

Assessing Effects of Price Regulation in European Retail Payment Systems

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May 4, 2004

Abstract

The higher prices of cross-border retail payments compared to domestic retail payments have recently been a widely debated issue in Europe. As a concrete policy measure to correct this situation, the European Parliament and the EU Council adopted the Regulation (EC) No. 2560/2001 on Cross-Border Payments in Euro in December 2001. This Regulation has stopped the price discrimination between domestic and cross-border retail payments in euro by imposing a uniform price for comparable payments. From the integration policy perspective, the Regulation can be seen to contribute towards the final goal of the *Single Euro Payment Area* by eliminating “payment borders” in the single currency area. However, an important policy question is whether the Regulation imposing uniform pricing will increase or decrease social welfare.

This paper considers effects of price regulation in retail payment systems. Because of many similarities between telecommunication and payment system networks, we are able to apply the model of telecommunications competition by Laffont-Rey-Tirole (1998b) to analyse competition in payment processing. Our analysis is done in a two-country world where there is one retail payment network located in each country. We use a segmented market Hotelling-model to describe this market set-up. Based on our model set-up, we are able to show that the optimal price under the Regulation is the weighted average of pre-regulation domestic and cross-border prices where the degree of home-bias in making payments serves as the weight. Furthermore, we find that gross social welfare is higher under price discrimination than under price regulation in a special case where costs of access to banking services are high. However, when transportation costs are also taken into account, price discrimination reduces total welfare. For the general case, the welfare effects are ambiguous in our segmented market model. Finally, if the transportation costs are sufficiently lowered, the segmentation of the payment markets is eliminated. The markets become then fully-served as in the original Laffont-Rey-Tirole model, suggesting that price discrimination would be beneficial for welfare.

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1. Introduction

Payment system issues have received an increasing attention as the integration process in Europe has progressed. The final goal is to achieve a *Single Euro Payment Area (SEPA)*, where there should be no difference between domestic and cross-border euro payments. Concerning large-value value payments, much progress has been achieved, and today the central bank owned TARGET (Trans-European Automated Real-time Gross settlement Express Transfer system) and the privately owned Euro Banking Association's Euro 1 – payment systems are the main large-value payment systems offering their services in the EU-wide scale. In contrast, the development in the cross-border retail payment system area has been slower, and the fact that the prices of cross-border retail payments have remained higher than comparable domestic retail payments has provoked much discussion in recent years. In the advent of introduction of euro notes and coins, the authorities decided to resort to a strong regulatory measure to correct the situation as well as to foster the development in the cross-border retail payments area. As a concrete measure, and the European Parliament and the EU Council adopted Regulation (EC) No. 2560/2001 on Cross-border Payments in Euro (RPE) in December 2001. The RPE obliges banks to charge equal prices for domestic and cross-border retail payments. The RPE has been applied to card payments and ATM (Automated Teller Machine) withdrawals as from 1 July 2002 and to cross-border credit transfers as from 1 July 2003.

The exact wording of the Article 3 of the Regulation is the following:

- 1. With effect from 1 July 2002 at the latest, charges levied by an institution in respect of cross-border electronic payment transactions in euro up to EUR 12 500 shall be the same as charges levied by the same institution in respect of corresponding payments in euro transacted within Member State in which the establishment of that institution executing the cross-border transfer is located.*
- 2. With effect from 1 July 2003 at the latest, charges levied by an institution in respect of cross-border credit transfers in euro up to EUR 12 500 shall be the same as charges levied by the same institution in respect of corresponding credit transfers in euro transacted within Member State in which the establishment of that institution executing the cross-border transfer is located.*
- 3. With effect from 1 January 2006 the amount EUR 12 500 shall be raised to EUR 50 000.*

In a nutshell, the implementation of the Regulation has meant that the price discrimination between comparable domestic and cross-border euro retail payments has been banned and the payment service providers have been forced to change their previous pricing principles.

On the one hand, the Regulation can be seen as a strong regulatory measure to foster the integration process in financial markets by “forcing” the Single Market-concept also in the retail payment systems area. On the other, the Regulation and its welfare effects also offer an interesting research

question that can be approached theoretically by applying models of competition used in other network industries. This is justifiable on the grounds that payment industry has many characteristics in common with network industries, like telecommunications. Accordingly, the framework of our study is related to the literature on competition in telecommunications: e.g. Armstrong (1998), Laffont-Rey-Tirole (1998a, 1998b), Schiff (2001a, 2001b) and Dessein (2003).

The central research question of our study is simple: what are the effects of price regulation in retail payments in the light of an applied theoretical model. The question is topical because the Regulation on Cross-border Payments in euro (RPE) has only recently come in force. The adoption of the RPE was strongly criticised by the payment service provider sector (mainly the banking sector) who argued for a market-driven solution.² The authorities, in turn, saw the RPE as an ultimate measure to facilitate the lagging development efforts in the sector. These real-life controversies provide a fruitful background for our theoretical study. For policy analysis purposes, our study also aims at contributing to this debate by providing some aspects and theoretical considerations that can be taken into account.

A further motivation for our study is the scarcity of existing literature analysing the retail payment system industry as network industry.³ To our knowledge, there exist very few theoretical studies analysing the pricing of payment services based on price competition between the service providers. In fact, the study by Weinberg (2002) comes closest to our study. He analysed the differences between cooperative and independent setting of interbank prices (prices for customer payments between banks in this context) in alternative market environments. He concluded that cooperation in setting interbank prices typically leads to lower prices and greater consumer welfare and profits when markets are segmented. When markets become integrated (fully-served), cooperation in setting interbank prices can result in higher interbank prices and reduced consumer welfare.

In our study, we investigate similar questions as Weinberg (2002), but we base our analysis on the telecommunications competition framework of the Laffont-Rey-Tirole (1998a, 1998b) because many similarities exist between the payment and telecommunication industries. Moreover, there are several reasons to utilise the Laffont-Rey-Tirole modelling framework. First, the Laffont-Rey-Tirole model has become a "standard model" to analyse competition in telecommunications. Secondly, in contrast with many other network industry models, the Laffont-Rey-Tirole model provides an elegant way to

² However, after the adoption of the RPE, the banking sector activated and reacted by establishing a common decision making-body, the European Payments Council (EPC) to foster the development. The EPC has published a White Paper: European Payments Council (2002): "*Euroland: Our Single Payment Area!*" where measures and steps towards the Single Euro Payment Area are presented. Moreover, the EPC has also approved two market conventions to facilitate the adaptation of the RPE.

³ A brief review of literature on network effects in retail payment systems is provided e.g. in Chapter 3.4 in Kemppainen (2003).

introduce network externalities. Thirdly, if we give transportation costs a "payment technology interpretation", we can analyse the effects of deepening financial integration by lowering the transportation cost leading to integrated and fully-served payment markets where national borders do not pose obstacles for payment system competition.

The outline of the paper is as follows. Chapter 2 presents the main building blocks of the Laffont-Rey-Tirole –based model that is used to analyse the effects of price regulation in retail payments. Chapter 3 studies first the pre-regulation pricing case (discriminatory pricing) and then the post-regulation case (uniform pricing) that prevails when the Regulation is in force. Thereafter the welfare changes between the two cases are examined. Chapter 4 concludes and provides a discussion on the main policy issues as well as on the potential future work.

