Intraday Liquidity in Gross Payment Systems

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Abstract

The purpose of this paper is to make a comparative analysis of modern gross payment systems, emphasizing on the implications of the availability of intraday liquidity and the different mechanisms used to provide this liquidity. The possibility of default and the risk of the intraday credit are first introduced to determine the implications on banks' behaviour and on the probability of a systemic crisis. This allows for the comparison of the effects on social welfare for different sets of parameters that characterize social risk aversion, opportunity set of banks and the functioning of each settlement model. Finally, the performance of each model is analysed using real data to resemble the payment and financial structure of a group of countries.

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Introduction

In a world of economic globalisation and financial markets' development, the value and volume of transactions channelled through payment systems have grown intensively in the last years. This evolution has increased the attention paid by financial authorities to the security of existing settlement systems and, in particular, to their ability to prevent systemic crisis. The global financial crisis that is nowadays affecting the whole world enhances the importance of this concern.

Generally, there are two types of settlement systems: net and gross. The fundamental difference between them is that whereas gross systems process each operation individually, net systems make just one settlement, usually at the end of the day, for the net position of each participant in the system. In this way, gross systems achieve, at first, the minimization of the risk that the inability of a financial institution to satisfy its commitments could affect the rest of participants. However, this greater security is only obtained at the expense of demanding to each institution sufficient liquidity to pay every single payment order, something that, obviously, end up with an increase in the effective cost of transactions.

The greater cost of gross systems arises when financial institutions rely only on their own funds to obtain the liquidity needed to process their payments. In fact, in some countries -like Switzerland before 1999- financial institutions only have at their disposal the liquidity deposited at their accounts in the central bank to settle their payments. If one participant fails to deliver sufficient funds to process an order, this order goes either to a queue, waiting for the required funds to arrive, or it is cancelled. However, in the last years, complementary liquidity facilities have been implemented within gross systems; such as intraday credit from the central bank. There exist two ways to instrument this credit facility. One of them consists in obtaining intraday liquidity by means of a credit backed up by collateral assets with zero interest rate. This is the procedure used in TARGET system of the European Union and in the

Swiss Interbank Clearing System (SIC) after 1999. In the other one, liquidity can be obtained without collateral but paying a price for the overdraft to the central bank that provides the liquidity. The FedWire, run by the Federal Reserve, uses this mechanism. In both systems, intraday credit reduces liquidity needs but financial institutions incur in a cost, either in the form of an opportunity cost to maintain guarantee assets in the former or as a consequence to pay for the credit provided by the central bank in the latter.

On the side of Central Banks, intraday liquidity provision could make them bear the credit risk associated. This is clearly the case of the Federal Reserve model. If a bank fails to deliver sufficient funds at the end of the day, the credit must be covered by the monetary authority. In the case of TARGET and SIC the risk of the intraday credit is covered by the collateral assets posed by each participant. In this environment credit risk could be considered as absent[1]. However, this depends mainly on the composition of the list of eligible assets and on the risk control measures implemented. The existence of non-marketable instruments in the list, as in TARGET, could make credit risk arise if the operation is covered with such type of assets[2]. If a bank fails to deliver sufficient funds at the end of the day, the credit must be covered by selling the collateral assets. If they were not sellable the European Central Bank would bear the opportunity cost of holding an illiquid asset and, therefore, of covering the corresponding credit. In the case of SIC collateral assets are limited to marketable instruments, such as securities, and therefore credit risk is eliminated. Besides, in the event of a financial crisis like the one most financial systems from developed countries are going through, each of the three systems allows financial authorities the provision of additional liquidity preserving financial system health. This provision would also bear the risk concerns presented above.

[1] In fact the use of collateral assets aims at protecting the Eurosystem from incurring losses in its monetary policy operations (ECB (2004)).
[2] Tier two assets can be non-marketable see ECB(2004)

It is obvious that both the introduction of intraday credit facilities in gross systems and the possibility of the emergence of credit risk can modify, importantly, the nature of the trade-off between security and cost in both mechanisms and, therefore, the conditions under which one or the other become socially preferred. The accession to intraday credit reduces the cost incurred by financial institutions in gross systems. On the other side, the existence of an intraday credit imposes a risk on monetary authorities that have to be controlled taking into account the possible consequences for the entire financial system.

