THE CHOICE AMONG ALTERNATIVE PAYMENT SYSTEMS:

The European Experience

Angelo Baglioni (*) – Rony Hamaui (**)

(*) Catholic University, Milan (Italy)
(**) Catholic University and Banca Commerciale Italiana, Milan

Abstract. The paper addresses the choice of banks between alternative channels for interbank payments. The conventional view assumes a trade-off between the safety of real time gross settlement and the liquidity savings of multilateral netting. Moreover, correspondent banking is believed to be inefficient both in term of liquidity and of administrative costs. On the basis of the recent evolution of payment systems in Europe, we offer a slightly different view, where banks' choice is mainly influenced by the cost and availability of intraday liquidity, the nature of payments flows (value, commercial vs. financial), fees and other transaction costs, some structural features of the banking systems (concentration and efficiency). This view is supported both by our formal analysis and by a cross-country comparison relative to the European countries (based on three data sources: ECB, EBA and SWIFT).

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1 Introduction

The conventional view on payment systems assumes a trade-off between real time gross settlement (RTGS) and multilateral net settlement (MNS), where the former is seen to be safer but more costly in term of liquidity. Moreover, it is a common wisdom to assume that correspondent banking (CB) is inefficient both in term of liquidity and of administrative costs. The basic features of each of these systems are well known. Under CB, banks agree to debit/credit their bilateral accounts (so-called “nostro/vostro accounts”), in order to settle transfers of money between them.[1] In a MNS system, banks typically settle only the balance of their payments, accumulated during a pre-specified time period (normally, one day): at the end of a business day, each bank has to pay (or receive) the amount resulting from the sum of all its incoming/outgoing payments accumulated during that day vis-à-vis all other banks. Finally in a RTGS system each payment is settled separately in real time[2]. Both MNS and RTGS systems usually rely on the central bank, as the transfer of money from one bank to another is done by debiting/crediting their respective accounts at the central bank; the latter works as a clearing house.

In the last decade, however, substantial changes occurred in the actual organization of payment systems. First of all under the impulse of the Committee on Payment and Settlement Systems, sponsored by the Bank of International Settlements, the safety of MNS systems has been considerably improved and some of these changes have increased their liquidity cost (for example through collateral requirements and debit caps). On the other side central banks that managed RTGS systems have tried to reduce the liquidity cost of such systems in several ways (for example through queuing mechanisms and overdrafts), increasing however the risk present in RTGS. Technology innovations and the concentration of the financial sector have finally allowed banks to improve the efficiency of their liquidity management and their operating system, reducing the cost of CB and increasing the role of internal book transfer within large banking institutions.

1 For a detailed description of the CB model, see Blommestein – Summers (1994).
2 Van den Bergh (1994) provides a nice exposition of the mechanics of both MNS and RTGS models.

On the basis of these changes in the paper we cast some doubts on the above-mentioned conventional view. Even if our analysis confirms that in principle a trade-off between risk and liquidity exists, it is not correct to identify actual MNS with the system having a higher risk level and RTGS with the one imposing a higher liquidity burden: the real organization of payment systems often reduces considerably the differences between the two systems and makes other elements more relevant. Between them the natural candidates are the level of concentration of the banking systems, the features of payments flows (value, commercial or financial nature) and the operation cost of payment systems.

In this respect, European countries represent an interesting case study, because they share a common currency and their two major cross-border payment systems (TARGET[3] and Euro I[4]), but they still preserve some specific features, related to the structure of their financial systems. Thus, we have the unique opportunity of analyzing a situation where banks located in different countries, working in the same monetary environment, choose to send their cross-border payments through different channels because of their country-specific features. The decision to leave out of our analysis domestic payments is due to the fact that they still remain too much influenced by moral suasion and institutional constraints. Moreover in the case of cross border payments, in addition to the data provided by the European Central Bank, we are able to use two completely new data set provided by the EBA and SWIFT(Society for Worldwide Interbank Financial Telecommunication).

The plan of the paper is the following. In section 2 we review the conventional view, which stresses the trade-off between risk and liquidity in MNS versus RTGS systems. In section 3 we introduce an analytical framework, which we then apply to the European cross-border payment systems, namely CB, Euro I and TARGET. Such framework enables us to show (in section 4) that the actual organization of systems may considerably reduce the differences between RTGS and MNS in term of risk and liquidity. Other factors turn out to be more relevant: (i) the transaction costs (for which

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3 Actually, TARGET is made up of 15 RTGS systems (one for each EU member country), linked together through the "Interlinking" infrastructure. The system is run by the European System of Central Banks (ESCB). For details on TARGET, see: EMI (1995) and ECB (1998).

4 Euro I is a private MNS system, run by the EBA (Euro Banking Association) Clearing Company. The settlement of balances at the end of the day is done on accounts held at the ECB.

we provide an accurate description); (ii) the nature of payment flows; (iii) some structural features of the banking systems; (iv) the availability and cost of intraday liquidity. The relevance of these factors is then tested in section 5 where, after providing some descriptive evidence, we carry out a cross-country comparison, using data on the cross-border payments in the 15 EU countries. Finally, section 6 summarizes our results.

2 The conventional view

Among the three alternatives, CB-MNS-RTGS, the CB model is commonly seen as less efficient than the other two. This is because CB requires each bank to maintain many "nostro accounts" at its correspondent banks, which turns out to be very costly in a highly integrated banking system, where the number of such interbank deposits has to grow substantially. A huge number of "nostro accounts" makes a bank suffer from two kinds of costs: (i) administrative costs (fees to be paid to other banks as well as internal processing costs); (ii) liquidity costs (a bank has to maintain a minimum balance on each interbank deposit, to be able to settle all payments). For this reason, as long as the number of interbank payments grows, the CB system is being gradually substituted by MNS and/or RTGS. Both the latter systems share one important feature: they settle payments in central bank money; therefore, they require each bank maintaining a "nostro account" only at one settlement agent (e.g. the central bank), reducing both administrative and liquidity costs.

As a consequence, most of the recent literature on payment systems has concentrated on the comparison between the MNS and the RTGS models, trying to identify their comparative advantages.[5] There is a general consensus on the existence of a *trade-off between the reduction of risk and the liquidity cost of RTGS versus MNS*. We try to summarize this view in this paragraph.

The MNS system implies a relevant risk, due to the time lag between clearing and settlement of a payment (the so-called "settlement lag"). We may identify clearing as the transmission of a payment order from the payer to the payee, while settlement

5 Freixas – Parigi (1998), Kobayakawa (1997) and Holthausen – Ronde (2000) provide theoretical models where a comparison is made between the two systems. For analyses applied to existing payment systems, see: Eisenbeis (1995), Berger – Hancock – Marquardt (1996) and

takes place when funds are actually transferred from the former to the latter. In a MNS system, there is a lag between these two moments, as the settlement of payment orders is carried out only at the end of the operating day: thus, MNS implies that a paying bank is *de facto* receiving an intraday loan from the receiving bank. This extension of credit makes the receiving bank face both credit and liquidity risks: credit risk refers to the possibility that the paying bank may not be able to meet its obligations, because of an insolvency situation; liquidity risk refers to the case where the paying bank has not sufficient liquid funds to settle its payment orders in due time. Now, suppose a bank is not able to settle its payments at the end of day: this negative shock may be transmitted from its counterparts to other banks, through the interbank chain of payments: thus an individual problem may spread to the whole system. This is what is known as "systemic risk", which is particularly relevant for large value payment systems: when the amount of each payment is large, a bank may accumulate a huge net debit position vis-à-vis the rest of the system, thereby increasing the risk of a liquidity shortage at the end of day.

The RTGS model is commonly believed to be safer, because the settlement of payments one-by-one prevents the accumulation of an intraday debit position by one bank vis-à-vis other banks. In other words, the time lag between clearing and settlement is eliminated, as each payment order has to be settled immediately in central bank money: when a bank receives a payment, its account at the central bank is credited at the same time (this is what is known as "immediate finality" of a payment, meaning that the receiving bank is sure, when it receives the payment order, that such payment is irrevocable and it is already settled in "good money").

The above arguments are at the origin of the initiatives taken in the nineties by the monetary authorities, aimed at reducing the level of risk in interbank transactions. Under this regard, we may distinguish two phases. The first one began in 1990, when the "Lamfalussy Report" (produced by a working group set up by the G-10 central bank governors) provided a set of guidelines for the MNS systems.[6] Among the "Lamfalussy criteria", let us mention the following. (i) MNS systems should have clearly defined procedures for the management of credit and liquidity risks, including limits to credit exposures among participants. (ii) MNS should at least be able to ensure same-day

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other papers in the special issue of the Journal of Money, Credit and Banking (1996, vol. 28, n.4), Horii – Summers (1994) and other papers in Summers (1994).
6 See BIS (1990).

settlement in the event of default by the participant having the largest net debit position.[7] (iii) MNS should have objective and clear access criteria. The second phase, regarding Europe, began in 1993, with a Report by a working group of the EU central bank governors,[8] establishing ten common principles aimed at the harmonization of national payment systems. One of such principles requested the introduction, by each member country, of a RTGS system for handling large-value payments.

