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Standardising Electronic Means of Payment?

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Abstract. In this paper it is discussed whether electronic means of payments should be standardised. Having answered this question affirmatively, it is analysed which form of standardisation will be appropriate. Three forms are discussed: Standardisation by market forces, by co-operations among firms and by state intervention. The result is that it is possible to solve the standardisation problem with co-operative firms or market forces. The question is, however, whether these solutions are compatible with a competitive market. State intervention in the form of prescribing basic technical standards and enforcing interconnection might be required to ensure the efficiency of the EPS market. A state monopoly with electronic money is not appropriate because it tends to be dynamically inefficient and to have problems with cost control.

Keywords: electronic payment system (EPS), SET, critical mass

1. Introduction

The development of electronic commerce initiated new forms of payment via the Internet. In the real world, electronic payment systems are as well available and are used very often. However, some peculiarities of the virtual world required special forms of payment.

There are different notions for on-line payment systems: electronic payment systems, electronic money, cyber cash, digital money to mention only a few. The meaning of these notions is very similar with small differences. In this paper, the notion *electronic payment system* (EPS) will be used. It encompasses all forms of retail payments which are available on-line.

With electronic payment systems relevant data for payments are transmitted electronically whereby well known means of payment as credit cards may be used. But also smart cards, DigiCash etc. are included. The payments are denominated in the respective national currencies. This means that no new currency is created. (A new currency would require that it is not denominated in a known national currency, but in a new one. The number of currencies world-wide would increase with the introduction of new electronic currencies.)

The problems to be considered in this paper are as follows: Credit cards are to a large extent standardised. This means that one can use different cards without being restricted very much. There exist well known rules how to proceed in the case of loss, theft and fraud. In addition to that (possibly as a consequence of it) credit cards are widely accepted, especially for payments over the Internet. One of the remaining problems is security. But even in this respect, a standard has been developed, SET (see [7] as well as [17]). Only one problem remains: The lack of interconnection (see [6] for an introduction to the economics of interconnection), i.e., one cannot transmit money with a credit card x to a merchant who accepts solely card y.

At the time being, other forms of EPS are neither standardized nor interconnected. This may be a major problem as there are network externalities with EPSs. A customer as well as a merchant must decide which smart card or electronic money to have or to accept. Because card readers are relatively expensive and only very few customers use existing EPS (except credit cards), the market is relatively small and both sides of the market are reluctant to invest in EPSs; see, however, [18] for an analysis of the activities of providers of electronic purses with respect to interoperability.

In this paper I shall investigate standardisation problems for EPSs. The crucial question is whether there should be any standardisation, and if yes, how far should the standardisation go. These are questions which can be analysed within a welfare economic framework, taking network externalities into consideration. By and large, two rather extreme positions can be distinguished:

1. *Let the markets decide*! This means, that neither state intervention nor co-operation of firms is necessary to solve the problem of network externalities. The idea is that the test of the market is the only criterion which can be justified from an economic point of view. Since the authorities do not know more than the market participants, it is simply not possible to reach a better allocation of resources than the market. If only one EPS survives, the market can only bear one. If several survive, then this is optimal. In addition to that, even a co-operation of firms is not liked very much because this will necessarily mean a restriction of competition for the best solution(s).
2. *Only state intervention can solve the network externality problem*! This position assumes that the market forces cannot work adequately because the network externality destroys the private incentives of the market participants to choose the 'right' EPS. As a consequence, either the volume of transactions would be very low (lower than the socially optimal volume) because the costs of transactions with several different not interchangeable and not interoperable means of payment are too high, or a technically bad EPS survives and dominates the market. The latter means a loss of welfare because other means of payment could be at hand if the state intervened and prescribed a solution (which can be either a standard which makes the different means of payment interoperable and interchangeable, or a prescription of only one means of payment).

