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In 2005 all ECB publications will feature a motif taken from the €50 banknote.

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The Public Good Factor in TARGET2

This paper is part of the research conducted under a Special Study Group analysing various issues relevant for the design of TARGET2. TARGET2 is the second generation of the Eurosystem's Trans-European Automated Real-time Gross settlement Express Transfer system, which is planned to go live in 2007. (See http://www.ecb.int/paym/target/target2/html/index.en.html for further details on the TARGET2 project). The Special Study Group operated between spring 2003 and summer 2004. It was chaired by Philipp Hartmann, assisted by Thorsten Koeppl (both ECB). The Group was further composed of experts from the ECB (Dirk Bullmann, Peter Galos, Cornelia Holthausen, Dieter Reichwein and Kimmo Soramäki), researchers from national central banks (Paolo Angelini, Banca d'Italia, Morten Bech, Federal Reserve Bank of New York, Wilko Bolt, de Nederlandsche Bank, Harry Leinonen, Suomen Pankki, and Henri Pagès, Banque de France) and academic consultants (David Humphrey, Florida State University, Charles Kahn, University of Illinois at Urbana Champaign, and Jean-Charles Rochet, Université de Toulouse). Following the completion of the Group's work, the ECB Working Paper Series is issuing a selection of the papers it produced.

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Abstract: We study optimal pricing rules for a public large-value payment system (LVPS) that produces a public good (like prevention of systemic risk) but faces competition by a private LVPS for the private provision of large value payments. We show that the marginal cost of the public LVPS has to be corrected by a "public good factor" that can be interpreted alternatively as the decrease in the cost of providing the public good when the private activity of the public system increases, or as the subsidy needed for private banks to internalize the cost of systemic risk. In either interpretation, the public good factor is easy to measure: it corresponds to the subsidy needed for private banks to allocate their payments in the way that is desired by banking authorities.

Keywords: large-value payment systems, public goods, pricing rules.

JEL codes: G28, H41.

Non-Technical Summary

This paper proposes a pricing scheme for publicly run Large Value Payment Systems that takes into account a possible "public good factor".

Most interbank payments of a certain size are transferred via so-called Large Value Payment Systems (LVPS). In most countries, LVPS are organized and operated publicly, often by the central bank. In others, these systems are privately organized entities, which are usually regulated to some extent. In many countries, both private and public payment systems compete for customers.

Public involvement in large value payment systems has many reasons. Historically, central banks had a unique role in the provision of payment services. Also, a central bank has a strong interest in the smooth and efficient functioning of the payments system because it is used for monetary policy operations, and because it is the backbone of any financial system and a possible channel through which a financial crisis could spread. It is often argued that from a welfare perspective, central banks are better able to run a payment system than private providers. Reasons include a central banks' greater concern for systemic risk, scope economies between different central banking functions, or the ability to react quicker in crisis times when the central bank is involved in the operation of the payment system.

Accordingly, the provision of payment services by a central bank is often linked to other central-bank-specific services it provides, be it monetary policy operations, oversight over the payment system, or possible emergency liquidity assistance. This makes it extremely difficult to allocate costs to the different functions. If costs cannot be separated according to their functions but are instead allocated to the operation of the payments system, the latter may not be able to operate competitively. As a consequence, cost recovery, as required in the statutes of some central banks, for instance the European Central Bank, is difficult to achieve. A departure from the cost recovery principle may therefore be justified in order to guarantee the provision of the public good services.

This paper takes as given that the central bank provides a 'public good' in addition to normal payment services. It asks how to incorporate this public good activity into the pricing of the large value payment services. It is assumed that there are economies of scope between the provision of payment services (which is a private good that can also be supplied by the private sector) and other, central bank specific services. In other words, the public good can be supplied more cheaply when the volume of payments processed through the public large value payment system is large. We are interested in determining the welfare-maximizing price schedule.

We find that a subsidy to the public system is a way to guarantee a sufficient provision of the public good services. The economic intuition is that without this subsidy, that is with marginal cost pricing, prices would not reflect the impact on the system's settlement activity an the cost of providing the public good: a reduction of these costs requires a high level of output which can only be achieved by a reduction in prices that are charged to customers.

