Reforming the Postal Universal Service

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Abstract: The postal sector has undergone dramatic changes over the recent years under the double effect of ongoing liberalization and increased competition with alternative communication channels (e-substitution). As a result, the mail volume handled by the historical operator has declined sharply while the latter's ability to match the same standard of universal service may be under threat. Thus, a reform of the postal universal service is on the agenda. This paper examines possible reforming options ranging from keeping universal service within the postal sector to redefining universal service as spanning postal and electronic technologies.

Keywords: digitalization; postal market; universal service.

JEL codes: L51; L86; L87.

1 Introduction

Whereas the postal sector has a long tradition of providing universal service, its future is now under debate. The recent market liberalization (in Europe) and a growing use of electronic media have both contributed to eroding the mail flow handled by the universal service provider. In most developed economies, volumes are declining. In France, mail volume has declined around 3.5% per year on average since 2007[1] and in the UK, the addressed mail fell by 8% per year between 2011 and 2013 (NAO 2014). These trends are clearly related to the digitalization of the economy and e-substitution. Consumers have alternatives to paper communication: e-mail and telephone replacing personal letters, SMS replacing Season's greetings, on-line billing and business documents, on-line newspapers, e-administration, e.g. for tax statements and payments, on-line advertising, etc.

1 In a mid-term horizon, some expect a decline of 50% of the mail volume.

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In the long run, declining volumes may threaten the sustainability of the universal postal service (Crew and Kleindorfer 2005) and the digitalization of the economy reinforces urge arguments in favor of a reform.

In the postal sector, the universal service is defined along three dimensions (Ambrosini et al. 2006): The product range, service quality and pricing constraints (affordability, uniform pricing). The quality of postal services has multiple aspects including territorial coverage (ubiquity), transit time, accessibility of contact points and delivery frequency. One particularity of the universal postal service is its actual ubiquity. With few exceptions, everyone has a postal address, hence is a user of the postal service, eventually only has a mail recipient.[2]

Reforms of the universal service obligations (USO) are on the agenda almost everywhere, with all three dimensions of the universal service being concerned. First, the range of products covered by the universal service can be reduced. This is for instance the case in the UK, where bulk mail was excluded from the universal service package in 2012. Second, pricing constraints may be relaxed, for instance by removing special rates for certain consumers or by restricting the uniform price constraint to single-piece mail. Finally, the quality of the universal service might be reduced. All the OECD countries have reduced the number of post offices and letter boxes (Schuster 2013), sometimes quite drastically. For instance, there were 18.393 post offices in the UK in 2000 and, there are now 11.780. The geographical coverage can also be reduced by converting door-to-door delivery into community mail box delivery. Projects of this kind exist in Canada and in New Zealand. Reduction in delivery frequency is presumably the most important reform of the USO and several countries have such plans. In the Netherlands where the overall letter volume has dropped 14% between 2005 and 2010, the government plans to reform the USO and is considering dropping the Monday delivery, thus reducing delivery frequency to 5 days. Further reductions to 3 days are also being considered. In the US, the Postal Reform Act of 2013 made the Saturday delivery of letters no longer compulsory for the universal service provider. New Zealand is examining the option of a 3-day-a-week day minimum guaranteed delivery frequency. Such reforms are discussed in this paper. We use a model of competition between technologies to show that larger internet penetration calls for a lighter postal USO, possibly integrated in a larger communication USO.

2 This is in contrast with the universal service in telecommunications where there is a difference between the *availability* and the *use* of the service. For instance, the Universal Service European Directive (2002/22/EC) imposes that a fixed connection to the public phone network be made available to all users on request, independently of geographical location. At the same time, consumers are cutting the cord and recent evidence from the US suggests that, despite a growing offer of services, the universal service is currently declining (Gideon and Gabel 2011).

The Internet nowadays is the postal sector main competitor. But, despite rapid growth, internet remains far from being ubiquitous. In the EU-27, the internet penetration rate (the percentage of households having an internet connection) was 73% in 2011 (Source: Eurostat) with most of the households using a broadband connection (the broadband penetration rate was 68% in 2011). The reasons for the absence of an internet connection are numerous: lack of interest, lack of competence (digital illiteracy), service cost, equipment cost and non-availability of the service in the area (mainly for broadband connections). Indeed, broadband connections are not available everywhere. While metropolitan areas are usually well connected, this is not necessarily the case of rural and less-populated regions where the deployment of infrastructure is more costly.[3,4] Universal internet coverage is a concern and therefore must be taken into account in any reform of the universal service.

We investigate the impact of electronic communications on the *design* of the universal postal service. Given competition from the internet, how should the universal service be reformed? To our knowledge, this question has not yet been treated explicitly even though several authors have focused on the related question of reforming the universal service obligations (hereafter USO) after entry of a postal competitor.[5,6] Crew and Kleindorfer (2006) focusing on the accessibility of contact points argue that the USO should be reduced after entry. The argument is based on economies of scale and scope that can no longer be exploited in a competitive environment. Gautier and Paolini (2011) and Gautier and Wauthy (2012) argue that lightening the universal service is one way of keeping the universal service sustainable in a competitive environment. On the contrary, Calzada (2009) shows that the entry of a low-quality postal competitor with limited territorial coverage and lower delivery frequency improves the quality offered by the incumbent.

In this paper, we consider a model of competition between two communication technologies, the internet and the postal service, each being identified by a unique provider. Internet and postal services compete on two dimensions: territorial coverage and service quality. Broadband connections are not necessarily available everywhere due to high infrastructure costs. In the sequel, we distinguish two regions within the country: a rural and an urban one. Whereas , the

3 This situation is likely to last with the deployment of "next generation access networks" (NGANs) that are currently concentrated in business districts and city centers.

4 The existence of a digital divide between urban and rural regions is now well-documented (Billón et al. 2009; Bouckaert et al. 2010) and can partially be accounted for a lack of infrastructure.

5 The privatization of postal operators has also led to a decline in the quality of the universal service as documented by Schuster (2013).

6 Reforming the telecom USO is also on the agenda, see Alleman et al. (2010).

postal services are ubiquitous, often because the ubiquity constraint is part of the universal service definition, the internet may not cover the rural region.

Quality of communication has several dimensions (security, reliability, speed of delivery, etc). In this paper, we focus but one of them: delivery frequency or equivalently on transit time, upon which the internet has an obvious advantage. Our model differs from Calzada (2009) as we consider that each technology dominates the other in one dimension: the internet allows faster delivery it may not be ubiquitous. In this context, we consider the following question: should the postal USO be reformed as households use increasingly internet rather than postal services for communication? And the reform we consider is a change in delivery frequency. Currently, the universal service imposes delivery on 5 or 6 days per week with, possibly, additional early deliveries for newspapers.[7] When technologies are competing, the internet skims the most profitable customers of the market[8] which results in (1) lower profits for the postal firm because of e-substitution and (2) the remaining clients being those with a low willingness to pay for quality. For these reasons, welfare-maximization calls for a universal postal service of lower quality, and this reducing effect is proportionate to broadband coverage. Reducing delivery frequency is motivated primarily by a lower (average) willingness to pay for quality as those who are the more interested in high-speed communication no longer use postal services. In addition, as competition erodes mail volume and quality is costly to deliver, financial constraints may call for reducing delivery frequency even further.[9]

Next, we show that infrastructure deployment in the rural region may be suboptimal from a welfare viewpoint. We then consider a reformed *communication universal service* that spans the two technologies.[10] In particular, we consider universal coverage obligations for broadband internet.[11] We discuss the conditions for welfare

7 Delivery of newspapers is sometimes included as an additional requirement of the universal service, see Ambrosini et al. (2006).