The objective of this paper is precisely to make a comparative analysis between modern gross systems, emphasizing on the implications of the availability of intraday liquidity both collateralized and uncollateralized. To do so, we start from the model developed by Diamond and Dybvig (1983), as it has been adapted to the study of payment systems by Freixas and Parigi (1998) and by Freixas, Parigi and Rochet (2000). The novelty of this paper is the introduction of the possibility of default and the risk of the intraday credit to determine the implications for banks' incentives and behaviour -that affects their return and performance. This allows for the comparison of the effects on social welfare of each system for different set of parameters that characterize social risk aversion, opportunity set of banks and the functioning of each settlement model.

The paper is organised as follows. Section 2 presents the basic model, the functioning of the different versions of a gross system and the equilibria for each system. In section 3, results to compare the different systems in terms of social welfare are presented. Section 4 shows a comparative calibration among settlement systems for different countries from the European Union, USA, Japan and Canada. Finally, section 5 concludes.

2. Basic Model

2.1 Structure of the Economy

We consider a Diamond-Dybvig (1983) economy with two identical islands and one good. There is one bank in each island. There are three periods. Consumers are endowed with one unit of the good at t = 0, that can be consumed or stored. In this latter case, they deposit their endowment in the bank in their island, which stores it or invests it for future consumption. There exist two kinds of consumers, impatient that consume at t = 1 (fraction α of consumers) and patient that consume at t = 2 (1-α). Besides, a fraction (1-λ) of the patient consumers (*non strategic*) can consume only in the other island whereas the remaining fraction (*strategic*) can consume in any of the two islands. The non strategic are consumers that have real payment needs. That is, depositors or firms that have a payment to make and therefore the possibility of not having their funds transferred or brought to the other bank is not satisfactory. On the other hand, strategic are consumers that can choose whether they will make a payment or not. That is, they do not have the need to make that payment and can leave their funds at their bank or in their island. Consumers maximize their expected utility, defined as a function U of consumption C, so that U'(C)>0, U''(C)<0 and relative risk aversion greater than or equal to one.

Banks are risk neutral. Each bank has two investment opportunities: collateral assets (mainly public debt) and other assets. One unit of good invested in collateral assets at t = 0 yields a return of r_f at time 2, with $r_f \geq 1$. A unit of good invested in other assets at t = 0 can yield two returns at t = 2: R_H and R_L (L for low return and H for high return) with probability p_H and p_L respectively. Therefore, state L implies a high loss to the bank. That is to say, $R_L < 1 < R_H$ and $(r_f - R_L) \geq (R_H - r_f)$. The expected return on these assets is equal to $E(R) = p_H R_H + p_L R_L > r_f > 1$. If any investment is liquidated at t=1 the return is equal to *k*, with *k<1*. Therefore in the absence of any other requirements, banks, risk neutral, would invest all the money from depositors in risky assets. The structure of the economy and the agents' ex ante utility functions are common knowledge.

In order to attend consumers' payment needs the bank has to obtain liquidity either by selling assets (early liquidation) or by means of an intraday credit, depending on the payment system type. In a *gross system* the bank can usually obtain liquidity from the central bank. Liquidity comes from a credit that has to be covered either with sufficient collateral with zero interest rate or with an uncollateralized credit from the central bank with an interest rate. Therefore, two designs of modern gross systems are distinguished. In the first case, the bank has to cover the credit with collateral assets. In the second case, in the absence of collateral requirement, the credit has to be remunerated. Since, collateral assets eliminate the consequences of credit risk only if all guarantee assets are marketable, in the first model, two alternative subsystems can be analysed. On the one hand, a system with non-marketable instruments in its list, and therefore with a risk (like the EU Target). On the other, a system with no risk as it only uses public debt (like SIC).

In this scenario, in order to serve the agents that want to transfer money banks would hold an amount of collateral assets equal to the expected proportion of this kind of depositors.

In the second case, liquidity would come from a credit, whose amount is fixed by the financial authority, and can involve the payment of a determined interest rate (i) (this is the procedure implemented in the *Fedwire* system). Therefore, the central bank would bear the possible risk of this intraday credit in case of low return. Besides these three models and in order to have a better comparison, a gross system without intraday credit facility is included in the analysis (as it was the case for SIC before 1999, as to now SIC99).