However, there is a third option available. This option is a co-operative solution. It implies that firms may co-operate to find a solution for standards, despite the fact that different solutions compete with each other. There would be a trade-off between two effects under these circumstances, a network externality effect and a substitution effect: There are incentives for firms in the EPS business to co-operate in this form because they risk otherwise that no solution at all will be widely accepted, but at the same time they compete with each other due to substitution between the respective EPS.[1]

The question is, however, whether these incentives are strong enough to overcome the network externality. In addition to that it is necessary to analyse the strategic aspects of such a private solution. Thereby one crucial question is whether there is still a need for state intervention. One could imagine, e.g., that state authorities could accelerate the process of defining a standard by termination: If up to a certain time no agreement is reached, the state could threaten to intervene and set itself a standard which is mandatory for the industry.

In addition to these points the question is whether national standards suffice. The reason is that electronic commerce is a global phenomenon. The full benefits of electronic commerce can only be realised when the transaction costs are minimised worldwide. The Internet provides the technical infrastructure, but not the rules and standards necessary to minimise all transaction costs. Insofar, the question of standards with respect to EPSs is an international problem.

This, however, does not make it easier to reach a solution. Take as an example the new European payment system TARGET.[2] It was recognised that the European Monetary Union cannot work if the countries did not have a common payment system. The problem was that on the national level, several payment systems between banks already existed. There was even a payment system that connected different countries with each other. The solution was the invention of a new supra-national system which could be superimposed on the existing national systems. The question is what kind of EPS is required for transnational payments.

Although it is not intended to answer all these questions in this paper, it seems important to analyse at least the question of standardisation: Should be there a standardisation of EPS at all on a national or international level? How should the standardisation take place, via co-operation between firms or via state intervention? Is there a role for the state even if firms are willing to co-operate for standards?

The structure of the paper is as follows: First, using welfare economics it is shown that there is a need for standardisation. Second, three methods of standardisation are analysed: market forces, negotiation among firms and prescription of the state. Thereby the crucial point is a differentiation between a static and a dynamic point of view whereby a dynamic viewpoint takes technical progress with respect to EPSs into account. Third, the policy implications are investigated.

2. Is standardisation necessary?

2.1. *The private optimum demand for monies*

The consumer i's problem is to select a combination of monies (including EPSs, cash, checks, etc.) which maximizes his or her utility (see [15, pp. 18 ff] for a similar approach):

$$\max_{\mu_{ij} \geqslant 0} u^i(\mu_{ij}) = \left(\mu_{ij} + \sum_{k \neq 1} \mu_{kj}^{*p}\right)^{\alpha} \qquad (1)$$

subject to the budget constraint:

$$c_i = \sum_j p_j^* \mu_{ij}, \tag{2}$$

with $u^i(\ldots)$: utility of consumer i, $i = 1, \ldots, n$, with $u^i_j(\ldots) > 0$ and $u^i_{ij}(\ldots) < 0$, u^i_j: marginal utility of the jth money, μ_{ij}: demand for money $j = 1, \ldots, m$ of consumer i, $\sum_{k\neq i} \mu_{kj}^{*p}$: optimal demand for money j of all consumers $k \neq i$, α: parameter of the utility function, $0 < \alpha < 1$, c_i: consumption expenditures of consumer $i = 1, \ldots, q$, p_j^*: competitive equilibrium price of the jth money.[3]

In this setting, individual consumers assume that the decision of other consumers to use a particular money is given. Therefore, the concept to be applied is the non-cooperative Nash-equilibrium.

The individual maximization program can be written as:

$$\max_{\mu_{ij}} u^i(\mu_{ij}) = \left(\mu_{ij} + \sum_{k\neq i} \mu_{kj}^{*p}\right)^{\alpha} - p_j \mu_{ij} \tag{3}$$

where the utility of the monies can be transformed by a quasi-linear function into units of a numeraire which serves also as a basis for the prices p_j. Then the program can be interpreted as the maximization of the individual consumer surplus with respect to the different monies.

The first-order conditions for the individual optimal money demand are given by:

$$\mu_{ij} = \left(\frac{\alpha}{p_j}\right)^{\frac{1}{1-\alpha}} - \sum_{k\neq i} \mu_{kj}^{*p}, \quad j = 1, \ldots, m. \tag{4}$$

The individual rule for selecting a portfolio of monies is quite simple: Choose that amount of money j where the marginal utility of that money is equal to its price.

