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Single Euro Payment Area and Banking Industry: Discriminatory Pricing vs. Non-Discriminatory Pricing

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Single Euro Payment Area and Banking Industry:

Discriminatory Pricing vs. Non-Discriminatory Pricing

Abstract

The Single Euro Payment Area (SEPA) project eliminates the incompatibility of domestic payment systems across European countries. It also enforces uniform pricing between national and international transactions. How does this policy affect competition among European banks in the retail payment market? To address this issue, I explore and solve a model of non-linear price competition between two asymmetric banks in terms of capital by considering price discrimination in pre-SEPA and uniform pricing in post-SEPA under the presence of economies of scale. My results show that the transaction pattern has a vital role in the effect of SEPA on competition between banks. Competition is less intense in post-SEPA when the transaction pattern is domestically oriented. Moreover, comparison of pre- and post-SEPA suggests that SEPA intensifies competition when economies of scale are large enough. I further show that consumer surplus improves in post-SEPA.

Key words: SEPA project, Banking industry, Non-linear pricing.

JEL classification numbers: L50, G20, L11.

1. Introduction.

The growth of international trade, cross-border e-commerce, and migration show that cross-border retail payment[1] is increasingly important in the last century. Many businesses serve clients abroad and purchase goods from international suppliers; many people make online purchases from international sellers, and migrants send money to their families in their home country; government agencies purchase from international suppliers or pay international aids. In Europe, cross-border payments have not been easy as domestic ones. For instance, an individual in Spain could not authorize a direct debit[2] by a German company (to pay a bill, receive a salary, etc.) unless he had a bank account in Germany. A business needed to maintain different bank accounts in the European countries in which it operated in order to conform to their instructions. Moreover, the price of cross-border payment was higher than domestic one.

The European Commission (henceforth EC), European Payment Council (henceforth EPC), and the European Central Bank (henceforth ECB) have debated that the source of customers' problems for making a cross-border payment in Europe was the incompatibility of domestic payment systems between European countries. Accordingly, the EC enforced the Single Euro Payment Area (henceforth SEPA) project towards the retail payment market in Europe. The SEPA project started in 2002 with the mission of applying principles in which all non-cash euro payments are treated in accordance with the same rights and obligations irrespective of their location. In particular, the intention was to overcome the problem of incompatibility of national payment systems across Europe and implement uniform pricing for domestic and cross-border transactions. In fact SEPA has created one union-wide retail payment market in the euro area. Payment service providers such as the banking industry were responsible for implementing SEPA which required the adoption of common standards and rights at significant cost.

Compliance with SEPA has resulted in fundamental changes in the payment system in Europe. Thus, it is of great importance to analyse the consequences of this policy. In this regard, the main concern of this paper is to address the question of how uniform pricing with respect to harmonization of payment systems affects competition between European banks. Analytical studies on this research question are almost rare. In this regard, the purpose of the present paper is to make a contribution to this rather undiscovered area. Since banks have the main role to execute payments, as well as being considerable participants in the financial markets and are important owners and users of the payment systems, I focus my attention on the banking industry as a proxy for payment service providers.

To analyse the potential effects of SEPA, it is essential to consider the prevailing conditions prior to SEPA project. In this paper, pre-SEPA is considered as a period in which payment systems are diversified across countries and banks are allowed to discriminate between the price of domestic and cross-border payments. Post-SEPA refers to a period in which banks complied with the SEPA system and applied the uniform pricing for making domestic and cross-border payments.

Given this generalized framework, I extend the duopoly model by Laffont et al. (1998a, b) (henceforth LRT model) who provide a theoretical framework for the telecommunication market, to

[1]Cross-border retail payment is a term referring to the transfer of low value of funds between at least two different countries; for instance, a retail payment from Spain to Germany or from the United Kingdom to France is regarded as a cross-border payment.

[2]Direct debit is an instruction from the payer to his bank in order to pay his debt. The payer authorizes payee to collect money from his account by giving advanced notice of the amounts and dates of collection.

consider competition between two asymmetric banks, in terms of capital, under non-linear pricing and in the presence of economies of scale. The large bank is defined as a bank with large capital compared to a small bank with low capital. The capital is intended versus the labour and is referred here to transaction technologies and modernization initiatives by banks. The adoption of modernization such as mobile wallets, Apple Pay, and so on involves a gradual reduction in banks costs (particularly, labour costs). The non-linear pricing consists of two prices: a fixed fee that is a subscription fee and a transaction price to make a payment that may depend on whether the payment is domestic or cross-border. Kokkola (2010) among others states that economies of scale are one of the main features of the banking industry since they allow banks to recover their high cost of investment in infrastructure. Humphrey (2009) estimates the scale economies among 11 European countries like Germany, France, U.K, Spain, Netherlands, Italy, Belgium, Sweden, Finland, Norway, and Denmark over 1987-2004. He finds that banks in the payment market are acting under economies of scale. Beccalli, Anolli, and Borell (2015) study the existence of economies of scale for 103 European banks from 2000 to 2011. They find that there are economies of scale among different banks, and they are significantly large for the largest banks. In this regard, I analyse competition between banks under the existence of economies of scale.

The major difference between the model of this paper and the LRT model is the definition of the cost function. In the framework of the LRT model, it is considered that two networks have the same cost structures and fixed marginal cost. Here, I consider that two banks have different marginal costs and the large bank is cost-efficient due to the larger capital level. Based on the existing work of Schmiedel (2007) and Mermelstein *et al.* (2014), I build the cost function by taking into account the capital and economies of scale. In post-SEPA, payment services are consolidated[3] and compatible across Europe, thus, SEPA is identified as the infrastructural project[4]. Schmiedel (2007) and Mermelstein *et al.* (2014) allow me to introduce the infrastructural change in the model through the cost functions. In particular, in pre-SEPA, the domestic payment systems are incompatible. This feature is captured by considering different marginal costs depending on payment termination: the domestic transaction cost is lower than the cross-border one since the latter includes connectivity cost to a third party. While, in post-SEPA, the compatibility between payment systems across countries implies the same costs per transaction for domestic and cross-border payments. However, in post-SEPA, banks have to make substantial investments to adopt the common standards required by this project. I consider it as a fixed adjustment cost.

For the sake of tractability, I take a narrower view of the cost functions introduced by Mermelstein *et al.* (2014) and only focus on the case where economies of scale equal the inverse of the labour share. It leads to constant marginal cost in terms of transaction volume.

My analysis stands in two phases: pre-SEPA with price discrimination and post-SEPA with uniform pricing in terms of payment destination. In this setup, I analyse the impacts of SEPA on competition and welfare by comparing pre-SEPA with post-SEPA. Given economies of scale, I start the analysis in the symmetric case where the two banks have the same levels of capital.

[3]So far, consolidation of payment services means two or more national services acting based on one standard and rule but not the merging of national markets.

[4]Following the European Payments Council (2009), the infrastructure is defined as '*the technology delivery system and network entity that supports a payment scheme*'.

Comparison of the results in pre- and post-SEPA shows that symmetric banks could not take advantage of SEPA, but SEPA would be beneficial for the customers because of the transaction prices. Welfare would improve in post-SEPA when increasing transaction volumes can offset the fixed adjustment cost. Then, I analyse the impacts of SEPA in the asymmetric case. The main result is that the transaction pattern affects the competition between banks in post-SEPA which is consistent with Leibbrandt (2010) and Schaefer (2008). I show that when the transaction pattern is dominated by the domestic market, then competition between banks is less intense in post-SEPA. I further show that consumer surplus improves in post-SEPA. The effect of SEPA on welfare depends on the amount of fixed adjustment cost. If this cost is sufficiently small, then welfare improves in post-SEPA. On further analysis, I consider the case where economies of scale are improved in post-SEPA. It is motivated by empirical evidence that the harmonization and standardization of national payment systems are likely to foster economies of scale in the payment market in Europe (see, Bolt and Humphrey (2007), Beijnen and Bolt (2009)). The results show that if economies of scale improve, then SEPA intensifies competition between banks. This result is in line with the EC expectation about the effect of SEPA on competition between banks.

The rest of the paper is organised as follows. Section 2 generally describes SEPA project and reviews some related literature. The structure of the models in pre-SEPA and post-SEPA are laid out in Section 3. Section 4 analyses the competition in pre- and post-SEPA. The comparisons of pre-SEPA with post-SEPA are shown in Section 5. Conclusion is presented in Section 6. Appendix gathers proofs.

2. Implementation of SEPA and Related Literature.

Before the introduction of SEPA, each European country was served by its own domestic payment system that was created under the national rules and standards, and therefore was incompatible among countries. For example, there was 'Iberpay' payment system in Spain, 'Vocalink' in the United Kingdom, and 'Wordline' in France. Therefore, a third-party like a correspondent bank was required to link domestic payment systems in order to make a cross-border payment, i.e., the correspondent bank provided international transaction services on behalf of the domestic payment systems.

Figure 1 shows the process of a cross-border payment in pre-SEPA. A payer and a payee are located at two different countries namely country A and country B. A payer is an individual (or a business, or a government agency) who gives the payment order to his bank and allows them to make a payment from his account. A payee is a beneficiary (could be an individual or a business or a government agency) who has received a fund to his account. The payer's bank receives a payment order. It then transfers information to the domestic payment system. The payment system settles the payment order based on domestic rules and technical standards. Then, the payment order goes to the correspondent bank in country A. If the fund needs to convert to the local currency, it is sent to the second correspondent bank in country B. Ultimately, the fund transfers to the payee's bank via the domestic payment's system of country B.

Figure 2 shows the process of a domestic payment in pre-SEPA. The payer and payee are located in the same country (for instance, country A) and the payment executes through the domestic payment system without involving any third-party.

Figure 1.Cross-border payment processes in pre-SEPA.

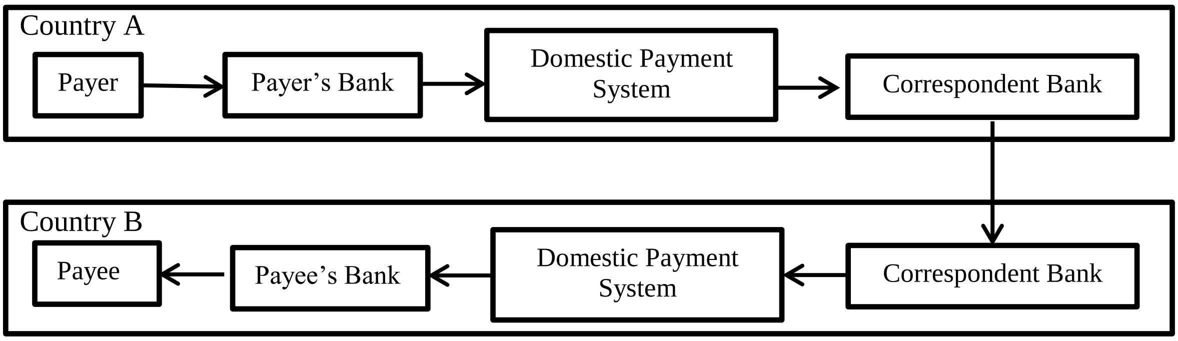
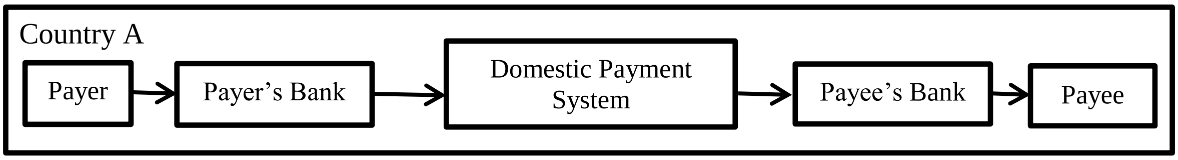


Figure 2. Domestic payment processes in pre-SEPA.



