Risks in Interlinked Settlement Systems: How to Measure the Impact of Settlement Delay in the Italian RTGS System (BIREL)*

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Abstract

The purpose of this paper is to provide an empirical investigation of settlement delay risk deriving from the coexistence of net and gross settlement systems in national payment systems. We examine the structural link between the Italian RTGS system (BIREL) and the security settlement system (SSS); due to this link, any delay in settling the multilateral balances in the SSS at the designated time during the day would likely result in a settlement delay in the RTGSS. In order to measure the possible costs of a settlement delay, the probability of the event is defined by three elements: the volatility of the time series of the net balances of SSS, the turnover ratio in RTGSS and the historical incidence of failures to settle. Results show that the potential cost is negligible at the aggregate level; nevertheless, there do emerge significant differences among relevant groups of banks in the efficiency of liquidity management.

1 Introduction

The globalisation of intermediaries' activities and markets, technological progress and the development of new financial instruments have posed new policy chal-

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lenges to the stability of domestic financial markets and payment systems. The systemic implications and risks of this rapidly growing network of international payments are of increasing concern. Central banking theory refers to two types of systemic risk, which, though often linked, should not be confused:

- one—the best-known—is that the insolvency or failure of one or more intermediaries will set off a general crisis of confidence, bank runs and a chain of insolvencies and/or failures;
- the other relates to the payment system and to the possibility of a netting system participant being unable to settle its end-of-day multilateral balance, resulting in a chain of defaults by the other members.

Against this background, it comes as no surprise that more intensive use of real-time gross settlement (RTGS) in central bank money throughout the operating day has been the preferred path in all countries for reducing the systemic risk inherent in clearing procedures.

The literature has investigated the risks associated with net and gross settlement systems, but only in the last few years has the debate focused on the difficulties involved in controlling risks deriving from the closer interconnections *between* and *within* national settlement systems. The former mainly involve cross-system settlements for cross-border payments; the latter, the common coexistence of net and gross settlement systems domestically. Owing to these linkages, the control of settlement risk achieved through RTGS could easily be jeopardised by an "imported" settlement crisis, triggered in a linked settlement system with a different timing of intraday finality.

Risks associated with the settlement delay could be amplified in case of *gridlock*. Such a situation ('a case of system illiquidity in which the failure of some transfers to be executed prevents a substantial number of other transfers from other participant banks from being executed')[1] can occur either when the aggregate liquidity is insufficient or when it is 'adequate overall but poorly distributed.'[2] However, a gridlock can occur *after* a settlement delay problem has arisen; it should not be confused with a settlement delay. Operating RTGS systems in industrialised countries, even those without the supply of intraday liquidity (e.g. the Swiss SIC), have experienced no serious problems of gridlock to date.

This paper provides an empirical evaluation of the potential costs of settlement delays in case of problems in linking the Italian RTGS (the BIREL system) and the securities settlement system (SSS), which in Italy is based on designated-time settlement of net positions in RTGS. The explicit inclusion of SSS is a consequence of its relevant share in the present Italian net settlement system (more than half of total payments, by value, channelled through the net settlement procedure).

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[1] BIS, 1997.
[2] Ibidem.

2 A survey of the literature

The debate on risks in large-value payment systems is increasingly concerned with critical factors affecting the functioning of RTGS systems when linked to settlement systems with different timing of intraday finality or with different operating hours and legal rules (Borio and Van den Bergh 1993, BIS 1993). The systematic analysis of "linking problems" for RTGS systems is relatively recent, deriving from the interconnections between national settlement systems for large-value payments (BIS 1996, Lo Faso and Tresoldi 1997). Within an RTGS environment, close interdependency could reduce the effectiveness of the "zero settlement lag" principle, which is pivotal to reducing settlement risk (Schoenmaker 1994): participants may be forced to delay the posting of time-critical payments or, if the RTGSS has centralised queuing mechanisms, the waiting time for payments without cover may increase. Hence, the main risk of linking RTGSS and other settlement systems is a *settlement delay risk*.

