Reforming the Postal Universal Service

Paper prepared for the 7^{th} Postal conference on the economics of the postal sector in a digital world

Preliminary

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April 17, 2012

Abstract

The postal sector has dramatically changed in the recent years with the ongoing liberalization process and the increased competitive pressures from alternative communication channels (e-substitution). These two effects concur to decrease the mail volume handled by the historical operator which in turn may threaten the financial viability of the universal service and may call for a reform of the universal service. This paper examines the question of reforming the postal universal service, first by considering that the universal service remains confined in the postal word and, latter, by defining a universal service that includes postal and electronic technologies.

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1 Introduction and summary

The postal sector has a long tradition of universal service provision but its future is now under debate. The recent market liberalization (in Europe) and the growing use of electronic media have both contributed to the erosion of the mail flow handled by the universal service provider. Indeed, all the postal operators are now facing huge decline (>-20%) in their mail volume due to digitalization and e-substitution. Declining volumes may, in the long-term, threaten the sustainability of the universal postal service (Crew and Kleindorfer, 2005) and the digitalization of the economy calls for a reform of the universal postal service.

In the postal sector, the universal service is defined along three dimensions (Boldron *et al.*, 2007): the scope of products, the quality of the service and the pricing constraints (affordability, uniform pricing). 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 that it is truly ubiquitous. With few exceptions, everyone has a postal address and is thereby a client of the postal service, eventually only has a receiver. 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 connection to the public phone network at fixed location are made available to all users on request, independently of geographical location. At the same time, consumers are cutting the cord and recent evidences from the US suggest that, despite a growing offer of services, the universal service is currently declining (Gideon and Gabel, 2011).

In the EU-27, the internet penetration rate[1] was 73 % in 2011 (Source: Eurostat) with most of the households being connected with a broadband connection.[2] Despite a rapid growth, internet is far from being ubiquitous. Raisons for not being connected are numerous: lack of interest, lack of competence (digital illiteracy), cost of the service, cost of the equipment and non-availability of the service in the area (mainly for broadband connections). Indeed, broadband connections are not available everywhere. If metropolitan areas are usually well-connected, it is not necessarily the case for rural and less-populated regions where deployment of new infrastructure is more costly. Table 1 illustrates the lack of infrastructure in less-populated areas

[1]The percentage of households with an internet connection.

[2]The broadband penetration rate was 68% in 2011 (source: Eurostat).

for the EU-27. It contains survey data collected by Eurostat on the reasons for not having a broadband connection at home. Interestingly, household in less populated areas mention more frequently the lack of infrastructure than those living in more populated place.[3]

Population density	2007	2009
. > 500 hab/km^2	10	9
100< . <499 hab/km^2	20	22
. <100 hab/km^2	34	30

Source: Eurostat

Table 1: Households without broadband connection because it is not available in the area expressed as a percentage of households without broadband access

The postal sector is thus competing with a new technology that is not (yet?) deployed everywhere.[4] Our first research question is to investigate the impact of electronic communications on the design of the universal postal service. Facing competition from the internet, how should the universal service be reformed? To our knowledge, this question has not yet be treated explicitly but several authors have focused on the related question of reforming USO after entry of a postal competitor.[5] 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 a tool to keep the universal service sustainable in a competitive environment. On the contrary, Calzada (2009) show that the entry of low-quality postal competitor that has a limited territorial coverage and a lower delivery frequency increases 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 one being identified by a unique provider. Internet and postal services differ along two dimensions: territorial coverage and quality of the service. As mentioned,

[3]The existence of a digital divide between urban and rural regions is now well-documented (Billón *et al.*, 2009; Bouckaert *et al.*, 2010) and it is partially explained by a lack of infrastructure.

[4]Some countries (notably Swiss and Finland) have included broadband connection as part of the universal service.