On the other hand, the drawback of the RTGS systems is their liquidity cost. A bank has to maintain enough funds on its account at the central bank, in order to be able to settle each outgoing payment. To the contrary, a MNS system provides a bank with "free liquidity", as only the *balance* between its outgoing and incoming payments has to be settled: the amount of liquid funds needed for transactions is significantly reduced. Therefore, the RTGS system implies a higher liquidity cost, because it constraints banks to hold a liquid position higher than otherwise needed, and because deposits at the central bank are usually remunerated at rates below the market level.[9]

In order to reduce the cost of liquidity in RTGS systems, different instruments may be employed, like: (i) central bank intraday overdrafts; (ii) allow banks to make use of their funds, deposited for complying with the compulsory reserve requirement; (iii) queuing systems. In particular, with the first instrument the central bank stands ready to accommodate for a liquidity shortage of a bank, by extending intraday credit to it. But this solution, in turn, is not without costs.[10] For banks, such costs may be of two kinds: (i) fees levied by the central bank on intraday exposures; (ii) the cost of providing the collateral required by the central bank: basically, this is the cost of holding a portfolio of securities constrained by the collateral requirement. On the other side, the central bank faces a credit risk, unless such overdrafts are fully collateralized. In addition, when banks are not able to repay their debt within the operating day, the intraday credit becomes an overnight credit, with possible undesired effects on the creation of monetary base ("spillover effect").[11]

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7 A system able to meet this requirement is called "secured" (see Emmons, 1997).

8 See BIS (1993).

9 In order to economize on liquidity holdings, banks may be induced to postpone payments during the day, imposing a negative externality on other banks (see Angelini, 1998).

10 For detailed analyses of such costs, see: Hancock – Wilson (1996) and Richards (1995).

11 See Giannini – Monticelli (1995).

3 An analytical framework to analyze the European cross-border payment systems

Following Rochet – Tirole (1996), we introduce a general framework for analyzing the interbank settlement systems; we then apply such a framework to the analysis of the correspondent banking model, Euro I and TARGET. This analysis provides some tools, able to give us a deeper understanding of issues like risk and liquidity in the different settlement systems.

3.1 General framework

We have *N* banks participating in a payment system. We denote by *t* the time during a business day, so that *t* goes from 0 (opening of the system) to *T* (closing time). We denote by *d* the calendar day. Let us now focus on what happens during a particular business day. Starting by *t=0*, each bank *i* sends payment messages to (and receives from) other banks: a payment message from bank *i* to bank *j* (denoted by p_{ij}) is an outgoing payment for bank *i* and an incoming payment for bank *j*. We have to stress that the transmission of the payment message p_{ij} does not necessarily coincide with the actual transfer of funds from bank *i* to bank *j* (settlement): the time lag (if any) between these two moments is the *settlement lag*. This implies that bank *j* is allowing a credit to bank *i*, until the payment is settled.

At each moment (*t*) during the day, a bank *i* has accumulated a net balance vis-à-vis another bank *j*, denoted by $\Delta_{ij}(t)$, which is the sum of all payment messages from *j* to *i* minus all payment messages from *i* to *j*:

$$\Delta_{ij}(t) = \sum\nolimits_t p_{ji} - \sum\nolimits_t p_{ij} \qquad (1)$$

where the sum $\sum_t$ is taken from the opening time up to *t*. At any time *t*, if $\Delta_{ij}(t) > 0$, bank *i* has a net claim versus bank *j*: the sum of (still to be settled) received payments exceeds the sum of those sent. To the contrary, if $\Delta_{ij}(t) < 0$, bank *i* has net obligation versus bank *j.* The cumulative net balance of each bank *i* vis-à-vis all other banks is given by: $\sum_{j \neq i} \Delta_{ij}(t)$. In addition, a bank *i* has a balance ($\Delta_{i0}(t)$) on its account at the central bank (denoted as bank 0). The overall position of bank *i* is then given by:

$$\Delta_i(t) = \Delta_{i0}(t) + \sum_{j \neq i} \Delta_{ij}(t) \tag{2}$$

In principle, we may think of an agreement where each bank grants a credit limit to each of the other N-1 banks. Let us denote by L_{ji} the credit limit allowed by bank j to bank i. The sum of all the credit limits received by bank i gives its *debit cap*: $L_i = \sum_{j \neq i} L_{ji}$. In addition, the central bank as well may grant a credit limit to each bank i, denoted by L_{0i}. Thus, when bank i sends a payment message to another bank j, this payment is cleared provided the following condition is met:

$$\Delta_i(t) - p_{ij} \geq -\left(L_{0i} + L_i\right) \tag{3}$$

This means that the overall position of bank i, including the last outgoing payment p_{ij}, cannot become negative for an amount exceeding the sum of all the credit limits received by other banks (central bank included). We will refer to condition (3) as the "debit cap condition".

In addition to the constraint set by equation (3), a system may impose the following condition for the clearing of a payment from bank i to bank j:

$$\Delta_{ij}(t) - p_{ij} \geq -L_{ji} \tag{4}$$

meaning that the bilateral balance of bank i versus bank j (p_{ij} included) cannot become negative for an amount exceeding the bilateral credit limit allowed by j to i.[12]

Actually, condition (4) turns out to be redundant, provided the following loss sharing rule is adopted. Suppose bank i fails, so that it is unable to settle its obligation $\Delta_i(t) < 0$. Denote by l_{ji} the loss incurred by bank j, due to the default of bank i. Let this loss share be calculated as follows:

$$l_{ji} = \frac{L_{ji}}{L_{0i} + L_i}\left(-\Delta_i(t)\right) \tag{5}$$

This loss sharing rule (together with the debit cap condition) makes sure that the maximum loss each bank j may incur, due to the default of another bank i, is equal to the bilateral credit limit set by j itself with regard to i: $l_{ji} \leq L_{ji}$. This conclusion follows trivially from condition (3): this implies that $\Delta_i(t) \geq -\left(L_{0i} + L_i\right)$, from which: $-\Delta_i(t)/\left(L_{0i} + L_i\right) \leq 1$.[13]

3.2 Correspondent banking

Many cross-border transactions are still executed through correspondent banks. We may apply the general framework outlined above to the correspondent banking model. We have here: $L_{0i} = 0$ for all banks (*i*=1,…*N*), as no central bank credit is involved in the working of this settlement system. To the contrary, the system works through deposit accounts held by banks at their correspondent banks, which imply the extension of bilateral credit between banks themselves.

Let us try to describe the system in the following way. Consider two banks, *i* and *j*, where the first one has a deposit account with the latter: we denote by D_{ij} this deposit account of bank *i* at bank *j*: then, provided it has a positive balance, D_{ij} is an asset for bank *i* and a liability for bank *j*. Bank *i* may then send an outgoing payment through its correspondent bank *j*, by debiting the account D_{ij}: if $D_{ij}(t)$ is the balance of such an account at the time when the payment message p_{ij} is sent from *i* to *j*, after that the balance becomes $D_{ij}(t) - p_{ij}$. Bank *i* may as well receive an incoming payment by crediting the account D_{ij}: in this case, the balance becomes $D_{ij}(t) + p_{ji}$ (where p_{ji} is a payment from bank *j* to bank *i*). In the terminology of correspondent banking, D_{ij} is a "nostro" account for bank *i* and a "vostro" account for bank *j*. In a reciprocal relationship, bank *j* may have a deposit account with bank *i*, denoted by D_{ji}: this is a nostro account for bank *j* and a vostro account for bank *i*. Then, bank *i* works as a correspondent for bank *j*.[14] For example, *j* may send an outgoing payment through bank *i* by debiting the account D_{ji}, so that the balance on such account becomes

12 This is what happens in CHIPS (see Rochet – Tirole, 1996); to the contrary, Euro I does not impose condition (4). On the other hand, Euro I requires a credit cap condition being met (see below).

13 We are assuming here that bank i is the only one in default. In case of several defaulting banks, the loss sharing rule has to be more complicated (see below the calculation of the "loss share increases" in Euro I).

14 The present framework is able to treat the (more simple) case where only bank j acts as correspondent for bank i, and not viceversa: in the following, simply set $D_{ji} = 0$.

$D_{ji}(t) - p_{ji}$; it may as well receive an incoming payment by crediting D_{ji}, so that its balance becomes $D_{ji}(t) + p_{ij}$.

If we assume, for simplicity, that at the beginning of an operating day both deposit accounts have a zero balance ($D_{ij}(0) = D_{ji}(0) = 0$), then, at any time during that day, the net balance accumulated by bank *i* vis-à-vis bank *j* is given by:[15]

$$\Delta_{ij}(t) = \sum_t p_{ji} - \sum_t p_{ij} = D_{ij}(t) - D_{ji}(t) \qquad (6)$$

Bilateral agreements between the two banks may set limits to their exposure with each other.

In principle, we may apply condition (4) of our general framework: continuing to denote by L_{ji} the credit limit allowed by bank *j* to bank *i*, the latter is able to send an outgoing payment p_{ij} provided condition (4) is met, where $\Delta_{ij}(t)$ is given by the difference between the balances on its nostro and vostro accounts with bank *j* (equation 6).

However, it is a common practice in correspondent banking to set separate limits on each of the two deposit accounts (D_{ij} and D_{ji}), instead of limiting the net bilateral position ($\Delta_{ij}(t)$). This may be explained by the fact that, traditionally, correspondent banking relationships across countries involve two different currencies, so that D_{ij} and D_{ji} are not denominated in the same currency. Obviously, this practice gives rise to clearing conditions quite different from the one described above (determined by (4) and (6) together). For example, if the reciprocal agreement between two banks *i* and *j* imposes that each of their bilateral accounts should have a non-negative balance, then we have the following constraints:

$D_{ij} - p_{ij} \geq 0$ for any payment order sent by bank *i* to bank *j*,

$D_{ji} - p_{ji} \geq 0$ for any payment order sent by bank *j* to bank *i*.

These constraints induce each of the two banks to maintain a positive balance, during the business day, on its nostro account with the other bank, as a reserve of liquidity; however, this reserve may be driven down to zero at the end of the day, in order to minimize the liquidity cost.

15 This was defined by equation (1) in the general framework.

Should bank i fail, having a debit position $\Delta_{ij}(t) < 0$ vis-à-vis bank j, the latter would suffer a loss equal to the whole amount: $l_{ji} = -\Delta_{ij}(t)$. In other words, no loss sharing mechanism is at work here.