The functioning of the model is as follows. At time 0, banks decide the composition of their portfolio and offer depositors a contract that allows them to choose when to withdraw. Independently of the kind of payment system used, it is assumed that banks know the normal volume of payments they usually make, although they can not say what kind of consumer is each depositor. The volume of payments is assumed to be equal to the proportion of patient

non-strategic consumers. A bank participating in a gross system with collateral invests a percentage in guarantee assets equal to this proportion of patient non-strategic consumers, whereas the bank participating in a system with no collateral will invest only in risky assets. In this latter case the central bank would grant a credit equal to this proportion[3]. In the case of not having access to intraday liquidity this proportion of deposits would not be invested, and maintained in reserves (cash)**.** Then, the ability to make payments of a bank in all systems will be limited to the proportion of patient non-strategic consumers. Any consumer that wanted to travel in addition to that proportion would not be able to do it as the payment system would not allow the additional transfer of funds. In all systems banks maintain an amount of liquid reserves equal to the proportion of impatient consumers.

At t = 1, patient consumers receive a signal that fully reveals the return on the risky asset in their home island. The signal will be $K \in (L, H)$, L for low return and H for high return, its distribution is independent in each island. On the basis of this information they decide the strategy to follow. The set of strategies for strategic consumers is S = { T, W, R }, where T stands for transfer your money to the other island, W for waiting and withdrawing at t = 2, and R for running. For non strategic consumers we have S' = { T, R }. As can be seen $S' \subset S$. However, a patient strategic consumer choosing an action from S' does not necessarily mean that a non strategic consumer will choose the same action due to the limit on payments mentioned above. A strategy would look like this: [$(W_{SC}(H), T_{NSC}(H))$, $(W_{SC}(L), R_{NSC}(L))$]. Where the first pair means that in a high return island the strategic consumers will wait, and depositors with payment needs will travel to the other island. The second pair corresponds to the strategies in the low signal island. So, the strategic consumers wait and the non strategic run. Once consumers have chosen their strategy, the bank liquidates a portion of

[3] The limit could be different from the proportion of non-strategic consumers. In section 3 the set of this limit will be analysed.

the initial investment to cover the withdrawals. At t = 2 the investment matures and the proceeds are shared according to the following rule:

Bankruptcy Rule: Depositors (consumers) have a right to all the assets of their own bank. Patient consumers earn the return on the bank investment from their origin island independently of whether they have travelled or not.

Contagion occurs when consumption of depositors from one bank is affected by the return on the other bank. In this model, efficiency is achieved when the risky assets from a low return signal bank are liquidated at t = 1 and the ones from the high return signal bank are maintained till maturity at t = 2.

2.2 Equilibrium under certainty about investment returns

As a benchmark, it is useful to compare the four models of gross payment systems -no intraday credit, marketable collateral assets, non marketable collateral assets and intraday credit with a cost- when there is certainty on investment returns. In this case gross systems with intraday credit are not affected by default risk of participants.

Proposition 1. Assuming that $p_H = 1$,

(i) Equilibrium in all systems is (W_{SC}, T_{NSC});

(ii) The utility ordering is the following: credit with cost, flexible collateral, collateral and no intraday credit.

Proof. Point (i), given that the signal is always of high return, strategic consumers do not have incentives either to run or to travel whereas non strategic do not liquidate at t = 1 but

travel to the other island. (ii): given that there is no uncertainty, the difference between all systems comes from the different composition of bank portfolios and not from the earlier liquidation of investment. The return of a portfolio for a bank participating in collateral systems is always lower than that of an intraday credit with cost, since the former holds a greater fraction invested in collateral assets that have a lower return and therefore, provides a lower level of consumption. Within the collateral approach, a flexible list allows for a greater return on eligible assets than the one with securities. If there is no intraday credit the return is the lowest since it does not invest in any asset.

Logically, if there did not exist a restriction on the assets that can be used in intraday credit operations of the central bank, the same utility would be obtained in the first three models of gross systems. However, nowadays, existing payment systems have a restricted list of eligible guarantee assets for these credit operations. The kinds of assets in these lists usually have the best credit qualification and therefore their expected return is often lower than other financial instruments in the market.

2.3. Equilibrium under Uncertainty

As it has been stated, in the absence of return risk, Fedwire dominates TARGET and the two versions of SIC. However this conclusion might change when there is a probability of bank failure in the financial system.