2. A model for analysing price regulation in retail payment systems

The Laffont-Rey-Tirole (1998b) (hereafter LRT) model of telecommunications competition and interconnection is applied to analyse effects of price regulation in retail payment systems. In the original LRT-model, there are two horizontally differentiated networks that supply telecommunication services. The networks discriminate in their tariffs according to the destination network: a network offers two prices to its subscribers, one for calls made to other subscribers of the same network and one for calls to the rival network.

In our model, the two networks are interpreted to be retail payment networks located in two countries offering price-discriminated domestic and cross-border payment services to their customers. As in the LRT, we also assume that the retail payment networks are differentiated à la Hotelling and consumers are uniformly located on the segment $[0,1]$, while the payment networks are located at the two extremities of the segments. In contrast to LRT where the markets are assumed to be fully covered, we assume that the transportation costs (costs associated e.g. with access to banking services) are so high that the markets are segmented; i.e. only partially covered.⁴ This is the first change we make to the original LRT framework. Secondly, we modify LRT's balanced calling pattern assumption to correspond better the payment service world (discussed below) and, we also drop out the fixed cost term, f , of serving a customer. It turns out that these simple modifications change some results LRT obtained in their analysis on telecommunication markets.

There are two key assumptions made in LRT, (i) reciprocal access charges and (ii) balanced calling pattern (balanced payment pattern in our model), that deserve some attention in the payment systems context. The reciprocal access charge assumption fits to the retail payment systems. A network pays as much for the termination of a payment on the foreign network (cross-border payment) as it receives for completing a payment originated on the foreign network resembling thus multilateral interchange fees.

The balanced payment pattern assumption, in turn, means that statistically a consumer has an equal chance of making a payment to a given consumer belonging to her network and another given consumer belonging to the foreign network. Accordingly, the percentage of payments originated on a network and completed on the same network (domestic payments) is equal to that network's market size. In our framework, this would imply that the division of domestic and cross-border payments depended directly on the sizes (denoted by α_i and α_j) of payment networks in the two countries: i.e. fraction α_i of the payments originated in network i were domestic payments and fraction α_j cross-border payments.

However, this balanced payment pattern assumption is in conflict with the real-life situation because domestic retail payments are much more frequently made than cross-border payments. In fact, currently cross-border retail payments represent roughly 1-2% of all retail payments in the EU. Therefore, in order to better reflect the real-life situation, we introduce a sort of "home bias" (denoted by a scale factor, S) in making payments. Home bias in making payments simply means that the cross-border payments are scaled down by a multiplier S ($0 \leq S \leq 1$). The home bias is assumed to be the same in both countries. The aggregate payment pattern is then (α_1 and α_2 representing the sizes of payment networks in the two countries)

Aggregate payment pattern

	country 1	country 2
domestic payments:	$\alpha_1 \alpha_1$	$\alpha_2 \alpha_2$
cross-border payments:	$S \alpha_1 \alpha_2$	$S \alpha_2 \alpha_1$

⁴ The use of segmented market Hotelling model to describe the competitive situation in retail payment markets is grounded because, in the international context, the retail payment systems located in different countries are not directly competing with each other and are more or less acting as local monopolies. Furthermore, when assuming first segmented markets, we can also study the effects of technological progress lowering transportation costs: once transportation costs are so low that the payments markets are fully-served, we move back to the original LRT-framework.

The “home-biased” payment pattern in our model means that a consumer belonging to the payment network i has a probability α_i to make a domestic payment and a probability $S\alpha_j$ to make a cross-border payment. If $S=1$ (no home bias), then the situation is the same as in balanced payment pattern where the probabilities for domestic and cross-border payments are α_1 and α_2 , respectively. If $S=0$, then only domestic payments are made.

Cost and price structure

The two retail payment networks have the same cost structure. A network incurs a marginal cost c_0 per payment at the originating and terminating ends of the payment and marginal cost c_1 in between. The total marginal cost of a payment is thus

$$c = 2c_0 + c_1.$$

The total marginal cost of a *domestic payment* (a payment that is originated and terminated in one network) is then c .

The cost of a *cross-border payment* differs from c because payment networks pay each other a reciprocal two-way access charge for terminating each other’s cross-border payments. The unit access charge to each other’s network is denoted by a and is assumed to be same for both networks. Accordingly, the total marginal cost of a cross-border payment is $c + a - c_0$.

Under price discrimination, p_i and \hat{p}_i denote domestic and cross-border prices charged by retail payment network i , and α_i denote network i ’s market size defined in terms of network subscribers. In our model, markets are segmented so that $\alpha_1 + \alpha_2 < 1$ (in LRT-model markets are fully covered: $\alpha_1 + \alpha_2 = 1$).

The cost and price structure can be summarised as follows:

	Network 1	Network 2
<u>Domestic payment:</u>	price p_1 , cost c	price p_2 , cost c
<u>Cross-border payment:</u>	price \hat{p}_1 , cost $c + a - c_0$	price \hat{p}_2 , cost $c + a - c_0$.

Demand structure

Following the LRT-model, we assume that the retail payment networks are differentiated à la Hotelling. Consumers are uniformly located on the segment $[0,1]$ and the networks are located at the two extremities of the segments, $x_1 = 0$ and $x_2 = 1$. Given income y and payment consumption q , a consumer located at x and joining network i has a utility

$$y + v_0 - t|x - x_i| + u(q)$$

where v_0 represents a fixed surplus from being connected to a payment network, $t|x - x_i|$ denotes the cost associated with access to banking services (t being the "transportation cost"). The variable gross surplus $u(q)$ is given by

$$u(q) = \frac{q^{1-(1/\eta)}}{1 - \frac{1}{\eta}},$$

which yields constant elasticity demand function

$$u'(q) = p \Leftrightarrow q = p^{-\eta}.$$

It is assumed that the elasticity of demand, η , exceeds one and is same for both domestic and cross-border payments. It is also assumed that v_0 is "large enough" so that both networks have positive market sizes even though the transportation cost t is also assumed to be so high that the payment networks in the two countries are local monopolies (segmented market assumption).

Under linear pricing and the possibility of price discrimination, and for market sizes (α_1, α_2) , network i offers its customers a *variable net surplus*

$$w(p_i, \hat{p}_i) = \alpha_i v(p_i) + S\alpha_j v(\hat{p}_i) \quad (1)$$

where $v(p_i) = \max_{q(p_i)} \{u(q(p_i)) - p_i q(p_i)\} = \frac{p_i^{-(\eta-1)}}{\eta-1}$ (net surplus from domestic payments)

$$v(\hat{p}_i) = \max_{q(\hat{p}_i)} \{u(q(\hat{p}_i)) - \hat{p}_i q(\hat{p}_i)\} = \frac{\hat{p}_i^{-(\eta-1)}}{\eta-1}. \quad (\text{net surplus from cross-border payments})$$

According to Equation (1), consumer's variable surplus depends on the prices of both domestic and cross-border payments, on the market sizes of the networks as well as on the magnitude of home bias, S , in making payments. From equation (1), it can also be seen that price discrimination creates positive, tariff-mediated network externalities. Customers of network i are better off the bigger (smaller) the network is if $p_i < \hat{p}_i$ ($p_i > \hat{p}_i$). The existence of these network externalities can lead to the same kind of coordination problem for consumers, and possibility of multiple equilibria, as in models of network externalities where there is no interconnection, such as Katz and Shapiro (1985).