3.3 The EURO I system

Applying our general framework to the Euro I system, first we notice that such a system works without any credit allowance by the central bank: the ECB acts as settlement agent at the end of the business day, when the multilateral net balances are settled through TARGET payments; however, no extension of credit by the ECB is implied by this operation. Therefore, we have: $L_{0i} = 0$ for all banks (i=1,…N).[16]

Bilateral credit limits are made up of two parts: a mandatory limit (denoted by ML) and a discretionary limit (DL_{ji}); therefore, the credit limit allowed by bank j to bank i is equal to $L_{ji} = ML + DL_{ji}$.[17] In addition to a *debit cap* (defined as above: $L_i = \sum_{j \neq i} L_{ji}$), each bank i has a *credit cap*, defined as $C_i = \sum_{j \neq i} L_{ij}$: this is the sum of all the credit limits allowed by bank i to the other banks. Both L_i and C_i are limited by the system rules: $L_i \leq L^{\max}$ and $C_i \leq C^{\max}$.[18]

A payment message p_{ij} (from bank i to bank j) is cleared, provided the following two conditions are met:

$$\Delta_i(t) - p_{ij} \geq -L_i \qquad (7)$$

$$\Delta_j(t) + p_{ij} \leq C_j \qquad (8)$$

While (7) is analogous to (3) above (the debit cap condition), (8) is the credit cap condition, meaning that the overall position of bank j (including the last incoming

16 In order to simplify matters, we do not consider here the linkages between the two systems (Euro I and TARGET), due to the fact that the settlement of Euro I takes place through TARGET payments. If such linkages were taken into consideration, we should consider that the liquidity condition of a bank in one system affects its condition in the other one: for example, its ability to settle its end of day obligation in Euro I is conditioned by its availability of liquidity in TARGET, which in turn is affected by its ability to get credit by its NCB. In addition, we should consider those linkages due to the "Euro I - TARGET swaps", which may take place during the operating day.

17 The system rules currently impose that: $ML = 5$ millions euro and $0 \leq DL_{ji} \leq 25$ millions.

18 Presently, the maximum debit and credit caps are: $L^{\max} = C^{\max} =$ 1 billion euro.

payment p_{ij}) cannot get larger than its credit cap. If any of these two conditions is violated, the payment p_{ij} is queued, waiting for being processed when both (7) and (8) hold.

End of day settlement is guaranteed in case one bank is unable to pay its net obligation $\Delta_i(T)$, even if such bank has the largest possible obligation, that is: $\Delta_i(T) = -L^{\max}$.[19] This task is accomplished by the *liquidity pool*: each participating bank has to maintain (through TARGET payments) a cash deposit with the ECB, serving as collateral for all its obligations with the system. Individual deposits (CO_i) are determined as follows: $CO_i = \dfrac{L^{\max}}{N-1}$. Therefore, the aggregate amount (LP) deposited in the liquidity pool is larger than the maximum debit cap, because: $LP = N \cdot CO_i = \dfrac{N}{N-1} L^{\max}$. This enables the settlement agent (ECB) to complete the end of day settlement procedure, by drawing on the liquidity pool, even when one bank defaults having a net obligation equal to $L^{\max}$.

In case of default by one or more banks, the use of the liquidity pool gives rise to a "temporary loss allocation", which has to be later adjusted to the definitive "loss allocation". When the aggregate loss to be covered exceeds *LP*, additional funds are requested to the participating banks, so that the end of day settlement procedure may be completed. The loss allocation is determined through the following sharing rules. First of all, the net loss (nl_i) caused by a default of bank *i* to the rest of the system is determined, by drawing on its collateral deposit, so that $nl_i = \max\{[-\Delta_i(T) - CO_i],0\}$: thus, other banks do actually incur in a loss only if the obligation of bank *i* is larger (in absolute value) than its collateral deposited in the liquidity pool. Then, one of the two following rules is adopted, depending on the number (*n*) of defaulting banks.

If $n \leq 3$, the loss share of bank *j*, due to the default of bank *i*, is determined as follows:[20]

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19 Obviously, this implies $L_i = L^{\max}$.

20 When $n \geq 2$, the (aggregate) loss share of a defaulting participant (exceeding its collateral deposit) is shared among the non-defaulting participants, in proportion to the bilateral credit limits granted by each of them to such defaulting bank (this procedure gives rise to the "loss share increases", which must be added to the loss shares).

$$l_{ji} = \frac{nl_i}{N-1}, \qquad \text{if } nl_i \leq (N-1)\cdot ML \qquad (9.i)$$

$$l_{ji} = ML + \left[nl_i - (N-1)ML\right]\frac{DL_{ji}}{\sum_{k\neq i} DL_{ki}}, \qquad \text{if } nl_i > (N-1)\cdot ML \qquad (9.ii)$$

So, the loss is shared equally if it can be covered through the mandatory limits. Otherwise, the remaining part is shared in proportion to the discretionary limits granted to the defaulting bank by the other banks.

If $n > 3$, the loss share of bank *j*, due to the default of bank *i*, is determined as follows:[21]

$$l_{ji} = nl_i \frac{C_j}{\sum_{k\neq i} C_k} \qquad (10)$$

The loss generated by bank *i* is then shared in proportion to the credit caps of the other participating banks.

In the general framework, we found that the following property holds: $l_{ji} \leq L_{ji}$, meaning that the loss each bank *j* may incur, due to the default of another bank *i*, is limited by the bilateral credit limit set by *j* itself with regard to *i*. Now, we are able to show that this property indeed holds in Euro I. Suppose bank *i* fails.[22] If (9.i) applies, then we have trivially: $l_{ji} \leq ML \leq L_{ji}$. If (9.ii) applies, we may show that $\frac{\left[nl_i - (N-1)ML\right]}{\sum_{k\neq i} DL_{ki}} < 1$. We need: $nl_i < (N-1)ML + \sum_{k\neq i} DL_{ki}$, where the right hand side is just equal to L_i, so that the last inequality is equivalent to $nl_i < L_i$, which in turn is true because of (7), from which we have: $nl_i < -\Delta_i(T) \leq L_i$. Therefore, the loss sharing rule (9), together with the debit cap condition (7), makes sure that $l_{ji} \leq L_{ji}$.

3.4 TARGET

As it is well known, in the TARGET system the ESCB plays the role of clearing house: each payment is cleared only if it can be debited on the account held by the

21 In this case, the loss share increases are calculated consistently with equation (10): the aggregate of loss shares of a defaulting participant (exceeding its collateral deposit) is shared among the non-defaulting participants, in proportion to their credit caps.

sending bank at its NCB. This implies that, in principle, the settlement lag is avoided;[23] then no bilateral credit among banks is needed in this framework. Instead, each bank may receive an intraday credit from its NCB: this becomes necessary whenever the sending bank does not have enough funds, available on its account, to settle an outgoing payment. With reference to the general framework described above, we then have: $L_i = 0$ and $L_{0i} > 0$ for all banks (i=1,…N), meaning that each bank may receive credit only from the central bank. In addition, as required by the EU Treaty, all extensions of credit by the ESCB must be fully collateralized.

Let us focus first on "*in* countries".[24] Here, intraday liquidity is provided by two sources. (i) Mobilization of compulsory reserves: as the daily reserve holding of a bank is calculated as the end-of-day balance on its reserve account with the ESCB, the funds deposited to meet the compulsory reserve requirement may be used for intraday settlement purposes.[25] (ii) Overdrafts with the ESCB: banks located in *in* countries are granted unlimited access to intraday credit, based on eligible collateral; no fee is applied. The list of eligible assets is the same as for monetary policy operations.[26] A bank may obtain credit by its NCB, also by making use of the collateral held in a foreign member country, thanks to the Correspondent Central Banking Model (CCBM).[27]

Consider bank i. Let us call R_i^d the desired end-of-day balance on its reserve account, in a particular calendar day d. This implies the following constraint on the treasury management: $\Delta_{i0}^d(T) = R_i^d$, meaning that at the end of that day the balance of bank i on its account at the central bank must be equal to its desired reserve position. This also means that, at the start of that operating day, the bank has a balance with the central bank equal to $\Delta_{i0}^d(0) = R_i^{d-1}$, which can be used as intraday liquidity. In

22 As in the general framework, we assume here that only bank i fails.
23 This statement actually needs a caveat, due to the possibility that a settlement lag is introduced by the queuing mechanism (we will expand on this point in the next paragraph).
24 By "in (out) countries" we mean EU members which do (do not) belong to the euro area.
25 See EMI (1997).
26 See EMI (1997)
27 The cost of cross-border use of collateral is 30 euro for each asset delivery through the CCBM, plus a custody and administration fee proportional to the value of assets (see ECB, 1999).

addition, a bank may get an intraday overdraft, up to the amount of collateral deposited (CO_i); thus, the limit to such overdraft is given by: $L_{0i} = CO_i$.

During the business day *d*, the following finality condition must be met, relative to a payment sent by bank *i* to any other bank *j*:

$$\Delta_{i0}^{d}(t) - p_{ij} \geq -CO_i^d \qquad (11)$$

This means that the balance of the sending bank at its NCB (including the last outgoing payment p_{ij}) cannot become negative for an amount exceeding the value of the collateral deposited on that day. If condition (11) is met, the payment is cleared and final; otherwise, it is queued until sufficient liquid funds are available. Should a bank fail, condition (11) guarantees that its negative balance at the central bank is fully covered by the deposited collateral.

Banks located in "*out* countries" are imposed specific limitations with regard to the use of intraday credit. They are given access to collateralized intraday overdrafts in euro with their NCB, but within the limit of 1 billion euro. Within such a limit, intraday credit from the central bank is still limited by $L_{0i} = CO_i$. In addition, starting at 5 p.m. they cannot have a debit position in euro with the central bank: every outgoing TARGET payment must be settled by drawing on a positive balance with their NCB.[28] These measures have been introduced in order to avoid any liquidity creation in euro outside the euro area, due to possible spillovers from intraday to overnight credit.[29] Therefore, for $t < 5$ p.m. the finality condition is still given by (11),[30] while for $t \geq 5$ p.m. the finality condition becomes: $\Delta_{i0}^{d}(t) - p_{ij} \geq 0$.