Assuming that $\mu_{kj}^* = \mu_{ij}^*$, the private market demand can be calculated:

$$\mu_j^P = \sum_i \mu_{ij}^* = n\mu_{ij}^* = \left(\frac{\alpha}{p_j}\right)^{\frac{1}{1-\alpha}}. \tag{5}$$

2.2. *The social optimum of the demand for monies*

To calculate the socially optimal demand for the monies, let

$$\mu_j := \sum_i \mu_{ij} \quad j = 1, \ldots, m \text{ and } i = 1, \ldots, n. \tag{6}$$

The objective is to maximize the sum of all individual utilities:

$$\max_{\mu_j} \sum_i u^i(\mu_j) := \sum_i \mu_j^{\alpha} = n\mu_j^{\alpha} \tag{7}$$

subject to the cost function $C(\mu_j)$ with $C_j(\mu_j) > 0$ and $C_{jj} \geqslant 0$, $j = 1, \ldots, m$.

The first-order conditions for a social optimum are:

$$\mu_j^{*s} = \left(\frac{n\alpha}{p_j}\right)^{\frac{1}{1-\alpha}}, \quad j = 1, \ldots, m, \tag{8}$$

where $p_j = C_j$ and C_j is the derivative of the cost function with respect to the jth money. (It is assumed that the monies are supplied competitively.)

The necessary conditions for a private and social optimum are:

$$\text{Private optimum:} \quad m_j^{p*} = \left(\frac{\alpha}{p_j}\right)^{\frac{1}{1-\alpha}}, \tag{9}$$

$$\text{Social optimum:} \quad m_j^{s*} = \left(\frac{n\alpha}{p_j}\right)^{\frac{1}{1-\alpha}}. \tag{10}$$

Proposition 1. The private demand for each of the monies is smaller than the socially optimal amount of the monies:

$$\sum_i \mu_{ij}^{*p} < \mu_j^{*s} \quad \forall j \text{ and } n > 1.$$

Proof. Assume an interior solution, i.e., $\mu_{ij} > 0$. Then by direct calculation:

$$\mu_j^{*s} > \mu_j^{*p} \Leftrightarrow \left(\frac{n\alpha}{p_j}\right)^{\frac{1}{1-\alpha}} > \left(\frac{\alpha}{p_j}\right)^{\frac{1}{1-\alpha}} \Leftrightarrow n > 1 \tag{11}$$

which holds true since $n > 1$ has been assumed. □

This result is well known in the literature on network externalities (see, e.g., [4] and [5]). However, it seems quite new for different means of payment. Its implication is that *all* monies, including EPSs, suffer from positive network externalities. Central bank money is the only exception because it is the legal tender.

However, that is not the whole story. The reason is that there are two implicit assumptions in the model above:

1. All kinds of money meet different needs of the consumers and are, therefore, useful.
2. The network externality is marginal and, therefore, Pareto relevant. The extent of the externality seems to be constant.

The first assumption ensures that all kinds of money are socially necessary. However, this is not necessarily true. It may be argued that one EPS is sufficient for on-line and off-line transactions. In this case, it is easy to see that only one EPS is socially optimal. The reason is that the provision of EPSs consumes resources (relatively high set-up costs). The implementation of more than one EPS is then a waste of scarce resources and, hence, inefficient.

However, the crucial question is whether there is a technically dominant form of EPSs. Following [14], what counts are the *characteristics* of the monies. As argued by [15] the relevant characteristics are *security* and *liquidity*. The liquidity of a money depends heavily on the number of other customers and merchants who use the respective money. The security of money on-line is determined by its cryptographic standards and the infrastructure of the payment system [3]. According to these characteristics the available EPSs are technically different. In addition to that, the costs (prices) of the EPSs are also different. Therefore, there seems to be no *dominant* EPS (in the sense of Lancaster). Hence, it is an open question whether one or more EPSs are socially optimal.

The consequence of multiple EPSs is that they must be *interconnected.* Interconnection means that different EPSs are connected with each other with the consequence that by using one particular EPS allows to transfer money to all other EPSs. Therefore, interconnection constructs one very comprehensive network out of many single networks. Put differently, it creates a large benefit for all participants of the different single networks. Consumers can interact with merchants who belong to a different EPS-network *et vice versa*.