8 Models of competition between postal firms (Crew and Kleindorfer 2005; De Donder 2006; Billette de Villemeur et al. 2007) have already identified cream-skimming of the markets as a major threat for financing the universal service. Yet, competition from the internet differs from field competition from postal operators at least in two respects. First, postal competition is a competition between firms using similar technologies while internet is a radically different one. Second, while postal competitors offer similar or lower quality products, electronic communications are viewed as higher quality products, at least with respect to the speed of delivery. For these reasons, our model is a model of vertical product differentiation with firms having an asymmetric cost structure.

9 Financial constraints may be partially overcome by creating a universal service fund to share the burden of the universal service between internet and the postal sector.

10 On this point, see the discussion in Jaag and Trinkner (2011).

11 Some countries (notably Switzerland and Finland) have included broadband connection as part of the universal service.

improvement of such a reform. Notice that a communication USO could overcome a regional divide between non-connected and connected areas, redistributive concerns may also be a motivation for implementing a communication USO.

Finally, we consider the possibility for consumers of using both technologies (multihoming) and for the postal firm using the electronic technology as a substitute for parts of the supply chain, e.g. launching hybrid mail services for registered mail.[12] These combinations of technologies by consumers or the firm may limit the necessity to reduce the quality of the USO.

This paper is organized as follows. Section 2 introduces our model and our main assumptions. Section 3 considers the postal USO and Section 4 a broader communication USO. Section 5 analyzes some relevant extensions of our analysis: Multihoming and hybrid mail. Finally, Section 6 presents our conclusions. All the proofs are relegated in the Appendix.

2 Model

2.1 Consumers

We consider a country composed of two regions: a rural and an urban one with subscript u and r, respectively. The rural region is characterized by a higher deployment cost for the broadband infrastructure. The country has a mass of one. There is a mass $n<1$ of consumers in the urban region and a mass $1-n$ in the rural one.

Each customer is characterized by a taste for quality parameter θ. We assume that θ is uniformly distributed on $[\underline{\theta}, \overline{\theta}]$ and $\Delta\theta=\overline{\theta}-\underline{\theta}=1$. Furthermore, we assume that $\overline{\theta}\geq 2\underline{\theta}$ so that $\underline{\theta}\in]0, 1]$. The assumption of identical distribution of willingness to pay is made for keeping the model tractable. In reality, urban areas and business districts are characterized by higher θ than urban areas. The utility of customer of type θ consuming a good of quality x at price p is equal to $U(\theta)=\theta x-p$. Consumers buy one unit of the good when $U(\theta)\geq 0$.

Pricing for internet and postal services is structurally different. For the internet, consumers pay a subscription fee for being connected with a given bandwidth and use is free of additional charges. For postal products, there is no subscription fee but a price per item sent. Our model considers that the price paid to the internet firm is the subscription fee while the price paid to the postal firm is equal to the total expenses for a given and fixed mail volume. In the baseline

12 Hybrid mail uses both the internet and the physical postal network for mail delivery. Hybrid mail is prepared and sent electronically on computers but distributed physically to mailboxes.

model, we do not consider the possibility for consumers to multihome but it will be considered as an extension.

2.2 Firms

There are two firms: firm 1 is the postal operator, firm 2 is the internet provider. Firms provide differentiated services to customers and compete locally in price for consumers.[13] We identify the quality of the service by a unique dimension x, the speed of delivery. The internet offers quality x_2, the postal operator offers services of lower quality $x_1<x_2$, as delivery of messages is instantaneous with internet. Quality x_2 is considered to be exogenous. Quality x_1 is flexible and it can be understood as delivery frequency. Despite its flexibility, the quality offered by the postal firm can vary only within a certain range and we define a lower bound on the quality of postal services. We assume that x_1 must belong to the interval $[\underline{x}_1, x_2]$; the lower boundary is defined hereafter to guarantee that, at equilibrium prices, the market is fully covered.

Assumption 1 $x_1 \geq \underline{x}_1 = x_2(1-\underline{\theta})/(1+2\underline{\theta})$.
To operate in region u, r, firm 2 must deploy its broadband telecommunication network. Infrastructure costs are given by F^u for the urban region and $F^r>F^u$ for the rural one and we set $F^u=0$ and $F^r=F>0$. Once a region is connected, there is no other cost for providing the service.

For the postal operator, the main cost driver is quality (delivery frequency), not mail volume.[14] Delivering mail nationwide at frequency x_1 costs $kx_1^2/2$. As for the internet, the marginal cost of the postal services is set to zero (for convenience).

2.3 Welfare and Universal Service Obligations

We consider that the postal universal service consists in making available to all users a service of given quality x_1 at an affordable rate.[15] More specifically, we

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13 Obviously price competition is a shortcut to encompassing a broader variety of competitive environments. This allows us to discuss competition between technologies using a simple standard model of vertical differentiation.
14 In the postal sector, cost elasticity is usually quite small. Boldron et al. (2007) estimate it at 0.25 for Germany and 0.31 for France. Conversely, the cost is quite sensitive to delivery frequency. In the same paper, Boldron et al. (2007) report the savings associated with a reduction of delivery frequency. They estimate that the French postal operator would reduce its cost by 29% if delivery frequency was reduced to 3 days a week and savings are especially high in low density areas.
15 For the economic motivations for the universal service, see Cremer et al. (2001).

consider that the universal service obligations are made of the following standard requirements:

– Ubiquity: the service must be offered to all consumers, irrespective of their location.
– Affordability: the service must be affordable to all consumers, i.e. the quality-price combination of the universal service provider must satisfy $U(\underline{\theta})\geq 0$.[16]
– Minimum quality: the regulator specifies a minimum quality x_1 for the service.[17]

Note that we do not include any other constraint on the prices than the affordability constraint. Thus, we allow the universal service provider to price discriminate between regions as long as the prices satisfy the affordability constraint. The affordability constraint is thus an upper price limit.

The welfare W is defined as the sum of the consumer surplus and the firms' profits. In this perspective, the prices do not affect welfare directly but only indirectly through the product chosen by consumers. The welfare is defined as:

$$W(\cdot)=n\left(\int_{\underline{\theta}}^{\overline{\theta}}\theta x^{u}(\theta)d\theta\right)+(1-n)\left(\int_{\underline{\theta}}^{\overline{\theta}}\theta x^{r}(\theta)d\theta\right)-\frac{1}{2}kx_1^2-\mu F$$

where $x^i(\theta)\in\{x_1, x_2\}$ is the quality of the product consumed by an agent of taste θ in region $i=u$, r and $\mu\in\{0, 1\}$ is a dummy variable equals to one if the broadband internet is deployed in the rural area. Notice that the welfare function W is concave in x_1. The USO problem is to set the quality level for postal service in order to maximize W subject to the affordability and participation constraints for firms.