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28 The closing time for TARGET is 6 p.m. for interbank payments and 5 p.m. for customer payments.

29 See ECB (1998). In addition to the limits mentioned in the text, spillovers are discouraged by penalties. In case of spillover from intraday to overnight credit, the penalty applied is 5% above the marginal lending rate of the ESCB and it is increasing with the frequency of spillovers within a 12 month period: in the extreme case, the participant may be excluded from access to intraday credit. These penalties are not applied to "in" countries.

30 Provided the 1 billion euro limit is met.

4 A comparison among the different systems

The above description provides some interesting insights, with regard to the distinguishing features of the three settlement systems considered: correspondent banking, MNS and RTGS. As a starting point for the following empirical analysis, we are particularly interested in understanding the reasons behind banks' choice among the different settlement systems.

As we argued in paragraph 2, the conventional view (formulated both by authorities and academics) points to the existence of a trade-off between safety and liquidity: RTGS systems are perceived to be safer than MNS systems, but they imply a higher liquidity cost. A closer look to the mechanics of TARGET and Euro I, following the analysis of the preceding section, casts some doubts on this view. We agree on the existence of a *trade-off between risk and liquidity*: some measures aimed at reducing risk may cause higher liquidity needs (for example: debit caps and liquidity pools in MNS systems); on the other hand, measures aimed at reducing the liquidity burden may introduce some risk (for example: queuing mechanisms and overdrafts in RTGS systems). However, *it is not correct to identify MNS with the system having a higher risk level and RTGS with the one imposing a higher liquidity burden*: although this may be correct in principle, the actual organization of payment systems often reduces considerably the differences between the two systems. It is possible to frame a MNS system with very high safety standards; on the other hand, the cost of liquidity in a RTGS system may be considerably reduced (in the limit, to zero)[31].

Another issue to be considered is the *transaction cost* of sending payments through different channels. The fees charged by the clearing houses are an important component of such cost.

In the remaining of this section, we deal in turn with these items: risk, liquidity and transaction costs.

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31 This happens if the central bank is willing to provide free intraday liquidity, with no collateral requirement.

4.1 Risk

We begin by considering risk factors. First: settlement, credit and operational risks are kept under control in Euro I, thanks to the following features:[32]

- Debit and credit caps put a limit to the net position a single bank may accumulate during the day.[33] Therefore, the risk that a bank may build up an unbounded debit position vis-à-vis the other participants is avoided.
- The liquidity pool guarantees that the end-of-day settlement procedure may be completed even in case of default by the "largest" participant (the one with the largest debit position).
- In case of default by one bank, the loss share of each participant is not larger than the bilateral credit limit granted by him to the defaulting bank. This makes sure that such bilateral credit limit is indeed the maximum loss each bank may suffer from the failure of another participating bank.[34]
- Finally, each participant has to meet some access criteria. For the purpose of security, the most relevant are the following financial and operational requirements. Financial: (i) minimum own capital;[35] (ii) minimum short term credit rating.[36] Operational: (i) availability of an account with a NCB, through which being able to make TARGET payments in euro; (ii) adequate technical and operational facilities, as detailed in the regulations of the system; (iii) adequate personnel in number and skill, as detailed in the regulations.

Second, credit risk is not completely removed in TARGET, due to the queuing mechanism. Suppose bank *i* sends a TARGET payment (p_{ij}) to another bank *j* at time *t* but, at that time, it does not have sufficient liquid funds available (condition 11 above is not met): the payment is queued. If bank *i* has a way to communicate to bank *j* that it has entered payment p_{ij} into the system, then bank *j* may be willing to "take as given"

32 These features allow the system to comply with the above mentioned Lamfalussy standards.

33 Actually, they put both an upper and a lower limit to the net cumulated balance of a single bank vis-à-vis all other banks (see conditions 7 and 8 above).

34 Formally: $l_{ji} \leq L_{ji}$ (as we have shown above).

35 As of May 1999: 1250 millions euro.

36 As of May 1999: P2 by Moody's, A2 by Standard & Poor's, or equivalent ratings from other agencies.

that p_{ij} will be processed before the end of the day, possibly before time $t' > t$. On the basis of this information, bank *j* may take obligations with other banks, being confident that the amount p_{ij} will be received in due time. This situation replicates what happens in a netting system, where the receiving bank works on the assumption that any payment message received during the day will be settled at the end of the same day. We may say that in both situations bank *j* grants a *de facto* credit to bank *i*. This is equivalent to say that also in a RTGS system a settlement lag may be introduced: this happens every time a bank gets information and puts confidence in an incoming payment, which actually has not yet been processed. Should the sending bank fail in the meantime, the receiving bank would suffer a loss equal to p_{ij}.

Third, we should consider the incentives created by the different systems, with regard to information gathering by each participant about the reliability of its counterparts. Of course, such information is a relevant factor in keeping risk under control. Under this regard, the system creating the most appropriate incentives is presumably the correspondent banking model, where each bank faces the full consequences of granting credit to another bank, should the latter become insolvent. In Euro I, a participating bank is induced to exercise some control on its counterparts, thanks to the loss sharing mechanism illustrated above. In particular, when the number of defaulting banks is not larger than three, each of the other banks may face a loss proportional to the discretionary credit limit(s) she has allowed to the defaulting bank(s):[37] this creates an incentive to set such credit limits on the basis of information about each other participants. To the contrary, a system like TARGET does not create any incentive to reciprocal monitoring among participants: only the central bank grants intraday credit (on a collateral basis).

Finally, TARGET (like any other system) is not immune from the so-called "operational" risk, relative to the possibility that some technical failure occurs (such as a computer breakdown), causing a gridlock of the system (or at least of a part of it).

These considerations lead to the conclusion that a MNS system is not necessarily more risky than a RTGS system; when it is so, the difference between the two systems may be much less significant than commonly believed, for several reasons. The

37 When equation (9.ii) above applies.

compliance with the Lamfalussy standards is able to guarantee a significant reduction of settlement and credit risks in a MNS system. On the other hand, the settlement lag, which is at the origin of risk in payment systems, may be present also in a RTGS system, when payment orders are queued. In addition, banks have better incentives to monitor each other in Euro I than in TARGET. Finally, the RTGS mechanism does not rule out the operational risk.

4.2 Liquidity

As far as liquidity is concerned, in principle the difference between MNS and RTGS systems is remarkable: while MNS provides “free liquidity”, RTGS requires liquid funds be available for the settlement of each payment, putting on banks a relevant cost. Again, the actual organization of payment systems may significantly reduce such difference.

First of all, we notice that in a RTGS system the cost of liquidity crucially depends on the policy of the central bank, relative to the provision of intraday credit. In TARGET, the provision of free intraday overdrafts by the ESCB significantly reduces the cost of liquidity: the only limitation and cost (for *in* countries) come from the required full collateralization (*out* countries are subject to further limitations, as we saw above). In other RTGS systems, intraday credit is not available,[38] or it is available but it is not free.[39] Second, both the intraday mobilization of the compulsory reserve deposits and the queuing mechanism contribute to reducing the liquidity needs in TARGET. Finally, the opportunity cost of liquidity is positively linked to the level of interest rates on the money market: if a bank is induced to maintain a higher balance than otherwise needed on its deposit account at the central bank,[40] the opportunity cost of such excess liquidity is proportional to the overnight interest rate level.

On the other hand, the provision of “free liquidity” by a MNS system is not unlimited. In fact, some limitations derive from debit and credit caps. When the

38 For example: the Swiss system (SIC) has no intraday credit, as it relies only on a queuing mechanism.

39 For example: starting on April 1994, US banks have to pay a fee on daylight overdrafts with the Federal Reserve Bank (15 basis points is the annual rate, applied on the daily average balance).

40 Of course, we are dealing here with free reserves, in excess of the compulsory reserve requirement. In particular, we are considering the possibility that a positive balance at the

constraint set by his debit cap is binding (say at time *t*), a participant cannot send further payments, until sufficient amounts are collected through incoming payments: this puts a limit to his ability to compensate payments outgoing at time *t* with other payments incoming at time $t' > t$. To the contrary, when the constraint set by his credit cap is binding, a participant cannot receive further payments before he sends outgoing payments for sufficient amounts.

Correspondent banking seems to be the more demanding system, in terms of liquid funds. As we saw above, a bank may be forced to maintain a positive balance on each of its “nostro” accounts at correspondent banks, to be ready to settle all outgoing payments. If the number of correspondent banks is large, the liquidity needs are remarkable. However, an efficient treasury management can significantly reduce this cost: in particular, a bank may be able to set to zero, at the end of the business day, the balances on the deposit accounts with its correspondents, thus avoiding that such balances become an overnight position. In addition, the CB model allows a flexible way to guarantee interbank lending, since all accounts usually imply the extension of a credit line.

4.3 Fees and other transaction costs

Euro I. The determination of the unit cost of payment orders sent through the Euro I system is rather complex, as several components must be taken into account. We try to summarize the cost structure of Euro I in Table 1, where each column refers to a different (hypothetical) bank, sending a daily volume of 500, 1000, 2000 and 4000 payment orders respectively.[41] First, each participant has to contribute covering the EBA Clearing Company expenses and to pay an annual subscription fee. Second, each participating bank has to pay a quarterly service fee, to cover the operating charge of the system. Such fee is designed as follows: (i) an equal share of 25% of the operating charge; (ii) a “tier” contribution to cover the remaining 75% of the operating charge, calculated as shown in Table 2 (for example, a bank sending an average volume of 2000

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central bank, held by a bank for intraday settlement purposes, may spill over into an overnight position.