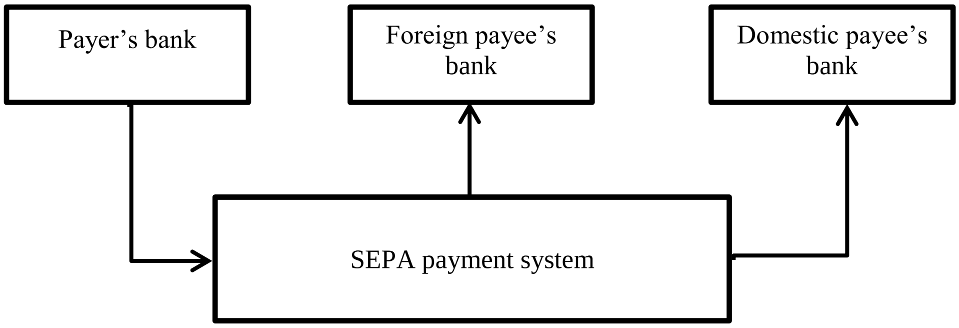
In pre-SEPA, the price of a cross-border payment was significantly higher than a domestic one. The EC and ECB argued that the price discrimination was due to the complexity of the cross-border payment systems. Moreover, the EC found that the price of cross-border payments varied significantly across European countries. The evidence provided by the EC in 2001 shows that the price of transferring €100 from Luxembourg to another European country was €9.58, from Germany was €11.93, from Spain was €20.56, and from Portugal was €31.04 (EC’s survey IP/01/992, 2001). From the EC point of view, the price diversification was problematic because it prevented an integrated market in Europe.

To overcome these problems, the first attempt after the introduction of the physical Euro as a single (cash) payment instrument across Europe was to enforce banks to charge the same transaction prices for domestic and cross-border payment up to €12,500, in 2002 (Regulation (EC) No.2560/2001). This regulation covered cross-border credit transfer and cross-border electronic payment. In 2007, the EC expanded the scope of uniform pricing for cross-border direct debit (Directive 2007/64/EC). In 2009, the uniform pricing regulation was enlarged to execute up to €50,000 (Regulation (EC) No.924/2009). The adoption of uniform pricing was an important step in reaching SEPA. The next step was to overcome the problem of diversity of the national payment systems, such as different standards, technologies, and rules across countries and form an integrated financial market in Europe to simplify the non-cash payment. In this regard, the last important stage of adopting SEPA was to implement the regulation (EC) No.260/2012 of the Commission and European Parliament. This regulation established the technical and business requirements for direct debit and credit transactions and cancelled €50,000 ceiling. All banks were obliged to comply with SEPA. They must adopt the common standards and rights that come with a significant cost. Based on the definition of the ECB (2009) ‘SEPA is an area, in which consumers, companies and other economic actors will be able to make and receive payments in euro, whether within or across national borders, with the same basic conditions, rights and obligations, regardless of their location’[5].

[5]SEPA consists of 34 countries which are 28 member states of the European Union and 6 other territories: Iceland, Monaco, Switzerland, Liechtenstein, Norway and San Marino. Some countries such as the UK, Sweden, Denmark, Switzerland, among others, that are located in SEPA but their economy is non-Euro based are obliged to comply with SEPA.

Under the SEPA system, there is no difference between domestic and cross-border euro payments; all euro payments in the SEPA zone are treated like domestic ones. All banks are obliged to make cross-border payment as cheap and easy as a domestic payment. Figure 3 shows domestic and cross-border payments are executed under a single system in post-SEPA.

Figure 3. Domestic and cross-border payment processes in post-SEPA.



The scope of influence of SEPA was extensive, so that retail payment market, every individual, business, and government agency in the euro area were affected by this project. In post-SEPA, customers rely on one bank account to make cashless euro payments to any payee under the same conditions, regardless of their location in the SEPA zone. It enables them to pay and receive funds from other SEPA countries without any extra costs when they travel, study, work, purchase goods and services. Businesses can integrate different bank accounts among different European countries into a unique one, thus they may be able to save cost and time for making payments. In general, SEPA provides better payment services since payments are executed within a certain time, the costs of making payments are clear and there is no hidden fees (banks are not allowed to make any deficit of the transferred amount), and payments are safe through SEPA via IBAN and BIC[6].

Although the analytical literature related to my research question is scarce, there are several studies that attempt to enhance understanding of the opportunities and costs of SEPA for customers and banks. These studies apply different methodologies. Some of them have examined the effects of SEPA from a theoretical or empirical standpoint, while others are interview-based studies.

Leibbrandt (2010) studies the effect of compatibility of Europe's payment systems on bank competition and welfare. He assumed that there are two equal sized countries served by two banks, one in each country. Moreover, he assumed that banks do not make price discrimination based on termination and that the marginal cost of a payment transaction is zero. He considers the case where two banks compete in two stages: in the first stage, they decide to comply or not with the compatible system and in the second stage, they compete on prices. Results show that the transaction patterns have the main role in bank's desire to choose the compatible system, i.e., if the transaction patterns are dominated by domestic transactions, banks maintain the incompatible system to avoid migration costs. In contrast, if this cost is zero, then banks make more profit with the compatible system than with the incompatible system but consumer surplus is lower due to higher prices charged by banks.

In another work, Schaefer (2008) studies the economic effect of SEPA project on the banking industry and welfare. He applies a spatial bank competition model between two banks and focuses on

[6]IBAN is an abbreviation of 'International Bank Account Number' which is a single standard for identifying and validating an account with a bank in Europe. A single bank identifier entails 'Bank Identifier Code (BIC)' that is also called Swift code. By BIC, European and international payment orders automatically reach the right bank and branch.

the cost implications to study SEPA-effects on welfare. From an analytical perspective, he considers the choice of adopting SEPA by comparing two cases, 'high initial investment cost and low cost of cross-border payment' against 'low or zero investment cost and high cost of cross-border payment'. From the results, he suggests that adopting SEPA may be welfare-enhancing if the initial investment cost reduces or the share of the cross-border payment is high enough to cover this cost. He also finds it welfare-enhancing due to intensifying cross-border competition between banks through reducing entry barriers. He extends his model to consider that foreign bank with cost advantage enters the market. He concludes that in spite of the increasing welfare, without public intervention, banks would not adopt SEPA since they suffer a considerable adjustment cost. In a complementary work, Kemppainen (2008) evaluates economic effects of SEPA in a spatial competition model in the debit card market. He considers two countries covered by two incompatible payment networks in pre-SEPA and compatible in post-SEPA. In pre-SEPA, customers only can use their cards in their home network, while they can use their cards both in home and foreign networks in post-SEPA. The model is built based on some SEPA elements such as the increased number of customers in demand-side and the SEPA adjustment cost in supply-side. The results show that SEPA causes an increase in prices, larger network size, and greater consumer surplus. Conversely, profit and welfare increase if SEPA adjustment cost is ignored. Furthermore, the model reveals that SEPA is not enough to lead to a fully competitive market. However, these studies do not further discuss the setting of price in pre- and post-SEPA that affect the profitability of banks and welfare.

In empirical work, Todorovic, Sedlarevic and Tomic (2017) evaluate the effects of SEPA on the performance of the banking industry among 17 European countries in the period 2002-2012. They find that the benefits of SEPA cannot cover its costs in the short term, while in the long term, SEPA will improve the performance of the banking industry.

A number of other contributions assess the economic impact of SEPA by focusing on survey- and interview-based studies. The analysis undertaken by Schmiedel (2007) provides insights into the economic impact of SEPA. In particular, he studies the benefits and costs of SEPA for the banking industry. For this purpose, he applies a questionnaire and interview-based fact-finding exercise from the European Central Bank. He finds that in the long term when national systems are completely replaced with the SEPA system, the cost of banks will decline because of potential economies of scale and scope. Furthermore, the revenue of banks will be affected by increasing competition as entry barriers in the market. In 2014, the EC asked PWC group to provide a report related to the benefits and opportunities of SEPA for stakeholders such as banks, companies, and customers. In an interview-based study, the PWC group states that companies and customers take advantage of SEPA at the expense of banks. In this study, it considers three categories of banks namely global bank that has global operations, regional bank that has regional operations and local bank that consists of smaller domestic banks. The results show that the local bank may have less opportunity to benefit from SEPA while the global and regional banks can attract more transaction volumes and make an additional profit in post-SEPA. The reason is that the local bank operates on a smaller scale than other banks and therefore would not afford to cover the SEPA cost.

Some important economic aspects of the SEPA are missing in previous works such as price setting and cost efficiency due to the consolidation of national payment systems. The present paper attempts to fill these gaps by analyzing a duopoly model. In the following, I present the main aspects of the model.

3. Model Specification.

In this section, I describe the structure of the model in the presence of economies of scale. I first characterize pre-SEPA and then post-SEPA phases. In pre-SEPA, the domestic payment systems are diversified across European countries and banks charge different transaction prices for making domestic and cross-border payments. In post-SEPA, the domestic payment systems are homogeneous across countries and banks charge the same transaction prices for making domestic and cross-border payments.

I consider a country located in the SEPA zone that is served by two asymmetric banks, a large bank with a large level of capital and a small bank with a small level of capital indexed by $i \neq j \in \{l, s\}$, that offer payment accounts. Customers located in this country subscribe only to one bank to conduct domestic and cross-border payments. I assume that customers are homogeneous and uniformly distributed on the segment [0, 1]. Banks are located at either extreme; w.l.o.g. I assume that the large bank is located at 0 and the small bank is located at 1. Moreover, suppose that two banks serve all customers, that is, there is full coverage.

3.1. Pre-SEPA Phase.

Three-part tariff. To handle a payment, each bank charges three-part tariff $T_i = \{f_i, p_i, \hat{p}_i\}$, where f_i is a fixed fee (or subscription fee), p_i is a domestic transaction price for each inter-bank payment inside the country and $\hat{p}_i$ is a cross-border transaction price for each inter-bank payment to another country located in the SEPA zone. To simplify the analysis, I assume that intra-bank transactions are free of charge. Banks are allowed to charge different transaction prices based on the payment destination, i.e., the transaction price for a domestic payment can differ from a cross-border payment: $p_i \neq \hat{p}_i$. The non-linear pricing scheme is motivated by the European Union (EU) report on retail financial services in 2009[7]. The study assesses the level of bank fees for 224 banks across the EU-27 including basic annual fees (e.g., package fees and account maintenance charges), account fees (e.g., over-the-counter transactions, accounts' movements, internet and phone banking, etc.), credit transfer charges (e.g., reception and transmission of credit transfers, standing orders including setup, modification and closure, etc.), direct debit charges (e.g., fees for setting up direct debits, sending and closure), among others. Accordingly, in my terminology, fixed fees refer to annual fees and transaction prices refer to credit or debit transfer charges.

For the sake of tractability, I assume that all inter-bank transactions have the same size, but volumes or number of transactions do depend on transaction prices. The total volume of transaction is $Q_i = (q_i + \hat{q}_i)$, where q_i is the domestic transaction volume and $\hat{q}_i$ is the cross-border transaction volume at bank i[8,9].

Individual demand. The customer's problem is to maximise utility $u(q_i, \hat{q}_i) = \omega.(q_i + \hat{q}_i) - \frac{({q_i}^2 + \hat{q}_i^2)}{2} + \vartheta_0$ where $i \in \{l, s\}$, $\omega > 0$ and ϑ_0 is the fixed surplus from being connected to either bank. Suppose ϑ_0 is large enough that customers always choose to have a bank account. The individual demands are given by $\frac{\partial u}{\partial q_i} = p_i$ and $\frac{\partial u}{\partial \hat{q}_i} = \hat{p}_i$which result in $q(p_i) = \omega - p_i$ and $\hat{q}(\hat{p}_i) = \omega - \hat{p}_i$.

[7] See European Commission 2009, EU report on retail financial services: fact sheet, MEMO/09/402.

[8] Equivalently, one could assume that each customer makes one transaction of size q.

[9] I omit the role of interchange fees that are paid for interconnection by a bank to its rival in a card payment which allows me to focus on the comparison between pre-SEPA and post-SEPA. The role of interchange fees in the banking industry is studied in Shy (2012) and Wright (2004); for a survey of recent contributions on this topic see Verdier (2009).