3. Effects of the Regulation

The Regulation on cross-border payments in euro means that the price discrimination is not anymore possible. In our model this indicates that the prices of domestic and cross-border payments must be equal, $p_i = \hat{p}_i = \bar{p}_i$. We first analyse the discriminatory pricing case and then compare it to uniform pricing case that prevails under the Regulation. We discuss the welfare implications of the regulation at the end of the Chapter.

3.1 Discriminatory pricing case

Market sizes

As mentioned above, the existence of network externalities in our model can lead to the possibility of multiple equilibria. Therefore, we assume, as e.g. in Shy (2001), that consumers have a perfect foresight and can thus correctly anticipate how many consumers will be subscribing each network. In other words, the expected network sizes will correspond to equilibrium network sizes as in fulfilled expectations equilibrium used in Katz and Shapiro (1985). Accordingly, when assuming $\alpha_i^e = \alpha_i$, we are able to circumvent multiple equilibria problem and get unique market sizes.

Let x_1 denote a customer who is indifferent between using network 1's payment services and not using payment services at all. Similarly, let x_2 denote a customer who is indifferent between using network 2's payment services and not using payment services at all. This means that consumers between 0 and x_1 use network 1 (located at 0) while those between x_2 and 1 use network 2 (located at 1). The corresponding market sizes (denoted by $\alpha_1 = x_1$ and $\alpha_2 = 1 - x_2$) are determined by the consumers' net utilities:

Network 1

$$v_0 + w(p_1, \hat{p}_1) - t\alpha_1 = 0$$

Network 2

$$v_0 + w(p_2, \hat{p}_2) - t\alpha_2 = 0$$

which, when utilising Equation (1), become

$$v_0 + \alpha_1 v(p_1) + S\alpha_2 v(\hat{p}_1) - t\alpha_1 = 0$$

$$\alpha_1 = \frac{v_0 + S\alpha_2 v(\hat{p}_1)}{t - v(p_1)}$$

$$v_0 + \alpha_2 v(p_2) + S\alpha_1 v(\hat{p}_2) - t\alpha_2 = 0$$

$$\alpha_2 = \frac{v_0 + S\alpha_1 v(\hat{p}_2)}{t - v(p_2)}$$

Accordingly, the market sizes can be written as

$$\alpha_1 = \frac{v_0(t + Sv(\hat{p}_1) - v(p_2))}{(t - v(p_1))(t - v(p_2)) - S^2v(\hat{p}_1)v(\hat{p}_2)} \quad (2)$$

$$\alpha_2 = \frac{v_0(t + Sv(\hat{p}_2) - v(p_1))}{(t - v(p_1))(t - v(p_2)) - S^2v(\hat{p}_1)v(\hat{p}_2)}.$$

Before proceeding with the analysis, we first show that, like in LRT, “a proportionality rule” holds for the relation between domestic and cross-border payment prices. To simplify notations, we let

$m \equiv \frac{a - c_0}{c}$ denote the markup on access relative to the total cost of a payment.

The proportionality rule

The proportionality rule states that the ratio between cross-border and domestic payment prices reflects the relative markup on access

$$\frac{\hat{p}_1}{p_1} = \frac{\hat{p}_2}{p_2} = 1 + m.$$

Proof:

The proportionality rule is obtained by considering network i 's optimal price structure when keeping its market size constant. To keep its market size constant, network i must offer a constant average net surplus to its customers. In the discriminatory pricing case, the program can be written as

$$\max_{p_i, \hat{p}_i} \{ \tilde{\alpha}_i (p_i - c)q(p_i) + S\tilde{\alpha}_j (\hat{p}_i - c(1 + m))q(\hat{p}_i) \}$$

s.t.

$$\tilde{\alpha}_i v(p_i) + S\tilde{\alpha}_j v(\hat{p}_i) = \tilde{w}_i$$

where tildes indicate that the variable is kept constant.

The problem can be solved by using the following Lagrangean expression:

$$\max_{p_i, \hat{p}_i} L = \{ \tilde{\alpha}_i (p_i - c)q(p_i) + S\tilde{\alpha}_j (\hat{p}_i - c(1 + m))q(\hat{p}_i) \} - \lambda [\tilde{\alpha}_i v(p_i) + S\tilde{\alpha}_j v(\hat{p}_i) - \tilde{w}_i].$$

The program is the dual of the two-good Ramsey pricing problem, and here one maximises the network's profit subject to consumer surplus being set at some level.

The first-order conditions are:

$$\frac{\partial L}{\partial p_i} = \tilde{\alpha}_i(q(p_i) + (p_i - c)q'(p_i)) - \lambda \tilde{\alpha}_i v'(p_i) = 0$$

$$\frac{\partial L}{\partial \hat{p}_i} = S\tilde{\alpha}_j(q(\hat{p}_i) + (\hat{p}_i - c(1+m))q'(\hat{p}_i)) - \lambda S\tilde{\alpha}_j v'(\hat{p}_i) = 0$$

$$\frac{\partial L}{\partial \lambda} = \tilde{\alpha}_i v(p_i) + S\tilde{\alpha}_j v(\hat{p}_j) - \tilde{w}_i = 0$$

Assuming that the two payment services have the same elasticity, η , and utilising $q = p^{-\eta}$ and $v'(p) = -p^{-\eta}$, we get

$$\frac{p_i - c}{p_i} = \frac{1 + \lambda}{\eta}$$

$$\frac{\hat{p}_i - c(m+1)}{\hat{p}_i} = \frac{1 + \lambda}{\eta}$$

Therefore, $\frac{\hat{p}_i}{p_i} = 1 + m$, and the proportionality rule thus holds. Q.E.D.