1 Introduction

A new generation of TARGET, the European-wide system of public payment systems, is currently being designed. In TARGET2, a single price structure will apply to all national components. Prices will be such that the benchmark system, i.e. the most cost-efficient system, is able to recover costs, taking into account a so-called "public good factor". There are several possible justifications for such a public good factor. For example, a public good provided by TARGET could be related to the reduction in systemic risk that arises from the central bank involvement in the settlement process (or from having a central bank as operator of the system). Indeed, financial stability shows aspects of a public good, since it benefits everyone (and therefore fulfills the criterion of non-exclusivity), and banks can try to free-ride on others' willingness to pay for it. Examples for central bank involvement in the reduction of systemic risk could be the provision of backup facilities by the central bank, or its better ability to provide emergency liquidity assistance in times of crises. Also, the fact that the public system offers end-of-day settlement in central bank money can reduce systemic risk.

The objective of this article is to design a pricing framework for a public payment system which takes into account the existence of such a "public good", provided by this system. The article is to give a welfare theoretic foundation for pricing rules that are imposed in practice to public networks that are in competition with private firms. To this aim, we assume that standard payment services are offered both by a public and a private system. Additionally, the public system provides some type of public good. Due to the public good provision, the unit cost of processing payments is lower in the private system while the fixed cost component of the public good system can be allocated to both the private and the public good activities.

We find that the presence of the public good activity implies that prices should be set below marginal costs of providing settlement activities. The economic intuition is that without this subsidy, i.e. with marginal cost pricing, prices do not reflect the impact of TARGET's settlement activity on the cost of providing the public good. A reduction of these costs requires a high level of output and thus a reduction in prices that are charged to customers.

While the model is derived having in mind a public payment system, analogies to other sectors can be drawn. An example would be public hospitals: these provide the same services as private hospitals, but at the same time they may have a specific (costly) task of training young surgeons. Thus public hospitals typically have higher costs than private clinics but reducing their activity would also reduce the quality of surgeons training. This justifies some degree of subsidization of public hospitals. Another example is the universal service obligation in telecommunications and post office (see Choné et al. 2001).

2 A Simple Model of Large Value Payment Systems

There are two payment systems. System 1 is a public one (such as TARGET), and System 2 is a private system (for instance, Euro1). The private system is unregulated. Both systems provide interbank payments, a private good. Additionally, System 1 provides a public good. We take this market structure as given and do not discuss the possibility of auctioning off the right to provide the public good.[3] For simplicity, we take the level of public good activity as given but assume that its cost can vary.

Denoting q_1 TARGET's output of the private good, its costs of production are

$$C_1 = F(q_1) + c_1(\beta, e_1)q_1.$$

The first term F denotes the fixed cost of producing the public good. We assume that it is a decreasing function of the activity on the private good. This assumption is meant to capture the fact that backup facilities or end of day settlement are less costly to provide if Target is also used to process "ordinary" interbank payments. The assumption $F' < 0$ can be interpreted as having economies of scope between the public and the private good.

The second term relates to the production of the private good: c_1 is the marginal cost of producing the private good, which depends on two parameters: β is an efficiency parameter, e_1 is a cost reducing effort. The firm's efficiency parameter is drawn from a distribution $G(\beta)$ which is distributed on $[\underline{\beta}, \overline{\beta}]$. Here, $\underline{\beta}$ refers to the most efficient, and $\overline{\beta}$ to the least efficient possible type. The distribution is common knowledge. System 1's disutility of effort is $C(e_1)$.

For simplicity we assume

$$c_1(\beta, e_1) = \beta - e_1$$

In the present set-up, it is assumed that the cost of production of the private good are linear. One could easily introduce economies of scale in its production by adding a fixed cost term. However,

[3] This possibility is discussed in the literature on universal services obligations, for examples in the postal sector (see e.g. Choné et al. (2001) and the references therein).

the presence of a fixed cost would not have any effects on the subsequent results, therefore we abstract from it.

The costs of production for the private system are

$$C_2 = c_2 q_2$$

where q_2 denotes System 2's output of the private good.[4]

Banks are uniformly distributed on the unit interval, with System 1 being located at 0 and System 2 located at 1. Therefore, we assume that banks are heterogenous in their preferences about which payment system to use. For example, some may want more security for their payments and thus have an intrinsic preference for the public system. We assume that if the two systems have the same costs, it is efficient that they share equally the market, i.e. $q_1 = q_2 = \frac{1}{2}$. The unit transportation cost is t. Thus t measures the intensity of banks' tastes differentiation and thus determines the cross elasticity of demand. Each bank has an inelastic demand for one unit of the private good, but chooses to purchase it either from the public or from the private system.

Each system maximizes profits.[5] There is a regulator who wants to maximize overall social welfare. The regulator does not observe the efficiency parameter β, but it does observe costs.

