in S$ of products? Third, what deters bypass for that particular subset of products s? Fourth and more generally, given an entrant offering a product set s, (i) for which products in that set is access socially optimal and for which products in the set is bypass socially optimal, and (ii) how can E2E and access prices that promote the socially optimal access/bypass decision in each market simultaneously be implemented? In the single-product case, fixed costs are by definition product specific and bypass is deterred if $a \leq \hat{a}(p^I)$. However, in a multiproduct situation, fixed costs will not in general be product specific. With shared fixed costs, any cost allocation method such as fully distributed costing is arbitrary and hence cannot in general be used to determine conditions sufficient to deter bypass by an entrant offering any subset of the USP's full product set. These and other complex issues must be investigated as regulatory policy that promotes optimal pricing of postal products and revenue sufficiency in the presence of a USO is formulated for the EU and elsewhere.

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