41 In addition to the items reported in Table 1, each applicant has to pay: an application fee and an entrance fee, reflecting past amounts spent for the development of the system. Moreover, a withdrawing participant has to pay an exit fee, to cover its share of the Eba Company operating costs and of the equally shared part of the Euro I operating charge for the remainder of the budget period (plus 10,000 euro for administrative expenses).

payment orders per day is charged 0,14 euro on each payment). If the tier contributions do not fully cover the 75% of the operating charge, the remaining "shortfall" is shared: (i) equally for the first 25%; (ii) according to the ratio of each participant's transactions to the total number of transactions, for the remaining 75%. Third, the financial cost of the collateral deposited in the liquidity pool must be included: in Table 1, a prudential estimate is provided, by considering the opportunity cost of funds equal to the money market rate (which, in turn, is taken to be equal to the rate on the ECB main refinancing operations). Finally, banks have to pay a fee on each SWIFT message.

In Table 1, we can see how important are the fixed items in the cost structure of Euro I: for banks sending up to 1000 payment orders (daily), such items account for more than half of the payment cost. Correspondingly, the marginal cost of a payment order is rather low: 44 cents (for bank A in the table) or less (for banks generating a higher volume of transactions). Moreover, this marginal cost is decreasing in the daily volume of transactions, as Table 2 shows: this gives an incentive to participating banks, inducing them to enter a large number of payment orders into the system. On the other hand, Table 2 tells us that only banks entering a huge number of payment orders benefit from a significant reduction of marginal costs: actually, most banks are in the tiers with higher charges, while only one bank is able reach the lowest charge tier.[42]

TARGET. The fee for cross-border payments (reported in Table 3) is based on the number of transactions, according to a regressive scale:[43] 1.75 euro for each of the first 100 payments per month; 1.00 euro for each of the next 900 payments per month; 0.80 euro for each subsequent payment. The bank sending the payment is charged the fee by its NCB. The fee is independent of the size of the payment and of its destination, and it does not discriminate between *in* and *out* countries. In addition, banks have to pay for the cost of communication between them and their NCB: for example, this communication cost is equal to 0,23 euro (per message) for Italian banks. There is no additional periodic fee. Finally, the financial cost of the collateral, deposited at the ESCB to obtain intra-day liquidity, should be included; unfortunately, we are not able to

42 The balance sheet data of the EBA Company for 1999 report a total cost of 13,797,000 euro (including the depreciation of the Euro I system): this figure corresponds to an average cost of each payment order equal to 81 cents.
43 See ECB (1998).

provide a reliable estimate of such cost, because data on the amount of collateral deposited for such purpose are not available.

Euro I versus TARGET. In Table 3, we notice that in TARGET the number of payment orders necessary to reach the lowest fee is rather low (much lower than in Euro I). However, even for banks paying this fee (80 cents plus communication cost), the unit cost of a TARGET payment exceeds one euro (adding the cost of collateral, which is not shown in Table 3): comparing this figure with the last row of Table 1, we may say that the unit cost of a payment sent through Euro I is (roughly) equal or lower (depending on the number of payments) than the unit cost of a TARGET payment.

But the more remarkable difference between the two systems lies in the composition of such costs. As we saw above, a large share of the unit cost in Euro I is made up by fixed items. To the contrary, the unit cost in TARGET (as measured by the fees reported in Table 3) is entirely a variable cost. Moreover, the cost of collateral in TARGET is proportional to the value of payments (the higher this value, the larger the amount of collateral needed to get intra-day credit), while in Euro I the amount – and cost - of collateral is independent of the volume and value of payments.

Summarizing: the price structure of Euro I imposes high fixed costs on participants and allows banks to send payments at low marginal cost (in particular those banks sending a large volume of payment orders); to the contrary, in the TARGET system the variable cost components prevail, determining a higher marginal cost than in Euro I. Due to its cost structure, Euro I is a settlement system designed for medium-high size banks, generating a large volume of transactions; TARGET does not share this feature.

5 Empirical Evidence

5.1 Introduction

The recent experience of European countries is a remarkable “laboratory”: they share a common currency and two major cross-border payment systems, but they still preserve some specific features, related to the structure of their financial systems. Thus, we have the unique opportunity of analyzing a situation where financial intermediaries located in different countries, working in the same monetary environment, choose to send their cross-border payments through different channels because of their country-specific features. The decision to leave out of our analysis domestic payments is due to the fact that they still remain too much influenced by moral suasion and institutional constraints. Moreover in the case of cross-border payments, in addition to the data provided by the European Central Bank, we are able to use two completely new data set provided by the EBA and SWIFT.

In this paragraph we will start by analyzing these data sources and their limitations. Then, with the use of some graphs, we will give a preliminary view of the data. Finally will compute some statistical analysis.

5.2 Data sources and limitations

In the following analysis we use several data sources. First, the data provided by the European Central Bank for all European RTGS systems. In this case payments are carefully divided between cross-border and domestic payments in term of value and volume, but no distinction is made between commercial and financial payments. Second, the data that Euro1 provided to us: number of commercial and financial payments divided by country. The basic assumption of our analysis is that banks use this netting system just for cross-border payments, while all the other European netting systems (EAF, PNS, SEPI) are used only for domestic payments. Even if obviously both these assumptions might not be perfectly true, anedoctical evidence tends to confirm their validity. Moreover also the break down in term of countries should be considered with caution since large international banks tend to concentrate all the Euro payments in one financial center, notably London or Frankfurt. For example it is not totally clear if payments made by Bank of Tokyo Mitsubishi Frankfurt should be considered German. The third source of data is obtained from SWIFT. This refers to messages exchanged between banks located in the different fifteen E.U. countries. We assume that the total number of payments are given by the sum of the messages used to transmit commercial payments (MT100-MT102-MT103-MT104-MT400-MT405) plus the messages used to transmit financial payments (MT200-MT201-MT202-MT203-MT205) plus the messages used by central banks for sending Target payments (MT198 divided by two[44]).

[44] For each payment Central Banks send two MT198 messages : one for instructing and one for confirming the transaction.

Swift data refer to messages and not to payments. Sometimes however one payment needs more than one instruction to be processed. For example, if a client A of bank xx wants to send a payment to a client B of bank yy with which bank xx has no account, bank xx will send a message MT 100 to bank yy with the order to pay its client B. At the same time bank xx sends an MT 200 to a third bank zz (which has accounts with both bank xx and yy) asking bank zz to transfer money to bank yy . So the number of messages overvalues the number of payments and this could overvalue the use of CB.

5.3 A preliminary view of the data

Figure 1 shows that the correspondent banking continues to represent, at least in term of volume, the main channel used by banks to execute cross-border payments in Euro: in the first quarter of 2000 CB accounts for almost 58% of the number of cross-border payments. However this percentage has substantially decreased (-13%) during the first year of life of the European currency. At the same time the number of payments managed through both Euro1 and Target have almost doubled (the daily averages have grown respectively from 52,000 to 90,000 and from 24,000 to 37,000). So the share of Euro1 has grown from 19.7% to nearly 30%, while the share of Target cross-border payments has increased from 9.3% to 12.5%.

Figure 2 allows a better understanding of the different role played by the two main European payments systems. While in term of volume Euro1 handles as much as twice the number of payments handled by Target, in term of value these proportions appear reversed. This feature seems to increase through time since the share of Euro1 has slowly increased in term of volume and decreased in term of value during the first year of the EMU.

As expected, Figure 3 shows that the average value of payments is much smaller for Euro1 than for Target. Moreover both systems has experimented a substantial decline in the size of payments. However in absolute term the decline has been more pronounced for Target.

These changes are mainly due to the fact that many commercial payments, previously handled through CB, are now managed through Euro1 and Target. This is evident in Figure 4: this shows that financial payments used to be the majority of Euro1 payments (55.8%) in first quarter of 1999, while now this role is played by commercial payments (50.7 %). The same seems to have happened in Target, even if we have no precise figure.[45]

Finally in Figures 5 and 6 the analysis moves at country level, which will be the focus of our following analysis. Figure 5 shows that Greece, Austria, Denmark, Spain and Portugal are the countries where banks tend to use more extensively the CB to manage their Euro payments, while Belgium, Ireland, Germany and France are the countries where payments systems (Euro1 and Target) are more popular. On the other hand Figure 6 shows that Austria, Portugal, Germany and Italy are the countries where banks make a higher use of Target, while Sweden, Denmark and Netherlands tend to use more Euro1.

In the next paragraph we will try to understand these differences on the basis of some features of the payments and banking systems.

5.4 Some statistical analysis[46]

We try to explain the percentage of payments managed through CB over all cross-border payments and the percentage of payments handled through TARGET over the total number of payments managed through payment systems (Euro I plus TARGET) through three kind of variables. In the first place, a variable that captures the cost and availability of intraday liquidity that banks can obtain through the ECB. Specifically, we build a dummy variable that takes value one for countries outside EMU, which are subject to the above mentioned limitations in the access to intraday facilities. In the second place, some variables that capture the nature of payments flows: the average value of cross-border payments handled through RTGS systems and the percentage of the number of commercial payments over cross-border total payments less TARGET[47]. Finally, some variables that measure the efficiency and concentration of the banking sector: (i) the percentage of operational costs over operating income; (ii) the percentage of non-interest income over operating income; (iii) an indicator of

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[45] The share of customer payments in total cross-border TARGET payments is now around 31% in term of volume and 3.1% in term of value (ECB *Monthly Bulletin*, June 2000).

[46] See Table 4 for a description of each variable and of the corresponding data sources.

47 This is due to the fact that TARGET data do not allow to distinguish between commercial and financial payments.

concentration of the banking system: the assets of the five biggest credit institutions as a percentage of total assets in each country.