The timing of the game is the following. At stage 1, System 1 learns β. At stage 2, the regulator offers to the public system a contract that specifies a price or quantity in the private market and a transfer as long as the system's costs satisfy a certain objective. We will invoke the revelation principle where the system stating type $\widehat{\beta}$ gets contract $\{p_1(\widehat{\beta}), T(\widehat{\beta})\}$, where $T(\widehat{\beta})$ is the transfer to System 1 if it meets its cost objective. If the system sends no message, it gets a profit of 0. After accepting a contract, the public system chooses its effort $e_1 = e\left(\beta, \widehat{\beta}\right)$.[6]

We assume that the private system is competitive, so it acts as a price-taker and chooses $p_2 = c_2$. There is a cost of public funds, denoted $\lambda > 0$.

We find the equilibrium by solving backward. The demand functions for the private good (as

[4]We could also decompose the cost of the private system by introducing an efficiency parameter β_2 and a cost reducing effort e_2. This would complicate our analysis but would not alter the qualitative results.

[5]The "profit" of the public system can be interpreted as a rent that is dissipated through higher salaries or better conditions of work for the personnel. This rent is necessary to provide incentives to the public system for attaining its objectives.

[6]An equivalent formulation is that the transfer to TARGET is a function of its realized unit cost q, so that the effort needed to attain its objective is $e_1 = c_1 - \beta$. TARGET then selects c_1 so as to maximize its profit.

functions of the price of the public system) are:

$$q_1(\widehat{\beta}) = \frac{1}{2} + \frac{c_2 - p_1(\widehat{\beta})}{2t} \tag{1}$$

for the public system, and

$$q_2 = 1 - q_1(\widehat{\beta}) = \frac{1}{2} - \frac{c_2 - p_1(\widehat{\beta})}{2t}, \tag{2}$$

for the private system.

Notice that the demand for payments in each system is exactly $\frac{1}{2}$ when either the public system chooses the same prices as the private one ($p_1(\widehat{\beta}) = p_2 = c_2$) or when the transportation costs become infinitely high ($t \to \infty$), which corresponds to a complete absence of substitutability between the two systems.

The profit of TARGET is

$$\begin{aligned} \pi_1(\beta, \widehat{\beta}) &= \left[p_1(\widehat{\beta}) - c_1(\beta, e(\beta, \widehat{\beta}))\right]\left[\frac{t + c_2 - p}{4t}\right] \\ &\quad + T(\widehat{\beta}) - F(q_1) - C\left(e\left(\beta, \widehat{\beta}\right)\right) \end{aligned} \tag{3}$$

3 First Best Allocation (perfect information benchmark)

We first derive the optimal solution for the benchmark of a regulator that has perfect information, i.e. can observe β. The regulator can control the effort of firm 1 and outputs of both firms.

Given that the total payment volume and the level of the public good activity are fixed, the objective is to minimize total costs. There are three types of costs: transportation cost, cost of production, and cost of transfers. The total transportation cost is

$$\frac{t}{2}\left[q_1^2 + (1 - q_1)^2\right]$$

The total cost of production of all goods (including the disutility of cost reduction efforts) is

$$(\beta - e_1)q_1 + c_2(1 - q_1) + C(e_1) + F(q_1),$$

and the cost of transfers to the public system is

$$\lambda\left[(\beta - e_1)q_1 + F(q_1) + C(e_1) - p_1 q_1\right]$$

Taking all these terms together, the social cost is

$$SC = \frac{t}{2}\left[q_1^2 + (1 - q_1)^2\right] + c_2(1 - q_1) + (1 + \lambda)\left[c_1 q_1 + F(q_1) + C(\beta - c_1)\right] - \lambda p_1 q_1. \tag{4}$$

We would like to determine the optimal level of payments made through the public system q_1 as well as the optimal level of effort. The first order conditions are

$$\frac{\partial SC}{\partial e_1} = q_1 - C'(e_1^*) = 0 \tag{5}$$

and

$$\frac{\partial SC}{\partial q_1} = t(2q_1 - 1) - c_2 + (1+\lambda)\left[c_1 + F'(q_1)\right] - \lambda(p_1 q_1)' = 0. \tag{6}$$

The first of these equations gives the efficient level of effort e_1^*. With a convex disutility of effort, we have that e_1^* is an increasing function of q_1, the level of activity of TARGET. Furthermore, since we have assumed that firm 2 is a competitive firm setting $p_2 = c_2$, from the second equation it follows that

$$c_2 + t(1 - 2q_1) = (1+\lambda)\left[c_1 + F'(q_1)\right] - \lambda(p_1 q_1)'.$$