[5]Reforming the telecom USO is also on the agenda, see Alleman *et al.* (2010).

broadband connections are not available everywhere due to a lack of infrastructure. In the sequel, we distinguish two regions within the country: a urban region where broadband internet is made available to end-users and a rural region where it is not. By contrast, postal services are made available everywhere because of the ubiquity constraint. Quality of communication has several dimensions (security, reliability, speed of delivery...). In this paper, we will focus exclusively on one dimension, the delivery frequency[6], for which the internet has a clear advantage. Our model is thus different from Calzada (2009) as we consider that each technology dominates the other in one dimension: the internet allows for faster delivery but it is not available everywhere. In this context, the question we consider is the following: should the postal USO be reformed as the households use more and more the internet for their communication and less the postal services? And the reform we consider is a change in the delivery frequency. Currently, the universal service imposes five or six days delivery and, in some cases, there is an additional early delivery for the newspapers.[7] When the technologies compete, the internet skims the most profitable customers of the urban market with as consequences (1) lower profits for the postal firm because of e-substitution and (2) the remaining clients in the urban area are those with a low willingness to pay for quality. These two effects concurs to design a universal service of lower quality. Reducing the 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 in the urban area no longer use the postal services. In addition, as competition erodes the mail volumes and quality is costly to deliver, financial constraints may call for a further reduction of the delivery frequency. The digitalization of the communications calls for a lightening of the postal USO and, there are, indeed, projects to reform the USO in such a way.[8]

But, such a reform of the USO would thus create a regional divide between rural and urban areas. In the latter, the two technologies compete and consumers can choose their preferred technology while in rural areas, consumers will be offered a lower quality of service without having the possibility to switch to the new technology. Thus, in a second-step, our objective

[6]Or equivalently on the transit time.

[7]Delivery of newspapers is sometimes included as an additional requirement of the universal service, see Boldron *et al.*, (2007).

[8]In The Netherlands where the overall letter volume has dropped by 14% in the period 2005-10, the government plans to reform the USO and considers dropping the Monday delivery and thereby reducing the delivery frequency to five days. Similar reforms are under discussion in Norway where the Saturday delivery might be abandoned.

is to broaden the question of the USO design by looking at combinations of postal and electronic technologies to provide a reformed 'communication universal service'.[9] In particular, we consider the following alternatives: (1) shared-financing: the USO is still provided by the postal operator but the cost is shared between the two technologies, (2) a change of technology: the USO are imposed on the digital technology and the postal operator is relieved from its universal service obligations, (3) A broader USO, where a postal USO is combined with a ubiquity constraint imposed on the internet and finally (4) a technological mix where the postal network is used to distribute electronic media (or the reverse). For each of these alternative, we computed the preferred quality of the postal service as well as the financial constraints that apply. Our conclusions shed light on the pros and cons of each alternative.

2 Model

Consumers We consider a country composed of a continuum of size one of local markets or cities. A local part is either part of the urban region (u) or the rural region (r). The urban region is compose of n^u cities and the rural one of $n^r = 1 - n^u$ cities. In each city, there is a continuum of mass one of customers. 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 $\underline{\theta} \leq 1$. The utility of customer of type θ when he consumes a good of quality x at price p is equal to $U(\theta) = \theta x - p$. Consumers buy one unit of the good when $U(\theta) \geq 0$.

Firms There are two firms: firm 1 is the postal operator, firm 2 is the internet provider. Firms provide differentiated services to customers. We identify the quality of the service by a unique dimension x, the speed of delivery. The internet offers the highest possible quality $\bar{x}_2$ as delivery of messages is instantaneous. The postal operator offers services of quality $x_1 < x_2$; the quality x_1 is flexible and it can be understood as the delivery frequency.

To operate in region u, r, firm 2 must deploy its telecommunication network. Infrastructure cost are given by f^u for the urban region and $f^r > f^u$ for the rural one. We will assume that f^r is sufficiently large so that it is not profitable for the internet to connect the rural region (see the formal

[9] On this point, see Jaag and Trinkner (2011).

condition in equation 4) and, without loss of generality, we set $f^u = 0$ and $f^r = F > 0$. Once a region is connected, there is no other cost of providing the service.