Settlement delay cost (SDC) may be due to: i) inadequacy, at the level of the individual bank, of the technical structure or staff needed to optimise the management of incoming and outgoing payments in RTGSS; ii) absence or weakness, at the system level, of mechanisms for improving the transmission network for interlinked settlement systems (BIS 1996). For each participant, a settlement delay in RTGSS affects intraday liquidity requirements; the SDC is one of the two main components of the cost of intraday liquidity, the other being the cost of obtaining liquidity from the central bank (Iwabuchi 1996).

The current literature generally assesses the magnitude of SDC in the framework of a comparison between alternative settlement systems. The analysis is conducted in the framework of micro-founded models where single banks face the problem of minimising the overall cost of their participation in one or both of the settlement systems (net and gross). This cost-minimising approach is useful to capture and model some typical trade-offs of settlement systems, namely between the (costly) holding of intraday liquidity (in RTGSS, in the form of central bank overdraft facilities or idle reserves) and the cost of delaying the settlement of payment orders; or—in different models of RTGSS—between fully collateralized overdrafts with no fee charge and overdraft facilities with fees but no collateral requirements.

Angelini (1994) develops a model based on a trade-off between the SDC and the liquidity maintenance cost and derives equilibrium conditions for a bank's optimal decision on borrowing (or maintaining) reserves at the central bank and delaying payments. He shows that the individual bank's cost minimisation entails externalities owing to which the results of the system deviate from the social optimum. An individual bank may be induced to delay payments at least for two reasons: first, the cost of a delayed payment is paid by the *receiving bank* and not by the *sending bank*; and second, the SDC is not perceived as a cost until the customers' dissatisfaction at the delay impinges on the individual bank's revenue or reputation.[3] 'These effects imply that, in absence of corrective measures, the effectiveness of RTGS systems for the reduction of risk in financial market transactions, which constitutes their main attraction, may potentially be impaired.'

A detailed analysis of the cost components of net and gross settlement systems is provided by Schoenmaker (1995), who explicitly makes it part of an investigation of 'the merits and problems of alternative settlement arrangements.' Schoenmaker recognises that 'payments might become increasingly time critical in a (future) real-time gross settlement environment. Receiving banks or customers might need to raise liquid funds to bridge the period from the time at which payments are expected (or contractually agreed to be made) to the time at which they are actually made.' 'Moreover, the time of settlement needs to be stipulated ex ante for certain transactions, e.g. delivery-versus-payment transactions.'

Like for the other cost components, Schoenmaker examines the SDC both from a 'private' and a 'social' point of view. 'The likelihood of settlement delays for any bank depends on the level of payment reserves of that bank ... divided by its payment flow (i.e. the inverse of the *turnover ratio*)...: the lower the level of payment reserves (i.e. the *higher* the turnover ratio), the more and longer the expected settlement delays ... moreover, it is assumed that the SDC will rise at an increasing rate, as it will become increasingly difficult to avoid serious settlement delays when reserves drop to very low levels.' Thus, 'the private SDC is an increasing and convex function of the turnover ratio,' which is tantamount to stating that 'the level of payment reserves is the relevant decision variable for banks.' Since pledging collateral or maintaining reserve balances is costly, 'there is a trade-off between the cost of reserve holding and the SDC.'

According to Schoenmaker, the 'social' nature of SDC simply stems from the aggregation of individual delays, and therefore can well be represented by gridlock. He provides no explicit formulation or measure of SDC deriving, at the aggregate level, from linkages either between or within settlement systems.

Kobayakawa's model (1997) investigates two broad questions, namely i) 'how two RTGSS (the 'EU-type' and the 'US-type') affect the profit of each participant' and, ii) the 'economic rationale behind the coexistence of the RTGS and the net settlement systems in the single economy.' His analysis of the SDC takes into consideration the cost of customer dissatisfaction, like Angelini: if one of two banks involved in a simultaneous payment 'fails to carry out its obligation on time, the counterpart will face a tighter liquidity position, which can lead to the following problems. Until the counterpart receives the payment, all the payments in subsequent periods may face a higher chance of being cancelled. Should any payment be cancelled, the banks will again incur the cost of customer dissatisfaction .... In the US-type RTGS system, the overdraft is explicitly charged fees. In the EU-type, if [a bank] fails to overcome its overdraft position, the collateral can be distrained. In this case, the bank may have to incur an additional cost solely as a result of the settlement delay.' In the individual profit maximisation,

[3] For the analysis of 'reputation' see also Mengle-Vital 1991.

delaying the settlement is a possible equilibrium outcome, 'depending on the relative effect of two variables: the fee charged by the central bank and the amount of reserves banks hold initially.' It turns out that in the EU-type RTGSS equilibrium is settling with no delay, while in the US-type framework 'there can be an incentive to free-ride on the incoming payments, thus being able to avoid overdrafting.'