Note that from the demand function (1), the left-hand side of the equation is equal to p_1. Furthermore, denoting by $\epsilon_1 = \frac{\partial q_1}{\partial p_1}\frac{p_1}{q_1}$ the elasticity of demand for TARGET, we find

$$p_1 = c_1 + F'(q_1) + \frac{\lambda p_1}{(1+\lambda)\epsilon_1}$$

or

$$\frac{p_1 - c_1 - F'(q_1)}{p_1} = \frac{\lambda}{(1+\lambda)\epsilon_1}. \tag{7}$$

This formula has a standard interpretation: if $\lambda = 0$ (no cost of public funds) and $F\prime = 0$ (no economy of scope between public and private good) then the optimal price for TARGET is marginal cost c_1. As long as there are fixed costs related to either the public or the private good provision, this would lead to a deficit, so transfers from the taxpayer to the public system would be required.

If there are economies of scope (so that $F' < 0$) but no cost of public funds ($\lambda = 0$) it is optimal to charge a generalized marginal cost $c_1 + F'(q_1)$, which is lower than c_1. The resulting price would take into account that the public system bears a cost for the provision of the public good. The economic interpretation is that TARGET should be subsidized so that its output is higher, because this decreases the cost of providing the public good.

Finally, if $\lambda \neq 0$, i.e. the provision of public funds is costly, there is an additional term a la Ramsey, which is inversely proportional to the elasticity of demand. In other words, the more elastic the demand for payments in the public system, the lower should be its price. Thus in this model, the unit price charged by TARGET, p_1 should correspond to its marginal cost c_1, minus a subsidy equal to the difference between the economies of scope factor $|F'(q_1)|$ and a factor $\frac{\lambda}{(1+\lambda)\varepsilon_1}p_1$ that increases with the cost λ of public funds.

3.1 Second Best (Private information)

We now turn to the more interesting case in which there is private information on the efficiency parameter β. We assume that β is drawn from $[\underline{\beta}, \overline{\beta}]$ with distribution $G(\beta)$. Again, there is a planner who would like to minimize total costs, but he does so without knowledge of the efficiency parameter. In order to provide incentives to reduce the costs of TARGET, the planner has to give a rent π to the employees of TARGET.

The contract given to the providers of the public system is now a function of the signal $\widehat{\beta}$, and therefore, the system's profit depends both on β and $\widehat{\beta}$. Truth-telling[7] by the system requires that choosing $\widehat{\beta} = \beta$ maximizes its profit. Assuming truth-telling, the profit of TARGET can therefore be stated as a function of the true type β as

$$\pi(\beta) = Max \left[T(\widehat{\beta}) + (p_1(\widehat{\beta}) - c_1(\widehat{\beta}))q_1(\widehat{\beta}) - F(q_1(\widehat{\beta})) - C(\beta - c_1(\widehat{\beta}))\right]. \tag{8}$$

Here, we have used

$$c_1(\widehat{\beta}) = \widehat{\beta} - e_1(\widehat{\beta}) = \beta - e_1(\beta, (\widehat{\beta})).$$

Furthermore, we have:

$$\dot{\pi}(\beta) = -\dot{C}(e_1(\widehat{\beta})) \text{ and } \pi(\overline{\beta}) = 0$$

The first equation is a consequence of the incentive compatibility condition (8), and is derived by using the envelope condition. The second condition states that no rent should be given to the least efficient type. It is a consequence of the fact that it is costly for the regulator to give rents to the system.[8]

Thus,

$$\pi(\beta) = \int_{\beta}^{\overline{\beta}} \dot{C}(e_1(s))ds$$

The total expected rent of TARGET is

$$\int_{\underline{\beta}}^{\overline{\beta}} \pi(\beta)dG(\beta) = \int_{\underline{\beta}}^{\overline{\beta}} \dot{C}(e_1(\beta))G(\beta)d\beta$$

[7] By the revelation principle (Myerson, 1979) this is without loss of generality.

[8] These conditions are fairly standard in the literature on mechanism design. For more details see, for instance, Laffont and Tirole (1993).