Correlations in Table 5 show that "out" countries and those where banks are more involved with commercial activity tend to make a wider use of CB. On the other hand, the banking structures seem to play a minor role in explaining the use of CB. Moreover we find a positive even if low correlation between the use of the CB and of TARGET.

As far as the use of TARGET, as expected, "out" countries tend to use less the RTGS system reasonably because of the difficulties to obtain intraday liquidity. Moreover, countries that show the higher average value of cross-border payments tend to prefer a net system like Euro I. This result could be explained by the fact that banks who handle large payments are more concerned by the cost of liquidity than by the counterpart risk. Countries that send a greater percentage of commercial payments tend to make a lower use of TARGET. Finally, more concentrated banking systems rely more on Euro 1 than on TARGET.

Even though our sample is composed only of 15 observations (the European countries), we tried to estimate two multiple regressions in order to assess the cross-effects of our explanatory variables on the use of CB and of TARGET. In Table 6 we present the first regression, where the dependent variable is the percentage of CB payments over the total number of cross-border payments. The results of the regression reinforce those obtained by the correlation analysis: the positive role played by the dummy variable for out countries and by the amount of commercial payments. In addition this regression shows that countries where the average value of cross-border RTGS payments is higher tend to use more the CB model. Finally bank with a higher share of non interest income make a lesser use of CB (although the coefficient is only marginally significant).

In Table 7 we present the second regression, where the dependent variable is the percentage of the number of TARGET payments over total payments channeled through payment systems (TARGET plus Euro I). Here again the results confirm the previous correlation analysis, since "out" countries, those where cross-border payments are larger and the concentration of banking system is higher, tend to use less the TARGET system.

6 Summary and conclusions

In this work we provide a critical view of the conventional wisdom about payment systems; the latter points to the existence of a trade-off between the safety of RTGS and the liquidity savings of MNS. Moreover, correspondent banking is believed to be inefficient both in terms of liquidity and of administrative costs.

First, building on the contribution by Rochet – Tirole (1996), we present a formal framework for analyzing the different settlement procedures. By applying this framework to the two major European cross-border payment systems (TARGET and Euro I) and to CB, we are able to show the following points:

(i) in term of risk, the actual organization of payment systems may considerably reduce the difference between RTGS and MNS: debit caps and collateral requirements - among other things – reduce the risk of MNS, while the queuing mechanism introduces a settlement lag in RTGS; in addition, in TARGET banks have no incentive to get information on their counterparts.

(ii) as far as liquidity is concerned, again the difference between the two systems may be lower than usually believed: the provision of free (but fully collateralized) intraday liquidity by the ESCB reduces considerably the liquidity cost of RTGS for the European banks, while the debit and credit caps in Euro I set some limits to the netting capability of the MNS system.

On the other hand, we show that the cost structures of the two systems may significantly differ: in particular, Euro I imposes high fixed costs on participating banks, allowing them to send payment orders at low marginal cost, while in TARGET the variable cost components prevail. These features, together with access rules, make Euro I a system suitable for medium-large size banks.

The above considerations lead us to test the hypothesis that factors other than risk may be the relevant ones in the choice of banks between the different payment channels. In addition to RTGS and MNS, we consider here also CB, which still represents the main channel - in term of volume – for sending cross-border payments. By using a combination of three data set on the European countries (provided by the ECB, EBA and SWIFT), we make a cross-country comparison in order to asses the relevance of the following factors: (i) limitations of “out” countries in their access to intraday liquidity, pointing to the importance of the cost and availability of liquidity; (ii) the nature of the payment flows (their value; whether commercial or financial); (iii) some features of the banking systems, like the concentration level and their efficiency.

Our empirical results (although preliminary, due to the small number of available data) show the following interesting points. (i) “Out” countries make a lesser use of TARGET and a greater use of Euro 1 and CB, reasonably due to the limitations in their access to intraday liquidity. (ii) Countries that show a higher average value of cross-border payments tend to prefer a netting system (Euro I) over RTGS (TARGET): this may be interpreted as a confirmation that banks handling large payments are more concerned with the cost of liquidity than with the settlement risk. (iii) Banking systems handling larger volumes of commercial payments rely more heavily on CB and Euro I. (iv) Countries where the banking system is more concentrated rely less on TARGET. This is an evidence that the RTGS system is more popular within small banks .

The future evolution of the payment systems in Europe seems to further reduce the traditional features of RTGS and MNS systems. In fact, on one side national central banks in Europe are implementing the so-called RTGS+ (an hybrid between RTGS and netting systems); on the other side EBA is planning to launch the so-called STEP1 (that will allow small banks to have access to a netting system through a Euro I settlement bank).

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Table 1 - Yearly cost accounting for participants in Euro I

(amounts in Euro)

	Bank A	Bank B	Bank C	Bank D
Daily average number of transactions Yearly number of transactions (250 working days)	500 125,000	1,000 250,000	2,000 500,000	4,000 1,000,000
1. Yearly subscription fee	**10,000**	**10,000**	**10,000**	**10,000**
2. EBA Clearing Co.'s Operat./Admin. Expenses (2,750,000 equally shared among participants)	**38,194**	**38,194**	**38,194**	**38,194**
3. Euro I yearly operating charge: (8,200,000) **3.1 25% (2,050,000) equally shared** 3.2 75% (6,150,000) tier contributions according to Table 2	 **28,472** 22,500	 **28,472** 40,000	 **28,472** 70,000	 **28,472** 120,000
4. Cost of "shortfall" (2,472,600) **4.1 25% (618,150) equally shared** 4.2 75% (1,854,450) allocated proportionally to the traffic generated by each participant	 **8,585** 13,609	 **8,585** 27,218	 **8,585** 54,436	 **8,585** 108,872
5. Cost of SWIFT messages (6 BEF per message = Euro 0,148734)	18,592	37,184	74,368	148,736
6. Collateral financial cost (0.25% on 15,000,000 deposit) (*)	**37,500**	**37,500**	**37,500**	**37,500**
YEARLY TOTAL COSTS **% fixed costs (1+2+3.1+4.1 +6): 122,751**	177,452 **69%**	227,154 **54%**	321,557 **38%**	500,360 **24.5%**
UNIT COST OF PAYMENT ORDER	1.42	0.91	0.64	0.50

Note: this table is based on 1999 data (number of participating banks: 72). It does not include the loss incurred by the EBA Clearing Company in that year (496,350 euro, to be shared equally among participants), assuming that such loss is an exceptional event (anyway, its impact on the unit cost would - on average - amount to less than 3 cents).
(*) The collateral deposit is remunerated at a rate equal to the interest rate paid by the ECB on the main refinancing operations minus 25 basis points.

Table 2 – Tier contributions in Euro I

Tier (Number of banks)	Daily average number of transactions	Charge per transaction (in cents of euro)
A (31)	Less than 800	18
B (17)	From 800 to 1499	16
C (9)	From 1500 to 2499	14
D (6)	From 2500 to 3499	13
E (5)	From 3500 to 4499	12
F (2)	From 4500 to 5499	10.5
G (1)	5500 and above	9.5

Note: This table reports tier pricing (with the number of banks belonging to each tier) as of April 2000.

Table 3 – Fees in TARGET

(amounts in Euro)

	Number of payments per month		
	Up to 100	From 101 to 1000	Above 1000
Fee per payment order	1,75	1,00	0,80
Cost of communication (per message) between banks and NCB Example: Italy	0,23	0,23	0,23
GLOBAL UNIT COST (not inclusive of collateral financial cost)	1,98	1,23	1,03

Table 4 - Description of variables and data sources

Variable	Description	Data sources
Noninterest	Non interest-income expressed as a percentage of operating income in 1998	ECB (2000)
Costop	Operating cost over operating income in 1998	ECB (2000)
Quota5	Assets of the five biggest credit institutions as a percentage of total assets in 1999 (*)	Bankscope and ECB
Avcross	Average value of cross border RTGS in 1999	ECB
Comms	Percentage of volume of commercial payments over total cross-border payments (except Target) in 1999	SWIFT
Ytarget	Percentage of volume of TARGET over payment systems (TARGET + Euro I) in 1999	ECB
Ycorr	Percentage of volume of CB over total payments in 1999	SWIFT and ECB

(*) Except for "out" countries, for which data refer to 1997.

Table 5 – Correlation analysis

	Ycorr	YTarget
"Out" Country	0.37	-0.38
Avcross	0.08	-0.31
Comms	0.47	-0.26
Costop	0.02	-0.12
Noninterest	0.08	-0.12
Quota5	0.16	-0.39
Ytarget	0.21	1

Table 6 – First regression

Dependent Variable: YCORR				
Method: Least Squares				
Included observations: 15				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
YTARGET	0.607442	0.122006	4.978783	0.0006
OUT	17.55811	4.368735	4.019038	0.0024
AVCROSS	0.242515	0.079363	3.055756	0.0121
NONINTEREST	-0.449583	0.294049	-1.528941	0.1573
COMMS	0.958049	0.161505	5.932002	0.0001
R-squared	0.789569	Mean dependent var		69.60205
Adjusted R-squared	0.705397	S.D. dependent var		12.57556
S.E. of regression	6.825684	F-statistic		9.380387
Sum squared resid	465.8997	Prob(F-statistic)		0.002042

Table 7 – Second regression

Dependent Variable: YTARGET				
Method: Least Squares				
Included observations: 15				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
YCORR	1.002023	0.161687	6.197321	0.0001
OUT	-20.63086	6.740955	-3.060525	0.0108
AVCROSS	-0.300166	0.102039	-2.941685	0.0134
QUOTA5	-0.470672	0.165626	-2.841780	0.0160
R-squared	0.667508	Mean dependent var		29.85623
Adjusted R-squared	0.576828	S.D. dependent var		17.07481
S.E. of regression	11.10744	F-statistic		7.361166
Sum squared resid	1357.128	Prob(F-statistic)		0.005603