Proposition 2 if investment returns are uncertain, the unique sustainable equilibrium in a gross system under all models of intraday liquidity is [$\mathbf{(W_{SC}, T_{NSC})}$ $\mathbf{(R_{SC}, T_{NSC})}$].

Proof. See appendix

In a gross system banks are only able to transfer money to the other island if these transfers are backed with adequate collateral or if the bank obtains the credit from the central bank. If there is a high return signal consumers behave as in the case of perfect certainty. That is, strategic consumers wait and non strategic travel. With these strategies, the volume of funds transferred to the other island corresponds to the investment in collateral assets and to the intraday credit limit. The equilibrium in a low signal island is (R, T). The bank processes, in the first place, the usual payment operations that correspond to the non-strategic consumers since the existing level of collateral and the credit limit allows this processing. A strategic consumer, that in normal circumstances maintains his deposit till maturity, tries to transfer his money to the other island once he receives a low signal to have access to a greater expected return than the one he gets from running. However, after processing the payments of non-strategic depositors, the amount of collateral assets and the credit limit is insufficient to guarantee the strategic's transfers. As they can not make the transfer, their action is to run. In a sense, the use of a restricted list of eligible assets (mainly debt) and the credit granted by the central bank sets a limit on the amount of credit a bank could obtain and then on the proportion of payment orders that can be processed. Given that investing a greater amount of money in collateral assets reduces portfolio expected return, banks will not allow strategic consumers to carry out speculative money transfers. This limit is similar to the suspension of convertibility mechanism characterized in Diamond and Dybvig (1983) and extensively analysed in Gorton (1985).

The rest of possible strategies would not be sustainable as equilibrium because a good deviation can always be found for some type of consumers. For example, for the set of strategies [(W, T), (W, R)], non strategic consumers from the low signal bank would have incentives to deviate to transfer their money. The expected value of consumption if they

travelled to the other island would be greater than the one they would obtain liquidating their deposits. Therefore it would not be sustainable as an equilibrium.

We then analyse the special characteristics of each model.

2.3.1 Gross system with no Intraday Liquidity.

In this model banks do not have access to intraday credit and have to maintain a proportion of liquid assets equal to proportion of impatient and non strategic consumers. In the case of low return the bank has to decide how to share the yield from cash and from the earlier liquidation of risky assets[4]. We assume that all consumers from a low return bank receive the same amount of money independently of whether they transfer their money or not.

With no intraday credit, there is no risk neither for the rest of banks nor for financial authorities. Therefore the failing bank is liquidated in isolation and the stability of the financial system is preserved

2.3.2 Gross System with Collateralised Intraday Liquidity.

In this model banks have access to intraday credit by means of a collateralised loan with no interest rate. Two sub-models can be distinguished.

First, when the list of eligible assets is formed by marketable assets (mainly public debt). In the case of low return the bank has to decide how to share the yield from no risky collateral assets and from the earlier liquidation of risky assets. As in the previous case, we assume that all consumers from a low return bank receive the same amount of money independently of whether they transfer their money or not.

With intraday credit, there is no risk for the rest of banks but there could be a risk for financial authorities. However this risk is overcome with the use of no risky eligible assets to

[4] In the presence of a low return signal the bank decides to liquidate all the risky assets since their value at t = 2 will be lower than that of earlier liquidation.

cover the intraday credit of the central bank. Therefore the risky investment of a failing bank is liquidated and, thanks to the guarantee assets, financial authorities preserve their position and therefore that of financial system.

In the second sub-model, the list of eligible assets is formed by marketable and non-marketable assets. In the case of low return, the assets that guarantee the intraday credit are either not sufficient or not easily transformed into cash. Then, consumers that transfer their money end up with the nominal amount of the credit. The rest of depositors receive consumption stipulated in the contract if withdrawing at t = 1.

Therefore the central bank has to bear a loss in covering the credit in terms of illiquid assets. With intraday credit, there is no risk for the rest of banks but there is in fact a risk for financial authorities. Although the risky investment of a failing bank is liquidated, the guarantee assets can not preserve the financial authorities' position and might affect the financial system.

2.3.3 Gross System with Costly Intraday Credit.

In this model banks have access to intraday credit by means of a credit from the central bank with an interest rate payment.

In the case of low return, the value of the assets, early liquidated or at maturity, is not sufficient to cover the credit granted by financial authorities. Then, consumers that transfer their money end up with consumption equal to the nominal amount of the credit. The rest of depositors receive consumption stipulated in the contract if withdrawing at t = 1.