Proposition 2. For society as a whole one all inclusive network of payment systems and monies is optimal. If there is a need for different single payment systems, interconnection of all these single co-existing networks into one is optimal.[4]

Proof (sketch). The decision to participate in a single network depends on the number of participants in this specific network. Interconnection of all existing single networks increases the number of people already participating in this grand network. Hence, the private incentive to participate is far larger in a grand than in a single network. From an individual viewpoint, the network externality is mitigated via interconnection. □

The second point mentioned above concerns the extent of the network externality and its Pareto relevance.[5] The problem is that the network externality changes to a large extent as the network grows. The switching point is the so-called *critical mass*. Before this point is reached, the network externality is positive, i.e., the utility of the network participants increases with the total number of persons using it. During this phase, the network externality is large and marginally relevant. Furthermore, as the network grows the externality is declining. Beyond the switching point, there is a positive feedback effect as the number of network participants is so large that only people with very low benefits of the network good or service can afford to stay outside. In this phase, the network externality could even become infra-marginal and loose its Pareto relevance.

There might also be a new negative effect when the network size is larger than the critical mass. People and society as a whole could become *locked-in* on an inferior network, if there is only one (EPS-) network. (See [2] for the significance of network technologies and lock-in.) The reason is that the size of the network itself determines the switching costs; (see [8] for an overview on the implications of switching costs). Thereby the switching costs encompass the costs of the new gadgets as well as the indirect costs of a delayed introduction of the technically superior EPS due to network externalities. Since a very large part of the population participates in the existing network there is again a large positive marginal network externality which inhibits the move to a new superior network. The more relevant this aspect is, the higher is the pace of technical progress with respect to the network good or service.

However, this danger does not exist if there is a grand network created by interconnection of single different networks. The reason is that it is very cheap to leave a single network if one can move to another (new) single network *that is also interconnected with the other existing single networks.*

Proposition 3. A grand network consisting of interconnected single networks is socially superior to one big network if the switching costs in the big network are larger than the set-up costs and interconnection costs of a number of single networks.

Because the interconnection costs depend on the compatibility of the different interfaces, there is a strong reason to standardise the interfaces so that interconnection becomes easy and cheap. This means that there is a strong reason to define minimum standards for the technical structure of EPSs that allow easy and cheap interconnections.

The possibility of interconnections might solve another important problem: competition (to this point see [11,12] and [13]). If there were only one EPS, there would be almost no competition on the market for EPS. In other words, the supplier of the implemented technique would hold the position of a natural monopolist because the customers and merchants would be locked-in.

This could be different with a number of different EPSs that are interconnected. Interconnection provides different qualities of the monies (security, convenience, etc.) so that the users have an actual choice. The suppliers of the different monies compete to a certain extent with each other in terms of quality and price. This argument will be considered in greater detail in the following sections.

To sum up the results of this section: There is a need for technical standards with respect to EPSs. However, if different EPSs meet different needs, a number of them should be on the market. To mitigate network externalities, interconnection of the different systems is required. To this end, common technical standards are necessary to enable easy and cheap interconnection. In addition to that, interconnection mitigates also lock-in effects and creates to a certain extent competition between suppliers.

The remaining question is how the necessary standards will be created: By competition, co-operation among firms or by state intervention. This is investigated in the next section.

3. Methods of standardisation

To analyse the effects of different forms of standardisation, a very simple model with network externalities will be developed in the following.

The welfare of customers is given by:

$$\sum_j \sum_i u^i(\mu_{ij}) = \sum_j \sum_i \left(\mu_{ij} + \sum_{k \neq i} \mu_{kj}^{*p}\right)^{\alpha} \tag{12}$$

with μ_j: number of people using money j, α: parameter of the utility function, $0 < \alpha < 1$.

Furthermore it is assumed that there are two suppliers of monies, A and B. The reason is that there are barriers to entry into the market for EPSs in form of a high level of fixed costs. A substantial reduction of fixed costs per unit can only be reached when the number of people using a particular EPS is large. If the supplier remains small, it cannot recover fixed costs. Therefore it is assumed that there will be an oligopoly. Thereby it is assumed that the firms are of equal strength.[6] Each supplier offers only one money. In what follows, however, the notions ‘money’ and ‘EPS’ are used as synonyma. Hence, there are two monies (EPS) available. In addition to that, *the monies are complete substitutes for each other*, but they are not interconnected. The fixed costs of A are a, of B they are b, $a, b \geqslant 0$. The marginal costs are $\delta \geqslant 0$ and $\varepsilon \geqslant 0$, respectively.