Delivering mails at frequency x_1 costs $k^u x_1^2/2$ in the urban region and $k^r x_1^2/2$ in the rural one and we assume that $k^r > k^u$ i.e. mail delivery is more costly in the rural area due to a lower population density. Our modeling assumption captures the fact that delivery costs are mainly driven by the delivery frequency and not by the mail volume. In addition, the provision of postal services require a fixed cost f. As for the internet, the marginal cost of the postal services are set to zero (for simplicity).

Universal service obligations We will consider that the universal consists in making available to all users a service of given quality at an affordable rate.[10] More specifically, we will consider that the universal service obligations are made of the following requirements:

- Ubiquity: the service must be offered in two regions.
- Affordability: the service must be affordable for all consumers, that is the quality-price combination of the universal service provider must satisfy $U(\underline{\theta}) \geq 0$.
- Uniform quality: the quality of the universal service must be the same for all users irrespective of their geographical location.

Note that we do not include any other constraint on the prices that the affordability constraint. Thus, as long as this constraint is satisfied, we allow the universal service provider to price discriminate between regions.

Timing of the events We consider the following sequence of decisions:

- The regulator chooses the universal service provider and imposes the quality of the service to be delivered.
- Firms decide on market coverage
- Firms compete in prices

[10]For the economic motivations for the universal service, see Cremer *et al.* (2006).

3 Postal USO

3.1 Benchmark: designing a postal USO in a non-competitive environment

Suppose that the postal technology is the only one available. Under the assumption of fully covered market, the profit realized by firm 1 is:

$$\pi_1^m(x_1) = (n^u + n^r)p_1 - (k^u + k^r)x_1^2/2 - f$$

Subject to the constraints of affordability and uniform quality, the profit-maximizing price and quality are given by:

$$x_1^m = \frac{(n^u + n^r)\underline{\theta}}{k^u + k^r} \text{ and } p_1^m = \underline{\theta} x_1^m$$

In the sequel, we will assume that $\pi_1^m(x_1^m) \geq 0$, meaning that quality x_1^m can be delivered to all profitably (so that $f < f_0 = \frac{1}{2}\left((n^u + n^r)\underline{\theta}\right)^2 / (k^u + k^r)$).

Define the welfare as the sum of the consumers' utility and the firm's profit:

$$W^m(x_1) = (n^u + n^r)\int_{\underline{\theta}}^{\bar{\theta}} \theta x_1 d\theta - (k^u + k^r)x_1^2/2 - f$$

The welfare-maximizing affordable price and uniform quality are given:

$$x_1^o = \frac{(n^u + n^r)(1 + 2\underline{\theta})}{k^u + k^r} \text{ and } p_1^o = \underline{\theta} x_1^o$$

Unsurprisingly, welfare maximization calls for a higher quality than profit maximization: $x_1^o > x_1^m$. Moreover, for the quality x_1^o sold at price p_1^o to be sustainable, the following firm break-even constraint must be satisfied: $\pi_1^m(x_1^o) \geq 0$ that is

$$f \leq f_1 = \frac{(n^u + n^r)^2}{8(k^u + k^r)}(2\underline{\theta} + 1)(2\underline{\theta} - 1) \tag{1}$$

Proposition 1 *The optimal quality for a postal USO is defined by x_1^o if $f \leq f_1$. Otherwise, the optimal quality solves $\pi_1^m(x_1) = 0$ subject to $p_1 = \underline{\theta} x_1$ and $x_1 \in [x_1^m, x_1^0[$.*

Proposition 1 defines the welfare-maximizing quality when the postal technology is the only one available. Our aim is to compare this benchmark level of quality with the optimal quality when the postal service and the internet compete.