The trade-off between the contagion risk and the opportunity cost of higher liquidity, and hence between net and gross settlement systems, is analytically addressed in the model developed by Freixas and Parigi (1997). They analyse the features of net and gross settlement systems within a Diamond-and-Dybvig-style model of financial intermediation. They explicitly consider net and gross settlement systems separately; the authors propose to derive the relation between the two analytically, namely as a function of frequency of the clearing moments.

Considering the nature of RTGS for large value payments, the micro-founded perspective developed by the literature underscores the analysis of incentives to co-operative behaviour among participants aimed at reducing settlement delay risk. In fact, in actual large value payment systems there is a substantial overlap between the customers and the suppliers of wholesale payment services, so that membership size might identify a 'club,' or a set of clubs among homogeneous banks. From this perspective, an empirical assessment of settlement delay risk for the system is necessary in order to measure the actual overall cost of immediate finality for time-critical payments in different national settlement systems; this approach still needs to be developed.

3 Cost of settlement delay in RTGS systems

The methodology adopted here is intended to provide an empirical assessment of the settlement delay cost. According to Schoenmaker (1995), a settlement process may involve three types of cost: i) settlement failure; ii) pledging collateral and iii) settlement delay. The overall cost of a settlement crisis should equal the sum of the three costs, even if only the first and the last are relevant in the case of linking problems. Schoenmaker proxies the probability cost of a settlement failure of a participant in a net settlement system by the average annual bank failure rate, defined by the assets of failed banks as a percentage of total assets. However, he provides no analogous criterion to proxy the probability of a settlement delay in presence of linkages between real-time gross and securities settlement systems. These links are relevant for RTGS systems which are commonly used to settle the final balances of netting procedures at designated times during the working day. This is the case for the Italian SSS, which adopts a DVP approach of model 3 as classified by the BIS (1992).[4]

[4] The BIS identifies three common structural approaches or models for achieving DVP (or, more generally, for linking delivery and payment in an SSS): model 1, gross-to-gross (transfer instructions for both securities and funds are settled on a gross basis); model 2, gross-to-net (transfer

The structural link between RTGS systems and SSS implies that any delay in settling the multilateral balances of the netting system would very likely result in a settlement delay in the RTGS system. The possible consequences include:

- a *weakening of the risk control* achieved through real-time settlement (zero settlement lag, immediate finality);
- a *higher cost of intraday liquidity* for RTGS participants and/or
- a *reduced velocity of circulation* of bank reserves.

In the present analysis the cost of a settlement delay equals the amount of negative final balances of SSS multiplied by the probability of settlement delay. This measures the *maximum cost of delay* (MDC) in the SSS-RTGSS link, which can be expressed as:

$$\text{MDC} = Mbal * P \qquad (1)$$

where *Mbal* represents the simple mean of daily net outflows of the cash leg of SSS in the period, that is

$$Mbal = \sum_{g=1}^{G} Y_g \,/\, \text{G} \quad \text{for } \text{Y}_\text{g} = \text{the } \text{g}^{\text{th}} \text{ - day negative balances and g = 1, ..., G.} \qquad (2)$$

In order to evaluate the *maximum* cost of the delay, no correction is made in (1) for the concentration of net outflows among individual banks. If the debit position in SSS is concentrated in one or few participants, the negative externalities related to settlement delay might be significant; in this case the central bank might be asked for intervention. In (1) the concentration ratio is implicitly assumed to be 1 (the extreme hypothesis).