3.1. Market forces

Suppose that there is no state intervention and no co-operation among the firms. Under these circumstances, the firms form a duopoly because of the high fixed costs when there are only a few customers at the beginning. It is assumed that the firms play Cournot–Nash strategies, i.e., the firms choose the volume of money they issue and let the market decide its price. In equilibrium, there will be only one price for the monies. The market demand curve is (as shown above):

$$\mu_{A+B} = \mu = \left(\frac{\alpha}{p}\right)^{\frac{1}{1-\alpha}} \tag{13}$$

where p is the common market price for both monies.

The profit of the firms is given by:

$$\Pi_A = \mu_A \frac{\alpha}{\mu^{1-\alpha}} - \delta\mu_A - a, \tag{14}$$

$$\Pi_B = \mu_B \frac{\alpha}{\mu^{1-\alpha}} - \varepsilon\mu_B - b. \tag{15}$$

Both firms play – as said above – Cournot–Nash strategies. The first order conditions determine the optimal quantities of the monies μ_A and μ_B:

$$\mu_A = \frac{\mu - \frac{\delta}{\alpha}\mu^{2-\alpha}}{1-\alpha}, \tag{16}$$

$$\mu_B = \frac{\mu - \frac{\varepsilon}{\alpha}\mu^{2-\alpha}}{1-\alpha}. \tag{17}$$

However, these equations contain μ. Since $\mu = \mu_A + \mu_B$ it follows:

$$\mu = \frac{\mu - \frac{\delta}{\alpha}\mu^{2-\alpha}}{1-\alpha} + \frac{\mu - \frac{\varepsilon}{\alpha}\mu^{2-\alpha}}{1-\alpha} = \frac{2\mu - \frac{\varepsilon+\delta}{\alpha}\mu^{2-\alpha}}{1-\alpha}. \tag{18}$$

Solving this equation for μ yields:

$$\mu_{A+B} = \left(\frac{\alpha(1+\alpha)}{\delta+\varepsilon}\right)^{\frac{1}{1-\alpha}}. \tag{19}$$

This is the quantity of the monies in use. One can also calculate the monies which firm A and firm B provide, but this is not of interest here. However, the straightforward calculation leads to:

$$\mu_A = \frac{\left(\frac{\alpha(1+\alpha)}{\delta+\varepsilon}\right)^{\frac{1}{1-\alpha}}\left(1 - \frac{\delta}{\alpha}\frac{\alpha(1+\alpha)}{\delta+\varepsilon}\right)}{1-\alpha}$$

and

$$\mu_B = \frac{\left(\frac{\alpha(1+\alpha)}{\delta+\varepsilon}\right)^{\frac{1}{1-\alpha}}\left(1 - \frac{\varepsilon}{\alpha}\frac{\alpha(1+\alpha)}{\delta+\varepsilon}\right)}{1-\alpha}.$$

The quantity of monies under a Cournot–Nash duopoly (CND) can be compared with the socially optimal quantity (S). For ease of calculation, assume $\delta = \varepsilon$. The question is, then, whether $\mu_S = \mu_A^s + \mu_B^s$ is larger or smaller than $\mu_{CND} = \mu_A + \mu_B$:

$$\mu_S > \mu_{CND} \Leftrightarrow 2\left(\frac{n\alpha}{\delta}\right)^{\frac{1}{1-\alpha}} > \left(\frac{\alpha(1+\alpha)}{2\delta}\right)^{\frac{1}{1-\alpha}} \Leftrightarrow n > \frac{1+\alpha}{2^{2-\alpha}}, \tag{20}$$

which is the case for $\alpha \in (0, 1)$. I.e., the quantity of monies under a Cournot–Nash duopoly is smaller than the socially optimal quantity.

In this section it is assumed that the networks established by firm A and firm B are *neither* compatible *nor* connected. Are there incentives for the Cournot–Nash duopolists to interconnect their EPSs?