3.2 Designing a postal USO in a competitive environment

Consider the case in which firms compete and find the profit maximizing and welfare-maximizing price-quality pair. As quality is vertically differentiated, firm 2 skims the urban market but prefers not to serve the unprofitable rural market (by assumption) so its profit is

$$\pi_2(p_2) = n^u\left(\bar{\theta} - \hat{\theta}\right)p_2 \tag{2}$$

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

As a US provider, firm 1 has to respect the ubiquity constraint and it must provide the same quality everywhere. But we allow firm 1 to price discriminate between the monopolistic rural region (price p_1^r) and the competitive urban one (price p_1^r) as long as the affordability constraint is satisfied. So firm 1's overall profit is:

$$\pi_1(p_1^u, p_1^r, x_1) = n^u\left(\hat{\theta} - \underline{\theta}\right)p_1^u + n^r p_1^r - (k_1^u + k^r)x_1^2/2 - f \tag{3}$$

Equilibrium prices are given by

$$p_1^u = \frac{1 - \underline{\theta}}{3}(x_2 - x_1),\ p_2^u = \frac{\underline{\theta} + 2}{3}(x_2 - x_1) \text{ and } p_1^r = \underline{\theta}x_1$$

The affordability constraint is satisfied in the urban region if $p_1^u \leq p_1^r$ that is if $x_2 \leq x_1\frac{1+2\underline{\theta}}{1-\underline{\theta}}$. In the case this condition holds true, the profits of the firms are given by

$$\begin{aligned}\pi_1(x_1) &= n^u\left(\frac{(1-\underline{\theta})^2}{9}(x_2 - x_1)\right) + n^r\left(\underline{\theta}x_1\right) - (k_1^u + k_1^r)x_1^2/2 - f \\ \pi_2(x_1) &= n^u\left(\frac{(2+\underline{\theta})^2}{9}(x_2 - x_1)\right)\end{aligned}$$

The profit-maximizing quality for the postal firm is given by

$$\hat{x}_1^m = Max[0, \frac{9n^r\underline{\theta} - n^u(1-\underline{\theta})^2}{9(k^u + k^r)}]$$

For the postal operator, the profit in the urban region decreases with quality, an application of the standard principle of maximum product differentiation, while the profit in the rural region increases with quality. Thus, depending on the relative size of the two regions, the profit-maximizing quality is either the lowest possible one or an interior solution. In both case, the firm's preferred quality is unambiguously lower than in the benchmark case. We will assume that the quality $\hat{x}_1^m$ guarantees a non-negative profit to the postal operator, that is $\pi_1(\hat{x}_1^m) \geq 0$.

We also assumed that connection cost for the internet firm are high enough in the rural region. This non-coverage condition for the internet formally writes as follows:

$$n^r \left(\frac{(2+\underline{\theta})^2}{9} (x_2 - x_1) \right) < f^r = F \tag{4}$$

USO Design: The welfare is given by

$$W(x_1) = n^u \left(\int_{\hat{\theta}}^{\overline{\theta}} \theta x_2 d\theta + \int_{\underline{\theta}}^{\hat{\theta}} \theta x_1 d\theta \right) + n^r \int_{\underline{\theta}}^{\overline{\theta}} \theta x_1 d\theta - (k_1^u + k^r) x_1^2/2 - f$$

The welfare maximizing quality is:

$$\hat{x}_1^o = \frac{n^u(1-\underline{\theta})(5\underline{\theta}+1) + 9n^r(1+2\underline{\theta})}{18(k^u + k^r)} \tag{5}$$

The consumer's average value for the quality of postal services decreases because the internet skims the high valuation consumers from the urban region. Consequently, the welfare maximizing quality $\hat{x}_1^o$ is lower than the quality delivered in the monopoly case x_1^o.

Quality $\hat{x}_1^o$ is sustainable if $\pi_1(p_1^u, p_1^r, \hat{x}_1^o) \geq 0$. This condition can be written as $f < f_2$ where

$$f_2 = \frac{n^u(1-\underline{\theta})^2}{9} x_2 + \frac{4\underline{\theta}^2 - 1}{8} (n^r)^2 + \frac{(1-\underline{\theta})(4\underline{\theta}^2 - 7\underline{\theta} - 3)}{36} n^r n^u - \frac{(1-\underline{\theta})^2 (5\underline{\theta}+1)(\underline{\theta}+5)}{648} (n^u)^2$$

As in the benchmark case, the optimal quality for the universal service is defined as