The indirect utility of payment or customer's variable net surplus is $V(p) = \max_q u(q) - p.q$, yielding

$$V(P) = \frac{(\omega - p)^2}{2}$$

where $V(p_i)$ is the domestic surplus and $V(\hat{p}_i)$ is the cross-border surplus. The derivative of indirect utility with respect to the transaction price is $\frac{\partial V}{\partial p} = -q$; the indirect utility strictly decreases with the transaction price. Without price discrimination, the surplus equals $V = (\omega - p)^2$.

Market share. Banks offer payment services that are horizontally differentiated á la Hotelling and there is full coverage, i.e., each bank can offer its services to all customers. The net surplus offered by bank i is:

$$w_i = V(p_i) + V(\hat{p}_i) - f_i$$

with $i \in \{l, s\}$.Then, the net utility that a customer x derives from subscribing to bank i is:

$$U_i = w_i - \tau|x - x_i|$$

Parameter τ is product differentiation. Customers subscribe to a bank from which they obtain a higher net utility. Since $x_l = 0$ and $x_s = 1$, a customer located at x is indifferent to subscribe to the large or small bank if and only if

$$w_l - \tau x = w_s - \tau(1 - x).$$

The term τx is the transportation cost of going to the large bank and $\tau(1 - x)$ is the transportation cost of going to the small bank. Transportation cost is used here as a means to capture product differentiation. Solving for x, I obtain the market share of the large bank as follows:

$$\alpha_l = \frac{1}{2} + \sigma(w_l - w_s) \tag{1}$$

Parameter $\sigma = \frac{1}{2\tau} > 0$ is the degree of substitutability between the two banks. Since there is full participation (i.e., each customer subscribes to one bank), the market share of the small bank is $\alpha_s = 1 - \alpha_l$. In a symmetric equilibrium with $w_l = w_s$, the market share equals $\frac{1}{2}$.

Consumer surplus. Consumer surplus is determined by

$$CS = \alpha_l w_l + \alpha_s w_s - \frac{\tau}{2}(\alpha_l^2 + \alpha_s^2) \tag{2}$$

The term $\frac{\tau}{2}(\alpha_l^2 + \alpha_s^2)$ is the customer disutility from not being able to subscribe to his preferred services.

Cost function. By following Schmiedel (2007), I consider that banks incur two types of costs to execute a payment: *'Distribution/Maintenance Cost'* (as a fixed cost) and *'Processing Cost'* (as a variable cost).

Distribution/Maintenance Cost. Banks incur the fixed cost, $\bar{c}$, to serve each customer. This cost covers all the costs which are not directly linked to a transaction but are necessary to its execution[10].

Processing Cost. In pre-SEPA, each country has a national payment system with particular requirements in terms of technology, standards, and services. Thus, banks use different methods to execute domestic and cross-border payments[11]. As a result, the processing cost of each payment depends on its destination. In this regard, there are two kinds of processing costs: the cost of the domestic transaction ($C(q_i)$) and the cost of the cross-border transaction ($\hat{C}(\hat{q}_i)$). In order to introduce the economies of scale and capital in the model, I adopt the marginal cost function proposed by Mermelstein *et al.* (2014). From this perspective, processing costs are defined as follows:

$$C(q_i) \ = \frac{q_i^{(\frac{1}{(1-\beta)\theta})}}{k_i^{\frac{\beta}{(1-\beta)}}}$$

$$\hat{C}(\hat{q}_i) = \frac{\hat{q}_i^{\left(\frac{1}{(1-\beta)\theta}\right)}}{k_i^{\frac{\beta}{(1-\beta)}}} + z\hat{q}_i.$$

The marginal costs of the domestic and cross-border transactions are thus given by:

$$c(q_i) = \frac{1}{(1-\beta)\theta} \frac{q_i^{(\frac{1}{(1-\beta)\theta})-1}}{k_i^{\frac{\beta}{(1-\beta)}}} \tag{3}$$

$$\hat{c}(\hat{q}_i) = \frac{1}{(1-\beta)\theta} \frac{\hat{q}_i^{\left(\frac{1}{(1-\beta)\theta}\right)-1}}{k_i^{\frac{\beta}{(1-\beta)}}} + z \tag{4}$$

with $i \in \{l, s\}$. Equations (3) and (4) show that marginal costs are function of transaction volumes. Parameter $\theta > 1$ represents economies of scale, $\beta \epsilon\ (0{,}1)$ is the capital share ($(1-\beta)$ is the labour share)[12], k_i is the capital owned by bank i to settle a payment. Remind that the large bank is cost-efficient due to having a larger capital level. The parameter z shows the connectivity cost to execute a cross-border payment. It is worth noting that if there is a bilateral agreement between banks in order to execute payments through one payment system, then $z = 0$, which means that the domestic and cross-border payments execute in the same ways. In this case, the third party does not have any role and there is no problem with incompatible systems. As long as the main concern of the present paper is to analyse the effect of harmonization of payment systems through SEPA, I consider the case with $z > 0$.

Profit function. Under the price discrimination, bank i's profit is given by:

$$\Pi_i = \alpha_i[p_i q_i - C_i + \hat{p}_i \hat{q}_i - \hat{C}_i + f_i \ - \bar{c}] \tag{5}$$

The profit consists of two parts: the profit from the execution of payments and the profit from the fixed fee.

Welfare. Welfare is defined as follows:

$$W = \Pi_l + \Pi_s + CS \tag{6}$$

[10]Based on the directive (EU) 2015/849 of the European Parliament and Council on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing, banks have to monitor accounts.

[11]For more details see Park (2006).

[12] The variable cost function comes from the Cobb-Douglas production function $F(K,L) = K^{\beta\theta} L^{(1-\beta)\theta}$: the share of output that comes from labour is $1-\beta$ while the share of output that comes from capital is the constant β.

3.2. Post-SEPA Phase.

Two-part tariff. In post-SEPA, banks are constrained to set uniform pricing, i.e., they must charge the same price for domestic and cross-border payments. Therefore, each bank sets two-part tariff $\tilde{T}_i = \{\tilde{f}_i, \tilde{p}_i\}$ where $\tilde{f}_i$ is a fixed fee (or subscription fee) and $\tilde{p}_i$ is a transaction price for each transaction regardless of its destination.

Individual demand. Following similar steps as in pre-SEPA case, total individual demand function in post-SEPA can be written as

$$\tilde{q}_i = 2(\omega - \tilde{p}_i) = 2q(\tilde{p}_i)$$

which is twice the domestic payment at price $\tilde{p}_i$. Under uniform pricing, the indirect utility of payment or consumer's variable net surplus is $\tilde{V}(\tilde{p}) = \max_{\tilde{q}} u(\tilde{q}) - \tilde{p}.\tilde{q}$, yielding

$$\tilde{V}(\tilde{p}) = (\omega - \tilde{p})^2$$

where $\frac{\partial \tilde{V}}{\partial \tilde{p}} = -\tilde{q}$.

Market share. It is as pre-SEPA case where:

$$\widetilde{w}_i = \tilde{V}(\tilde{p}_i) - \tilde{f}_i$$

with $\tilde{V}(\tilde{p}_i) = \frac{\tilde{q}_i^2}{4} = q_i^2$. The net utility of customer x from subscribing to bank i is:

$$\widetilde{U}_i = \widetilde{w}_i - \tau|x - x_i|$$

where $i \in \{l, s\}$ and $x_l = 0$ and $x_s = 1$. The market share is given by the location of the customer that is indifferent between the two banks:

$$\widetilde{w}_l - \tau x = \widetilde{w}_s - \tau(1 - x)$$

Consequently,

$$\tilde{\alpha}_l = \frac{1}{2} + \sigma[\widetilde{w}_l - \widetilde{w}_s] \tag{7}$$

As before, parameter $\sigma = \frac{1}{2\tau}$ is the degree of substitutability between two banks. Under full coverage assumption, market shares add up to unity: $\tilde{\alpha}_s = 1 - \tilde{\alpha}_l$.

Consumer surplus. Consumer surplus is as in (2).

Cost function. The consolidation of national payment systems in post-SEPA leads to a change in the cost structure of each bank. The following categories are distinguished:

Fixed Adjustment Cost. Banks incur a fixed adjustment cost to comply with SEPA, F. This cost is due to the technology investments required for SEPA such as the cost associated with updating and upgrading to new technologies. To simplify the analysis, I assume that this cost is the same for both large and small banks.

Distribution/Maintenance Cost. As pre-SEPA, serving a customer involves a fixed cost, $\bar{c}$.

Processing Cost. Regardless of a payment destination, in post-SEPA, the processing cost of each payment is defined as

$$\tilde{C}(\tilde{q}_i) = \frac{\tilde{q}_i^{\left(\frac{1}{(1-\beta)\theta}\right)}}{k_i^{\frac{\beta}{(1-\beta)}}}.$$

The marginal cost is thus given by:

$$\tilde{c}(\tilde{q}_i) = \frac{1}{(1-\beta)\theta} \frac{\tilde{q}_i^{\left(\frac{1}{(1-\beta)\theta}\right)-1}}{k_i^{\frac{\beta}{(1-\beta)}}} \tag{8}$$

In post-SEPA, the payment systems are compatible across countries leading to the same processing costs per transaction regardless of termination (Bolt and Humphrey, 2007). Equation (8) shows the cost of cross-border payment is decreased since there is no connectivity cost, $z = 0$.

Profit function. In post-SEPA, bank i profit is:

$$\tilde{\Pi}_i = \tilde{\alpha}_i[\tilde{p}_i\tilde{q}_i - \tilde{C}_i + \tilde{f}_i - \bar{c}] - F \tag{9}$$

where F is the fixed adjustment cost. Again the profit consists of profit from the execution of payments and fixed fees.

*Welfar*e. Welfare in post-SEPA is given by (6).

4. Non-Linear Price Competition.

This section provides a general analysis of non-linear price competition in pre- and post-SEPA.

4.1.Competition in Pre-SEPA.

In pre-SEPA, each bank maximizes its profit by optimally setting $T_i = \{f_i, p_i, \hat{p}_i\}$. By following the lines of Laffont *et al*. (1998), I analyse the case where banks compete in prices, $p_i, \hat{p}_i$, and w_i rather than in $p_i, \hat{p}_i$, and f_i due to the one-to-one relationship between w_i and f_i. By solving systems $\frac{\partial \Pi_i}{\partial p_i} = 0$ and $\frac{\partial \Pi_i}{\partial \hat{p}_i} = 0$ for p_i and $\hat{p}_i$ from equation (5), I get:

$$p_i^* = c_i \tag{10}$$

$$\hat{p}_i^* = \hat{c}_i \tag{11}$$

Equations (10) and (11) show that banks set transaction prices at the marginal costs and consequently, make price discrimination for domestic and cross-border payments in pre-SEPA. Note that the marginal cost is a function of price, so equations define implicitly optimal transaction prices: it can be easily shown that $p_i^* = c_i$ and $\hat{p}_i^* = \hat{c}_i$ have the unique solution (see proof of Proposition (1) in Appendix). The optimal fixed fee and market share are characterized in the following Proposition.

Proposition1. In pre-SEPA, at the equilibrium, transaction prices equal marginal costs, $p_i^* = c_i$ and $\hat{p}_i^* = \hat{c}_i$, and the fixed fee and the market share for each bank equal:

$$f_i^* = \frac{1}{2\sigma} + \frac{1}{6}[(q_i^2 + \hat{q}_i^2) - (q_j^2 + \hat{q}_j^2)] - \frac{1}{3}[2n_i(q_i^\rho + \hat{q}_i^\rho) + n_j\left(q_j^\rho + \hat{q}_j^\rho\right)] + \bar{c} \tag{12}$$

$$\alpha_i^* = \frac{1}{2} + \frac{\sigma}{6}[(q_i^2 + \hat{q}_i^2) - (q_j^2 + \hat{q}_j^2)] + \frac{\sigma}{3}[n_i(q_i^\rho + \hat{q}_i^\rho) - n_j\left(q_j^\rho + \hat{q}_j^\rho\right)] \tag{13}$$

with $i \in \{l, s\}$, $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\frac{\beta}{(1-\beta)}}}$, $n_j = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_j^{\frac{\beta}{(1-\beta)}}}$, and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$.