Therefore the central bank has to bear a loss equal to the amount of credit given to the bank at t = 1 minus the liquidation value of part of the bank assets. As in the previous case, with intraday credit, there is no risk for the rest of banks but there is in fact a risk for financial authorities. The risky investment of a failing bank can either be liquidated or not, but in any

case the value of a bank's assets can not preserve the financial authorities' position and might affect the financial system.

None of the models exhibits contagion, that is, the return of each bank island does not affect the consumption in other banks. In the first two, the non existence of credit and the list of marketable assets prevent other banks and financial authorities from having a loss. In the last two, the "safety net" of central banks, avoids contagion with other participants in the system but imposes the burden on financial authorities. This loss is usually greater in the case of non collateralized credit, since guarantee assets could cover part of the losses from the credit.

3. Trade-off between Gross and Net payment systems

As it has been stated above, in the absence of default risk a system with uncollateralized intraday credit dominates the other models with guarantee assets and with no intraday liquidity due to the greater return of the banks' portfolio. But it is precisely the existence of a positive probability of failure what might unbalance this first result. The main advantage of a gross system comes from the absence of contagion in case of a bank failure as the results of each financial institution do not depend on others' results. This greater security is obtained at the expense of maintaining either a greater amount of liquidity or of collateral in the banks' balance sheets which means a cost in terms of return. On the other hand, non-collateralized credit systems do not need so much collateral but are exposed to the risk of credit loss in case a participant is not able to fully meet its payment needs.

Therefore, collateral volume needed and the difference in return between the list of eligible assets and the rest of investments have a word to say in the preference for one of the different intraday credit systems. To make a comparative analysis the expected utility in each model should be evaluated.

Proposition 3

(i) A non collateralized system is preferred over the rest of models with intraday liquidity the greater the difference in return between the list of eligible collateral assets and the risky assets and the smaller the probability of failure.

(ii) The greater the proportion of payment orders (1-λ) the greater the attractiveness of the non collateralized model.

(iii) For sufficient high values of the return on collateral assets ($r_f > \frac{k(1-\lambda)}{k-\lambda}$) the greater the proportion of impatient consumers the lower the utility under the model with marketable collateral assets

Proof. See appendix

Proposition 3 implies that the composition of the list of eligible assets will play an important role in the design of a gross system that uses this type of intraday facility and above all in the objective of improving their relative position with respect to other existing models. First, the list should include assets that are usually held by financial institutions. In this way the different composition of investment portfolios among banks that participate in each of the four systems would be smaller, reducing the cost of maintaining a given amount of collateral. Second, the profitability of the list should be high enough to diminish the cost of collateral maintenance while preserving the security and the ability of the system to reduce systemic risk in intraday credit.

The influence of the amount of consumers with real payment needs (1-λ) is ambiguous for some of the models analysed. Except for the case of uncollateralized intraday credit (result (ii)), an increase in the consumers' payment needs (higher (1-λ)) brings about two movements

in expected utility in opposite directions. For the non intraday liquidity and the marketable collateral assets models, a higher (1-λ) under the good state means a lower return on the portfolio and therefore a lower consumption. With low return, consumption is greater due to the greater amount of eligible assets (riskless) in their portfolio. Which of the reactions is greater depends on the value of the parameters and on the utility function. For non marketable collateral assets we have a similar situation. A higher (1-λ) means a greater utility for private consumers but at the same time, a greater cost for financial authorities. The evolution of the expected utility for changes in the proportion of non patient consumers does not have a clear sign except for the case of the marketable collateral assets under some circumstances (result (iii))

Other interesting parameter to look at is the limit to intraday credit set by financial authorities in the corresponding model. The following propositions deals with this issue.

Proposition 4

Under a non collateralized system there can exist an optimum policy with respect to the intraday credit limit imposed on the participants in the system.

Proof. See appendix

An increase in the limit of intraday credit brings about two movements in expected utility in opposite directions. A higher value for this parameter means a greater utility for private consumers since more depositors are allowed to benefit from this credit. However, at the same time, this increase in the credit granted means a greater cost for financial authorities in case of low return. The optimum policy would be obtained by calculating the limit that

equals the marginal increase of the private utility of consumers with the marginal cost of covering the credit loss.

Then, to obtain more information on welfare differences between each of the systems analysed it is helpful to resort to numerical simulations.