Proposition 2 *The optimal quality for a postal USO is defined by $\hat{x}_1^o$ if $f \leq f_2$. Otherwise, the optimal quality solves $\pi_1(x_1) = 0$ and $x_1 \in [\hat{x}_1^m, \hat{x}_1^0[$.*

Comparisons The welfare maximizing quality for the universal service unambiguously decreases when the two technologies compete in part of the country. But, as stated in propositions 1 and 2, quality is either at the optimal level or at the highest sustainable level. Comparison of the optimal quality level is thus not sufficient. Nevertheless, we can establish that:

Proposition 3 *The optimal quality for the postal universal service decreases when the postal firm faces competition from a higher quality technology.*

Proof: The proof is obvious if the qualities x_1^o and $\hat{x}_1^o$ are both sustainable. If not, under the assumption of fully covered urban markets ($x_2 \leq x_1 \frac{1+2\theta}{1-\theta}$), the prices satisfy $p_1^u \leq p_1^r$ and the profits of the postal firm unambiguously decline with competition: $\pi_1^m(x_1) > \pi_1(x_1)$. Thus a quality level that is sustainable in the competitive case is also sustainable in the benchmark case and this is sufficient to have a lower quality in the competitive environment.

The digitalization of the economy calls for a reform of the universal postal service that is not only motivated by financial constraints. Such a reform would consist in reducing the quality of the service offered (in our case, reducing the delivery frequency).

Such a reform of the universal service would affect differently the users. Clearly enough, those living in the rural area are certainly worse if quality declines, since, subject to the affordability constraint, welfare increases with quality. The service offered has a lower quality and they do not have the option to buy the higher quality one. The impact on those living in the urban area is not clear-cut compared to the benchmark case as some consume a higher quality good and other a lower one. But, urban consumers are certainly better off than the rural ones. Not only they do have access to the high quality technology, the internet, but they are also charged a lower price for the postal services. Hence, we do observe a kind of regional divide between the two regions that was not present without competition.

4 Communication USO

As we have shown, the rapid growth of electronic communications calls for a lightening of the universal postal service. But such a change is definitely not beneficial to all and, for this reason, it might be politically difficult to implement. More generally, we have considered, so far, that the universal service was organized and financed on a postal base exclusively. But with the technologies becoming closer substitutes (for newspaper delivery for instance), one may imagine to broaden the scope of the universal service. The universal service can evolve from a postal service based on paper delivery into mailboxes to a more general communication universal service where both technologies, the internet and the postal sector, contribute either to the provision of the service or to the financing.

In the sequel, we will analyze in turn, the following options: a shared financing of the universal postal service between the two technologies, the imposition of the universal service obligations (ubiquity, affordability and uniform quality) to the internet, the imposition of the ubiquity constraint to both technologies and the provision of the universal service with an hybrid technology.

4.1 Shared-financing USO

The USO is still provided by the postal operator but the cost is shared between the two technologies. Consider now that a balanced scheme is set up by the regulator in order to fund USO. Lump sum taxes (t_1, t_2) are levied in profitable urban markets to compensate losses in the rural market, which is also unitary subsidied. Hence, for a given unit subsidy s and taxes t_i, from (2) and (3), profits are now respectively given by $\pi_2(p_2) - t_2$ and $\pi_1(p_1^u, p_1^r + s, x_1) - t_1$ so that the Nash price equilibrium remains the same and the indifferent consumer is not affected by the funding scheme. Affordability constraint is to be satisfied in urban region if $\hat{p}_1^u \leq \hat{p}_1^r$ that is if $\underline{\theta}x_1 - p_1^u \geq 0$ Therefore profits are now written as

$$\begin{aligned} \hat{\pi}_1(x_1) &= \pi_1(x_1) - t_1 + n^r s \\ \hat{\pi}_2(x_1) &= \pi_2(x_1) - t_2. \end{aligned}$$