In Section 4, we consider a more general communication universal service where the ubiquity constraint is imposed on internet technology. The welfare-maximization problem then is to set the quality of the postal service and the coverage for the internet (represented by the dummy variable μ) subject to participation and affordability constraints. Notice that in this communication USO, there is no affordability constraint for the internet. Indeed, an affordability constraint imposed on both technologies would evict the one offering the lower quality, i.e. the internet USO would replace the postal USO. Rather than that, we consider the communication USO as a mix between the two technologies.

16 This specification of the affordability constraint is similar to Calzada (2009).
17 It is generally acknowledged that a monopolist produces a lower quality than the welfare-maximizing one. Imposing a minimum quality standard may, however, not necessarily be welfare-improving (Crampes and Hollander 1995; Valletti 2000).

2.4 Timing of the Events

We consider the following sequence of decisions:

- The regulator solves the USO problem.
- Unless specified in the USO problem, the internet decides to cover or not the rural region.
- Firms compete in prices, subject to the price constraints specified in the USO.

3 Postal USO

In this section, we first describe the optimal quality of the postal service in the absence of competition from internet. This first case represents the “old age” universal service.[18] Our objective is to assess possible reforms of the USO created by competition between postal and electronic communications. We show that the emergence of electronic communications unambiguously calls for a decrease in service quality.

3.1 Designing a Postal USO in a Non-Competitive Environment

Suppose that the postal technology is the only one available. Thus, the quality level x_2 is not a reference point at all and at all locations, $x^i(\theta)=x_1$. Under the assumption of a fully covered market, the profit realized by firm 1 and the welfare are:

$$\pi_1^m(x_1)=p_1-kx_1^2/2,$$
$$W^m(x_1)=\int_{\underline{\theta}}^{\overline{\theta}}\theta x_1 d\theta-kx_1^2/2.$$

The USO problem is given by:

$$\max_{x_1,p_1} W^m(x_1) \text{ s.t. } p_1\geq\underline{\theta}x_1 \text{ and } \pi_1^m(x_1)\geq 0.$$

Proposition 1 *The optimal quality and price for a postal USO are defined by* $x_1^m=\min\left\{\frac{1+2\underline{\theta}}{2k},\frac{2\underline{\theta}}{k}\right\}$ *and* $p_1^m=\underline{\theta}x_1^m$.

18 In Europe, the universal service obligations were defined in a directive dating back to 1997 and most of the Member States imposed delivery frequency long before the development of electronic communications.

Proposition 1 defines the welfare-maximizing USO quality when the postal technology is the only one available. It results from a trade-off between the average valuation of quality and the marginal cost of providing quality.[19] Our aim is to compare this level of quality with the optimal quality when the postal service and the internet are competing with each other.

3.2 Designing a Postal USO in a Competitive Environment

Consider the case in which firms and technologies compete and solve again the USO problem. We solve the game backward identifying first the market prices when firms compete, next the decision of firm 2 to cover the rural region (i.e. here $\mu \in \{0, 1\}$ is a control variable for firm 2) and last the welfare-maximizing USO level. As a universal service provider, firm 1 has to respect the ubiquity constraint as well as provide minimal quality everywhere. Yet, we allow firm 1 to price discriminate between regions as long as the affordability constraint is satisfied. This implies that we can solve the price game independently in each region.

3.2.1 Price Game

Suppose that the broadband is available in both regions u and r. Firm 2 skims the market and the demands addressed to each firm in region $i=u, r$ are

$$D_1^i(p_1^i, p_2^i)=n_i(\hat{\theta}^i-\underline{\theta}) \text{ and } D_2^i(p_1^i, p_2^i)=n_i(\overline{\theta}-\hat{\theta}^i),$$

where $\hat{\theta}^i=\dfrac{p_2^i-p_1^i}{x_2-x_1}$ is the indifferent consumer between quality x_1 at price p_1^i and quality x_2 at price p_2^i. Profits then write

$$\pi_1=p_1^r D_1^r(p_1^r, p_2^r)+p_1^u D_1^u(p_1^u, p_2^u)-kx_1^2/2 \text{ and } \pi_2=p_2^r D_2^r(p_1^r, p_2^r)+p_2^u D_2^u(p_1^u, p_2^u)-F.$$

For given qualities x_1 and x_2, the profit maximizing prices are equal in each regions and given by:

$$p_1^*=\frac{1-\underline{\theta}}{3}(x_2-x_1),\ p_2^*=\frac{2+\underline{\theta}}{3}(x_2-x_1). \tag{1}$$

19 A profit-maximizing firm would trade-off the marginal quality – which is lower than the average quality – with marginal cost. For this reason, the minimum quality obligation imposed in the USO is binding.

At these prices, the indifferent consumer is characterized by $\hat{\theta}^i=\theta^*=\frac{1+2\underline{\theta}}{3}$ and equilibrium qualities entail for each $i=r, u$, $x^h(\theta)=x_1$ when $\theta\leq\theta^*$ and $x^h(\theta)=x_2$ otherwise.

Assumption 1 guarantees that, for all x_2 and $x_1\in[\underline{x}_1, x_2]$, the market is fully covered at equilibrium prices (p_1^*, p_2^*) and that the equilibrium prices defined above are the unique Nash equilibrium in the price game (Wauthy 1996). Notice that under Assumption 1 the price p_1^* satisfies the affordability constraint.

If the broadband is not installed in region r, then the postal firm charges the affordable price $p_1=\underline{\theta}x_1$ in this region, so that $x^r(\theta)=x_1$ for all θ; $x^u(\theta)=x_1$ when $\theta\leq\theta^*$ and $x^u(\theta)=x_2$ otherwise.

3.2.2 Broadband Coverage Decision

We now turn to the coverage decision of firm 2. Given that $p_2^*D_2(p_1^*, p_2^*)>0$, firm 2 is always active in the urban region. If firm 2 covers both regions [Full Coverage (FC), $\mu=1$], its profit is

$$\pi_2^f(x_1)=(\overline{\theta}-\theta^*)p_2^*-F.$$

If it only covers the urban region [Partial Coverage (PC), $\mu=0$] its profit is:

$$\pi_2^p(x_1)=n(\overline{\theta}-\theta^*)p_2^*.$$

Firm 2 will cover the rural market if $\pi_2^f(x_1)\geq\pi_2^p(x_1)$. The coverage of the rural region depends on whenever $F\leq F^*(x_1)$ where $F^*(x_1)=(1-n)\frac{(2+\underline{\theta})^2}{9}(x_2-x_1)$. Notice that if $F>F^*(\underline{x}_1)$ then firm 2 never finds it profitable to cover the rural market.