The proportionality rule can be used to reduce price competition to the choice of a single price p_i per network. Under the proportionality rule, consumer variable net surplus (Equation (1)) becomes

$$\begin{aligned} w_i &= \alpha_i v(p_i) + S\alpha_j v(\hat{p}_i) = \alpha_i v(p_i) + S\alpha_j \frac{v(p_i)}{(1+m)^{\eta-1}} \\ &= (\alpha_i + Sk\alpha_j)v(p_i) \end{aligned} \quad (3)$$

where

$$k \equiv \frac{1}{(1+m)^{\eta-1}}.$$

When utilising the proportionality rule, the market size equations (3) can be written as

$$\alpha_1 = \frac{v_0(t + Skv(p_1) - v(p_2))}{(t - v(p_1))(t - v(p_2)) - S^2 k^2 v(p_1)v(p_2)} \quad (4)$$

$$\alpha_2 = \frac{v_0(t + Skv(p_2) - v(p_1))}{(t - v(p_1))(t - v(p_2)) - S^2 k^2 v(p_1)v(p_2)}.$$

Finally, when we denote the index of access to banking services as the inverse of the transportation cost, $\sigma = 1/t$, the market sizes become

$$\alpha_1 = \frac{v_0 \sigma [1 - \sigma(v(p_2) - Skv(p_1))]}{1 - \sigma(v(p_1) + v(p_2)) + \sigma^2 v(p_1)v(p_2)(1 - S^2 k^2)} \quad (5)$$

$$\alpha_2 = \frac{v_0 \sigma [1 - \sigma(v(p_1) - Skv(p_2))]}{1 - \sigma(v(p_1) + v(p_2)) + \sigma^2 v(p_1)v(p_2)(1 - S^2 k^2)}.$$

Differentiating (5) we can see that the effect of network 1's price on market size is (similarly for network 2):

$$\frac{\partial \alpha_1}{\partial p_1} = \frac{-v_0 \sigma^2 q(p_1)(1 + Sk)(1 - \sigma v(p_2))}{\{1 - \sigma(v(p_1) + v(p_2)) + \sigma^2 v(p_1)v(p_2)(1 - S^2 k^2)\}^2} \cdot [1 - \sigma v(p_2) + Sk\sigma v(p_2)]$$

$$\frac{\partial \alpha_2}{\partial p_1} = \frac{-v_0 \sigma^2 q(p_1)(1 + Sk)Sk\sigma v(p_2)}{\{1 - \sigma(v(p_1) + v(p_2)) + \sigma^2 v(p_1)v(p_2)(1 - S^2 k^2)\}^2} \cdot [1 - \sigma v(p_2) + Sk\sigma v(p_2)].$$

Remark 1. The effect of network i 's price on market size goes in the same direction for both networks. This is in contrast with LRT results and is due to our segmented markets assumption.

For the calculation of the first-order conditions, it is also useful to note that $\frac{\partial \alpha_2}{\partial p_1} / \frac{\partial \alpha_1}{\partial p_1} = \frac{Sk\sigma v(p_2)}{1 - \sigma v(p_2)}$.

In the discriminatory pricing case, the expression for network i 's profits is:

$$\pi_i = \alpha_i \left[\alpha_i (p_i - c)q(p_i) + S\alpha_j (\hat{p}_i - c(1 + m))q(\hat{p}_i) \right] + S\alpha_i \alpha_j mcq(\hat{p}_j) \quad (6)$$

domestic cross-border payments access revenue

Accordingly, payment network i 's profit is composed of revenue from domestic and cross-border payments as well as access revenue (assuming that $m > 0$) it receives for terminating other network's cross-border payments.

Under the proportionality rule, the profit function for network 1 (similarly for network 2) can be written as

$$\pi_1 = \alpha_1 [(\alpha_1 + Sk\alpha_2)R(p_1)] + S\alpha_1\alpha_2 \frac{kmc}{1+m} p_2^{-\eta} \quad (7)$$

where $R(p_1) = (p_1 - c)q(p_1)$.

The first order condition for profit maximisation for network 1 is (similarly for network 2)

$$\begin{aligned} \frac{\partial \pi_1}{\partial p_1} &= \frac{\partial \alpha_1}{\partial p_1} [(\alpha_1 + Sk\alpha_2)R(p_1)] + \alpha_1 \frac{\partial \alpha_1}{\partial p_1} R(p_1) + \alpha_1 Sk \frac{\partial \alpha_2}{\partial p_1} R(p_1) + \alpha_1 (\alpha_1 + Sk\alpha_2) R'(p_1) \\ &+ \frac{\partial \alpha_1}{\partial p_1} S\alpha_2 \frac{kmc}{1+m} p_2^{-\eta} + \frac{\partial \alpha_2}{\partial p_1} S\alpha_1 \frac{kmc}{1+m} p_2^{-\eta} = 0. \end{aligned}$$

Under symmetry, $\alpha_1 = \alpha_2 = \alpha$, $p_1 = p_2 = p$, and from the proportionality rule

$\hat{p}_1 = \hat{p}_2 = \hat{p} = (1+m)p$, and denoting $v = v(p)$, the first-order condition can be written as

$$\begin{aligned} \frac{p-c}{p} &= \frac{\hat{p}-c(1+m)}{\hat{p}} = \\ &\frac{1}{\eta} \left[1 - \frac{\sigma(1-\sigma v)}{(1-\sigma v)^2 - S^2 k^2 \sigma^2 v^2} R(p) \left(2 + Sk + \frac{S^2 k^2 \sigma v}{1-\sigma v} \right) \right] \\ &- \frac{1}{\eta} \frac{\sigma(1-\sigma v)}{(1-\sigma v)^2 - S^2 k^2 \sigma^2 v^2} \frac{Skmc}{1+m} p^{-\eta} (1-\sigma v + Sk\sigma v) \\ &= \frac{1}{\eta} \left[1 - \frac{\sigma(1-\sigma v)}{(1-\sigma v)^2 - S^2 k^2 \sigma^2 v^2} \left(R(p) \left(2 + Sk + \frac{S^2 k^2 \sigma v}{1-\sigma v} \right) + \frac{Skmc}{1+m} p^{-\eta} (1-\sigma v + Sk\sigma v) \right) \right]. \end{aligned} \quad (8)$$

The first-order condition equation (8) implicitly gives the optimal prices for domestic and cross-border payments in the discriminatory pricing case.

3.2 Uniform pricing case

The Regulation means that both domestic and cross-border retail payments must be priced equally. In our model this means that $p_i = \hat{p}_i = \bar{p}_i$, i.e. only one uniform price is charged for both type of payments. In the following, we refer this case as the uniform pricing case.

The market sizes

The procedure to define market sizes follows similar steps as in the case of price discrimination. Accordingly, under perfect foresight assumption $\alpha_i^e = \alpha_i$, market sizes are determined by the consumers' net utility expressions:

Network 1

$$v_0 + \alpha_1 v(\bar{p}_1) + S\alpha_2 v(\bar{p}_1) - t\alpha_1 = 0$$

$$\alpha_1 = \frac{v_0 + S\alpha_2 v(\bar{p}_1)}{t - v(\bar{p}_1)}$$

Network 2

$$v_0 + \alpha_2 v(\bar{p}_2) + S\alpha_1 v(\bar{p}_2) - t\alpha_2 = 0$$

$$\alpha_2 = \frac{v_0 + S\alpha_1 v(\bar{p}_2)}{t - v(\bar{p}_2)}$$

and we can solve the market sizes to be

$$\alpha_1 = \frac{v_0(t + Sv(\bar{p}_1) - v(\bar{p}_2))}{(t - v(\bar{p}_1))(t - v(\bar{p}_2)) - S^2 v(\bar{p}_1)v(\bar{p}_2)} \quad (9)$$

$$\alpha_2 = \frac{v_0(t + Sv(\bar{p}_2) - v(\bar{p}_1))}{(t - v(\bar{p}_1))(t - v(\bar{p}_2)) - S^2 v(\bar{p}_1)v(\bar{p}_2)}$$