Proof: See Appendix.

The fixed fee and the market share are functions of transaction volumes. Depending on the value of ρ, f_i^* and α_i^* increase or decrease with transaction volumes. If either $\rho \leq \frac{1}{2}$, or $\rho = 1$, or $\rho > \frac{1}{2}$ but $\rho \neq 1$ and ω is large enough, f_i^* increases with q_i and $\hat{q}_i$. In contrast, f_i^* decreases with q_j and $\hat{q}_j$ if $\rho \geq 2$, or $\rho = 1$, or $\rho < 2$ but $\rho \neq 1$ and ω is large enough. Under these ranges of ρ, α_i^* increases with q_i and $\hat{q}_i$ and decreases with q_j and $\hat{q}_j$. When $\rho = 1$, the bank with greater transaction volumes sets higher fixed fee and gains higher market share than the rival.

Note that setting fixed fee depends on the degree of substitutability between banks. In the extreme case where σ tends to zero, banks' fixed fees tend to infinite and the market is split equally given the full participation assumption. Competition in fixed fees is thus intensified as sigma increases, i.e., as the degree of substitutability increases. In this case, a bank with greater transaction volumes than the rival has a greater market share.

The profit of bank i at the equilibrium is given by:

$$\Pi_i^* = \alpha_i^*[n_i(q_i^\rho + \hat{q}_i^\rho) + f_i^* - \bar{c}] \tag{14}$$

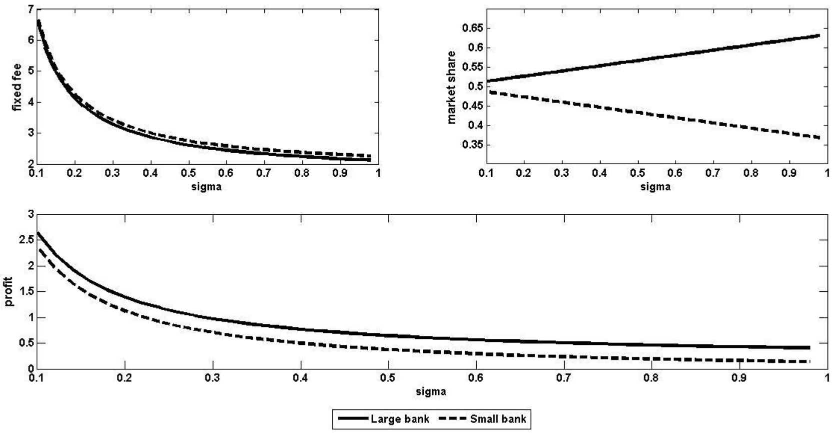
with $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\frac{\beta}{(1-\beta)}}}$, and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$.

Consider the extreme case where θ tends to infinite, then ρ tends to zero. In this case the domestic transaction price equals zero but the cross-border one equals z. In this case, banks compete on fixed fees. The profit is given by:

$$\Pi_i^* = \alpha_i^*[\frac{-2}{k_i^{\frac{\beta}{(1-\beta)}}} + f_i^* - \bar{c}]$$

where $f_i^* = \frac{1}{2\sigma} + \frac{2}{3}\left(\frac{2}{k_i^{\frac{\beta}{(1-\beta)}}} + \frac{1}{k_j^{\frac{\beta}{(1-\beta)}}}\right) + \bar{c}$ and $\alpha_i^* = \frac{1}{2} + \frac{\sigma}{3}(\frac{-2}{k_i^{\frac{\beta}{(1-\beta)}}} + \frac{2}{k_j^{\frac{\beta}{(1-\beta)}}})$. The large bank sets smaller fixed fee because of higher k_i and has greater market share than the small bank. Increasing asymmetry between banks leads to the large bank makes more profit when σ is sufficiently small: for sufficiently small σ, the sign of $\frac{\partial \Pi_l^*}{\partial k_l} = \frac{2\beta\sigma}{3(1-\beta)k_l^{\frac{\beta}{(1-\beta)}+1}}(\frac{-4}{3k_l^{\frac{\beta}{(1-\beta)}}} + \frac{4}{3k_s^{\frac{\beta}{(1-\beta)}}} + \frac{1}{\sigma} - \bar{c})$ is positive. It shows that when the product differentiation is high, then the large bank makes more profit because of higher k_i. Figure 4 shows this extreme case: the fixed fee, market share, and profit are plotted as a function of σ. If the degree of substitutability between banks is large, then the large bank sets smaller fixed fee than the small bank. As a result, more customers join the large bank and consequently the large bank gains more market share. The profit of banks decreases with σ, which is due to the higher degree of competition in the market.

Figure 4. Behaviour of asymmetric banks when $\rho = 0$ in pre-SEPA.



$\omega = 3, z = 0.1, k_l = 6, k_s = 2, \bar{c} = 0.2, \beta = 0.2$

4.1.Competition in Post-SEPA.

Under uniform pricing, each bank maximizes its profit by optimally setting two-part tariff $(\tilde{f}_i, \tilde{p}_i)$. Given the one-to-one relationship between $\tilde{f}_i$ and $\tilde{w}_i$, I solve $\frac{\partial \tilde{\pi}_i}{\partial \tilde{p}_i} = 0$ for $\tilde{p}_i$ from equation (9) and obtain:

$$\tilde{p}_i^* = \tilde{c}_i \quad (15)$$

Equation (15) shows that banks set the transaction price at the marginal cost in post-SEPA. The following Proposition characterizes the fixed fee and the market share in the equilibrium.

Proposition 2. In post-SEPA, at the equilibrium, the transaction price equals marginal cost, $\tilde{p}_i^* = \tilde{c}_i$, and the fixed fee and the market share for each bank equal:

$$\tilde{f}_i^* = \frac{1}{2\sigma} + \frac{1}{3}\left[\frac{(\tilde{q}_i^2 - \tilde{q}_j^2)}{4} - \left(2n_i \tilde{q}_i^{\ \rho} + n_j \tilde{q}_j^{\ \rho}\right)\right] + \bar{c} \quad (16)$$

$$\tilde{\alpha}_i^* = \frac{1}{2} + \frac{\sigma}{3}\left[\frac{(\tilde{q}_i^2 - \tilde{q}_j^2)}{4} + n_i \tilde{q}_i^{\ \rho} - n_j \tilde{q}_j^{\ \rho}\right] \quad (17)$$

with $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\frac{\beta}{(1-\beta)}}}$, $n_j = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_j^{\frac{\beta}{(1-\beta)}}}$, and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$.

Proof: See Appendix.

Similar to pre-SEPA, depending on the value of ρ, the fixed fee and market share in post-SEPA increase or decrease with transaction volumes. If either $\rho \le \frac{3}{4}$, or $\rho = 1$, or $\rho > \frac{3}{4}$ but $\rho \ne 1$ and ω is large enough, then $\tilde{f}_i^*$ increases with $\tilde{q}_i$. For $\rho \ge \frac{3}{2}$, or $\rho = 1$, or $\rho < \frac{3}{2}$ but $\rho \ne 1$ and ω is large enough, then $\tilde{f}_i^*$ decreases with $\tilde{q}_j$. In this case, $\tilde{\alpha}_i^*$ increases with $\tilde{q}_i$ but decreases with $\tilde{q}_j$. Similar to pre-SEPA, when $\rho = 1$, $\tilde{f}_i^*$and $\tilde{\alpha}_i^*$ increases with $\tilde{q}_i$ but decreases with $\tilde{q}_j$, and the large bank sets higher fixed fee and gains market share than the small bank.

The profit of bank i at the equilibrium is given by:

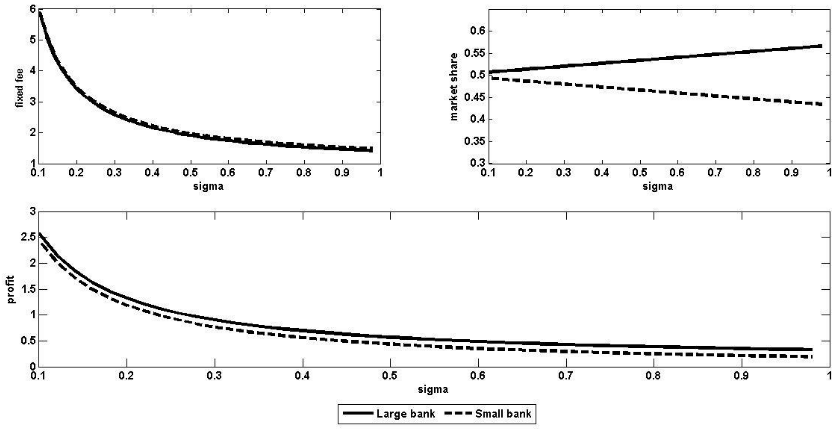
$$\widetilde{\Pi}_i^* = \tilde{\alpha}_i^*[n_i \tilde{q}_i^{\ \rho} + \tilde{f}_i^* - \bar{c}] - F \tag{18}$$

where $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\frac{\beta}{(1-\beta)}}}$, $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$, and F is the fixed adjustment cost. In the exterme case where $\rho = 0$, the profit is:

$$\widetilde{\Pi}_i^* = \tilde{\alpha}_i^*[\frac{-1}{k_i^{\frac{\beta}{(1-\beta)}}} + \tilde{f}_i^* - \bar{c}] - F$$

with $\tilde{f}_i^* = \frac{1}{2\sigma} + \frac{1}{3}(\frac{2}{k_i^{\frac{\beta}{(1-\beta)}}} + \frac{1}{k_j^{\frac{\beta}{(1-\beta)}}}) + \bar{c}$ and $\tilde{\alpha}_i^* = \frac{1}{2} + \frac{\sigma}{3}(\frac{-1}{k_i^{\frac{\beta}{(1-\beta)}}} + \frac{1}{k_j^{\frac{\beta}{(1-\beta)}}})$. Similar to pre-SEPA, banks compete on fixed fees when $\rho = 0$. If asymmetry between banks increases, then the profit of the large bank increases with k_l when σ is sufficiently small. Figure 5 shows the behaviour of asymmetric banks at equilibrium as a function of σ in post-SEPA. Similar to pre-SEPA, in this case, the large bank sets smaller fixed fee and has greater market share than the small bank.

Figure 5. Behaviour of asymmetric banks when $\rho = 0$ in post-SEPA.



$\omega = 3, k_l = 6, k_s = 2, \bar{c} = 0.2, \beta = 0.2, F = 0.$

The purpose of this paper is to study the effect of SEPA on competition between banks. When $\rho = 0$, the comparison between pre-SEPA and post-SEPA shows that the large bank loses market share but the small bank gains market share in post-SEPA. In other words, the SEPA project intensifies competition between banks when θ is large enough. When $\rho > 0$, the comparison is complicated because for values of ρ different from 0, marginal costs take different functional forms in terms of transaction volumes as follows.

$$c_i = \rho k_i^{1-\rho\theta} q_i^{\rho-1}, \hat{c}_i = \rho k_i^{1-\rho\theta} \hat{q}_i^{\rho-1} + z, \tilde{c}_i = \rho k_i^{1-\rho\theta} \tilde{q}_i^{\ \rho-1} \qquad i \in \{l, s\}$$

For instance, if $\rho = 2$, then marginal costs are a linear function of transaction volumes as $c_i = 2k_i^{1-2\theta} q_i$, $\hat{c}_i = 2k_i^{1-2\theta}\hat{q}_i + z$,and $\tilde{c}_i = 2k_i^{1-2\theta}\tilde{q}_i$. In another example, if $\rho = 0.5$, then marginal costs are a nonlinear function of transaction volumes as $c_i = 0.5k_i^{1-0.5\theta} q_i^{-0.5}$, $\hat{c}_i = 0.5k_i^{1-0.5\theta}\hat{q}_i^{-0.5} + z$, and $\tilde{c}_i = \rho 0.5 k_i^{1-0.5\theta}\tilde{q}_i^{-0.5}$. The diversity of marginal cost functions leads to obtain multiple solutions for transaction prices which complicate the analysis. To keep the model tractable, I take a narrower view and only focus on the case where $\rho = 1$. In this case, $\theta = \frac{1}{1-\beta}$ $(\rho = 1)$, the marginal costs are constant in terms of the transaction volumes. This assumption still captures the existence of the economies of scale[13].

$$c_i = k_i^{1-\theta},\ \hat{c}_i = k_i^{1-\theta} + z,\ \tilde{c}_i = k_i^{1-\theta} \qquad i \in \{l, s\}$$

5. Pre-SEPA vs. Post-SEPA.

This section analyses effects of SEPA on competition between banks and welfare when $\rho = 1$. Then I expand analysis by considering the case where θ tends to infinity and study effects of economies of scale on equilibrium.