3.2.3 USO Design

Let us first define the welfare and firm 1 profit under Full Coverage (i.e. $\mu=1$):

$$W^f(x_1)=\int_{\underline{\theta}}^{\theta^*}\theta x_1 d\theta+\int_{\theta^*}^{\overline{\theta}}\theta x_2 d\theta-kx_1^2/2-F$$
$$\pi_1^f(x_1)=(\theta^*-\underline{\theta})p_1^*-kx_1^2/2,$$

and Partial Coverage (i.e. $\mu=0$):

$$W^p(x_1)=n\left(\int_{\underline{\theta}}^{\theta^*}\theta x_1 d\theta+\int_{\theta^*}^{\overline{\theta}}\theta x_2 d\theta\right)+(1-n)\int_{\underline{\theta}}^{\overline{\theta}}\theta x_1 d\theta-kx_1^2/2$$
$$\pi_1^p(x_1)=n(\theta^*-\underline{\theta})p_1^*+(1-n)\underline{\theta}x_1-kx_1^2/2.$$

The USO problem is then piecewise

$$\max_{x_1}\begin{cases} W^f(x_1) \text{ s.t. } F\leq F^*(x_1) \text{ and } \pi_1^f(x_1)\geq 0 \\ W^p(x_1) \text{ s.t. } F\geq F^*(x_1) \text{ and } \pi_1^p(x_1)\geq 0 \end{cases} \tag{2}$$

Let us first formally define the unconstrained welfare maximizing qualities as:

$$x_1^f = \arg\max_{x_1} W^f(x_1) = \frac{(1-\underline{\theta})(5\underline{\theta}+1)}{18k},$$
$$x_1^p = \arg\max_{x_1} W^p(x_1) = \frac{n(1-\underline{\theta})(5\underline{\theta}+1)+9(1-n)(1+2\underline{\theta})}{18k}.$$

Comparing these qualities, it is easy to establish that, for $n>0$, $x_1^f < x_1^p < x_1^m$. The unconstrained welfare maximizing quality trades-off the average value of postal services for the postal users with the cost of providing it. As the average users' valuation for postal service decreases with broadband penetration, so do optimal qualities. But financial constraints for the postal firm should also be taken into account. Comparing the USO problem when technologies compete (2) with the benchmark case defined in Proposition 1 we can establish that:

Proposition 2 *The optimal quality for a postal USO decreases in a competitive market compared to the non-competitive case. Furthermore, the optimal quality for a postal USO decreases with internet coverage.*

The consumer's average value for the quality of postal services decreases because the internet skims the high valuation consumers in the regions where it operates. Consequently, the unconstrained welfare maximizing quality for the universal service unambiguously decreases when the two technologies are competing. This effect is stronger when internet has a full coverage. But, the optimal quality is either at the welfare-maximizing level or at the highest sustainable level. But as, $\pi_1^f(x_1)\leq\pi_1^p(x_1)\leq\pi_1^m(x_1)$, any quality level that is sustainable under FC is also sustainable under PC and any quality sustainable under PC is also sustainable in the non-competitive case. In other words, financial constraints are strongest under FC. When combining the two effects, the optimal USO quality decreases.

This Proposition demonstrates that the emergence of new communication technologies calls for lower quality for the universal postal service. This quality reduction results from a combination of lower willingness to pay for the quality of postal services and more severe financial constraints in a competitive environment. Indeed, the welfare-maximizing quality trades off consumer willingness to pay and the cost of providing quality. As a proportion of the high-valuation consumers abandon paper communications for digital ones, consumer willingness pay for quality declines while the cost of providing quality is left unchanged. Thus, welfare maximization calls for a reduction of service quality. But on top of that, competition erodes the profits of the postal firm and there are quality levels that were sustainable in the benchmark case that are no longer sustainable under competition. Quality may thus be reduced below the welfare-maximizing level to guarantee the financial viability of the universal service. These two elements concur to lower the optimal quality level in a competitive environment.

4 Welfare Analysis and Communication USO

Our central proposition establishes that the digitalization of the economy calls for a reform of the universal postal service and that such a reform is not only motivated by financial constraints (as it is often argued). The reduction of service quality depends on the firm's decision to cover or not the rural region with broadband internet. We now turn to this question and, in particular, we are interested in a possible conflict between the firm and the regulator regarding the decision to cover or not the rural region.

4.1 The USO Problem

To address this problem, we put aside the USO funding issues[20] so we impose additional restrictions on the parameters.

Assumption 2 $\pi_1^f(x_1^f)\geq 0$ and $\pi_1^p(x_1^p)\geq 0$.
Under Assumption 2, each unconstrained quality level is feasible. The regulator just needs to choose which to implement in order to maximize welfare, i.e. the problem (2) reduces to a simple binary choice $x_1=x_1^p$ and $\mu=0$ or $x_1=x_1^f$ and $\mu=1$. The solution x_1^f is implementable if $F\leq\Phi^f$ where $\Phi^f=F^*(x_1^f)$. Likewise the solution x_1^p is implementable if $F\geq\Phi^p$ where $\Phi^p=F^*(x_1^p)$. As the function $F^*(x_1)$ is decreasing in x_1 and $x_1^f<x_1^p$, then $\Phi^p<\Phi^f$. Hence for $F\in[\Phi^p, \Phi^f]$, both the PC and the FC unconstrained solutions are implementable.

20 So far we consider that the universal service is exclusively financed by the postal firm. To mitigate that problem, the burden of the universal service might be shared between the two technologies. In general, a universal service fund relaxes the financial constraints and allows the postal firm to deliver higher quality.

To compare welfare under PC and FC, let us define by Φ the value for the fixed cost F solving $W^f(x_1^f)=W^p(x_1^p)$. For $F\geq\Phi$, the fixed cost is so high that partial coverage is preferred by the regulator. Conversely, for $F<\Phi$, full coverage is preferred. However these decisions are conditioned by the internet coverage decision at the next stage of the game.

Indeed if $\Phi\in[\Phi^p, \Phi^f]$, then (*i*) for $F\in[\Phi^p, \Phi]$, $W^f(x_1^f)\geq W^p(x_1^p)$ and $\pi_2^f(x_1^f)\geq\pi_2^p(x_1^f)$ and *(ii)* $F\in[\Phi, \Phi^f]$, $W^p(x_1^p)\geq W^f(x_1^f)$ and $\pi_2^p(x_1^p)\geq\pi_2^f(x_1^p)$, i.e. there is no conflict between the firm and the regulator in which case there is no room for an additional regulatory intervention. The optimal quality x_1^f for $F<\Phi$ and x_1^p for $F>\Phi$ induces the welfare maximizing coverage decision by firm 2.

But this result holds true if $\Phi\in[\Phi^p, \Phi^f]$. If Φ lies outside this interval, optimal coverage may not be chosen by the firm. In particular, if $\Phi>\Phi^f$, for fixed costs parameters $F\in[\Phi^f, \Phi]$, we have $W^f(x_1^f)\geq W^p(x_1^p)$ and $\pi_2^p(x_1^f)\geq\pi_2^f(x_1^f)$, i.e. a *conflict* between the regulator and firm 2.[21] For a USO level x_1^f, the former prefers full coverage while the latter prefers to cover only the urban region. The following diagram (Figure 1) illustrates this conflict.

We now focus on the potential conflicting situations that arise when $\Phi>\Phi^f$. Analyzing this condition, we identify parameter ranges for which this condition holds true.

Lemma 1 *There exists* $\hat{n}<1$ *such that for* $n>\hat{n}$, $\Phi>\Phi^f$.