If we denote the index of access to banking services as $\sigma = 1/t$, the market sizes become

$$\alpha_1 = \frac{v_0\sigma[1 - \sigma(v(\bar{p}_2) - Sv(\bar{p}_1))]}{1 - \sigma(v(\bar{p}_1) + v(\bar{p}_2)) + \sigma^2 v(\bar{p}_1)v(\bar{p}_2)(1 - S^2)} \quad (10)$$

$$\alpha_2 = \frac{v_0\sigma[1 - \sigma(v(\bar{p}_1) - Sv(\bar{p}_2))]}{1 - \sigma(v(\bar{p}_1) + v(\bar{p}_2)) + \sigma^2 v(\bar{p}_1)v(\bar{p}_2)(1 - S^2)}$$

In the uniform pricing case, the effects of network 1's price on market sizes are (similarly for network 2)

$$\frac{\partial \alpha_1}{\partial \bar{p}_1} = \frac{-v_0 \sigma^2 q(\bar{p}_1)(1+S)(1-\sigma v(\bar{p}_2))}{\{1-\sigma(v(\bar{p}_1)+v(\bar{p}_2))+\sigma^2 v(\bar{p}_1)v(\bar{p}_2)(1-S^2)\}^2} \cdot [1-\sigma v(\bar{p}_2)+S\sigma v(\bar{p}_2)]$$

$$\frac{\partial \alpha_2}{\partial \bar{p}_1} = \frac{-v_0 \sigma^2 q(\bar{p}_1)(1+S)S\sigma v(\bar{p}_2)}{\{1-\sigma(v(\bar{p}_1)+v(\bar{p}_2))+\sigma^2 v(\bar{p}_1)v(\bar{p}_2)(1-S^2)\}^2} \cdot [1-\sigma v(\bar{p}_2)+S\sigma v(\bar{p}_2)].$$

Remark 2. The effect of network i 's price on market sizes goes in the same direction for both networks. This is in contrast with LRT results and is due to our segmented market assumption.

For the calculation of the first-order conditions, it is also useful to note that $\frac{\partial \alpha_2}{\partial p_1} / \frac{\partial \alpha_1}{\partial p_1} = \frac{S\sigma v(\bar{p}_2)}{1-\sigma v(\bar{p}_2)}$.

In the uniform pricing case, the expression for network i 's profits is:

$$\pi_i = \alpha_i \left[\alpha_i (\bar{p}_i - c) q(\bar{p}_i) + S \alpha_j (\bar{p}_i - c(1+m)) q(\bar{p}_i) \right] + S \alpha_i \alpha_j m c q(\bar{p}_j) \quad (11)$$

domestic cross-border payments access revenue

The first order condition for profit maximisation is for network 1 (similarly for network 2):

$$\begin{aligned} \frac{\partial \pi_1}{\partial \bar{p}_1} &= \frac{\partial \alpha_1}{\partial \bar{p}_1} \left[\alpha_1 (\bar{p}_1 - c) q(\bar{p}_1) + S \alpha_2 (\bar{p}_1 - c(1+m)) q(\bar{p}_1) \right] \\ &+ \alpha_1 \frac{\partial \alpha_1}{\partial \bar{p}_1} (\bar{p}_1 - c) q(\bar{p}_1) + \alpha_1 \alpha_1 q(\bar{p}_1) + \alpha_1 \alpha_1 (\bar{p}_1 - c) q'(\bar{p}_1) + S \alpha_1 \frac{\partial \alpha_2}{\partial \bar{p}_1} (\bar{p}_1 - c(1+m)) q(\bar{p}_1) \\ &+ S \alpha_1 \alpha_2 q(\bar{p}_1) + S \alpha_1 \alpha_2 (\bar{p}_1 - c(1+m)) q'(\bar{p}_1) \\ &+ \frac{\partial \alpha_1}{\partial \bar{p}_1} S \alpha_2 m c q(\bar{p}_2) + \frac{\partial \alpha_2}{\partial \bar{p}_1} S \alpha_1 m c q(\bar{p}_2) = 0 \end{aligned}$$

Under symmetry, $\bar{p}_1 = \bar{p}_2 = \bar{p}$, $\alpha_1 = \alpha_2 = \alpha$, and denoting $v = v(\bar{p})$, the first-order condition becomes

$$\frac{\bar{p} - c(1 + \frac{S}{1+S}m)}{\bar{p}} = \frac{1}{\eta} \left[1 - \frac{\sigma(1-\sigma v)}{(1-\sigma v)^2 - S^2 \sigma^2 v^2} R(\bar{p}) \left(2 + S + \frac{S^2 \sigma v}{1-\sigma v} \right) \right]. \quad (12)$$

The Equation (12) implicitly gives the optimal price in the uniform pricing case.

3.3 Welfare effects of price regulation

Fixing the reciprocal access charge a , the effects of price regulation are now studied in the case when the index of access to banking services, $\sigma = 0$. The results hold by continuity for small σ . It should be noted that low σ corresponds to large transportation cost t , and the case $\sigma = 0$ would in fact mean infinite transportation costs. Therefore, as in LRT, we have to assume that fixed surplus of being connected to a payment network, v_0 , increases as σ tends to zero so that the equilibrium market size of payment networks remain unchanged. In fact, the “case $\sigma = 0$ ” is defined by taking the limit as $\sigma \rightarrow 0$ and v_0 increasing.

We define p_u , p_d and \hat{p}_d to denote the equilibrium prices under uniform pricing and under discriminatory pricing for domestic and cross-border retail payments. For $\sigma = 0$, the equations (12) and (8) can be written as follows

$$\frac{p_u - \left(1 + \frac{S}{1+S}m\right)c}{p_u} = \frac{1}{\eta} \quad (\text{uniform pricing})$$

$$\frac{p_d - c}{p_d} = \frac{1}{\eta}$$

and

(discriminatory pricing)

$$\frac{\hat{p}_d - (1+m)c}{\hat{p}_d} = \frac{1}{\eta}.$$

Accordingly, the uniform price will be a weighed average of discriminatory prices

$$p_u = \frac{1}{1+S}p_d + \frac{S}{1+S}\hat{p}_d, \quad (13)$$

where the degree of home-bias in making payments, S , is the weight. Clearly, when there is no home bias in making payments, i.e. $S=1$, the uniform price will be the average of the discriminatory prices.

Welfare comparison

When looking at the global welfare by summing up the consumer and producer surpluses (for complete calculations, see Appendix 1), we get the following expressions for global welfare for the case of very high access cost to banking services ($\sigma = 0$).