To check this, assume that the firms interconnect their money systems. Then the market demand function is equal to that without network externalities, i.e. (IC = interconnected; NC = not connected):

$$\mu_{CND}^{IC} = \mu_{A+B} = \left(\frac{n\alpha}{p}\right)^{\frac{1}{1-\alpha}} \tag{21}$$

whereby the price for the monies is equal since they are assumed to be perfect substitutes for each other.

The profit of the firms is given by:

$$\Pi_A = \mu_A \frac{n\alpha}{\mu^{1-\alpha}} - \delta\mu_A - a, \tag{22}$$

$$\Pi_B = \mu_B \frac{n\alpha}{\mu^{1-\alpha}} - \varepsilon\mu_B - b. \tag{23}$$

Profit maximization leads to:

$$\mu_{\text{CND}}^{\text{IC}} = \left(\frac{n\alpha(1+\alpha)}{\delta+\varepsilon}\right)^{\frac{1}{1-\alpha}}, \tag{24}$$

$$p_{\text{CND}}^{\text{IC}} = \frac{\delta+\varepsilon}{1+\alpha}. \tag{25}$$

Hence the result is that the amount of money in circulation is larger than without interconnection, but the market price remains the same. This means that the socially optimal amount of the monies is still larger than the amount supplied by the Cournot–Nash duopolists. The network externality problem has been solved by interconnection, but not the market imperfection due to the oligopoly.

However, the market imperfection is assumed because of high fixed cost. The question is whether interconnection renders it possible that new entrants appear since interconnection ensures that they can gain a rather high number of customers by supplying their EPSs at a lower price. When this happens, the oligopoly will vanish and there would be a competitive market with prices equal to marginal costs. Taken this into account, it is not at all clear whether oligopolists will really interconnect.

3.2. Co-operation of firms

Next, the co-operation of firms is allowed. This means that the firms act as a monopolist. However, the money supplies are assumed to remain separated from each other.

The starting point is, then, the market demand:

$$\mu_j = \left(\frac{\alpha}{p_j}\right)^{\frac{1}{1-\alpha}}. \tag{26}$$

The joint profit is given by (thereby it is assumed that the monopolist has marginal costs of δ and fixed costs of a):

$$\Pi_{A+B} = p_j\mu_j - \delta\mu_j - a = \frac{\alpha}{\mu_j^{1-\alpha}}\mu_j - \delta\mu_j - a = \alpha\mu_j^{\alpha} - \delta\mu_j - a. \tag{27}$$

Maximising the profit function with respect to μ_j yields the following optimal quantities:

$$\mu_j^m = \left(\frac{\delta}{\alpha^2}\right)^{\frac{1}{\alpha-1}}. \tag{28}$$

Inserting this result into the market demand function yields the monopoly price:

$$p_j^m = \frac{\delta}{\alpha}. \tag{29}$$

These results can be compared with the socially optimal quantities of the monies:

$$\mu_{S_j} > \mu_j^m \Leftrightarrow \left(\frac{n\alpha}{\delta}\right)^{\frac{1}{1-\alpha}} > \frac{1}{\left(\frac{\delta}{\alpha^2}\right)^{\frac{1}{1-\alpha}}} \Leftrightarrow n > \alpha, \tag{30}$$

which is true since by assumption $n > 1$ and $\alpha \in (0, 1)$.

Next, it is assumed that the firms act co-operatively (CO) and at the same time they interconnect their money systems. The consequence is that the network externality of the monies vanishes and the market demand for the monies is (see above) (since the monies are supposed to be perfect substitutes, the subscript j is dropped):

$$\mu = \left(\frac{n\alpha}{p}\right)^{\frac{1}{1-\alpha}}. \tag{31}$$

Assuming furthermore that the marginal costs are δ, the joint profit of the firms is:

$$\Pi_{A+B} = \frac{n\alpha}{\mu^{1-\alpha}}\mu - \delta\mu - a. \tag{32}$$

Profit maximisation leads to:

$$\mu_{\mathrm{CO}}^{\mathrm{IC}} = \left(\frac{n\alpha^2}{\delta}\right)^{\frac{1}{1-\alpha}}, \tag{33}$$

$$p_{\mathrm{CO}}^{\mathrm{IC}} = \frac{\delta}{\alpha}. \tag{34}$$

Also in this case the socially optimal amount of the monies, μ^s, is still larger than that supplied by the co-operative, interconnected firms, $\mu_{\mathrm{CO}}^{\mathrm{IC}}$. In addition to that, it is easy to see that $\mu_{\mathrm{CO}}^{\mathrm{IC}} > \mu_{\mathrm{CND}}^{\mathrm{IC}}$. The reason for the sub-optimality of the interconnected, co-operative firms is that they have monopoly power in supplying money.