The social costs with asymmetric information is thus (for a given value of β)

$$\begin{aligned} SC &= t/2\left[q_1^2 + (1-q_1^2)\right] + c_2(1-q_1) + (1+\lambda)\left[c_1 q_1 + F(q_1) + C(\beta - c_1)\right] \\ &\quad -\lambda p_1 q_1 - \lambda \dot{C}(e_1(\beta))\frac{G(\beta)}{g(\beta)} \end{aligned}$$

Compared to the first-best case, there is now an additional term: this term reflects the cost associated with the presence of asymmetric information. From the first order conditions, again taken with respect to q_1 and e_1, we obtain

$$q_1 = 1/2 + \frac{1}{2t}\left[c_2 - (1+\lambda)c_1 + F'(q_1) + \lambda p_1(1 - \frac{1}{\epsilon_1})\right] \tag{9}$$

and

$$C'(e_1(\beta)) = q_1 - \frac{\lambda}{1+\lambda}C''(e_1(\beta))\frac{G(\beta)}{g(\beta)}. \tag{10}$$

Let us start by analyzing (10). Recall that in the first-best case, the optimal level of effort satisfied $C'(e_1) = q_1$. Therefore, the presence of asymmetric information implies that effort is lower and therefore that production costs are higher in the public system. The reason is that in order to induce a higher level of effort, the planner needs to give rents to TARGET. However, because of asymmetric information, he cannot observe whether a low production cost is the result of high effort or of a high level of efficiency. The regulator faces a trade-off between achieving a high level of effort and giving a high profit to the system, which is costly because there is a cost of providing public funds.

However, in the following we are going to prove that the pricing decision is unaffected by asymmetric information. Indeed, if firm 2 (EURO1) is competitive then

$$p_1 = c_2 - t(2q_1 - 1)$$

and using condition (9) above, we obtain again

$$\frac{p_1 - c_1 - F'(q_1)}{p_1} = \frac{\lambda}{(1+\lambda)\epsilon_1}.$$

Thus, while private information affects the effort undertaken by the public system, it leaves the optimal pricing rule unaffected. The reason for this is the fact that the private information concerns only the level of efficiency, which is a substitute to the level of effort. However, the total costs of producing q_1 are observable, and this is the reason why output and pricing (for a given level of c_1) are unaffected by the presence of private information.

4 Robustness Tests and Conclusion

We have derived a pricing framework for a public payment system that is in competition with a private system. We have assumed that, additionally, the public system provides a public good, whose cost of production F is a function of its supply q_1 of the private good. More specifically, we have assumed the presence of economies of scope: F is a decreasing function of q_1.

Our findings can be summarized as follows: In the absence of a public good, and in the absence of any fixed cost, the optimal pricing rule for TARGET would be to set the price equal to the marginal cost. This would imply a balanced budget for TARGET.

However, if there is a public good with a fixed cost F, but there are no economies of scope between the public and the private good (so that $F' = 0$), then the optimal pricing rule is similar to Ramsey pricing: it would be optimal to surcharge the marginal cost of a factor inversely proportional to demand elasticity. As a result, the higher the elasticity of demand, the lower the optimal price of the private good.

Instead, in the presence of scope economies (that is, when $F'(q_1) < 0$), it is optimal to introduce a "public good factor" in the pricing of TARGET. This public good factor is precisely equal to $F'(q_1)$, namely the reduction in the cost of producing the public good that is obtained when the volume of payments going through TARGET increases marginally.

Although our results have been derived under a particular specification (Hotelling model with uniform distribution, which gives linear demands) they can be easily extended to general demand functions. Moreover, the "public good" activity of the public system can be interpreted in a wider sense. Consider for example a situation where the public system incorporates a higher degree of protection against systemic risk than the private system. This may be because private banks do not internalize the cost of systemic crises, whereas the central bank does. This implies that the public system is more costly to operate, and that private banks tend to use it less often than social optimality would require. Our model can be reinterpreted to fit this situation: the "public good activity" is just the additional level of protection provided by the public system and $F(q_1) + (c_1 - c_2)q_1$ measures the cost difference between the public and the private systems, for a level of activity q_1. With this interpretation, the public good factor $|F'(q_1)|$ represents the correction factor (here, a subsidy) needed to make private banks internalize the cost of systemic risk. This leads us to a final remark about measurement.

If one accepts the view that the public good factor has to be interpreted as the price correction needed for private banks to internalize the costs of the public good activity (prevention of systemic risk or other), than there is a simple way to measure it. Indeed, once banking authorities have determined the fraction q_1 of (total) large value payments that they consider appropriate for the public system (this may be influenced by political considerations) the public good factor is just the subsidy needed for private banks to indeed allocate their payments in the way desired by banking authorities (i.e. q_1 for the public system, $q_2 = 1 - q_1$ for the private system). As we have seen in Section 3, incentives for cost reduction efforts within the public system can be provided independently by setting costs targets, monitoring realized costs, and adjusting the transfers to the public system accordingly.

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