Uniform pricing (price regulation)

$$W^{\text{uniform}} = 2\alpha_u^2(1+S) \left[\frac{\eta}{\eta-1} p_u^{-(\eta-1)} - c p_u^{-\eta} \right] - t\alpha_u^2 \quad (14)$$

Discriminatory pricing

$$W^{\text{discriminatory}} = 2\alpha_d^2 \left[\frac{\eta}{\eta-1} p_d^{-(\eta-1)} - c p_d^{-\eta} \right] + 2S\alpha_d^2 \left[\frac{\eta}{\eta-1} \hat{p}_d^{-(\eta-1)} - c \hat{p}_d^{-\eta} \right] - t\alpha_d^2 \quad (15)$$

For simplicity, the transportation cost terms ($t\alpha_i^2$'s) are first dropped out and we concentrate on the gross welfare comparisons:

$$\begin{aligned} & W_{\text{gross}}^{\text{discriminatory}} - W_{\text{gross}}^{\text{uniform}} \\ &= 2\alpha_d^2 \left[\frac{\eta}{\eta-1} p_d^{-(\eta-1)} - c p_d^{-\eta} \right] + 2S\alpha_d^2 \left[\frac{\eta}{\eta-1} \hat{p}_d^{-(\eta-1)} - c \hat{p}_d^{-\eta} \right] - 2\alpha_u^2(1+S) \left[\frac{\eta}{\eta-1} p_u^{-(\eta-1)} - c p_u^{-\eta} \right] \quad (16) \\ &= 2\alpha_d^2 W(p_d) + 2S\alpha_d^2 W(\hat{p}_d) - 2\alpha_u^2(1+S)W(p_u). \end{aligned}$$

Accordingly, we can establish the following inequality (stating that gross welfare is higher under discriminatory pricing) and examine whether it holds:

$$\begin{array}{cc} \text{uniform} & \text{discrimination} \\ 2\alpha_u^2(1+S)W(p_u) & \leq 2\alpha_d^2 W(p_d) + 2S\alpha_d^2 W(\hat{p}_d). \end{array} \quad (17)$$

By rearranging we get

$$W(p_u) \leq \frac{\alpha_d^2}{\alpha_u^2} \left(\frac{1}{1+S} W(p_d) + \frac{S}{1+S} W(\hat{p}_d) \right). \quad (18)$$

The validity of the equation (18) is checked in two steps

(i) *First examining the market size terms (α_d^2/α_u^2):*

In symmetry, the equilibrium market sizes under discriminatory pricing α_d (Equation (5)) and uniform pricing α_u (Equation (10)) can be written as

$$\alpha_d = \frac{v_0 \sigma}{1 - \sigma v(p_d) - S k \sigma v(p_d)} \quad \text{and} \quad \alpha_u = \frac{v_0 \sigma}{1 - \sigma v(p_u) - S \sigma v(p_u)}.$$

Accordingly, we get

$$\frac{\alpha_d}{\alpha_u} = \frac{1 - \sigma v(p_u) - S \sigma v(p_u)}{1 - \sigma v(p_d) - S k \sigma v(p_d)} = \frac{1 - \left(\frac{1+S}{1+S+Sm} \right)^{\eta-1} \sigma v(p_d) - \left(\frac{1+S}{1+S+Sm} \right)^{\eta-1} S v \sigma(p_d)}{1 - \sigma v(p_d) - S k \sigma v(p_d)}$$

>1 when m>0 (positive access charge, k<1)

=1 when m=0 (zero access charge, k=1)

< 1 when m < 0 (negative access charge, k>1), not relevant case here

(ii) Secondly, examining the term: $W(p_u) \leq \frac{1}{1+S} W(p_d) + \frac{S}{1+S} W(\hat{p}_d)$

By Jensen's inequality it strictly holds when m>0 and S>0 because the gross welfare function

$W(p) = u(q(p)) - cq(p) = \frac{\eta}{\eta-1} p^{-(\eta-1)} - cp^{-\eta}$ reaches a maximum at $p = c$ and is convex for p greater than $(\eta+1)c/\eta < p^M$. Because all prices weakly exceed the monopoly price, a mean-preserving price spread raises gross welfare.

When combining (i) and (ii), we get

$$2\alpha_u^2(1+S)W(p_u) < 2\alpha_d^2W(p_d) + 2S\alpha_d^2W(\hat{p}_d).$$

In other words, for high access cost to banking services (high transportation cost) and for positive markup on access (m>0) and no extreme home bias (S>0), gross social welfare is higher under price discrimination than under uniform pricing prevailing under price regulation. The reason for this is that price discrimination alleviates the double-marginalisation effect that arises when the access charge exceeds marginal cost. Price discrimination decreases the double markup for domestic payments and raises it for cross-border payments. This price dispersion benefits customers whose net surplus function is convex. Similarly as in LRT, in the second-best context in which prices are already distorted by a double-marginalisation, the distortion due to price discrimination may actually be beneficial.

The above results are reversed if we look at the total welfare comparison and include the transportation cost terms ($t\alpha_i^2$'s) as well:

$$\begin{aligned} & W^{\text{discriminatory}} - W^{\text{uniform}} \\ &= 2\alpha_d^2 \left[\frac{\eta}{\eta-1} p_d^{-(\eta-1)} - c p_d^{-\eta} \right] + 2S\alpha_d^2 \left[\frac{\eta}{\eta-1} \hat{p}_d^{-(\eta-1)} - c \hat{p}_d^{-\eta} \right] - 2\alpha_u^2 (1+S) \left[\frac{\eta}{\eta-1} p_u^{-(\eta-1)} - c p_u^{-\eta} \right] - t\alpha_d^2 + t\alpha_u^2. \end{aligned}$$

In this case the transportation cost terms would be dominating the welfare comparison because $\alpha_d > \alpha_u$ for positive access charges ($m > 0$). However, the meaningfulness of the analysis in this case is questionable because we are looking at the case in which $\sigma \rightarrow 0$ (i.e. transportation cost t approaches infinity) and v_0 increases simultaneously so that payment market sizes in each country remain unchanged.

By continuity, we can argue, as in LRT, that the above results hold for small σ . However, the analysis of the general case $\sigma > 0$, based on the equations (8) and (12), is difficult and would require simulations or modifications to modelling framework.

In conclusion, the above analysis showed that the welfare effects of price regulation in retail payment systems are difficult to be comprehensively evaluated. We were able to draw analytical results only in a special case. However, according to Laffont-Rey-Tirole, it is well known that welfare effects of price discrimination are ambiguous, both in monopolistic and competitive environments (see e.g. Lederer & Hurter (1986), Thisse & Vives (1988), Holmes (1989), Armstrong & Vickers (2001)). Therefore, it is not very surprising that that our model, at least in its present form, was not capable of producing clear-cut analytical welfare results. In order to quantify the possible welfare effects of price regulation in retail payments, simulations of the present model could be employed.

4. Discussion on policy implications

For potential policy implications, the predictions of our theoretical model must be assessed against the real-life phenomena. It is no doubt that the Regulation adopted by the European Parliament and the EU Commission on cross-border retail payments in euro (RPE) has proved to be a strong regulatory measure to foster the integration process in the European retail payment markets. In essence, the RPE has eliminated the price discrepancy between comparable domestic and cross-border retail payments provided that certain conditions for the payment are fulfilled⁵. From purely integration policy perspective, the Regulation has expanded the Single market concept also to the retail payments area. According to the EU Commission (2003), the RPE has contributed to a considerable reduction in the price of cross-border payments in the Internal Market. Even more importantly, it has also provided an incentive for the payment industry to modernise their EU-wide payment infrastructures. In general, the Commission sees the RPE as an important step in the process of achieving a Single Payment Area / Single Euro Payment Area (SEPA) for non-cash payments in the Internal Market, which has not been able to be put up before despite the introduction of the euro.