However, the question is again whether the profit of the monopoly attracts new entrants to the market. A barrier to entry is – as assumed – a high fixed cost. But if the EPSs of the firms were interconnected, the number of customers might be large enough to reduce the fixed cost per unit sufficiently and allow the entry of new suppliers. Therefore, it can be guessed, the monopolist firm will not be willing to interconnect their EPS with that of newcomers. In this way competition could be restricted or even destroyed.

To sum up and compare the different forms of competition between monies (EPSs), the quantities as well as the prices are presented in table 1 for the cases where the network externality is still there, but does no longer initiate a vicious circle. The market structure, however, remains an oligopoly or a monopoly, respectively. For the sake of simplicity it is assumed that $\varepsilon = \delta$.

As is easy to see the following rank-order holds true:

$$\mu_{\mathrm{S}} > \mu_{\mathrm{CND}}^{\mathrm{IC}} > \mu_{\mathrm{CO}}^{\mathrm{IC}},$$
$$p_{\mathrm{CO}} > p_{\mathrm{CND}} > p_{\mathrm{S}}.$$

Table 1

Form	# Money holders	Price of money
$\mu_{\text{CND}}^{\text{IC}}$	$\left(\frac{n\alpha(1+\alpha)}{2\delta}\right)^{\frac{1}{1-\alpha}}$	$\frac{2\delta}{1+\alpha}$
$\mu_{\text{CO}}^{\text{IC}}$	$\left(\frac{n\alpha^2}{\delta}\right)^{\frac{1}{1-\alpha}}$	$\frac{\delta}{\alpha}$
μ_{S}	$\left(\frac{n\alpha}{\delta}\right)^{\frac{1}{1-\alpha}}$	δ

To show which alternative is the best, the welfare levels have to be compared. As can be seen from the rank-order, the socially optimal quantity of the monies is always larger than that provided by a Cournot–Nash duopoly which itself is better than the co-operation of the firms. Since for the prices the reverse rank-order prevails, it is clear that state provision is better than Cournot–Nash and co-operative provision of the monies.

3.3. State intervention

In the previous section, it is argued that state intervention for the standardisation of EPSs is necessary because it might improve the *static* allocative efficiency of the economy. In addition to the arguments above, state intervention by prescribing basic technical standards reduces to a large extent the cost of negotiation between many potential suppliers. Therefore, even if the market for EPSs is competitive, this kind of state intervention may reduce transaction costs, which is an increase in welfare.

In this section it will be analysed whether state intervention can also be justified if *dynamic* efficiency aspects are taken into consideration.

Dynamic efficiency requires that there are sufficient incentives for research and development with EPSs that may result in improvements of the techniques used for transferring money (see [10] on the problem of investments in research and development with network externalities). The problem is as follows: Assume the state prescribes basic standards of compatibility for the EPS industry. How will the industry evolve under these circumstances?

First, there is a chance that the firms accept the standard, but deny to interconnect. If they do not interconnect, the basic standard would be meaningless. However, as argued above, since there are private incentives to interconnect, the risk that private firms will not interconnect their EPSs is rather small.

The remaining question is, then, whether the private incentives to innovate are strong enough to continue research and development for better systems. The risk is that the firms stop innovating because of the prescribed standard. However, how serious is this risk?

Firms will stop innovating if there is no chance to make a profit. With a prescribed standard there are chances to earn profits by innovating as long as there is downward compatibility of the new system. That private firms are able to innovate under such restrictions can be seen by the downward compatibility of software. Computer programs have been step by step improved with a certain guarantee that older versions could be used further.