5.1. Comparison between pre-SEPA and post-SEPA when $\theta = \frac{1}{1-\beta}$.

When the marginal costs are constant in terms of the transaction volumes, then the optimal transaction prices are given by

$$p_i^* = k_i^{1-\theta},\ \hat{p}_i^* = k_i^{1-\theta} + z,\ \tilde{p}_i^* = k_i^{1-\theta} \qquad i \in \{l, s\} \tag{19}$$

It notes that the optimal transaction prices decrease with the capital level since $\theta > 1$. This means that the large bank sets lower transaction prices than the small bank in pre- and post-SEPA. Comparison of optimal prices in pre-SEPA with post-SEPA shows that the transaction price in post-SEPA equals the domestic transaction price in pre-SEPA (owing to the same marginal cost) and smaller than the cross-border transaction price in pre-SEPA: $p_i^* = \tilde{p}_i^* < \hat{p}_i^*$. In other words, SEPA affects the cross-border transaction prices but not domestic ones. Since transaction prices are set at marginal costs, banks earn zero profit from the execution of payments but they earn positive profit from fixed fees. To gain our understating regarding the effect of SEPA on banks and customers, I start with the symmetric case as a benchmark and then expand my analysis to the asymmetric case.

Symmetric banks:

In the symmetric case, the two banks have the same level of capital ($k_l = k_s = k$) and market share equals $\frac{1}{2}$ ($\alpha^* = \tilde{\alpha}^* = \frac{1}{2}$), the optimal transaction prices are

$$p^* = \tilde{p}^* = k^{1-\theta} < \hat{p}^* = k^{1-\theta} + z.$$

From equations (12) and (16), it is obtained that the fixed fee in post-SEPA equals pre-SEPA with

$$f^* = \tilde{f}^* = \frac{1}{2\sigma} + \bar{c}.$$

It shows that SEPA has no effect on the fixed fee in the symmetric case.

The profit of banks in pre- and post-SEPA is given by $\Pi^* = \frac{1}{4\sigma}$ and $\widetilde{\Pi}^* = \frac{1}{4\sigma} - F$, respectively. For each $F > 0$, SEPA results in lower profit for banks. In contrast, SEPA favours customers in the symmetric case since

[13] When $\rho = 1$, the average total cost ($\frac{C_i + \bar{c}}{q}$) decreases with transaction volumes and the average variable cost equals marginal cost ($\frac{\partial C_i}{\partial q} = c_i$).

$$CS^* = \frac{q^2 + \hat{q}^2}{2} - \left(\bar{c} + \frac{5}{8\sigma}\right) < \widetilde{CS}^* = q^2 - \left(\bar{c} + \frac{5}{8\sigma}\right).$$

Observes that in post-SEPA customers take advantage of lowering transaction prices while banks must bear the fixed adjustment cost. The reason is that the harmonization of the national payment systems in post-SEPA leads to decrease cross-border transaction prices, thus, the transaction volumes are greater in post-SEPA than pre-SEPA ($q^2 > \frac{q^2+\hat{q}^2}{2}$). Consequently, consumer surplus is greater in post-SEPA than pre-SEPA. The effect of SEPA on welfare depends on the value of F. Welfare may improve in post-SEPA when the gain in consumer surplus offset the bank's fixed investments.

Asymmetric banks:

The aim of this paper is to analyse the effect of SEPA on asymmetric banks with $k_l > k_s$. In order to compare the results in pre- and post-SEPA, I recall $\tilde{q}_i^2 = 4q_i^2$. The next Proposition establishes the relationship between tariffs of the large bank and small bank in pre- and post-SEPA.

Proposition 3. For $\rho = 1$ and $k_l > k_s$, at the equilibrium I have

In pre-SEPA:

(i) $p_l^* < p_s^*$, $\hat{p}_l^* < \hat{p}_s^*$ but $f_l^* > f_s^*$ where

$$f_i^* = \frac{1}{2\sigma} + \frac{(q_i^2+\hat{q}_i^2)-(q_j^2+\hat{q}_j^2)}{6} + \bar{c} \quad i \neq j \in \{l, s\}$$

and f_i^* increases with k_i but decreases with k_j.

In post-SEPA:

(ii) $\tilde{p}_l^* < \tilde{p}_s^*$ but $\tilde{f}_l^* > \tilde{f}_s^*$ where

$$\tilde{f}_i^* = \frac{1}{2\sigma} + \frac{\left(q_i^2-q_j^2\right)}{3} + \bar{c} \quad i \neq j \in \{l, s\}$$

and $\tilde{f}_i^*$ increases with k_i but decreases with k_j.

Proof. See Appendix.

The comparison of tariffs between pre- and post-SEPA shows that the large bank sets its transaction prices below the small bank, while the small bank sets its fixed fee below the large bank. This is due to the trade-off between transaction prices and fixed fees, so that where the transaction prices are low, the fixed fee is high and vice versa. The reason is that transaction prices are set at marginal costs so as to maximize consumer surplus, which banks then extract through the fixed fee. Since the large bank has a lower marginal cost, its transaction price is lower and its fixed fee is larger than that of the small bank. Proposition (3) shows that when asymmetry between banks increases, the large bank increases its fixed fee. The reason is that increasing asymmetry between banks makes the large bank relatively more efficient and consequently allows it to set lower transaction prices and a higher fixed fee. In contrast, if asymmetry between banks decreases then the competitive advantage of the large bank diminishes, and the difference between fixed fees becomes smaller.

Next, I discuss market shares. By inserting the optimal transaction prices and fixed fees into equations (13) and (17), I get the market share of bank i in pre- and post-SEPA, which are respectively:

$$\alpha_i^* = \frac{1}{2} + \sigma\left(\frac{(q_i^2+\hat{q}_i^2)-(q_j^2+\hat{q}_j^2)}{6}\right) \tag{20}$$

$$\tilde{\alpha}_i^* = \frac{1}{2} + \sigma\left(\frac{q_i^2-q_j^2}{3}\right) \tag{21}$$

with $i \neq j \in \{l,s\}$. The above equations point that for each $0 < \sigma \leq 1$ the large bank with greater transaction volumes has greater market share than the small bank in pre- and post-SEPA. The difference between market shares of the large bank and the small bank increases with σ, the less differentiated the products are. A closer look at Proposition (3) and equations (20) and (21) tells us that $\alpha_i^* = \sigma[f_i^* - \bar{c}]$ and $\tilde{\alpha}_i^* = \sigma[\tilde{f}_i^* - \bar{c}]$. Next, I use this relationship to determine the profit of banks in the pre- and post-SEPA.

Proposition 4. At the equilibrium, the large bank has greater market share and earns more profit than the small bank in pre- and post-SEPA:

$$\Pi_i^* = \frac{1}{\sigma}\alpha_i^{*2}$$

$$\tilde{\Pi}_i^* = \frac{1}{\sigma}\tilde{\alpha}_i^{*2} - F$$

with $\alpha_i^* = \sigma[f_i^* - \bar{c}]$ and $\tilde{\alpha}_i^* = \sigma[\tilde{f}_i^* - \bar{c}]$.

Proof. See Appendix.

Since transaction prices are set at marginal costs, banks earn profit from fixed fees in pre- and post-SEPA. Since f_i^* increases with q_i and $\hat{q}_i$ but decreases with q_j and $\hat{q}_j$, the bank with greater transaction volumes earns more profit than the rival. Moreover, similar to the effect of σ on market shares of banks, the difference between profits of banks increases with σ.

Let's define $\varphi = \frac{\hat{q}_l+\hat{q}_s}{q_l+q_s}$, the ratio of cross-border transaction volumes to domestic ones. This expression is important in my analysis since it measures asymmetry between the two phases. Corollary (1) summarizes the comparison of the performance of banks in pre- and post-SEPA.

Corollary 1. For $k_l > k_s$ and given θ, SEPA results in $\tilde{p}_i^* = p_i^* < \hat{p}_i^*$ with $i \in \{l,s\}$, then

i) The large bank (small bank) sets higher (lower) fixed fee in post-SEPA than pre-SEPA as $\varphi < 1$.
ii) Given $\varphi < 1$, the large bank (small bank) has greater (lower) market share and consequently makes more profit in post-SEPA than pre-SEPA with sufficiently small F.

Proof: See Appendix.

Corollary (1) shows that the transaction volume pattern plays an important role in determining the effects of SEPA on competition between banks. In my analysis, φ is always lower than one. It shows that the share of cross-border transaction volumes is smaller than the domestic ones since the domestic transactions are cheaper than the cross-border ones. This is consistent with Leibbrandt

(2010) who explains that the share of cross-border transactions is significantly lower than domestic ones for most countries, and it is around 1-2%. Under this transaction volume pattern, the large bank gains market share in post-SEPA since the marginal cost advantage of the large bank reinforces the differences between banks. Thus, competition between banks is less intense in post-SEPA and for sufficiently small F, the large bank makes more profit than pre-SEPA.

At the equilibrium, consumer surplus in pre- and post-SEPA are:

$$CS^* = \alpha_l^* \left(\frac{q_l^2 + \hat{q}_l^2}{2}\right) + \alpha_s^* \left(\frac{q_s^2 + \hat{q}_s^2}{2}\right) - \frac{5}{4\sigma}\left(\alpha_l^{*2} + \alpha_s^{*2}\right) - \bar{c}$$

$$\widetilde{CS}^* = \tilde{\alpha}_l^* \tilde{q}_l^2 + \tilde{\alpha}_s^* \tilde{q}_s^2 - \frac{5}{4\sigma}\left(\tilde{\alpha}_l^{*2} + \tilde{\alpha}_s^{*2}\right) - \bar{c}$$

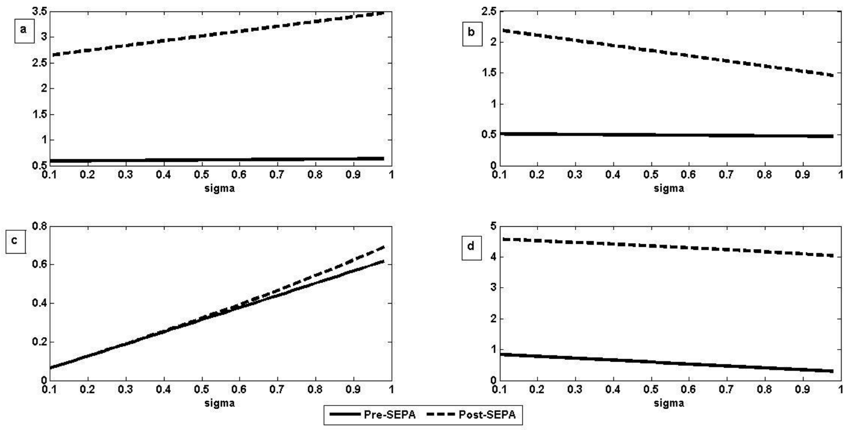
Figure 6 illustrates consumer surplus in pre- and post-SEPA as a function of σ. Figure 6-a shows the net surplus offered by the large bank, Figure 6-b shows the net surplus offered by the small bank, Figure 6-c shows the customer disutility, and Figure 6-d shows the accumulation of three former figures that is total consumer surplus. In pre-SEPA, when σ increases, the net surpluses offered by the large bank and the small bank do not change significantly, but the consumer disutility increases. Therefore consumer surplus decreases with σ in pre-SEPA. In post-SEPA, the situation is somewhat different. The net surplus offered by the large bank increases with σ but the net surplus offered by the small bank decreases. Similar to pre-SEPA, the consumer disutility increases with σ. As a result, consumer surplus decreases with σ. Comparison of consumer surplus (Figure (6-d)) in pre- and post-SEPA shows that SEPA results in greater consumer surplus. The two banks offered greater net surplus in post-SEPA than pre-SEPA but the consumer disutility is almost the same as pre-SEPA. Consequently, consumer surplus improves in post-SEPA.