4. Welfare Analysis

As proposition 3 establishes, the preference for one of the two models of gross payment systems depends on the value of the different parameters. In order to best approximate a real situation we will perform some numerical simulations to see where the frontier lies on the preference for each system.

In this section, we compare the different gross payment systems analysed for a group of countries. These countries are selected on the basis of data availability[5] and cover the EU-25[6], Canada, USA, Japan, Hong Kong, Singapore, Switzerland, Bulgaria and Romania. Using real data for the year 2002, the parameters of the model are set to resemble the payment and financial structure in each country. That is, cash holdings, overnight deposits and the value of payment processed, account respectively for variables t, λ and $(1-\lambda)$ of the model. The probability of default of the banking sector is obtained from Moody's rating and the interest rate from Eurostat[7]. With respect to the case of uncollateralized intraday liquidity, we set the interest rate based on the characteristics of the gross system of the Federal Reserve, *Fedwire*. In this system, banks can obtain intraday liquidity from the Federal Reserve at a cost of 36 basis points that is applied on the mean volume of daily overdrafts minus 10% of risk based capital of the institution. Simulations are made for different values of relative risk aversion.

[5] Data comes from ECB (2004(a)) and (2004(b)) and BIS (2003(b)).
[6] With the exception of Sweden.
[7] See Eurostat and Moody's (2006).

The utility function used is: $U(c) = \frac{(c+1)^{1-\gamma}}{1-\gamma}$ where γ is the relative risk aversion coefficient[8].

With this utility function and the parameter values the ex–ante expected utility is maximized and optimum period 1 consumption is obtained. This optimum consumption determines consumption at t = 2 and the ex-ante expected utility is calculated in each system.

A summary of results from this numerical exercise are presented in table 1 and a list of the different payment systems established in each country with their main characteristics can be consulted in table 2. The different models analysed have been ordered with respect to their expected utility taking into account the expected loss for financial authorities. The first interesting general result is that the most preferred model of intraday liquidity is the one with marketable collateral assets. That is, an intraday credit facility that improves the possibilities of transferring money through these systems while at the same time preserving the system from bank failures. Apart from this preference, the ordering allows dividing the countries into two different groups. The first group includes the EU-15, the EU enlargement countries (except Malta and Latvia), Singapore, Canada, Japan and Switzerland. Financial structure of these countries favours clearly the use first, of a system with marketable assets and then the alternative with no intraday credit. The third place is for the non-marketable collateral assets model and the less preferred would be the use of intraday credit (without collateral) with a cost. The systems established in some of these countries -namely Canada, Singapore, Switzerland, UK and partly Germany- are in agreement with the simulations results (see table 2). The assets used in these systems are mainly public debt and therefore with a limited, if not absent, credit or liquidity risk. The situation of the countries from the EU, especially those that form part of the monetary union is much more difficult to justify. The system chosen,

[8] This utility function allows for the analysis of situations where consumption is zero as it is the case in some propositions.

TARGET, has a list of eligible assets that includes some that are non marketable. This extended list was designed bearing in mind the situation of each country with respect to their banks' balances. The main objective was to reduce the opportunity cost of collateral for the banking system and, by facilitating the use of intraday credit, improve the performance of the system. According to our results, the gain in flexibility for banks would not overcome the expected loss for financial authorities. Therefore, the calibration suggests, as a possible way to improve the expected social benefit the financial system gets from TARGET, that it would be interesting to revise the composition of the list of eligible assets to approach the marketable collateral model..

Table 1
Ordering of gross systems for selected countries.

Country	First	Second	Third	Fourth
Belgium	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Denmark	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Germany	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Greece	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Spain	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
France	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Ireland	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Italy	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Luxembourg	Marketable Collateral Assets	No Intraday Liquidity Non Marketable Collateral Assets		Intraday Credit with cost
Netherlands	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Austria	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Portugal	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Finland	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
U.K.	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Canada	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Hong Kong	Marketable	No Intraday Liquidity		Non Marketable