Naturally, the real quantitative effects induced by the RPE can be assessed only over time when long enough data are gathered e.g. by the means of comprehensive pricing surveys. The Commission has been conducting such studies even earlier on and is going to do so also in the future. However, also there is a potential caveat to reliably assess the effects of the Regulation because it may prove to be cumbersome to detect "the pure regulation effects" on cross-border prices because the development in banking technology, especially in the internet banking, will put a downward pressure on these prices anyway. The Regulation contains also a Review clause (Article 8) stating that:

"not later than 1 July 2004, the Commission shall submit to the European Parliament and to the Council a report on the application of this Regulation in particular on: (i) changes in cross-border payment system infrastructures, (ii) the advisability of improving consumer services by strengthening the conditions of competition in the provision of cross-border services, (iii) the impact of the application of this Regulation on charges levied for payments made within a member State, (iv) the advisability of increasing the amount provided in Article 6(1) to EUR 50 000 as from January 2006, taking into account any consequences for undertakings." Accordingly, it will be

⁵ A cross-border retail payment is subject to the RPE and must be priced in a similar way as a comparable domestic payment, when the payment information provided by the payment originator fulfils criteria stipulated in the Regulation. For example, in cross-border credit transfers, the IBAN (the International Bank Account Number) and BIC (the Bank Identifier Code) must be employed. Therefore, in order to fully benefit from the Regulation, customers should consistently use these international retail payment standards, because otherwise the payment service providers are not obliged to price equally the comparable domestic and cross-border payments. For more practical information, see e.g. the web pages of the European Committee for Banking Standards (www.ecbs.org), the European Central Bank (www.ecb.int), the Commission (www.europa.eu.int); or for the Finnish case, Finnish Bankers' Association (www.pankkiyhdistys.fi)

interesting to see the results of the future price surveys and their impact on the application of the Review clause described above.

When studying the Regulation from the theoretical perspective, the following observations are worth stressing. As a regulatory measure, the RPE is strong and somewhat peculiar since it regulates directly the final retail prices. In many other network industries (like e.g. telecommunications, electricity etc.), the focus of regulation has been on the intermediate prices (access prices). In fact, it has been stressed (see e.g. Mason & Valletti (2001)) that access pricing and its regulation are very important in the network industries where the interconnection conditions among networks are crucial. In order to solve the potential interconnection disputes, different types of rules have been put forward in many network industries: Long-Run Incremental Cost (LRIC), Cost-based rules, Efficient Component Pricing Rule (ECPR), and Ramsey Charges and Global Caps. All these rules are used to determine the optimal access prices but, on the other hand, they also require the regulators to have an extensive and comprehensive knowledge of the cost structure of the industry in order for them to implement the rules properly. Accordingly, applicability of these rules to payment service industry may prove to be difficult because the real cost structure is "private information" of the payment service providers. Therefore, these access pricing rules - at least as such - are difficult to be implemented in the payment service industry.⁶

Even though the welfare effects of price regulation were difficult to quantify in our theoretical framework, we are able to draw some theoretically-based predictions from our model and compare them with real-life observations. *Firstly*, we are able to say something on the reactions of the retail payment prices when looking at the optimal pricing decisions suggested by our model. In the simplified case analysed at the end of the Chapter 3, our model indicated that the uniform price under the regulation would be a weighed average of discriminatory prices in the segmented retail payment markets. In real-life, short-run anecdotic evidence suggests that the post-regulation cross-border prices have indeed converged towards pre-regulation domestic payment price levels. In fact, when letting the home-bias factor S in making payments (Equation (13)) to be small (currently 1-2% of all retail payments are cross-border payments in the EU) the uniform price predicted by our model would be very close to pre-regulation domestic payment price which then seems to be in line with the real life developments. The driving force for this result is the assumed the home-bias in making payments (S very small). However, it should be noted that without any home-bias ($S=1$), the optimal uniform price suggested by our model would be the arithmetic average of pre-regulation domestic and cross-border prices.

⁶ In fact, there have been debates on justifiability and efficiency of these rules (especially concerning the Long Run Incremental Cost rule and the Efficient Component Pricing Rule) also in the academic and business circles. Much of discussions are related to the price regulation in the telecommunications field.

This real-life convergence of prices towards pre-regulation domestic price level is not surprising even when looking at the price-setting behaviour from purely economic and business policy perspectives: the cross-border payments are more expensive to be produced because the proper infrastructure has been lacking, but at the same time they represent such a minor fraction of the total retail payments that the payment service providers can possibly treat them as loss-leaders and cross-subsidise them using revenues from other banking services. In the future, this situation may change as the increasing cross-border trade is likely to bring about also the increasing need for cross-border retail payments and thereby reduce the present home-bias in making payments. Were the infrastructure for cross-border payments not to be improved accordingly, the cost-cutting pressures for payment service providers would increase considerably. However, at least in the credit transfer area, the activation by the service provider sector seems to result in the improved infrastructure. The launch of the Euro Banking Association's STEP 2 -system for processing cross-border bulk retail payments is likely to mitigate this problem by providing a Pan-European Automated Clearing House (PEACH) for cross-border payments. While the PEACH, if successfully and widely enough adopted, clearly facilitates the utilisation of the inherent economies of scale in retail payment service provision, a potential "access problem" can emerge: only the biggest players in the field are directly participating in the system and medium and smaller players act as indirect participants and buy their retail payments services from the bigger players. This may re-introduce the access pricing problem also in the retail payments area, and in this respect, guidance from regulatory principles used in the traditional network industries can then prove to be useful.

Secondly, another implication we are able to draw from our theoretical model deals with the transportation costs (in our model interpreted as costs associated with access to banking services) and the related segmentation of the payment service market. When assuming that access costs to banking services (t) would be declining as a result of deepening economic and financial integration and increased cross-border trade (like e.g. internet trade) and technological progress in providing banking services, the current segmentation of the retail payment markets is very likely to be reduced. At the end of such a development, our model set-up would be similar to the original Laffont-Rey-Tirole model where the markets are in fact fully-served and service providers compete directly with each other. Accordingly, in such a situation we can then directly apply and re-interpret their results. In general, the LRT-results suggest that allowing price discrimination is more beneficial for social welfare than imposing uniform pricing by regulation. However, it should be noted that also their welfare results were obtained in a similar simplified case as ours, and therefore, their generalisation should be done in a cautious way. Anyway, the LRT-results would seem to suggest that price discrimination is better for welfare when the markets are fully-served. This, in turn, would suggest

that the Regulation on cross-border retail payments in euro was not necessarily the right way to deal with the pricing problem in euro retail payments. However, it must also be admitted that the access price regulation used e.g. in telecommunication industry is hard to be implemented in the payment systems field. A clear merit of the Regulation is the fact that, after its adoption, the payment service provider sector has been forced to act to improve infrastructure. The establishment of the European Payments Council as a common decision-making body and the set-up of the STEP 2-payment system as a potential candidate for a Pan-European Automated Clearing House are nice examples of this "regulation-induced" activation of the service providers. Naturally, only the coming years will tell how successful - in terms of welfare improvements for EU citizens - the Regulation on cross-border payments in euro finally was.⁷

All in all, it can be concluded that, given the topicality of the price regulation question and the scarcity of studies on the pricing of retail payment services in general, future research on the topic is warranted. In this context, the rather extensive literature on the interconnection pricing in the telecommunications industry could serve as a good background. One direct possibility would be to modify and simplify the framework of the model presented above so that more tractable and general results could be obtained.