Welfare in pre- and post-SEPA are:

$$W^* = \alpha_l^* \left(\frac{q_l^2 + \hat{q}_l^2}{2}\right) + \alpha_s^* \left(\frac{q_s^2 + \hat{q}_s^2}{2}\right) - \frac{1}{4\sigma}\left(\alpha_l^{*2} + \alpha_s^{*2}\right) - \bar{c}$$

$$\widetilde{W} = \tilde{\alpha}_l^* \tilde{q}_l^2 + \tilde{\alpha}_s^* \tilde{q}_s^2 - \frac{1}{4\sigma}\left(\tilde{\alpha}_l^{*2} + \tilde{\alpha}_s^{*2}\right) - \bar{c} - 2F$$

Figure 6. Components of consumer surplus in pre- and post-SEPA.

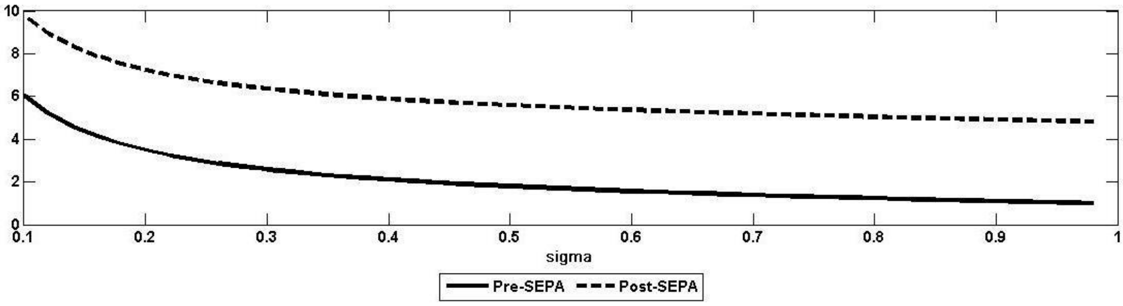


$\omega = 2, z = 0.1, k_l = 4, k_s = 2, \bar{c} = 0.2, \theta = 1.1$

Figure 7 illustrates welfare in pre- and post-SEPA. When the fixed adjustment cost is sufficiently small, then welfare improves in post-SEPA since consumer surplus improves. If the fixed adjustment cost is large, then welfare decreases in post-SEPA and can be even negative. In this case, both banks lose profit since they are not enabled to cover this cost. Literature has estimated various amounts for the fixed adjustment cost. For instance, the ECB (2019) estimated this cost at around GBP 10.2 billion or €15.3 billion; Boston Consulting Group (2006) estimated this cost around €5 billion. In contrast, PWC group estimated the net annual saving by banks is €5.9 billion without considering the fixed adjustment cost for the period 2014-2020. Thus, if the fixed adjustment cost is depreciated over some years, then SEPA may be profitable for banks. In this case, welfare would improve in post-SEPA.

In the following, I study how the performance of banks changes when economies of scale improve.

Figure 7. Welfare comparison in pre- and post-SEPA.



$\omega = 2, z = 0.1, k_l = 4, k_s = 2, \bar{c} = 0.2, \theta = 1.1$

5.2.Impact of Economies of Scale.

Concerning the economies of scale, I have assumed that it was the same in pre- and post-SEPA. Following the literature, economies of scale are likely to foster as a consequence of SEPA. Bolt and Humphrey (2007) and Beijnen and Bolt (2009) state that economies of scale are expected to improve in post-SEPA as a result of spurring consolidation among European payment systems. Because $\theta = \frac{1}{1-\beta}$, in my model the higher economies of scale are achieved when the capital share is relatively larger than the labour share. It leads to a reduction in the marginal costs. McKinsey (2005) points out that the potential cost saving from further consolidation in the payment market and consequently fostering economies of scale is around 25% in some European countries. For sufficiently large economies of scale, pre-SEPA domestic transaction prices and post-SEPA transaction prices equal zero, $p_i^* = \tilde{p}_i^* = 0$, since the marginal cost tends to zero. But the cross-border transaction price in pre-SEPA equals z which is the connectivity cost to execute the cross-border payment. In the symmetric case, fostering economies of scale has no effect on banks' profitability, but it results in increasing consumer surplus since there are more transaction volumes in post-SEPA than pre-SEPA. The following Corollary establishes the effect of improving economies of scale on the equilibrium in the asymmetric case.

Corollary 2. The increase in economies of scale as a consequence of SEPA results in

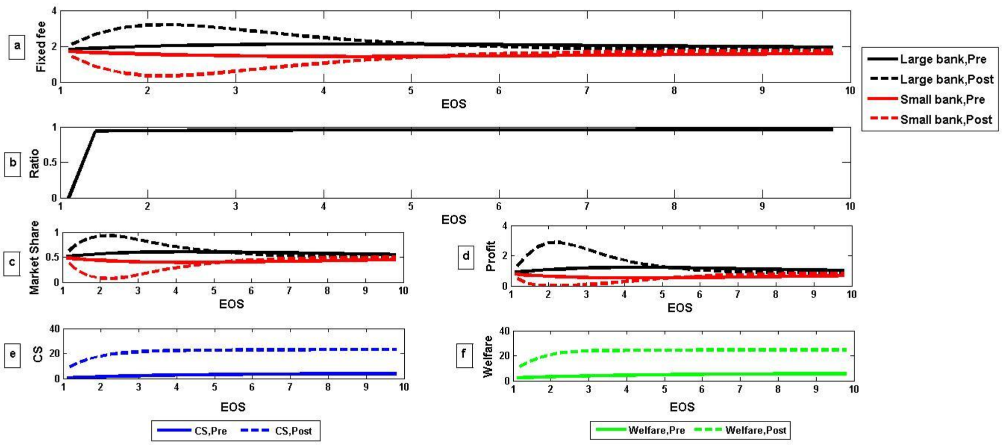
1- diminishing asymmetry between banks; for sufficiently large economies of scale the two banks will have the same market share and earn equal profit.

2- Consumer surplus converges to a certain amount.

Proof: See Appendix.

The above results are illustrated by means of numerical simulations in Figure 8. Here, the equilibria is plotted as a function of economies of scale. Parameter values are as follows: $\omega = 2.5, z = 0.1, k_l = 4,\ k_s = 2,\ \bar{c} = 0.1,\ \sigma = 0.3$. I shall further simplify the analysis by assuming that the fixed adjustment cost is arbitrarily set to zero as it does not affect the optimal transaction prices, thus $F = 0$. If this cost is larger than zero, then profit and welfare in post-SEPA will decrease accordingly. The fostering in economies of scale results in downward pressure on the transaction prices. Figure 8-a and 8-c show that in the range $\theta < 5$, the fixed fee and the market share of the large bank is greater in post-SEPA while the fixed fee and the market share of the small bank are smaller in post-SEPA. The reason is that transaction volumes of the large bank are greater than transaction volumes of the rival in this range of θ. Moreover, it is observed that when $\theta \cong 2$, in post-SEPA, the large bank corners the market as it has market share around 1, and the small bank loses almost all its market share, but in the range of $\theta > 2$, the large bank loses market share in post-SEPA while the small bank gains some market share. Therefore, if economies of scale foster in post-SEPA, then SEPA is pro-competitive. Figure 8-b shows that the ratio of cross-border transactions to domestic ones is lower than 1 that is consistent with the results of Corollary (1). Figure 8-d presents the profit of banks that follow the same path as their market shares. Figures 8-e and 8-f show that consumer surplus and welfare are improved in post-SEPA and increase till economies of scale reach a sufficiently large value and remain constant afterwards. Consumers benefit due to lower transaction prices and fixed fees that result from greater economies of scale. The figures depict that for sufficiently large θ, the asymmetry between banks reduces and both banks make the same profit in the market.

Figure 8. Compare results in pre-SEPA and post-SEPA.



6. Conclusion.

The present paper has examined the effect of SEPA on competition between two asymmetric banks in the presence of economies of scale. Based on available empirical evidence, the paper has considered two phases: pre-SEPA where payment systems are nationally diversified and banks are allowed to discriminate between transaction price of domestic and cross-border payments and post-SEPA where the national payment systems are compatible and banks apply uniform pricing for making domestic and cross-border payments. In post-SEPA, all banks are obliged to make a cross-border payment as cheap and easy as a domestic one. In this sense, there is no difference between domestic and cross-border euro payments and all euro payments in the SEPA zone are treated as domestic ones.

The results have shown that both banks set their transaction prices at the marginal costs. I found that in one extreme case where economies of scale tend to infinity, the pre-SEPA domestic transaction price and the post-SEPA transaction price equal zero, but the pre-SEPA cross-border transaction price is equal to connectively cost. In this case, banks compete on fixed fees and the large bank sets a lower fixed fee than the small bank resulting in greater market share and profit in pre- and post-SEPA. The comparison of market shares in pre- and post-SEPA has shown that SEPA intensifies competition between banks. In another case where the marginal costs are constant in terms of the transaction volumes ($\rho = 1$), the large bank with greater capital sets lower transaction prices than the small bank while the small bank sets a lower fixed fee than the large bank. It was observed that there is a trade-off between fixed fees and transaction prices. This means that where the transaction prices are low the fixed fee is high and vice versa. The lower transaction prices lead to increasing transaction volumes, and the higher fixed fee allows banks to extract more consumer surplus. Then, the comparison between pre- and post-SEPA has revealed the impact of SEPA on banks and customers. Given economies of scale, two banks would not make benefit equally from SEPA. The transaction pattern has a vital role in the competition between banks in post-SEPA. Based on results, if the share of cross-border transaction is smaller than domestic one, then competition between banks is less intense in post-SEPA. This result is consistent with Leibbrandt (2010), and the implication is that the SEPA project favours the large bank. The consumer surplus improves because customers receive better services in post-SEPA. Further analysis has focused on economies of scale that would have been affected by SEPA. In this regard, the cost saving through relatively large economies of scale leads to vanishing asymmetries between banks. In this case, SEPA helps the small bank to catch up and obtain the same profit as the large bank. This result was expected by the EC about the outcome of the SEPA project.

Further research will examine the enhancing cross-border competition due to lower entry barriers for payment systems. Moreover, the paper can be extended to consider ρ different from 1.

Appendix.