	Collateral Assets	Intraday Credit with cost[1]		Collateral Assets
Japan	No Intraday Liquidity	Marketable Collateral Assets	Non Marketable Collateral Assets	Intraday Credit with cost
Singapore	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets Intraday Credit with cost[2]	
Switzerland	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
USA	Intraday Credit with cost Marketable Collateral Assets		No Intraday Liquidity	Non Marketable Collateral Assets
Bulgaria	Marketable Collateral Assets	No Intraday Liquidity	Intraday Credit with cost	Non Marketable Collateral Assets
Cyprus	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Czech Republic	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Estonia	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Hungary	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Latvia	Marketable Collateral Assets	No Intraday Liquidity	Intraday Credit with cost	Non Marketable Collateral Assets
Lithuania	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Malta	Marketable Collateral Assets	No Intraday Liquidity	Intraday Credit with cost	Non Marketable Collateral Assets
Poland	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Romania	Marketable Collateral Assets	No Intraday Liquidity	Intraday Credit with cost	Non Marketable Collateral Assets
Slovakia	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost
Slovenia	Marketable Collateral Assets	No Intraday Liquidity	Non Marketable Collateral Assets	Intraday Credit with cost

(1) For sufficient high values of relative risk aversion the intraday credit model is preferred
(2) For sufficient high values of relative risk aversion share the same result

The second group is formed by USA, Bulgaria, Romania, Latvia, Malta and Hong Kong. In these countries, the model of intraday credit with cost is preferred over the non marketable collateral assets design. As risk aversion increases, this result is also obtained for Singapore. In this second group, USA deserves a deeper analysis. This country is the only one in which the model of intraday credit with cost beats the marketable collateral assets and the non intraday liquidity model. It is precisely the kind of system the Federal Reserve has implemented: *Fedwire* (see table 2). Results from these simulations seem to justify the decision made by financial authorities in this country. Although there is credit risk for the Federal Reserve, this system imposes lesser costs on banks and the final result is positive.

Financial structure and uses of USA banks and depositors allows this system to have a better expected social benefit than the rest of models.

Table 2. Characteristics of Payment Systems

PAYMENT SYSTEM	COUNTRY	TYPE	INTRADAY LIQUIDITY	LIMITS	COLLATERAL	ASSETS	PRICE
ELLIPS	**BELGIUM**	GROSS	YES	NO	YES	ECB LIST	NO
LVTS	**CANADA**	GROSS	YES	YES	YES	SECURITIES	NO
TBF	**FRANCE**	GROSS	YES	NO	YES	ECB LIST	NO
PNS	**FRANCE**	NET	n.a.	n.a.	n.a.	n.a.	n.a.
RTGSplus	**GERMANY**	GROSS	YES	NO	YES	ECB LIST	NO
HKD CHATS	**HONG KONG**	GROSS	YES	NO	YES	SECURITIES	NO
USD CHATS	**HONG KONG**	GROSS	YES	YES	YES-NO	SECURITIES	NO
EURO CHATS	**HONG KONG**	GROSS	YES	YES	YES-NO	SECURITIES	NO
BI-REL	**ITALY**	GROSS	YES	NO	YES	ECB LIST	NO
BOJ-NET	**JAPAN**	GROSS	YES	NO	YES	SEC-LOANS	NO
TOP	**NETHER**	GROSS	YES	NO	YES	ECB LIST	NO
MEPS+	**SINGAPORE**	GROSS	YES	NO	YES	SECURITIES	NO
K-RIX	**SWEEDEN**	GROSS	YES	NO	YES	SECURITIES	NO
E-RIX	**SWEEDEN**	GROSS	YES	YES	YES	ECB LIST	NO
SIC	**SWITZER**	GROSS	YES	NO	YES	SECURITIES	NO
CHAPS STERLING	**UK**	GROSS	YES	NO	YES	SECURITIES	NO
CHAPS EURO	**UK**	GROSS	YES	NO	YES	SECURITIES	NO
FEDWIRE	**USA**	GROSS	YES	YES	YES-NO	SEC-LOANS	YES
CHIPS	**USA**	GRO-NET	NO	-	-	-	-
TARGET	**EU**	GROSS	YES	NO	YES	ECB LIST	NO
EURO1	**EU**	NET	NO	n.a.	n.a.	n.a.	n.a.
EPM	**EU**	GROSS	NO	n.a.	n.a.	n.a.	n.a.
CLS	**INTERNAT**	GROSS	NO	n.a.	n.a.	n.a.	n.a.
SEBC/EUROSIC	**GER-SWITZE**	GROSS	YES	NO	YES	SECURITIES	NO
RINGS	**BULGARIA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
LVCTS	**CYPRUS**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
CERTIS	**CZECH REP**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
ESTONIAN RTGS	**ESTONIA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
ESTONIAN DNS	**ESTONIA**	NET	n. a.	n. a.	n. a.	n. a.	n. a.
VIBER	**HUNGARY**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
SAMS	**LATVIA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
TARPBANK	**LITHUANIA**	GRO-NET	n. av.	n. av.	n. av.	n. av.	n. av.
MARIS	**MALTA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
SORBNET	**POLAND**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
NPSGSS	**RUMANIA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
SIPS	**SLOVAKIA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.
SIBPS	**SLOVENIA**	GROSS	n. av.	n. av.	n. av.	n. av.	n. av.