The US fund balancing condition writes $B = t_1 + t_2 - n^r s \geq 0$, and let us define (t^*, s^*, x_1^*) the welfare-maximizing US funding scheme that solves the problem

$$\max_{x_1, t_1, t_2, s \geq 0} W(x_1) - B$$
$$\text{s.t. } \underline{\theta}x_1 - p_1^u \geq 0 \ ; \ \hat{\pi}_1(x_1) \geq 0 \ ; \ \hat{\pi}_2(x_1) \geq 0 \text{ and } B \geq 0.$$

Of course, at the optimum the US fund is strictly balanced so that $t_1^* + t_2^* = n^r s^*$ (no free lunch) and the internet participation constraint is binding $t_2^* = \pi_2 > 0$. Hence the choice of the optimal quality can be rewritten as $\max_{x_1} W(x_1)$ subject to $\underline{\theta}x_1 - p_1^u \geq 0$; $\hat{\pi}_1(x_1) + \hat{\pi}_2(x_1) \geq 0$. Let $\hat{f}_2$ the fixed cost bound for which the optimal quality $\hat{x}_1^o$ is sustainable with this funding scheme that is $\hat{\pi}_1(\hat{x}_1^o) + \hat{\pi}_2(\hat{x}_1^o) \geq 0$ whenever $f < \hat{f}_2$ and let $\hat{x}_2^f$ the internet quality level for which $\hat{f}_2 = f_2$. Finally let $\hat{x}_2^p$ the internet quality level for which the optimal quality x_1^* is affordable with this funding scheme that is $\underline{\theta}x_1 - p_1^u \geq 0$ when $x_1 = x_1^*$. Then we can state the following result

Proposition 4 *Quality level thresholds are ranked as follows :* $x_2^f > \hat{x}_2^p > \hat{x}_2^f$. *Hence whenever* $x_2^f > x_2 \geq \hat{x}_2^p$, *then US quality* $\hat{x}_1^o$ *is now more sustainable by means of the funding scheme since* $\hat{f}_2 > f_2$. *When* $\hat{x}_2^p > x_2 > \hat{x}_2^f$, *US quality is reduced more for affordability reasons than for financial ones, that it is set to* $x_1^p : \underline{\theta}x_1 = p_1^u$ *where* $x_1^p < x_1^*$.

Clearly enough, a funding scheme that englobe both the internet and the postal world is a mean to relax the financial constraint faced by the universal service provider and therefore quality can be improved at the benefits of the postal users. This solution would be particularly interesting when the optimal quality is not sustainable in a competitive environment i.e. the profits of the postal firm are not large enough to finance the welfare-maximizing quality. In such a case, broadening the tax base is clearly welfare-improving (as long as taxes are non-distortionnary).

4.2 Change of technology: Internet USO

Suppose that the regulator keeps the same definition for the universal service: ubiquity, affordability and uniform quality, but he changes the technology to deliver the universal service. The postal operator is thus relieved from the universal service obligations and the USO are imposed on the internet. In such a case, firm 2 would then be forced to supply the quality x_2 in the two regions, which implies an extra connection cost F, at the affordable rate $p_2 = \underline{\theta}_2 x_2$.

In this case, to compete with the internet, the postal firm must offer a quality price combination that satisfy $p_1 < \underline{\theta}x_1$. Furthermore, the postal firm is no longer obliged to deliver a uniform quality nationwide and qualities in the two regions differ. The profit of the postal firm is given by :

$$\pi_1(p_1^u, x_1^u; p_1^r, x_1^r) = n^u\left(\hat{\theta}^u - \underline{\theta}\right)p_1^u + n^r\left(\hat{\theta}^r - \underline{\theta}\right)p_1^r - k_1^u(x_1^u)^2/2 - k_1^r(x_1^r)^2/2 - f$$

where $\hat{\theta}^j = \frac{x_2 - p_1^j}{x_2 - x_1^j}$, $j = r, u$.

The profit maximizing prices are given by $p_1^j = \underline{\theta}x_1^j/2$. To gain market shares, firm 1 must undercut the affordable price offered, as part of the universal service, by the internet. And, given the cost of providing quality, the postal firm is not necessarily active in both regions.