Proof of Proposition 1. Given transaction prices equal marginal costs, fixed fee at equilibrium is obtained by:

$$\max_{w_i} \Pi_i = \max_{w_i} \alpha_i[(c_i q_i - C_i + \hat{c}_i \hat{q}_i - \hat{C}_i + V_i + \hat{V}_i - w_i - \bar{c}]$$

with $i \neq j \epsilon \{l, s\}$, $\alpha_i = \frac{1}{2} + \sigma[w_i - w_j]$. Using that $f_i = V_i + \hat{V}_i - w_i$, The first order condition can be written as:

$$\frac{\partial \Pi_i}{\partial w_i} = \sigma\left(n_i\left(q_i^\rho + \hat{q}_i^\rho\right) + f_i - \bar{c}\right) - \alpha_i = 0$$

with $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\frac{\beta}{(1-\beta)}}}$ and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$. Since α_i can be written as $\alpha_i = \frac{1}{2} + \sigma[\Delta_{ij} - f_i + f_j]$ with $\Delta_{ij} = V_i + \hat{V}_i - V_j - \hat{V}_j$, then $\frac{\partial \Pi_i}{\partial w_i}$ is given by:

$$\frac{\partial \Pi_i}{\partial w_i} = \sigma\left(n_i\left(q_i^{\rho} + \hat{q}_i^{\rho}\right) + f_i - \bar{c}\right) - \frac{1}{2} - \sigma[\Delta_{ij} - f_i + f_j] = 0$$

By solving for f_i, I get

$$f_i = \frac{1}{4\sigma} + \frac{1}{2}\left[\Delta_{ij} + f_j - n_i(q_i^{\rho} + \hat{q}_i^{\rho}) + \bar{c}\right] \tag{A-1}$$

By following the similar steps, f_j is given by:

$$f_j = \frac{1}{4\sigma} + \frac{1}{2}\left[\Delta_{ji} + f_i - n_j(q_j^{\rho} + \hat{q}_j^{\rho}) + \bar{c}\right] \tag{A-2}$$

where $\Delta_{ji} = V_j + \hat{V}_j - V_i - \hat{V}_i$. Solving the above system of equations (A-1 and A-2) for f_i and f_j, after simplifying, I get

$$f_i^* = \frac{1}{2\sigma} + \frac{1}{3}[\Delta_{ij} - \left(2n_i(q_i^{\rho} + \hat{q}_i^{\rho}) + n_j(q_j^{\rho} + \hat{q}_j^{\rho})\right)] + \bar{c}$$

By replacing $\Delta_{ij}$and $V = \frac{q^2}{2}$ in f_i^*, I obtain:

$$f_i^* = \frac{1}{2\sigma} + \frac{1}{6}[(q_i^2 + \hat{q}_i^2) - (q_j^2 + \hat{q}_j^2)] - \frac{1}{3}[2n_i\left(q_i^{\rho} + \hat{q}_i^{\rho}\right) + n_j\left(q_j^{\rho} + \hat{q}_j^{\rho}\right)] + \bar{c}$$

with $i \neq j \in \{l, s\}$, $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\frac{\beta}{(1-\beta)}}}$, $n_j = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_j^{\frac{\beta}{(1-\beta)}}}$ and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$.

To determine whether $(p_i^*, \hat{p}_i^*, f_i^*)$ with $i\epsilon\{l, s\}$ are optimal solution for the profit function

$$\Pi_i = \alpha_i[(p_i q_i - C_i + \hat{p}_i\hat{q}_i - \hat{C}_i + V_i + \hat{V}_i - w_i - \bar{c}]$$

with $\alpha_i = \frac{1}{2} + \sigma\left[w_i - w_j\right]$, I study the signs of leading principle minors of Hessian matrix. The Hessian of profit is given by

$$H = \begin{bmatrix} -\alpha_i(1 + n_i\rho q_i^{\rho-2}) & 0 & \sigma(-p_i + c_i) \\ 0 & -\alpha_i(1 + n_i\rho\hat{q}_i^{\rho-2}) & \sigma(-\hat{p}_i + \hat{c}_i) \\ \sigma(-p_i + c_i) & \sigma(-\hat{p}_i + \hat{c}_i) & -2\sigma \end{bmatrix}$$

By evaluating at the equilibrium $(p_i^*, \hat{p}_i^*, f_i^*)$, I get

$$H = \begin{bmatrix} -\alpha_i(1 + n_i\rho q_i^{\rho-2}) & 0 & 0 \\ 0 & -\alpha_i(1 + n_i\rho\hat{q}_i^{\rho-2}) & 0 \\ 0 & 0 & -2\sigma \end{bmatrix}$$

The leading principle minors show that the Hessian matrix is negative definite, and as a result there is not any incentives for bank i to deviate from $(p_i^*, \hat{p}_i^*, f_i^*)$.

$$\left|\frac{\partial^2 \Pi_i}{\partial p_i^2}\right| < 0, \begin{vmatrix} \frac{\partial^2 \Pi_i}{\partial p_i^2} & \frac{\partial^2 \Pi_i}{\partial p_i \partial \hat{p}_i} \\ \frac{\partial^2 \Pi_i}{\partial \hat{p}_i \partial p_i} & \frac{\partial^2 \Pi_i}{\partial \hat{p}_i^2} \end{vmatrix} > 0, \begin{vmatrix} \frac{\partial^2 \Pi_i}{\partial p_i^2} & \frac{\partial^2 \Pi_i}{\partial p_i \partial \hat{p}_i} & \frac{\partial^2 \Pi_i}{\partial p_i \partial w_i} \\ \frac{\partial^2 \Pi_i}{\partial \hat{p}_i \partial p_i} & \frac{\partial^2 \Pi_i}{\partial \hat{p}_i^2} & \frac{\partial^2 \Pi_i}{\partial \hat{p}_i \partial w_i} \\ \frac{\partial^2 \Pi_i}{\partial w_i \partial p_i} & \frac{\partial^2 \Pi_i}{\partial w_i \partial \hat{p}_i} & \frac{\partial^2 \Pi_i}{\partial w_i^2} \end{vmatrix} < 0$$

To check unique solutions, I study whether:

$$c_i\big(q(0)\big) > 0 \text{ and } c_i'\big(q(p_i)\big) < 0$$
$$\hat{c}_i\big(\hat{q}(0)\big) > 0 \text{ and } \hat{c}_i'\big(\hat{q}(\hat{p}_i)\big) < 0$$

where $p_i^* = c_i(q(p_i))$, $\hat{p}_i^* = \hat{c}_i(\hat{q}(\hat{p}_i))$, and $q(p_i) = w - p_i$, $\hat{q}(\hat{p}_i) = w - \hat{p}_i$. Equations (3) and (4) satisfy the conditions $c_i\big(q(0)\big) > 0$ and $\hat{c}_i\big(\hat{q}(0)\big) > 0$. Moreover, the first derivative of marginal costs with respect to transaction prices satisfy the conditions $\frac{\partial c_i}{\partial p_i} < 0$ and $\frac{\partial \hat{c}_i}{\partial \hat{p}_i} < 0$. Thus, the equation $p_i = c_i(q(p_i)$ has a unique solution.

To find the effect of transaction volumes on fixed fee, I compute the derivative of fixed fees in terms of transaction volume. In this regard, I get

$$\frac{\partial f_i}{\partial q_i} = \frac{1}{3}((1-2\rho)p_i + \omega) \text{ and } \frac{\partial f_i}{\partial \hat{q}_i} = \frac{1}{3}((1-2\rho)\hat{p}_i + \omega)$$

The above derivative is positive when $0 \le \rho \le \frac{1}{2}$,or $\rho > \frac{1}{2}$ with ω is large enough. There is one exceptional case that for $\rho = 1$ the above derivative is always positive. The fixed fee of bank i decreases with transaction volumes of rival when $\rho \ge 2$, or $0 \le \rho < 2$ with ω is large enough or $\rho = 1$ since

$$\frac{\partial f_i}{\partial q_j} = \frac{1}{3}(-\omega + (2-\rho)p_j) \text{ and } \frac{\partial f_i}{\partial \hat{q}_j} = \frac{1}{3}(-\omega + (2-\rho)\hat{p}_j).$$

At equilibrium, the market share is given by

$$\alpha_i^* = \frac{1}{2} + \sigma[\Delta_{ij} - f_i^* + f_j^*]$$

with $\Delta_{ij} - f_i^* + f_j^* = \frac{1}{6}[(q_i^2 + \hat{q}_i^2) - (q_j^2 + \hat{q}_j^2)] + \frac{1}{3}[n_i(q_i^\rho + \hat{q}_i^\rho) - n_j\left(q_j^\rho + \hat{q}_j^\rho\right)]$.

The market share of bank i increases with its transaction volumes but decreases with the transaction volumes of rival when ≥ 2 , or $\rho < 2$ with ω is large enough, or $\rho = 1$, since

$$\frac{\partial \alpha_i^*}{\partial q_i} = \frac{\sigma}{3}((\rho-2)p_i + \omega), \frac{\partial \alpha_i^*}{\partial \hat{q}_i} = \frac{1}{3}((\rho-2)\hat{p}_i + \omega),$$

$$\frac{\partial \alpha_i^*}{\partial q_j} = \frac{\sigma}{3}(-\omega + (2-\rho)p_j), \text{ and } \frac{\partial \alpha_i^*}{\partial \hat{q}_j} = \frac{\sigma}{3}(-\omega + (2-\rho)\hat{p}_j).$$

∎

Proof of Proposition 2. Given transaction price equals marginal cost, the fixed fee in the post-SEPA is acquired by:

$$\max_{\widetilde{w}_i} \widetilde{\Pi}_i = \max_{\widetilde{w}_i} \tilde{\alpha}_i\,[\tilde{c}_i\tilde{q}_i - \tilde{C}_i + \tilde{V}_i - \widetilde{w}_i - \bar{c}] - F$$

with $\tilde{\alpha}_i = \frac{1}{2} + \sigma[\widetilde{w}_i - \widetilde{w}_j]$, $\widetilde{w}_i = \tilde{V}_i - \tilde{f}_i$, and $i \neq j \epsilon \{l, s\}$. The first order condition for bank i is:

$$\frac{\partial \widetilde{\Pi}_i}{\partial \widetilde{w}_i} = \sigma[n_i\tilde{q}_i^\rho + \tilde{f}_i - \bar{c}] - \tilde{\alpha}_i = 0.$$

with $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\overline{\frac{\beta}{(1-\beta)}}}}$ and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$. By substituting the market share as $\tilde{\alpha}_i = \frac{1}{2} + \sigma[\tilde{\Delta}_{ij} - \tilde{f}_i + \tilde{f}_j]$ with $\tilde{\Delta}_{ij} = \tilde{V}_i - \tilde{V}_j$ into the above expressions, I get

$$\frac{\partial \breve{\Pi}_i}{\partial \widetilde{w}_i} = \sigma\left[n_i \tilde{q}_i^{\rho} + \tilde{f}_i - \bar{c}\right] - \frac{1}{2} - \sigma[\tilde{\Delta}_{ij} - \tilde{f}_i + \tilde{f}_j] = 0$$

By solving for $\tilde{f}_i$, I get

$$\tilde{f}_i = \frac{1}{4\sigma} + \frac{1}{2}\left[\tilde{\Delta}_{ij} + \tilde{f}_j - n_i \tilde{q}_i^{\rho} + \bar{c}\right] \tag{A-3}$$

By following the similar steps, I get

$$\tilde{f}_j = \frac{1}{4\sigma} + \frac{1}{2}\left[\tilde{\Delta}_{ji} + \tilde{f}_i - n_j \tilde{q}_j^{\rho} + \bar{c}\right] \tag{A-4}$$

where $\tilde{\Delta}_{ji} = \tilde{V}_j - \tilde{V}_i$. Solving the above system of equations (A-3 and A-4) for $\tilde{f}_i$and $\tilde{f}_j$, I get

$$\tilde{f}_i^* = \frac{1}{2\sigma} + \frac{1}{3}[\tilde{\Delta}_{ij} - \left(2n_i \tilde{q}_i^{\rho} + n_j \tilde{q}_j^{\rho}\right)] + \bar{c}$$

Equivalently:

$$\tilde{f}_i^* = \frac{1}{2\sigma} + \frac{1}{3}[\frac{(\tilde{q}_i^2 - \tilde{q}_j^2)}{4} - \left(2n_i \tilde{q}_i^{\rho} + n_j \tilde{q}_j^{\rho}\right)] + \bar{c}$$

with $n_i = \frac{1-(1-\beta)\theta}{(1-\beta)\theta k_i^{\overline{\frac{\beta}{(1-\beta)}}}}$ and $\rho = \left(\frac{1}{(1-\beta)\theta}\right)$. To check the concavity of profit function

$$\widetilde{\Pi}_i = \tilde{\alpha}_i[\tilde{p}_i \tilde{q}_i - \tilde{C}_i + \tilde{V}_i - \widetilde{w}_i - \bar{c}] - F$$

with $\tilde{\alpha}_i = \frac{1}{2} + \sigma[\widetilde{w}_i - \widetilde{w}_j]$, I get the Hessian of profit as

$$H = \begin{bmatrix} -\tilde{\alpha}_i(1 + n_i \rho \tilde{q}_i{}^{-2}) & \sigma(-\tilde{p}_i + \tilde{c}_i) \\ \sigma(-\tilde{p}_i + \tilde{c}_i) & -2\sigma \end{bmatrix}$$

By evaluating the Hessian in $(\tilde{p}_i^*, \tilde{f}_i^*)$, I get:

$$H = \begin{bmatrix} -\tilde{\alpha}_i(1 + n_i \rho \tilde{q}_i{}^{\rho-2}) & 0 \\ 0 & -2\sigma \end{bmatrix}$$

The leading principle minors show that the Hessian matrix is negative definite as

$$\left|\frac{\partial^2 \widetilde{\Pi}_i}{\partial \tilde{p}_i^2}\right| < 0, \quad \begin{vmatrix} \frac{\partial^2 \widetilde{\Pi}_i}{\partial \tilde{p}_i^2} & \frac{\partial^2 \widetilde{\Pi}_i}{\partial \tilde{p}_i \partial \omega_i} \\ \frac{\partial^2 \widetilde{\Pi}_i}{\partial \omega_i \partial \tilde{p}_i} & \frac{\partial^2 \widetilde{\Pi}_i}{\partial \omega_i^2} \end{vmatrix} > 0$$

So, $(\tilde{p}_i^*, \tilde{f}_i^*)$ characterised as optimal two-part tariff in the post-SEPA phase.