Figure 1 - Volume Shares of Different Systems

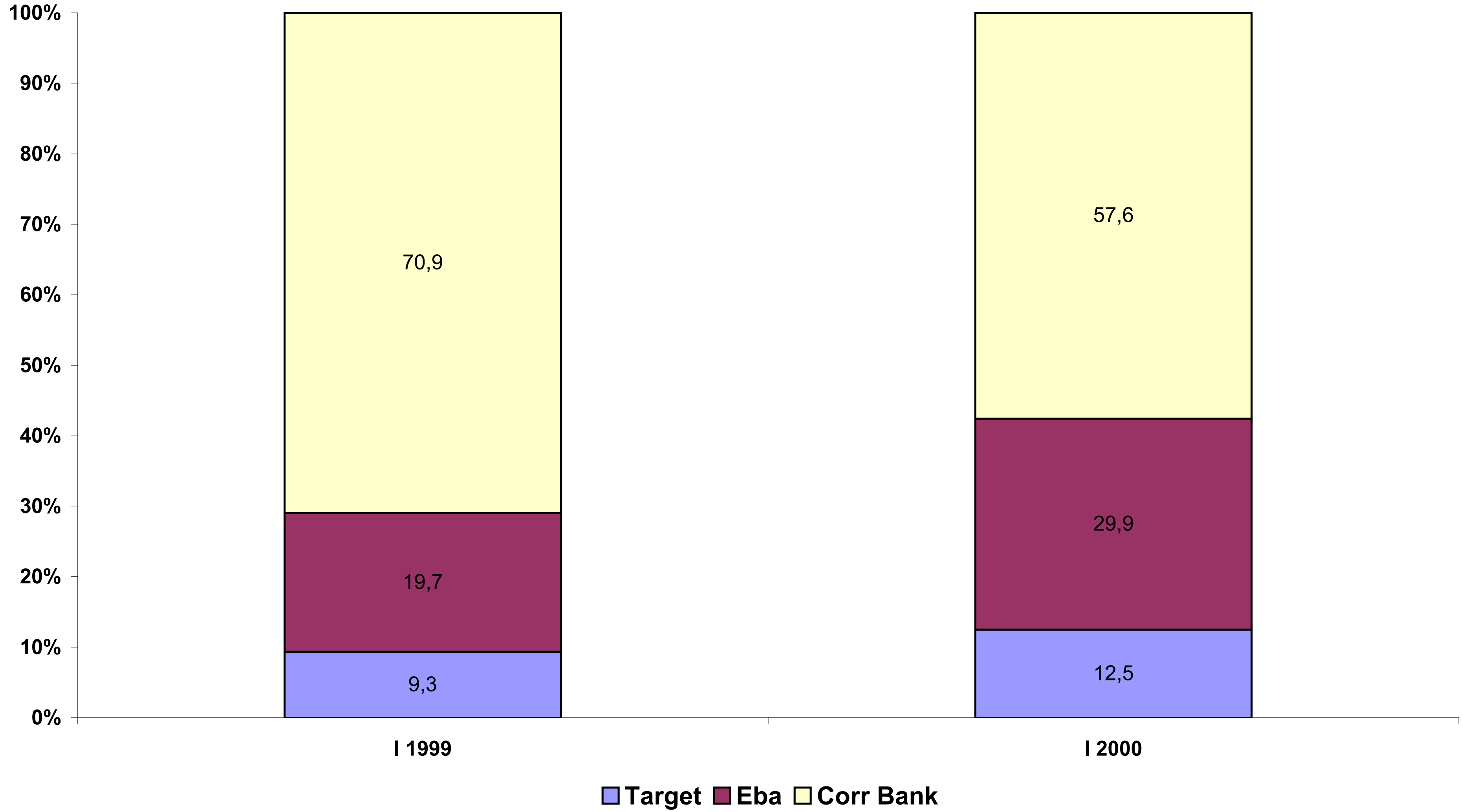

Figure 2 - Shares of Target and EBA

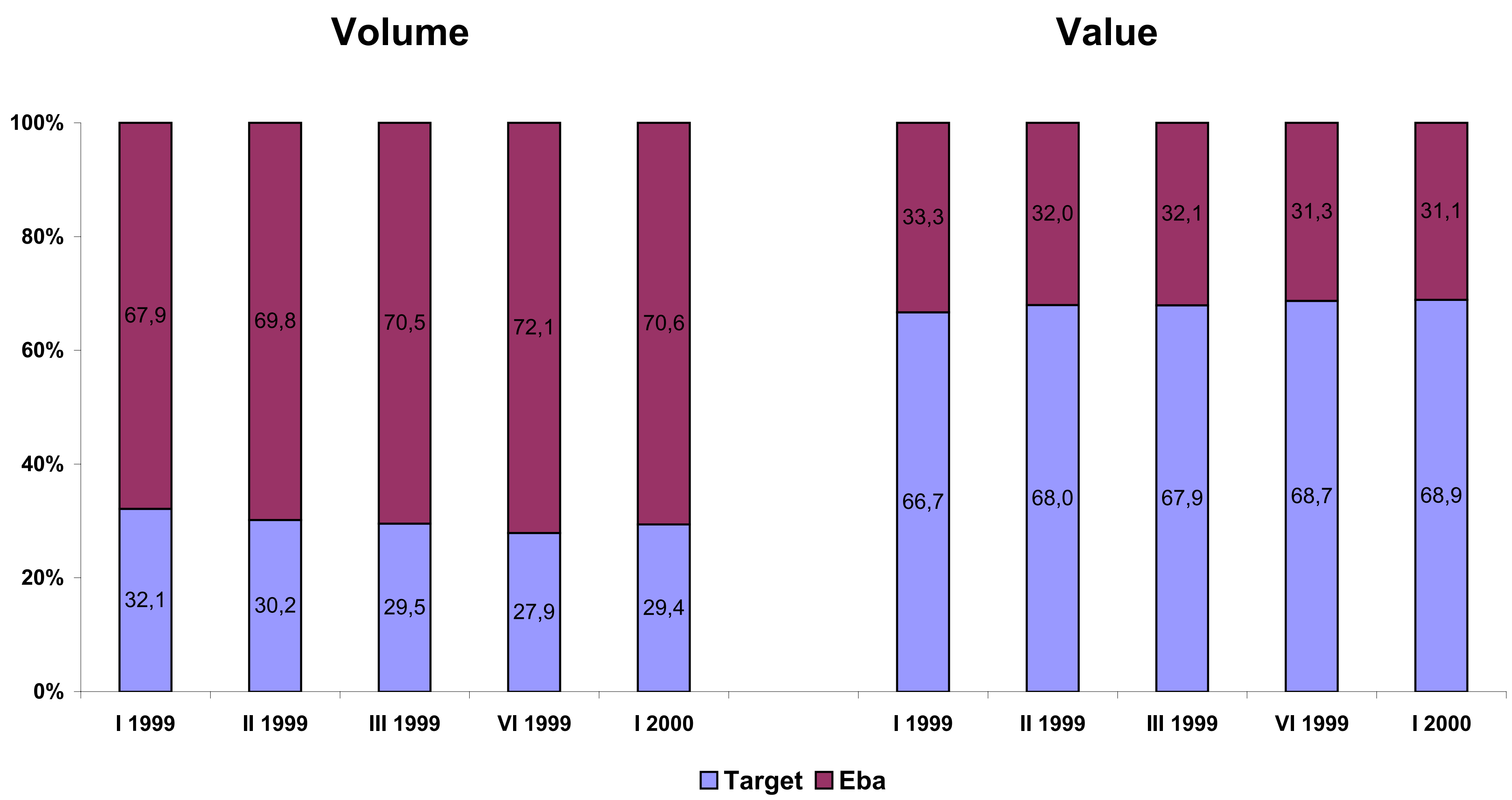

Figure 3 - Average value of Target and EBA

(millions of Euro)