In the remaining part of the analysis, we consider the case where the urban region is large and the regulator and the firm are in conflicts over coverage. To solve this conflict, the regulator can induce firm 2 to cover the rural market by making

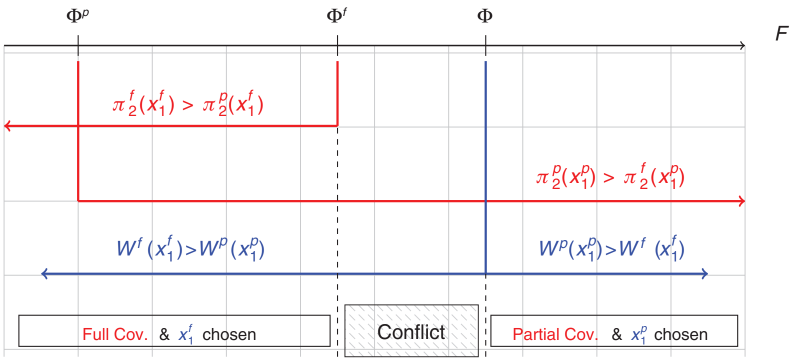

Figure 1: Diagram. Firm 2 in Red, Regulator in Blue.

21 The last configuration $\Phi<\Phi^p$ does not exist whenever $\Phi^p>0$.

this option more attractive. For that, the optimal USO quality must be given by the constraint $F=F^{*}(x_1)$, the quality level solving this equation $x_1^{*}(F)$ is smaller than x_1^{f}. By reducing the USO quality, the regulator inflates the firm's profit (by the principle of maximum differentiation) and changes its coverage decision. This strategy has two caveats. First, reducing quality reduces the welfare as $W^{f}(x_1^{*}(F))$ goes below $W^{p}(x_1^{p})$ for some fixed cost values near Φ. Second, it is not possible to reduce x_1 below the minimum quality level $\underline{x}_1$. For these reasons, we explore another alternative, which we call a communication USO.

4.2 Communication USO

To provide high-quality service nationwide, the regulator could enlarge the scope of the USO so as to include both technologies: the postal and the digital ones. In this section, we consider a more broadly defined communication USO that spans the universal service obligations to the internet technology. In particular, we focus on the imposition of a universal coverage constraint on the internet to force the deployment of broadband networks in the rural areas.[22] This is particularly relevant when infrastructure deployment is welfare improving but not the preferred choice of the firm because the commercial viability of the infrastructure is not guaranteed. Network financing is the key issue and it can be organized with subsidies from urban users or subsidies from taxpayers (public funds).[23] In the scenario considered here, the regulator requires that the internet be ubiquitous, without withholding its commercial freedom and that infrastructure cost be self supported, i.e. excluding public funding.

A communication USO is a way of relaxing the financial constraint and to facilitate broadband coverage. With the obligation to cover the urban region, firm 2 realizes a positive profit if $\pi_2^{f}(x_1)\geq 0$. Or equivalently if $F\leq \hat{F}^{*}(x_1)$ where

22 In the model, we consider that access to internet in the rural area is a binary while in reality, there are different infrastructure qualities in different areas. Whereas accessibility may not be the main concern, connection quality definitely is and a communication USO may then specify a minimum quality for the infrastructure in rural areas.

23 In Finland, the government has launched a broadband project to connect all citizens, including those living in sparsely-populated areas, to the Internet with fast fibre-optic or cable networks by 2015. The government has decided to make a 100 Mbit/s broadband connection a legal right by the end of 2015 and connections should be offered at a reasonable price. It is expected that telecommunication operators will construct fast connections in densely-populated areas. Public funding will be provided to projects that are not commercially viable in sparsely populated areas. More than 100 million euros of public subsidies will be necessary to carry out this project.

$\hat{F}^*(x_1)=\frac{(2+\underline{\theta})^2}{9}(x_2-x_1)$. With the communication USO, it is possible to finance infrastructure in the rural region with subsidies from the urban one while in the postal USO, infrastructure in the rural region should be self supported. This implies that $\hat{F}^*(x_1)>F^*(x_1)$, that is, higher infrastructure cost could be funded.

Now the coverage control $\mu\in\{0, 1\}$ in the hands of the regulator so the communication USO problem can be stated as:

$$\max_{\mu\in\{0,1\},x_1} \mu W^f(x_1)+(1-\mu)W^p(x_1)$$
$$\text{s.t.}\ \mu(\hat{F}^*(x_1)-F)\geq 0 \ \text{ and } \ \mu\pi_1^f(x_1)+(1-\mu)\pi_1^p(x_1)\geq 0$$

Indeed strictly speaking, communication USO are imposed whenever it is optimal for the regulator to set $\mu^*=1$ whereas they are unfeasible by lack of industrial funds so $\mu^*=0$ and a postal USO with partial coverage and USO quality level x_1^p is implemented by default. Hence under Assumption 2, it is optimal to set $\mu^*=1$ whenever $W^f(x_1^f)\geq W^p(x_1^p)$ with $F\leq\hat{F}^*(x_1^f)$, that is implementing a communication USO is optimal.

Let us denote $\hat{\Phi}^f=\hat{F}^*(x_1^f)$ where $\hat{\Phi}^f>\Phi^f$, and $\Phi^*=\min\{\Phi, \hat{\Phi}^f\}$, in the following lemma we provide the full solution of the communication USO problem.

Lemma 2 *There exists a value of* $\hat{\Phi}$ *of the fixed cost, such that, under Assumption* 2, *the solution of the communication USO problem entails:* (*i*) *when* $F<\Phi^*$ *then* $\mu^*=1$ *and* $x_1^*=x_1^f$, (*ii*) *when* $F\in[\Phi^*, \hat{\Phi}]$ *then* $\mu^*=1$ *and* $x_1^*=\hat{x}_1^*(F)$ (*iii*) *finally when* $F>\hat{\Phi}$ *then* $\mu^*=0$ *and* $x_1^*=x_1^p$. *The quality level* $\hat{x}_1^*(F)$ *is defined as the solution of* $\hat{F}^*(x_1)=F$ *and equals* $\hat{x}_1^*(F)=x_2-9F/(2+\underline{\theta})^2$.

Simply, one can see from Lemma 2, that communication USO allows the regulator to implement a full coverage for higher levels of the fixed cost F as with postal USO. One can also prove that this might be welfare improving. Indeed, as we focus on the communication USO decision of the regulator (as given in Lemma 2), we can state the following proposition.

Proposition 3 *If* $n>\hat{n}$, *then imposing a communication USO is welfare improving for* $F\in[\Phi^f, \Phi^*]$.

When the regulator defines a lighter version of the USO for the internet, it relaxes the financial constraint which allows broadband full coverage in all regions. Of course this can be done in a profitable way for the entire society if the coverage fixed cost is not too high and the rural region not too large. Indeed, when the fixed cost is low, communication USO are not needed as the internet provider may find an interest to cover the rural regions. When it is too high, it may be optimal to hold postal USO which are leading to higher postal quality and to profit from higher competitive pressure between technologies. In between, communication USO are welfare improving as full coverage is not self-enforced by the market but is preferable from a social point of view. Of course this amounts to degrading postal quality though not as much as if postal USO were implemented.

4.3 Redistributive Concerns

In the previous analysis, the main motivation for a communication USO is welfare maximization. In our model, preferences are quasi-linear and the planner is utilitarian so that prices only affect welfare as far as they affect which good is purchased by whom. The planner does not take into account how the total surplus is distributed among firms and various types of customers. Redistribution, however, is often put forward as a main motivation for imposing USO (see Cremer et al. 2008).