The likelihood of a settlement delay due to difficulties in settling the cash leg of SSS in RTGSS can be influenced by:

- the volatility (CV) of negative final balances of the cash leg of securities transactions: the higher the volatility, the greater the difficulties in funding unexpected debit positions;
- the ratio between the flow of payments and utilised reserves (*turnover ratio*, V): the higher the ratio, the lower the waiting time in queues of entered payments;

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instructions are settled on a gross basis for securities, on a net basis for funds); model 3, net-to-net (transfer instructions for both securities and funds are settled on a net basis). The scope of the present analysis falls within the last two 'models.' In fact, a settlement delay can occur when a participant in a net settlement system for securities transactions fails to settle its final balances on time, either in cash or in securities. The same problem could arise in linking two net settlement systems, one for the transfer of securities and the other for the transfer of funds.

- the ratio between the number of daily failures to settle and the number of negative daily balances of the whole netting system (*settlement failure ratio*, sf).

Therefore *P*, the probability of the settlement delay, can be expressed by the following function:

$$P = f\,(\underset{+}{CV},\ \underset{-}{V},\ \underset{+}{sf}) \qquad (3)$$

where *P* depends positively on the volatility of the final balances,[5] negatively on the turnover ratio.

The turnover ratio *V* is very important in RTGS systems since its level is associated with the duration of queued payments. A high level of V is associated with the possibility of minimising the waiting time in queues of entered payments in RTGSS. With $V \to \infty$ the duration of queued payments tends to zero and the likelihood of a settlement delay is very low. Hence, from the *system perspective* the likelihood of a settlement delay is a *negative* function of the turnover ratio. The rationale for this approach is related to the very functioning of the real-time gross settlement system with costly overdrafts. If the liquidity needed for a given payment 'traffic' is very high, the RTGS system is not working efficiently; the liquidity, that is the collateralized overdrafts to be refunded to the central bank, is either poorly distributed or costly.

In (3) the aggregate approach to V differs from Schoenmaker's analysis, which refers to the point of view of a *single participant*.[6] Moreover the turnover ratio in (3) can be measured as flows of payments on *utilised* funds, and not only on *available* funds, in order to identify groups of banks with significantly different performance in the management of daily settlements.[7]

The term *sf* in (3) considers the influence on the probability of settlement

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[5] According to McAndrews and Wasilyew (1995), the direct link between the variance of the amounts of payments and the systemic risks in payment systems can explain the risk of settlement failure in a multilateral net settlement system; they consider also the influence of other variables, namely the number of participants in the netting scheme and the extent of their interaction ('i.e. the connectivity of the network').

[6] In Schoenmaker, the probability of settlement delay is a direct function of the turnover ratio since the higher the amount of *available* funds of each participant, the lower the risk of settlement delay. See Schoenmaker (cit.), pp. 11-14.

[7] For this purpose, V can be decomposed into:

V = (RISd / RISu) * (NBA / RISd) * (FP / NBA)

where RISd and RISu are, respectively, the available and utilised reserves, NBA is the simple mean of the negative daily balances of the clearing system as a whole in the period and FP is the flow of payments (gross inflows + gross outflows) in the period. Such a decomposition connects the assessment of the likelihood of delays with that of the efficiency of banks in managing liquidity and payment flows. The ratio between available and used funds identifies banks with idle reserves: the higher the ratio, the less efficient the management of liquidity. The second ratio measures the weight of the negative balances on the available funds: NBA relative to RISd is an indicator of the relative incidence of the negative balances on the possibility to settle them in time. The third ratio simply explains the importance of the NBA in the flow of payments of each participant in the payment system.

delay of actual number of delays in settling the cash leg of SSS. Thus, even if the time series of the negative balances is a constant (CV = 0) and therefore perfectly predictable, *P* is positively influenced by *sf*.

4 Data

The empirical investigation of the potential costs of settlement delays is based on daily data. The analysis uses the final balances of the cash leg of SSS, recorded in the Banca d'Italia PSDB (Payment System Data Base) for each participant. The period covered by the analysis runs from the inception of the Italian RTGS system (26 January 1998) to the end of June.

The Italian gross settlement system for large value payments, BIREL, which enables Italy to participate in the European Union's TARGET system, is used to settle the balances of the clearing system (BICOMP), which handles retail transactions and the cash leg of the securities settlement procedure (Figure 1). In its first five months of operations BIREL handled a daily average of more than 45,000 transactions, with a value of more than 130 billion euro with an average waiting time for queued payments of less than two minutes (Figures 2 and 3).