But irrespective of the competitive pressure exerted by the postal firm, the profit of the internet in the urban area are lower with the universal service obligations. And, the internet may not be able to finance network extension to the rural area when the affordability constraint is imposed. Formally, when $x_1^j = 0$ (the postal service is no longer supplied), the condition for sustainability can be expressed as

$$(n^r + n^u)\underline{\theta}x_2 \geq F$$

and if the postal sector continues to supply services in at least one region, the condition is even stronger.

So this scenario may not be a realistic one as if the above condition is not satisfied, the internet USO needs huge public support and funding.

4.3 A broader USO: Ubiquity for Internet

To relax the financial constraints highlighted in the previous scenario, the regulator may impose the ubiquity constraint only on the internet, and the ubiquity, affordability and uniform quality to the postal firm. In this case, the internet firm must deploys its network in the rural area (at cost F) and it skims the profitable part of the rural market. Equilibrium prices are given by: $p_1^r = p_1^u = \frac{1-\underline{\theta}}{3}(x_2 - x_1), p_2^u = p_2^u = \frac{\underline{\theta}+2}{3}(x_2 - x_1)$. and the associated profits are

$$\begin{aligned}
\tilde{\pi}_1(x_1) &= (n^u + n^r)\left(\frac{(1-\underline{\theta})^2}{9}(x_2 - x_1)\right) - (k_1^u + k_1^r)x_1^2/2 - f \\
\tilde{\pi}_2(x_1) &= n^u\left(\frac{(2+\underline{\theta})^2}{9}(x_2 - x_1)\right) - F
\end{aligned}$$

The welfare maximizing quality is equal to:

$$\tilde{x}_1^* = \frac{(n^u + n^r)(1-\underline{\theta})(5\underline{\theta}+1)}{18\,(k^u + k^r)}$$

One can easily observe from (5) that $x_1^* < \hat{x}_1^o$. The quality imposed to the postal firm is lower when the internet is available everywhere.

This quality $\tilde{x}_1^*$ is sustainable if $f \le \tilde{f}_2$ and $F \le \tilde{f}_r$ where

$$\begin{aligned}
\tilde{f}_2 &= \frac{(1-\underline{\theta})^2}{9}(n^u + n^r)\left[x_2 - \frac{(n^u + n^r)(5+\underline{\theta})(5\underline{\theta}+1)}{72\,(k^u + k^r)}\right] \\
\tilde{f}_r &= \frac{(2+\underline{\theta})^2}{9}(n^u + n^r)\left[x_2 - \frac{(n^u + n^r)(1-\underline{\theta})(5\underline{\theta}+1)}{72\,(k^u + k^r)}\right]
\end{aligned}$$

Proposition 5 *US quality level $\tilde{x}_1^* < x_1^*$ and it is likely to be reduced for financial reasons more frequently since $\tilde{f}_r > 0$ and $\tilde{f}_2 < f_2$ for $x_2 < \tilde{x}_2^f < x_2^f$.*

4.4 Technological mix

A technological mix where the postal network is used to distribute electronic media (or the reverse). [To be continued]

5 Concluding remarks

In this paper, we have shown that, the emergence of electronic communications call for a reform of the universal service and, if postal services are considered to be of lower quality than internet services, the universal service should be lightened. In this paper, we have identified quality by a unique dimension, delivery speed for which the internet has a clear advantage. But this may not necessarily be the case for all dimensions of quality such as security or reliability.

Then, we have examined three possible reforms of the universal service that include both technologies. A shared financing where the internet contributes to the financing of the postal universal service. The imposition of the universal service constraints on the internet firm and, finally, the imposition of universal service constraints on both technologies but without treating them equivalently.

Our preliminary analysis has examined the quality of the postal service and the financial constraints in all these three cases. To summarize, we can show that the welfare maximizing quality for the postal service ranks as follows: the highest quality would be delivered in the case of a shared-financing. The second-highest corresponds to the case where the universal service is defined with reference to the postal sector exclusively. When some constraints are also imposed on the internet, then quality of the postal services is lower. And the quality decline is particularly important if the universal service is defined on the basis of the internet technology as in this case, the postal service may not necessarily be active nationwide. Table 2 summarizes the comparisons.