In our setting, if there is only partial coverage by the internet, rural and urban consumers are not equally affected by the proposed reform of the USO. Reducing delivery frequency in the postal USO would affect users differently. Clearly, those living in the rural area would certainly be worse off if quality declined, given that, subject to the affordability constraint, welfare increases with quality. The service offered to them is of lower quality and leaves no option to buy the higher quality one. The impact on those living in the urban area is not clear-cut compared to the non-competitive case as some use higher quality and others lower service quality. Still, urban consumers are certainly better off than rural ones. Not only do they have access to the high quality technology (the internet), they are also charged a lower price for postal services. Hence, between the two areas we observe a regional divide which was not present without competition between the two services. So, redistributional concerns between regions might be another motivation for enlarging the scope of the USO and defining a communication USO that would allow the two regions to have an equal access to both technologies.

5 Extensions

In this section, we extend the analysis in two dimensions. First, we enrich the model by allowing for multihoming, i.e. taking into account the fact that consumers usually purchase both postal and digital services. Second, we study the possibility that hybrid mails can be sold by the postal firm, combining the two technologies to improve the service quality at a lower cost, especially in the rural region. For these extensions, we assume that the internet does not cover the rural region (μ=0).

5.1 Multihoming

In the preceding analysis, we considered that consumers single-home, as clients of either the internet or the postal service. In this section, we introduce the possibility to multihome i.e. being a client of both services. Following the analysis of Gabszewicz and Wauthy (2003), we define as x_3, the value of the joint purchase option and assume that $x_2 \le x_3 \le x_2 + x_1$. In our model, the quality of postal services is endogenous and it is therefore natural to consider that the value of the joint purchase option increases with the quality of the postal services.

The utility of a consumer that multi-homes is given by:

$$U(\theta) = \theta x_3 - p_1 - p_2.$$

With this joint purchase option, the set of consumers is partitioned in three subsets: customers with type $\theta \in [\underline{\theta}, \hat{\theta}]$ single home at the postal service, customers with $\theta \in [\hat{\theta}, \hat{\hat{\theta}}]$ single home at the internet service and customers with type $\theta \in [\hat{\hat{\theta}}, \overline{\theta}]$ multihome. The customer with type $\hat{\hat{\theta}}$ is indifferent between the joint purchase option and the internet exclusively and is formally defined as $\hat{\hat{\theta}} = p_1 / (x_3 - x_2)$. The joint purchase option does not drive additional clients to the internet and the profit of the internet firm continues to be defined by $\pi_2^f(x_1)$. The postal firm increases its customer basis and its profit is now defined by

$$\pi_1^{mh} = n((\overline{\theta} - \hat{\hat{\theta}}) + (\hat{\theta} - \underline{\theta}))\, p_1^u + (1-n)\, p_1^r - kx_1^2 / 2. \tag{3}$$

Multihoming changes the nature of competition between firms. Rather than an exhaustive analysis, we focus on the impact on the welfare maximizing quality of the postal service when the joint purchase option is available. We can show that there exists a set of values for x_3 for which the joint purchase option calls for a better quality universal service.

Proposition 4 *There exists $\eta_2 > \eta_1 > 0$ such that for $x_3 \in [x_2 + \eta_1, x_2 + \eta_2]$, the quality of the universal postal service increases compared to the standard competitive case given in Proposition 2 and for $x_3 < x_2 + \eta_1$, the quality is equivalent to the standard competitive case.*

Multihoming means that postal and electronic communications are viewed by some of the customers at the upper tail of the distribution, not just as substitutes but also as complementary services. Competition between firms is affected. In particular, the postal firm now attracts consumers with a high valuation of quality provided that the additional quality of the postal services for the multihomers, measured by the difference x_3-x_2, is high enough compared to the service price.

If the joint purchase option has little value ($x_3<x_2+\eta_1$), it is too costly for the postal firm to attract the high valuation consumers and the joint purchase option is not used at equilibrium. For higher values of x_3, competition drives down prices, increases the number of postal customers and, importantly, increases the postal firm's profit compared to the standard competitive case. Thus, multihoming increases customer average willingness to pay for postal services and relaxes the firm's financial constraints. These reasons account for the increasing of the optimal quality of the universal postal service.

When x_3 increases further, products are becoming more differentiated and competition raises prices compared to the standard competitive case. The number of multihomers increases but the number of single homers at the postal firm decreases making it difficult to assess the impact on the average willingness to pay for postal services.

5.2 Technological Mixed USO: Hybrid Mail

In this section, we study the possibility of combining technologies to provide the universal service. We consider the case of hybrid mails where the postal network is used to distribute electronic media. A hybrid mail is prepared electronically, printed out and converted to a physical letter delivered to mailboxes.[24] There already exist hybrid mail platforms for registered and commercial mails as well as for postcards and greeting cards prepared on a smartphone, and this type of mail is likely to expand in future. By combining the two technologies, hybrid mail can be used to provide higher quality service at a lower cost, especially in the rural region.

Hybrid mail is a technological mix between the postal service and the internet, the quality of which depends on that of the two components. Let us define the quality of hybrid mail as y and assume that $y=\phi(x_2, x_1)$ where $\nabla\phi(x_2, x_1)>0$, with $\phi(0, 0)=0$ and $\phi(x_2, x_1)\leq x_2$ for all $x_1\leq x_2$. For the sake of simplicity and tractability we assume a linear technology $\phi(x_2, x_1)=\alpha x_2+x_1$ where the hybridity parameter α is exogenously picked up in $]0, \alpha^o[$; the upper bound α^o guarantying that $y<x_2$ for all admissible values of x_1.

24 Reverse hybrid mail is prepared physically but stored and distributed electronically. Reverse hybrid mail is not considered in this paper.

For hybrid mail, all upstream activities (preparation, collection and sorting) are performed electronically but delivery to mailboxes remains physical. The costs of the delivery network remain unchanged. Upstream activities are performed at zero cost by commercial firms. In our formulation, hybrid mail enables the postal operator to deliver a quality postal service at a lower cost.

Firms compete on the urban markets and the postal operator is the only service provider in the rural ones. The competitive setting is very close to our standard competitive case up to the quality mix. And some regular analogies can be derived. Profits are now given by:

$$\pi_2 = n(\overline{\theta} - \hat{\theta})p_2,$$
$$\pi_1 = n(\hat{\theta} - \underline{\theta})p_1^u + (1-n)p_1^r - kx_1^2/2,$$

where $\hat{\theta} = \frac{p_2 - p_1}{x_2 - y} = \frac{p_2 - p_1}{(1-\alpha)x_2 - x_1}$ is the now indifferent consumer between quality y at price p_1 and quality x_2 at price p_2.

Equilibrium prices are given by:

$$\hat{p}_1^u = \frac{1-\underline{\theta}}{3}((1-\alpha)x_2 - x_1),\ \hat{p}_2^u = \frac{\underline{\theta}+2}{3}((1-\alpha)x_2 - x_1) \text{ and } \hat{p}_1^r = \underline{\theta}(\alpha x_2 + x_1).$$

and these prices satisfy the affordability constraint for all $x_1 \geq x_1$. Hybrid mail is cheaper than traditional mail in the urban area because its improved quality is more than compensated by increased competition between the two products that are closer substitutes. For the same reason, the internet is also cheaper. In the rural area, hybrid mail is more expensive than traditional mail because the improved quality is not compensated by a market competition effect.