⁷ For a recent survey on the different facets of regulatory competition in EU financial services, see Hertig (2001).

Appendix 1. Welfare analysis

A.1.1. Discriminatory pricing

Producer surplus (PS)

$$\alpha_1[\alpha_1(p_1 - c)q(p_1) + S\alpha_2(\hat{p}_1 - c)q(\hat{p}_1)] + \alpha_2[\alpha_2(p_2 - c)q(p_2) + S\alpha_1(\hat{p}_2 - c)q(\hat{p}_2)]$$

which becomes under symmetry ($p_1 = p_2 = p_d$, $\hat{p}_1 = \hat{p}_2 = \hat{p}_d$, $\alpha_1 = \alpha_2 = \alpha_d$):

$$\begin{aligned} & \alpha_d[\alpha_d(p_d - c)p_d^{-\eta} + S\alpha_d(\hat{p}_d - c)p_d^{-\eta}] + \alpha_d[\alpha_d(p_d - c)\hat{p}_d^{-\eta} + S\alpha_d(\hat{p}_d - c)\hat{p}_d^{-\eta}] \\ & = 2\alpha_d^2(p_d^{-(\eta-1)} - cp_d^{-\eta}) + 2\alpha_d^2(\hat{p}_d^{-(\eta-1)} - c\hat{p}_d^{-\eta}) \end{aligned}$$

Consumer surplus (CS)

$$\alpha_1[\alpha_1 v(p_1) + S\alpha_2 v(\hat{p}_1)] - t\left(\frac{\alpha_1^2}{2}\right) + \alpha_2[\alpha_2 v(p_2) + S\alpha_1 v(\hat{p}_2)] - t\left(\frac{\alpha_2^2}{2}\right)$$

which becomes under symmetry ($p_1 = p_2 = p_d$, $\hat{p}_1 = \hat{p}_2 = \hat{p}_d$, $\alpha_1 = \alpha_2 = \alpha_d$)

$$\begin{aligned} & \alpha_d[\alpha_d v(p_d) + S\alpha_d v(\hat{p}_d)] - t\left(\frac{\alpha_d^2}{2}\right) + \alpha_d[\alpha_d v(p_d) + S\alpha_d v(\hat{p}_d)] - t\left(\frac{\alpha_d^2}{2}\right) \\ & = 2\alpha_d^2 v(p_d) + 2S\alpha_d^2 v(\hat{p}_d) - t\alpha_d^2 \\ & = 2\alpha_d^2 \frac{p_d^{-(\eta-1)}}{\eta-1} + 2S\alpha_d^2 \frac{\hat{p}_d^{-(\eta-1)}}{\eta-1} - t\alpha_d^2 \end{aligned}$$

Total welfare (PS+CS)

$$\begin{aligned} W^{\text{discriminatory}} & = 2\alpha_d^2(p_d^{-(\eta-1)} - cp_d^{-\eta}) + 2\alpha_d^2(\hat{p}_d^{-(\eta-1)} - c\hat{p}_d^{-\eta}) + 2\alpha_d^2 \frac{p_d^{-(\eta-1)}}{\eta-1} + 2S\alpha_d^2 \frac{\hat{p}_d^{-(\eta-1)}}{\eta-1} - t\alpha_d^2 \\ & = 2\alpha_d^2 \left(\frac{\eta}{\eta-1} p_d^{-(\eta-1)} - cp_d^{-\eta} \right) + 2S\alpha_d^2 \left(\frac{\eta}{\eta-1} \hat{p}_d^{-(\eta-1)} - c\hat{p}_d^{-\eta} \right) - t\alpha_d^2 \\ & = 2\alpha_d^2 W(p_d) + 2S\alpha_d^2 W(\hat{p}_d) - t\alpha_d^2. \end{aligned}$$

A.1.2. Uniform pricing

Producer surplus (PS)

$$\alpha_1[\alpha_1(\bar{p}_1 - c)q(\bar{p}_1) + S\alpha_2(\bar{p}_1 - c)q(\bar{p}_1)] + \alpha_2[\alpha_2(\bar{p}_2 - c)q(\bar{p}_2) + S\alpha_1(\bar{p}_2 - c)q(\bar{p}_2)]$$

which becomes under symmetry ($\bar{p}_1 = \bar{p}_2 = p_u$, $\alpha_1 = \alpha_2 = \alpha_u$)

$$\begin{aligned} & \alpha_u[\alpha_u(p_u - c)p_u^{-\eta} + S\alpha_u(p_u - c)p_u^{-\eta}] + \alpha_u[\alpha_u(p_u - c)p_u^{-\eta} + S\alpha_u(p_u - c)p_u^{-\eta}] \\ &= 2\alpha_u^2(1+S)(p_u - c)p_u^{-\eta} \\ &= 2\alpha_u^2(1+S)\left(\frac{p_u - c}{p_u^{-\eta}}\right) \end{aligned}$$

Consumer surplus (CS)

$$\alpha_1[\alpha_1 v(\bar{p}_1) + S\alpha_2 v(\bar{p}_1)] - t\left(\frac{\alpha_1^2}{2}\right) + \alpha_2[\alpha_2 v(\bar{p}_2) + S\alpha_1 v(\bar{p}_2)] - t\left(\frac{\alpha_2^2}{2}\right)$$

which becomes under symmetry ($\bar{p}_1 = \bar{p}_2 = p_u$, $\alpha_1 = \alpha_2 = \alpha_u$)

$$\begin{aligned} & \alpha_u[\alpha_u v(p_u) + S\alpha_u v(p_u)] - t\left(\frac{\alpha_u^2}{2}\right) + \alpha_u[\alpha_u v(p_u) + S\alpha_u v(\hat{p}_u)] - t\left(\frac{\alpha_u^2}{2}\right) \\ &= 2\alpha_u^2(1+S)v(p_u) - t\alpha_u^2 \\ &= 2\alpha_u^2(1+S)\frac{p_u^{-(\eta-1)}}{\eta-1} - t\alpha_u^2 \end{aligned}$$

Total welfare (PS+CS)

$$\begin{aligned} W^{\text{uniform}} &= 2\alpha_u^2(1+S)\left(\frac{p_u - c}{p_u^{-\eta}}\right) + 2\alpha_u^2(1+S)\frac{p_u^{-(\eta-1)}}{\eta-1} - t\alpha_u^2 \\ &= 2\alpha_u^2(1+S)\left[\frac{\eta}{\eta-1}p_u^{-(\eta-1)} - cp_u^{-\eta}\right] - t\alpha_u^2 \\ &= 2\alpha_u^2(1+S)W(p_u) - t\alpha_u^2. \end{aligned}$$

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