n.a. Non applicability, n.av. Not available.

As has been stated above, countries from the first group would benefit more from the use of non marketable collateral assets model as a third option. A smaller proportion of cash

in circulation, a medium return, an important proportion of payments and a lower probability of default can explain this preference. The second group of countries tends to opt for the use of intraday credit with a cost. This preference would be based on a greater proportion of cash in circulation, a higher return, a more important proportion of payments than the other group and a greater probability of default. However a subsequent distinction can be made with respect to this second group. Although all countries share the same preferences, the two developed countries (USA and Hong Kong) have very different characteristics. They have much lower cash in circulation than their group mates (but greater than the first group's), the greatest volume of payments, the lowest return and the minimum probability of failure. The explanation behind this distinction could be that economies with more developed financial systems (USA and Hong Kong) would benefit more from the use of the intraday credit model with cost. Less developed economies, where financial systems are still in their initial stage, would also benefit from the use of this system in payment processing. Countries from the group of non marketable assets could lie in the frontier between these two: the developed and less developed financial systems.

These results could give some interesting insights for the design and implementation of payments systems infrastructure. Economies with an important cash use and a limited volume of payments should rely more on intraday credit models. The development of financial markets and institutions, the use of electronic means of payment and the increase in the amount of payment processed will change this initial preference. Then, collateral systems should take the lead. Finally, when payment orders are very high, intraday credit facilities return to be preferred or cooperate with collateral systems in the market.

5. Conclusion

The comparison between the different models of gross systems is based on the trade-off between security and flexibility to make transactions. The terms of this comparison alter substantially when the possibility of collateralised overdrafts and intraday credits with a cost is introduced. The different models analysed: with no intraday credit, marketable collateral assets, non marketable collateral assets and intraday credit with a cost, cover the majority of nowadays existing gross payment system designs.

It is shown how the comparison in social welfare derived from each system depends crucially on parameters like: the normal level of transfers made ($1-\lambda$), the probability of failure for a financial institution (p_L), the return of eligible collateral assets (r_f) and the expected return of the banks' risky portfolio.

In particular, non collateral systems will tend to be preferred to the rest of gross systems, the greater the volume of payment to be made ($1-\lambda$), the lower the failure probability, the greater the expected return on risky assets and the lower the return on eligible assets. Besides, under the costly intraday credit model it is possible to design an optimum policy with respect to the limit on this credit. This optimum policy is obtained by equalling the expected marginal benefit for banks of a greater limit with the marginal expected cost for financial authorities.

Finally, using real data for a sample of countries, some interesting insights for the design and implementation of payments systems infrastructure are given. Results show that the marketable collateral assets model is superior to the rest of the models in almost any country, followed by the non intraday liquidity set up. Then, countries can be divided intro two groups. The first includes EU-15, the EU enlargement countries (except Malta and Latvia), Singapore, Canada, Japan and Switzerland. Financial structure of these countries favours clearly the use of a non-marketable collateral assets model when contrasted with the

use of costly intraday credit. The second group is formed by USA, Bulgaria, Romania, Latvia, Malta and Hong Kong with a preference for costly intraday credit instead.

When comparing these results with the model used in each country, Canada, Singapore, Switzerland, UK and partly Germany are in agreement with their actual design. USA also shows that the system established is precisely the best option. However, the situation of the countries from the EU, especially those that form part of the monetary union is much more difficult to justify. Their system, non marketable collateral, would offer more flexibility for banks but with a greater expected loss for financial authorities. Then, results suggest, as a possible way to improve the expected social benefit the financial system gets from TARGET, that it would be interesting to revise the composition of the list of eligible assets to approach the marketable collateral model..

Appendix

To be completed.

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