The equilibrium profits of the firms and are given by

$$\pi_1^h(x_1) = \pi_1^p(x_1) + H\alpha x_2 \text{ and } \pi_2^h(x_1) = \pi_2^p(x_1) - \frac{n}{9}(2+\underline{\theta})^2 \alpha x_2$$

where $H = (1-n)\underline{\theta} - n(1-\underline{\theta})^2/9$ and levels of profits $\pi_j^p(x_1)$, for $j=1, 2$ are defined in Section 3.2. One can directly see that hybrid mail is dissipating the profit of the internet provider due to increased competition, i.e. $\pi_2^h(x_1) \leq \pi_2(x_1)$. For the postal firm, the improved technology has two opposite effects. On the one hand, competition on the urban market is exacerbated because products are closer substitutes. On the other hand, the postal operator delivers higher quality and it can value that on the rural market. Formally, if $H \leq 0$, the postal firm has a lower profit for any delivery frequency x_1. This condition holds true if $n \geq \tilde{n} = 9\underline{\theta}/(7\underline{\theta} + \underline{\theta}^2 + 1)$, i.e. when urban market is large.

By linearity of the hybrid mail technology, the welfare can be written as

$$W^h(x_1)=W^p(x_1)+\left[n\int_{\underline{\theta}}^{\hat{\theta}}\theta d\theta+(1-n)\int_{\underline{\theta}}^{\overline{\theta}}\theta d\theta\right]\alpha x_2 \tag{4}$$

so that the maximizing postal quality is still given by x_1^p. The optimal quality for the postal service included in hybrid mail is equal to the standard competitive one. So the only channel through which hybrid mail impacts the postal USO is the profit constraint. If $H>0$, then hybrid mail increases the postal firm's profit and it can make the universal service more sustainable, i.e. the regulator can finance higher quality services. Conversely if $H<0$, then hybrid mail is an additional constraint that increases competition and makes the universal service more difficult to sustain.

6 Concluding Remarks

In this paper, we show that the emergence of electronic communications calls for a reform of the universal postal service such as to reduce service quality. In the postal case, this means providing a service with lower delivery frequency. It is often mentioned that the universal service constraint should be relaxed because increased competition reduces the possibility of financing the USO. We rather demonstrate that the primary reason for reforming the USO is evolving consumer habits resulting in a lower willingness to pay for the service. In addition, financial constraints may require a reform on a larger scale.

If the market does not provide all citizens with the services because firms do not find it profitable to deploy infrastructure in sparsely populated areas, then it might be welfare improving to develop a new universal service that integrates both the postal and the internet technologies. Considering the option of having a communication USO, we show that additional constraints imposed on the internet such as a universal coverage goes hand in hand with lower quality for the postal USO. In other words, the two versions of the universal service can be seen both in terms of substitute and complement. As substitute in that electronic communications reduce the need of a next-day delivery for postal services; as complement in that the two technologies are used together to define a new universal service.

Appendix

Proof of Proposition 1. Differentiating $W^m(x_1)$ w.r.t. to x_1 and finding the root leads to $x_1=(1+2\underline{\theta})/(2k)$. This solution is optimal as long as $\pi_1^m((1+2\underline{\theta})/2k)\geq 0$, i.e. whenever $\underline{\theta}\geq\frac{1}{2}$. When $\underline{\theta}<\frac{1}{2}$, the profit constraint binds $\pi_1^m(x_1)=0$ so $x_1=2\underline{\theta}/k$. Hence $x_1^o=\frac{1}{k}\min\{(1+2\underline{\theta})/2,\ 2\underline{\theta}\}$. ■

Proof of Proposition 2. *First*, let us consider the USO problem (2) and compare the unconstrained welfare maximizing qualities as given in the text and defined by the first order condition $\partial W^j(x_1^j)/\partial x_1=0$, for each $j=f, m, p$. Indeed,

$$x_1^p-x_1^f=\frac{1}{18k}(1-n)(2+\underline{\theta})(4+5\underline{\theta})>0 \text{ and } x_1^m-x_1^p=\frac{1}{18k}n(2+\underline{\theta})>0.$$

Hence whenever the constraints in (2) are slack, we have the ranking: $x_1^m>x_1^p>x_1^f$, for all $n>0$. *Second*, consider cases where unconstrained welfare maximizing qualities are non admissible so that the corresponding profit constraints are binding. As for each $j=f, m, p$, the welfare $W^j(x_1)$ and the profit $\pi_1^j(x_1)$ are quadratic strictly concave functions of x_1, then it is optimal to implement the constrained quality level $\tilde{x}_1^j=\arg\{x_1:\pi_1^j(x_1)=0\}$ if this first order condition is verified

$$\frac{\partial W^j(\tilde{x}_1^j)}{\partial x_1}+\lambda\frac{\partial \pi^j(\tilde{x}_1^j)}{\partial x_1}=0$$

where $\lambda>0$ is the Khun-Tucker multiplier associated to the constraint $\pi_1^j(x_1)\geq 0$ considered as binding. But by definition $W^j(x_1)=Z^j(x_1)+\pi^j(x_1)$ where $Z^j(x_1)$ is the sum of the consumers' surplus and the firm 2 profit. Hence, $\partial W^j(x_1)/\partial x_1=\partial Z^j(x_1)/\partial x_1+\partial\pi_1^j(x_1)/\partial x_1$, and one can check that $\partial Z^j(x_1)/\partial x_1>0$ for all admissible x_1 and $n>0$:

$$\frac{\partial Z^m(x_1)}{\partial x_1}=\frac{1}{2};\ \frac{\partial Z^f(x_1)}{\partial x_1}=\frac{1}{6}(1-\underline{\theta}^2) \text{ and } \frac{\partial Z^p(x_1)}{\partial x_1}=\frac{1}{2}-\frac{n}{6}(2+\underline{\theta}^2)>0$$

As a result, at $x_1=\tilde{x}_1^j$, necessarily $\partial\pi_1^j(\tilde{x}_1^j)/\partial x_1<0$ and $\partial W^j(\tilde{x}_1^j)/\partial x_1>0$, which, by concavity of $W^j(x_1)$ proves that $\tilde{x}_1^j<x_1^j$ for each $j=f, m, p$. *Third,* we show that $\pi_1^m(x_1)>\pi_1^p(x_1)>\pi_1^f(x_1)$ for all $x_1\geq\underline{x}_1$. Indeed, let the function of x_1, $\delta(x_1)=\underline{\theta}x_1-\frac{1}{9}(x_2-x_1)(1-\underline{\theta})^2$ then one can easily see that $\pi_1^m(x_1)-\pi_1^p(x_1)=n\delta(x_1)$ and $\pi_1^p(x_1)-\pi_1^f(x_1)=(1-n)\delta(x_1)$. Moreover as