	Coverage internet	Postal quality	Financial Financial
Shared financing	u	+++	Light
Change of technology	u and r	+	Strong
Broader USO	u and r	++	Medium

Table 2: Comparisons

Having established a quality ranking, our objective is to go further and classify the solutions with respect to the welfare.

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Appendix

•**Proof of Proposition 2.** Indeed derivating W w.r.t to x_1 and solving leads to x_1^o. Let $f = f_1$ defined in (1) in the text for which $\pi_1^m(x_1^o) = 0$. As $x_1^m = \arg\max \pi_1^m(x_1)$ and $x_1^m < x_1^o$, then for $f_0 > f > f_1$, the quality x_1 that solves the break-even equation $\pi_1^m(x_1) = 0$ yields necessarily $x_1^m < x_1 < x_1^o$. ■

•**Proof of Lemma ??.** First let's see that $x_1^o - x_1^*$ writes $\frac{n^u(2+\underline{\theta})(1+5\underline{\theta})}{18(k^u+k^r)} > 0$. Second the equation $f_2 - f_1$ turns out to be linear in x_2 (as f_2 is) so x_2^f is the unique solution and writes

$$x_2^f = \frac{(5+16\underline{\theta}+282\underline{\theta}^2+16\underline{\theta}^3+5\underline{\theta}^4)(n^u)^2+(54+72\underline{\theta}+450\underline{\theta}^2+72\underline{\theta}^3)n^r n^u+81(n^r)^2}{72(k^u+k^r)(1-\underline{\theta})^2 n^u}.$$

Furthermore $f_2 - f_1$ is increasing with x_2. Moreover from (5) in the text, we see that

$$x_2^f - x_1^* = \frac{(1+8\underline{\theta}+330\underline{\theta}^2+5\underline{\theta}^2(66-8\underline{\theta}+5\underline{\theta}^2))(n^u)^2+(18+72\underline{\theta}+558\underline{\theta}^2)n^r n^u+81(n^r)^2}{72(k^u+k^r)(1-\underline{\theta})^2 n^u} > 0$$

since $66 - 8\underline{\theta} + 5\underline{\theta}^2 > 0$ for all $\underline{\theta} \in [0,1]$. ■

•**Proof of Proposition 4.** it writes

$$\hat{f}_2 = f_2 + n^u(2+\underline{\theta})^2\left[\frac{x_2}{9} - \frac{n^u(1+4\underline{\theta}-5\underline{\theta}^2)+9n^r(1+2\underline{\theta})}{162(k^u+k^r)}\right]$$

Let x_2^f the unique value of x_2 such that $\hat{f}_2 = f_2$

$$\hat{x}_2^f = \frac{n^u(1+4\underline{\theta}-5\underline{\theta}^2)+9n^r(1+2\underline{\theta})}{18(k^u+k^r)}$$

it writes

$$\hat{x}_2^p = \frac{(1+2\underline{\theta})\left[n^u(1+4\underline{\theta}-5\underline{\theta}^2)+9n^r(1+2\underline{\theta})\right]}{18(k^u+k^r)(1-\underline{\theta})}$$

We directly see that $\hat{x}_2^p = \frac{1+2\underline{\theta}}{1-\underline{\theta}}\hat{x}_2^f > \hat{x}_2^f$. More tediously one can see that

$$x_2^f - \hat{x}_2^p = \frac{(1-4\underline{\theta}+294\underline{\theta}^2+28\underline{\theta}^3-35\underline{\theta}^4)(n^u)^2+(18-36\underline{\theta}+350\underline{\theta}^2+216\underline{\theta}^3)n^r n^u+81(n^r)^2}{72(k^u+k^r)(1-\underline{\theta})^2 n^u} > 0$$

for all $\underline{\theta} \in [0,1]$. Let $x_1^p = x_2\frac{1-\underline{\theta}}{1+2\underline{\theta}}$ the unique value of x_1 such that $\underline{\theta}x_1 = p_1^u$. ■