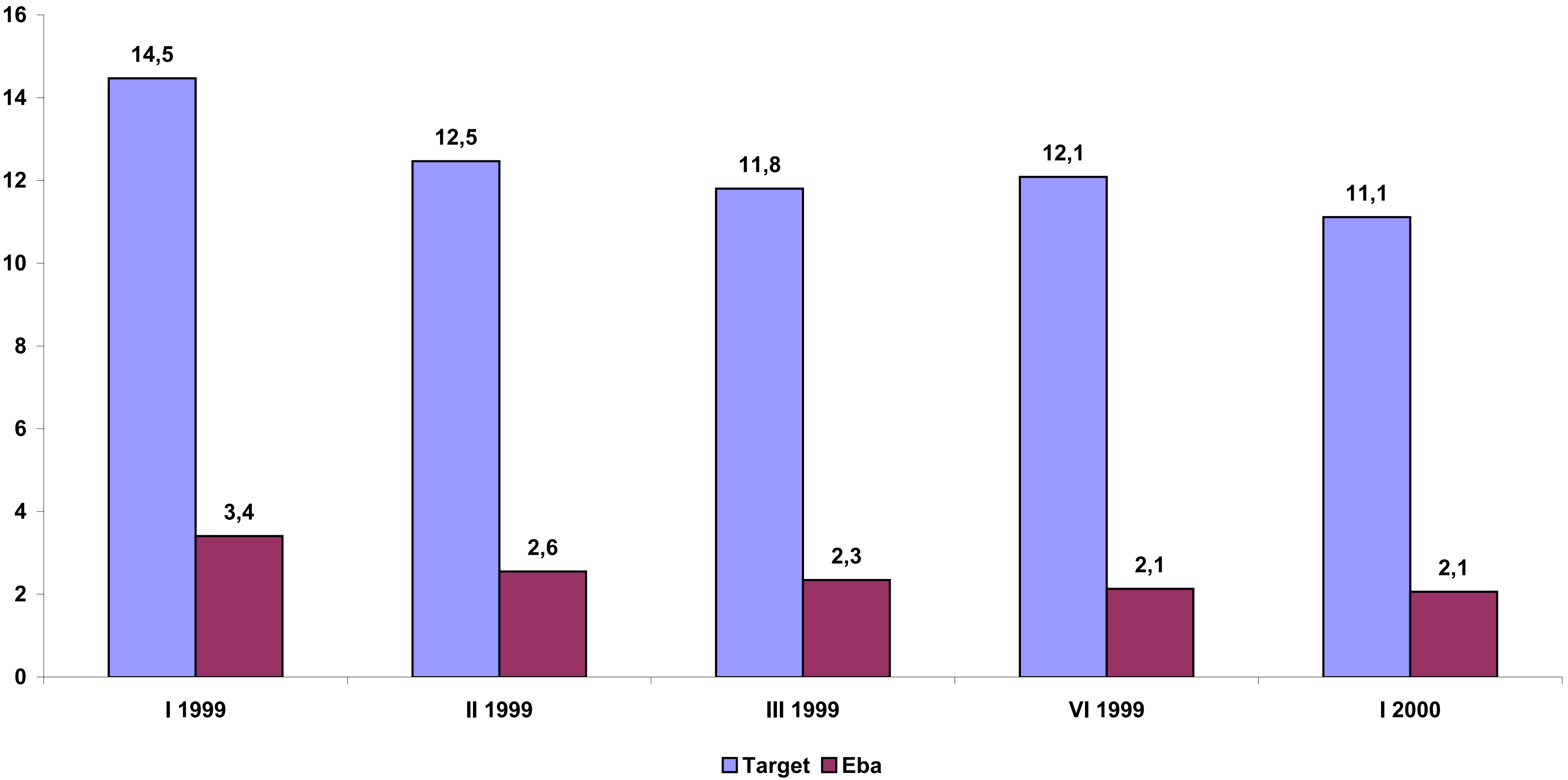

Figure 4 - Shares of Commercial and Financial Payments in EBA

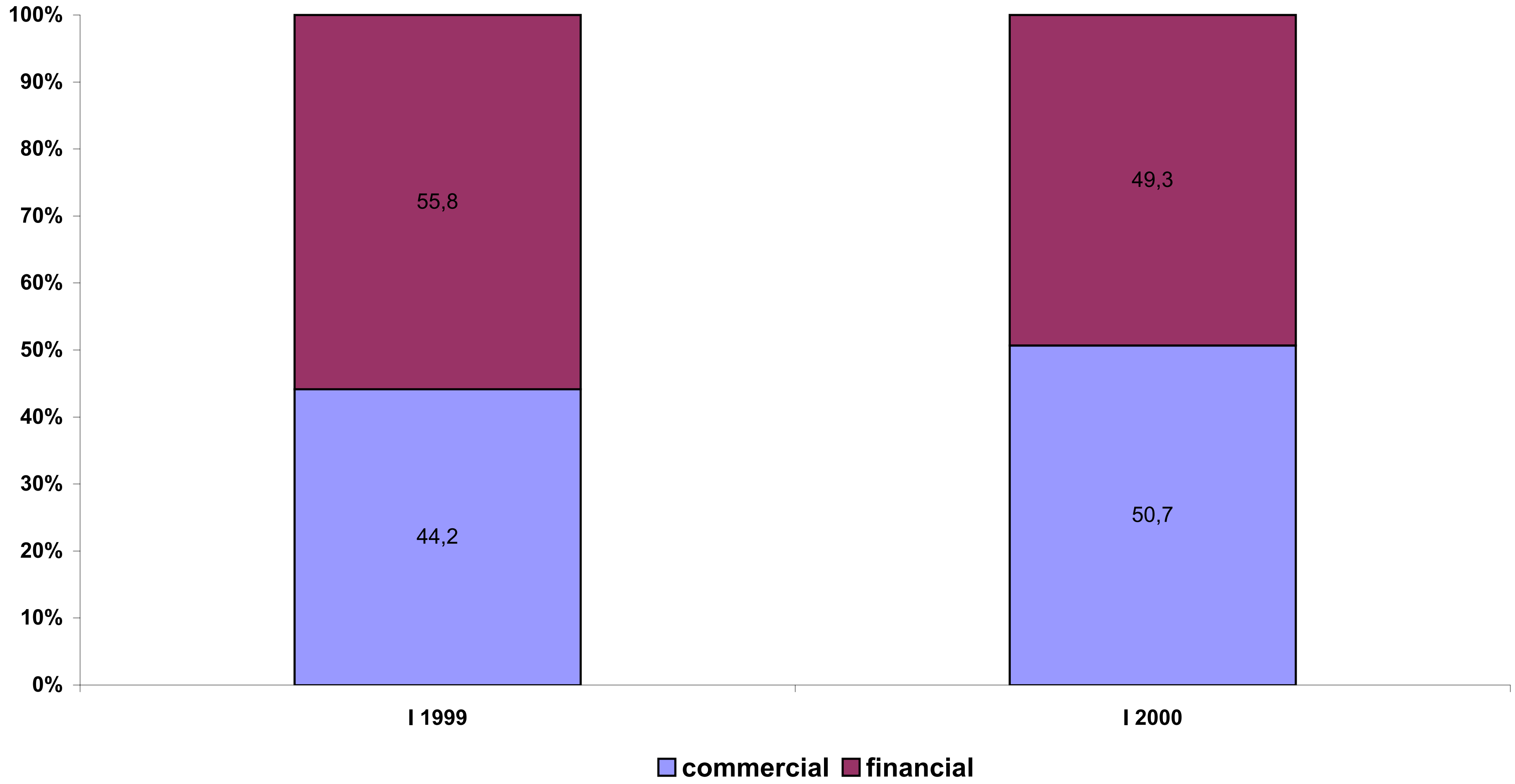

Figure 5 - Share of Volume of Different Systems in Different Countries (1999)

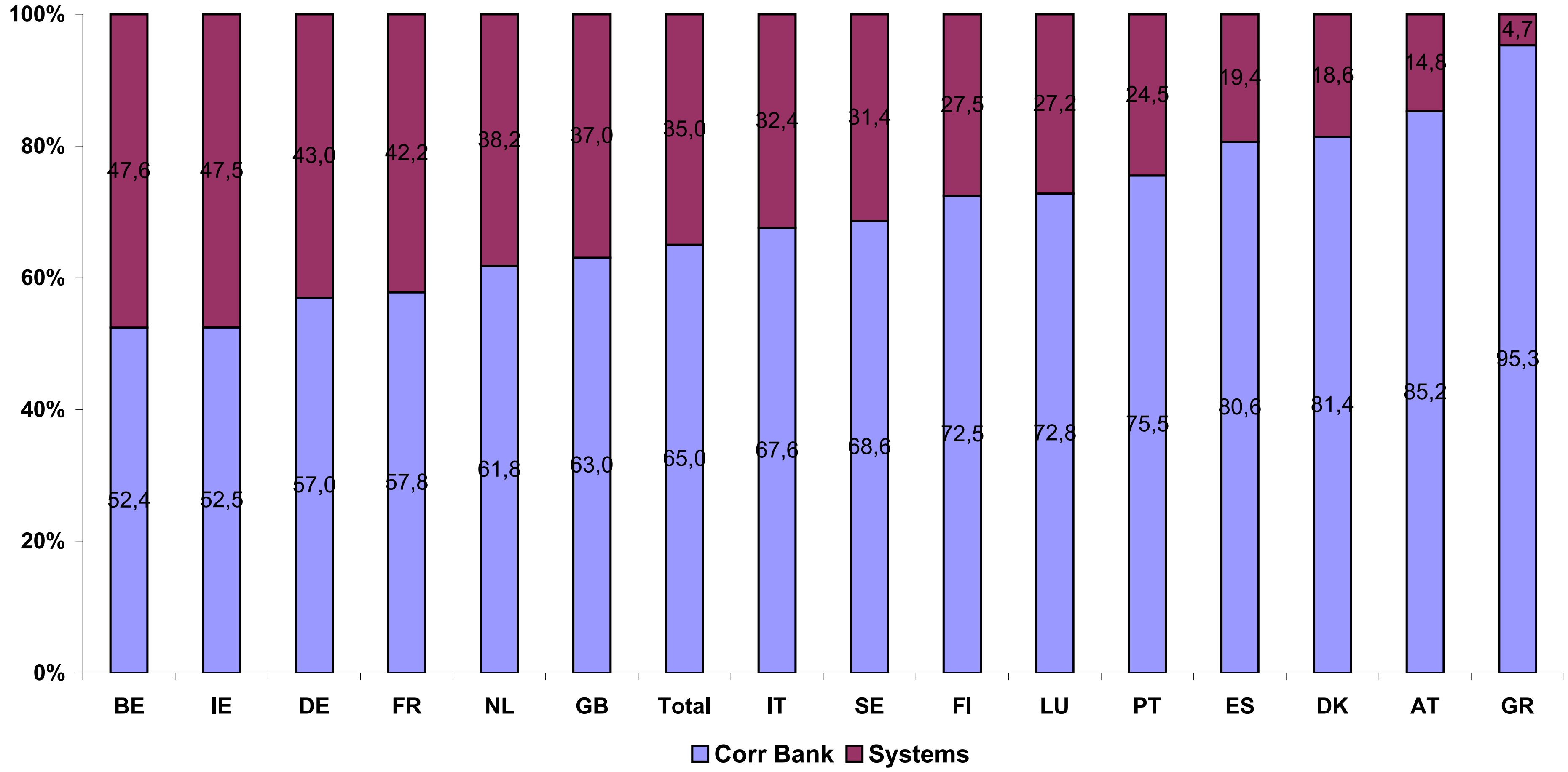

Figure 6 - Share of Volume of Different Systems in Different Countries (1999)