However, prescribed standards impede the development of completely new systems – as also can be seen with software, e.g., operating systems. The old standard locks-in users insofar as the introduction of a new solution will only take place if the advantages of the new product are larger than the costs of changing to the new solution.

This problem does not vanish if the state does not prescribe a standard. The reason is that interconnection requires basic compatibility standards even if private firms define them. Therefore there is no difference with respect to innovation between privately negotiated standards and state defined standards.

The question remains whether the state should at all intervene under these circumstances. The argument in the former section was that state intervention could enforce a more competitive market for EPSs and in this way it would enhance static allocative efficiency. Since the conclusion of the discussion in this section is that the prescription of basic compatibility standards has the same effect as private standards (which are necessary for interconnection), the dynamic efficiency is not reduced by prescribed standards. Hence, there is at least room for the prescription of basic standards with respect to EPSs.

However, despite the fact that there are private incentives to interconnect private networks of EPSs, there is a certain danger that a few large firms interconnect their networks and deny the access of other firms. In such a way, competition may be restricted although the technical conditions for interconnection are met. Should this happen or should a few dominant firms offer interconnection at monopoly prices, state intervention may be justified. Therefore, state agencies should be prepared to intervene if the market solution etablishes a cartel or monopoly.

There might be another source for inefficiencies even if the market for EPS becomes competitive: If a large number of firms provides monies which are perfect substitutes for each other, market forces will drive down prices to marginal costs, but the result is inefficient because the fixed costs invested may be higher than socially optimal. Therefore, it is reasonable to analyse whether it might even be necessary that the state itself provides *all* forms of money, including electronic ones.

The crucial question is whether (slightly) different forms of EPSs can meet the needs of people better than a single system. The problem is that we cannot be completely sure how people will answer this question. There is only one way to find it out – by experience. This means that the state should only then supply electronic forms of payment when it is certain that private firms do not meet different needs with their different EPSs. This solution solves also two other problems: (1) dynamic efficiency and (2) cost containment. As discussed above, dynamic efficiency requires that technical improvements will be carried out via research and development. If the state as a monopolist supplies EPSs, there seems to be hardly any incentive to innovate. Therefore, dynamic efficiency is not guaranteed by a state monopoly. In addition to that, cost containment could become a major problem. The reason is that there is no incentive for cost control because of public ownership of the EPS.

To sum up, state intervention may lead to an improvement of static allocative efficiency if it is restricted to the prescription of basic compatibility standards because this can stimulate competition. Especially a state monopoly with electronic money is economically no good solution. In addition to that, in the recent past almost all central banks were unable to provide electronic money as an innovation. An exception is the Bank of Finland, see [16]. To the contrary, central banks seem rather to make the introduction of new forms of payment more difficult.

4. Conclusions

The aim of this paper was to analyse whether it is necessary to standardise electronic means of payment. It is shown that an interconnected network of EPSs is necessary to overcome the network effect. However, it is argued that there are incentives for private firms to interconnect.

The problem of a purely private solution may be that the market for electronic means of payment is not competitive enough. Therefore, state intervention by prescribing certain basic technical standards might stimulate competition. Since it is not to be expected that these standards reduce the incentives to innovate more than privately negotiated standards, this intervention may be welfare enhancing.

If there is a need for different EPSs they should be provided privately. A state monopoly for EPS is economically not reasonable because it destroys private incentives to innovate to a large extent and risks higher costs of the EPS. Only if no private EPS at all existed a supply by the state would be acceptable.

Last but not least, if a few big firms try to cartellise the market for EPSs by denying the interconnection of other firms, state agencies should be prepared to intervene by enforcing interconnection at reasonable prices.

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Notes

1. I thank L. van Hove for this argument.
2. TARGET is not considered here as an EPS since it is a large-value payment system.
3. The price here is defined via the opportunity costs of holding a particular money. It includes the interest payments forgone as well as transaction and production costs.
4. For an analysis why different countries use different currencies see [9]. These different currencies are already interconnected via exchange rates.
5. The welfare economics of network externalities is described in [1].

6. The results will depend on this assumption as a strong and a weak firm imply that the strong firm has an incentive to remain incompatible with the weak one. See to this point [19].

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