To find the effect of transaction volume on fixed fee, I compute

$$\frac{\partial \tilde{f}_i}{\partial \tilde{q}_i} = \frac{1}{3}\Big((\frac{3}{2} - 2\rho)p_i + \frac{\omega}{2}\Big)$$

The sign of above derivative is positive when $\rho < \frac{3}{4}$, or $\rho = 1$, or $\rho > \frac{3}{4}$ and ω is large enough. The fixed fee of bank i decreases with transaction volumes of rival when $\rho > \frac{3}{2}$, or $\rho = 1$, or $\rho < \frac{3}{2}$ and ω is large enough, since

$$\frac{\partial f_i}{\partial q_j} = \frac{1}{3}(-\frac{\omega}{2} + (\frac{3}{2} - \rho)p_j).$$

The equilibrium market share is then

$$\tilde{\alpha}_i^* = \frac{1}{2} + \sigma[\tilde{\Delta}_{ij} - \tilde{f}_i^* + \tilde{f}_j^*]$$

with $\tilde{\Delta}_{ij} - \tilde{f}_i^* + \tilde{f}_j^* = \frac{1}{3}[\frac{(\tilde{q}_i^2 - \tilde{q}_j^2)}{4} + n_i\tilde{q}_i{}^{\rho} - n_j\tilde{q}_j{}^{\rho}]$.The market share of bank i increases with its transaction volumes but decreases with the transaction volumes of rival when $\rho \geq \frac{3}{2}$, or $\rho = 1$, or $\rho < \frac{3}{2}$ and ω is large enough since $\frac{\partial \tilde{\alpha}_i^*}{\partial \tilde{q}_i} = \frac{\sigma}{3}\Big((\rho - \frac{3}{2})p_i + \frac{\omega}{2}\Big)$ and $\frac{\partial \tilde{\alpha}_i^*}{\partial \tilde{q}_j} = \frac{\sigma}{3}(\Big(\frac{3}{2} - \rho\Big)p_i - \frac{\omega}{2})$.

■

Proof of Proposition 3. In pre-SEPA with $\rho = 1$, $k_l > k_s$, and given $\theta > 1$, I get

$$p_l^* = k_l^{1-\theta} < p_s^* = k_s^{1-\theta}.$$

The domestic transaction price charged by the large bank is less than the domestic transaction price charged by the small bank. It is straightforward to conclude that the cross-border transaction price charged by the large bank is less than the cross-border transaction price charged by the small bank since $\hat{p}_l^* = p_l^* + z < \hat{p}_s^* = p_s^* + z$. The large bank sets greater fixed fee than the small bank since

$$f_i^* = \frac{1}{2\sigma} + \frac{(q_i^2 + \hat{q}_i^2) - (q_j^2 + \hat{q}_j^2)}{6} + \bar{c} \qquad i \neq j \in \{l, s\}$$

and

$$f_l^* - f_s^* = \frac{(q_l^2 + \hat{q}_l^2) - (q_s^2 + \hat{q}_s^2)}{3} > 0$$

The expression of the fixed fee is simplified because of $n_i = 0$. The fixed fee charged by the large bank is greater than the fixed fee charged by the small bank since it has larger transaction volumes. Moreover, the fixed fee of bank i increases with k_i but decreases with k_j with $i \neq j \in \{l, s\}$ as long as

$$\frac{\partial f_i^*}{\partial k_i} = \frac{(\theta - 1)(q_i + \hat{q}_i)}{3k_i^{\theta}} > 0$$

$$\frac{\partial f_i^*}{\partial k_j} = -\frac{(\theta - 1)(q_j + \hat{q}_j)}{3k_j^{\theta}} < 0$$

In post-SEPA with $\rho = 1$, $k_l > k_s$, and $\theta > 1$, I get

$$\tilde{p}_l^* = k_l^{1-\theta} < \tilde{p}_s^* = k_s^{1-\theta}.$$

The fixed fee of bank i equals

$$\tilde{f}_i^* = \frac{1}{2\sigma} + \frac{\left(q_i^2 - q_j^2\right)}{3} + \bar{c}$$

with $i \neq j \epsilon \{l, s\}$. The large bank with greater transaction volumes sets its fixed fee above the small bank since

$$\tilde{f}_l^* - \tilde{f}_s^* = \frac{2}{3}\left(q_l^2 - q_s^2\right) > 0$$

As pre-SEPA, the fixed fee of bank i increases with k_i but decreases with k_j as long as

$$\frac{\partial \tilde{f}_i^*}{\partial k_i} = \frac{2(\theta - 1)q_i}{3k_i^\theta} > 0$$

$$\frac{\partial \tilde{f}_i^*}{\partial k_j} = -\frac{2(\theta - 1)q_j}{3k_j^\theta} < 0.$$

■

Proof of Proposition 4. At equilibrium, from equation (14), the profit of bank i in pre-SEPA is given by

$$\Pi_i^* = \alpha_i^*[f_i^* - \bar{c}] \quad \text{with } i \neq j \in \{l, s\}$$

Since $\alpha_i^* = \sigma[f_i^* - \bar{c}]$, I get the other expression for profit of bank i as follows:

$$\Pi_i^* = \frac{1}{\sigma}\alpha_i^{*2} \quad \text{with } i \neq j \in \{l, s\}$$

The difference between profit of the large bank and small bank is equal to

$$\Pi_l^* - \Pi_s^* = \frac{1}{\sigma}(\alpha_l^{*2} - \alpha_s^{*2})$$

The large bank has more profit than the small bank since it has greater market share.

In post-SEPA, from equation (18), the profit of bank i is given by

$$\tilde{\Pi}_i^* = \frac{1}{\sigma}\tilde{\alpha}_i^{*2} - F \text{ with } i \neq j \in \{l, s\}$$

Similar to pre-SEPA, in post-SEPA, the large bank has more profit than the small bank since it has greater market share.

■

Proof of Corollary 1. In order to study the relation between fixed fees of the large bank in the pre- and post-SEPA I compute:

$$\tilde{f}_l^* - f_l^* = \frac{1}{3}\left(q_l^2 - q_s^2 - \frac{(q_l^2 + \hat{q}_l^2) - (q_s^2 + \hat{q}_s^2)}{2}\right)$$

After simplifying I get:

$$\tilde{f}_l^* - f_l^* = \frac{(q_l^2 - q_s^2) - (\hat{q}_l^2 - \hat{q}_s^2)}{6}$$

The large bank sets higher fixed fee in the post-SEPA than pre-SEPA when $\frac{(\hat{q}_l+\hat{q}_s)}{(q_l+q_s)} < 1$. This ratio always holds since the cross-border transaction is more expensive than the domestic one. Similar analysis for the small bank gives

$$\tilde{f}_s^* - f_s^* = \frac{(q_s^2 - q_l^2) - (\hat{q}_s^2 - \hat{q}_l^2)}{6}$$

The small bank sets higher fixed fee in the post-SEPA than pre-SEPA when $\frac{\hat{q}_l+\hat{q}_s}{q_l+q_s} > 1$, but this ratio never establishes.

By considering $\alpha_i^* = \sigma[f_i^* - \bar{c}]$, $\tilde{\alpha}_i^* = \sigma[\tilde{f}_i^* - \bar{c}]$, it follows that the large bank has greater market share in the post-SEPA than pre-SEPA but the small bank loses market share in the post-SEPA than pre-SEPA. For sufficiently small fixed adjustment cost, the large bank makes more profit in the post-SEPA than pre-SEPA.

■

Proof of Corollary 2.

1-

The differences between domestic transaction prices charged by the large bank and the small bank in pre-SEPA is:

$$p_l^* - p_s^* = \frac{1}{k_l^{\theta-1}} - \frac{1}{k_s^{\theta-1}}$$

For sufficiently high economies of scale, I get

$$\lim_{\theta\to\infty}(p_l^* - p_s^*) = \lim_{\theta\to\infty}(\frac{1}{k_l^{\theta-1}} - \frac{1}{k_s^{\theta-1}}) = 0$$

It shows that the difference between transaction prices deminishes when $\theta \to \infty$. It is also satisfied for cross-border transaction prices as:

$$\hat{p}_l^* - \hat{p}_s^* = p_l^* - p_s^* + z - z$$

$$\lim_{\theta\to\infty}(\hat{p}_l^* - \hat{p}_s^*) = \lim_{\theta\to\infty}(p_l^* - p_s^*) = 0.$$

Since $\tilde{p} = p$The result of post-SEPA is the same as for pre-SEPA:

$$\lim_{\theta\to\infty}(\tilde{p}_l^* - \tilde{p}_s^*) = 0$$

The differences between fixed fees of the large bank and the small bank in pre-SEPA diminish when $\theta \to \infty$:

$\lim_{\theta\to\infty}(f_i^* - f_j^*) = \lim_{\theta\to\infty}\frac{1}{3}\left((\omega - p_i)^2 + (\omega - \hat{p}_i)^2 - ((\omega - p_j)^2 + (\omega - \hat{p}_j)^2)\right) = 0$ with $i \neq j \in \{l, s\}$.

Similarly in post-SEPA:

$\lim_{\theta\to\infty}(\tilde{f}_i^* - \tilde{f}_j^*) = \frac{2}{3}(q_i^2 - q_j^2) = 0$ with $i \neq j \in \{l, s\}$.

The market share of the large bank when $\theta \to \infty$ equals market share of the small bank in pre- and post-SEPA:

$$\alpha_l^* = \alpha_s^* = \frac{1}{2}$$
$$\tilde{\alpha}_l^* = \tilde{\alpha}_s^* = \frac{1}{2}$$

So, they earn the same profit as

$$\Pi_l^* = \Pi_s^* = \frac{1}{4\sigma}$$
$$\widetilde{\Pi}_l^* = \widetilde{\Pi}_s^* = \frac{1}{4\sigma} - F$$

2-

The effect of greater economies of scale on consumer surplus is obtained by compting

$$\lim_{\theta\to\infty}(CS) = \frac{\omega^2 + (\omega - z)^2}{2} - \frac{5}{8\sigma}$$

$$\lim_{\tilde{\theta}\to\infty}\left(\widetilde{CS}\right) = \omega^2 - \frac{5}{8\sigma}$$

For sufficiently large economies of scale, consumer surplus converge to a certain amount.

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