$\delta(\underline{x}_1)=\frac{1}{3}x_2\underline{\theta}(2+\underline{\theta})(1-\underline{\theta})/(1+2\underline{\theta})>0$ and $\delta'(x_1)=\frac{1}{9}(1+7\underline{\theta}+\underline{\theta}^2)>0$, this proves that $\delta(x_1)>0$, $\forall x_1\in[\underline{x}_1, x_2[$. As a result, if the optimal quality is chosen as the PC profit constraint binds, i.e. $x_1=x_1^p$ then necessarily at this quality level $\pi_1^m(x_1)>0$ so that unconstrained welfare maximizing quality for the non-competitive case is admissible we just have seen that $\tilde{x}_1^p<x_1^p<x_1^m$. Same argument holds if the FC profit constraint binds, i.e. $\tilde{x}_1^f<x_1^f<x_1^m$. If the profit constraints binds in the non-competitive case, (i.e. $x_1^m=2\underline{\theta}/k$), then profit constraints bind in all cases. *Finally*, just notice that is the fixed cost constraint is binding alone, that is $F=F^*(x_1)$ or equivalently $x_1=x_1^*(F)$ with $x_1^*(F)=x_2-\frac{9F}{(1-n)(2+\underline{\theta})^2}$, then $W^f(x_1^*(F))\geq W^p(x_1^*(F))$ for all $F\leq F^*(\underline{x}_1)$. All these arguments put together prove the Proposition 2. ■

Proof of Lemma 1. Computing the welfare difference $W^f(x_1^f)-W^p(x_1^p)$ and solving in F leads to the fixed cost value Φ which is quadratic concave function of n that can be written as

$$\Phi=(1-n)\frac{(2+\underline{\theta})^2(5\underline{\theta}+4)^2}{648k}(n-\tilde{n})$$

where $\tilde{n}=\frac{10+22\underline{\theta}-5\underline{\theta}^2-36kx_2}{(2+\underline{\theta})(5\underline{\theta}+4)}$. On the other hand, $\Phi^f=F^*(x_1^f)$ writes as a linear function of n:

$$\Phi^f=(1-n)\frac{(2+\underline{\theta})^2}{162k}(18kx_2-(5\underline{\theta}+1)(1-\underline{\theta}))$$

Notice $\Phi^f>0$ if $kx_2>(5\underline{\theta}+1)(1-\underline{\theta})/18$. Of course if $n=1$ then $\Phi=\Phi^f=0$. Hence solving in $n\in[0, 1[$, the equation $\Phi=\Phi^f$ leads to a unique solution:

$$\hat{n}=1-6\underline{\theta}\frac{18kx_2-(5\underline{\theta}+1)(1-\underline{\theta})}{(2+\underline{\theta})(5\underline{\theta}+4)^2}.$$

Moreover one can see that $\hat{n}<1$ whenever $\Phi^f>0$. Finally as $\Phi/(1-n)$ is increasing in n while $\Phi^f/(1-n)$ is constant, the result follows. ■

Proof of Lemma 2. First under Assumption 2, the profit constraint in the communication USO problem is always verified. Second by construction this problem is linear in μ and using proof of Lemma 1 we know that when the funding constraint is ignored, then if $F>\Phi$ then $\mu^*=0$ and $x_1^*=x_1^p$. Therefore if $F\leq\Phi$, $\mu^*=1$ but then the funding constraint $F-\hat{F}^*(x_1)\geq 0$ must be considered. If

$F<\hat{F}^*(x_1^f)=\hat{\Phi}^f$, then the unconstrained quality $x_1^*=x_1^f$ is implementable, if not, the quality is equal to $\hat{x}_1^*(F)$ such that $F=\hat{F}^*(\hat{x}_1^*(F))$. The former case occurs if $\Phi\leq\hat{\Phi}^f$, the latter if $\Phi>\hat{\Phi}^f$. However when $\Phi>\hat{\Phi}^f$, the solution remains $\mu^*=1$ if $W^f(\hat{x}_1^*(F))\geq W^p(x_1^p)$ that is if $F\leq\hat{\Phi}^\#$ where $\hat{\Phi}^\#$ is the highest root in F of the quadratic equation $W^f(\hat{x}_1^*(F))=W^p(x_1^p)$. If not, i.e. $F>\hat{\Phi}^\#$ then $\mu^*=0$. Hence defining $\hat{\Phi}=\min\{\Phi, \hat{\Phi}^\#\}$ leads to build all points of the lemma. Note that if $\Phi^*=\hat{\Phi}=\Phi$ then part (*ii*) of the lemma does not occur. ■

Proof of Proposition 3. We aim to compare the welfare levels in both postal and communication USO regimes when $n>\hat{n}$. Indeed, on the one hand, from Lemma 1 we have $\Phi>\Phi^f$, and on the other, $\hat{\Phi}^f>\Phi^f$ as a result necessarily $\Phi^f<\Phi^*$. As a result, for $F\in[\Phi^f, \Phi^*]$, from Lemma 2, we have $\mu^*=1$ and x_1^f implementable, so the welfare with communication USO is $W^f(x_1^f)$ but is $W^f(x_1^*(F))$ with postal USO. Clearly $W^f(x_1^f)=\arg\max_{x_1} W^f(x_1)>W^f(x_1^*(F))$ when $F>\Phi^f$. ■

Proof of Proposition 4. From the maximization of the profit functions $\pi_2^f(x_1)$ and $\pi_1^{mh}(x_1)$, we can derive a candidate equilibrium: $p_1^u(x_3)$, $p_2^u(x_3)$ and p_2^r and the associated cut-off types for the demand functions $\hat{\theta}(x_3)$ and $\hat{\hat{\theta}}(x_3)$. It is possible to show that (1) the prices in the urban market are increasing in x_3, (2) the cut-off types are decreasing in x_3 and (3) the profit of firm 1 is increasing in x_3.

Define $\overline{x}_3$ as:

$$\overline{x}_3=\frac{1}{3}\frac{(5+\underline{\theta})x_2-2(1-\underline{\theta})x_1}{1+\underline{\theta}}. \tag{5}$$

For this particular value of x_3, the prices are identical to the standard competitive case: $p_1^u(\overline{x}_3)=p_1^u$ and $p_2^u(\overline{x}_3)=p_2^u$. Furthermore, $\hat{\theta}(\overline{x}_3)=\theta^*$ and $\hat{\hat{\theta}}(x_3)=\frac{1+\underline{\theta}}{2}<\overline{\theta}$.

As there is a positive mass of customers that multihome and the mass of exclusive postal customers is identical to the standard competitive case, the joint purchase option unambiguously increases the profits of the postal firm. Thus, postal profits are higher and customer willingness to pay for postal service increases (because of the multihomers). For these reasons, the welfare maximizing quality for x_1 increases when $x_3=\overline{x}_3$.

For $x_3=\overline{x}_3$, prices are lower and more consumer buys the postal services. Thus, welfare maximization calls for a higher quality of postal services as long as this extra quality is sustainable, i.e. as long as the profit of the postal firm is higher compared to the standard competitive case. But as shown by Gabszewicz and Wauthy (2003, Proposition 1), should the profit be lower with multihoming, the postal firm would deviate to the "single purchase" price p_1^u and multihoming would not occur at equilibrium, i.e. $p_1^u(x_3)$, $p_2^u(x_3)$ are no longer an equilibrium. Given that the firm 1's profit increases in x_3 and its is unambiguously smaller when the joint purchase option has no value ($x_3 = x_2$), there exists a value for x_3 smaller than $\bar{x}_3$ but higher than x_2 below which the multihoming equilibrium ceases to exists and this proves the existence of $\eta_1 > 0$.

By continuity of the profit and the welfare functions, there are values of $x_3 > \bar{x}_3$ in the neighborhood of $\bar{x}_3$ for which the quality x_1 will be increased compared to the standard competitive case, thus establishing that a value $\eta_2 > \eta_1$ exists. ■

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