The clearing and settlement of securities transactions are carried out by means of a nation-wide system (Liquidazione dei Titoli - LDT) owned and managed by the Banca d'Italia through seven clearing houses, which are part of the Bank of Italy's own organisation. Participation in LDT is allowed only to banks and non-bank intermediaries (securities firms and stockbrokers). It is compulsory for participants in the clearing system to maintain securities accounts both with the central bank (for government securities) and with the Monte Titoli (for other securities; Figure 1).

Figure 1: The Italian payment and settlement system

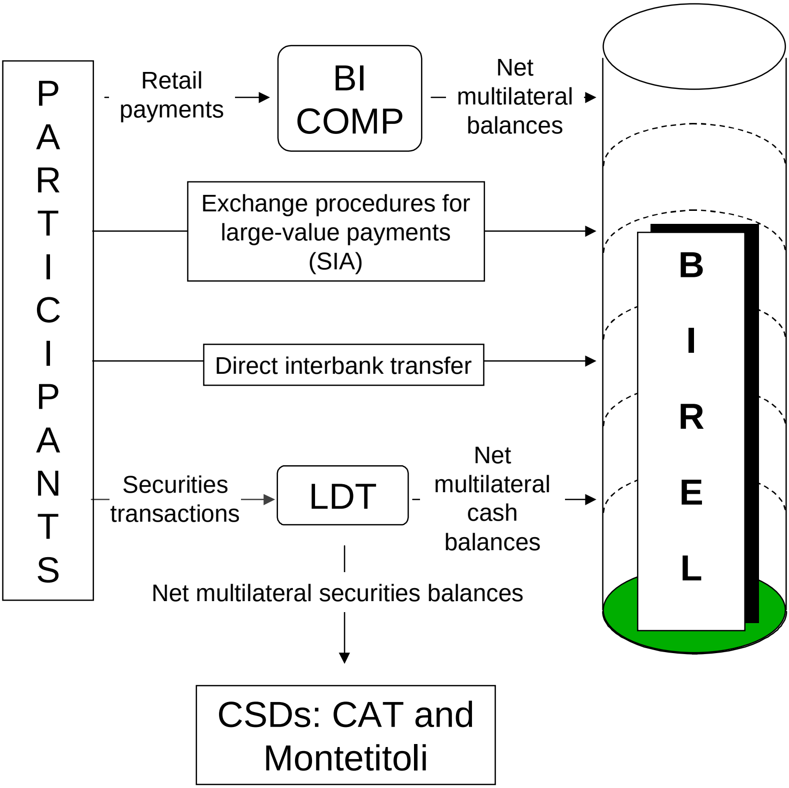


Figure 2: Settled payments per hour

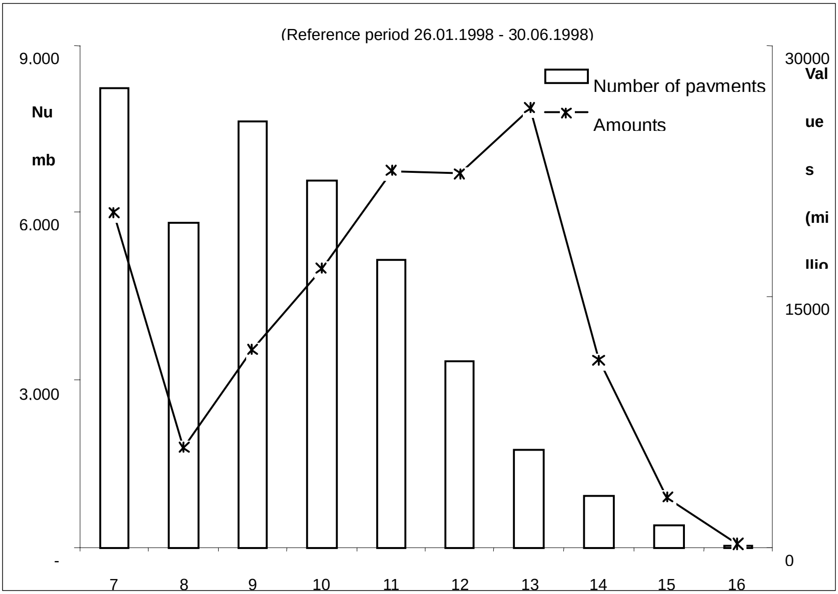
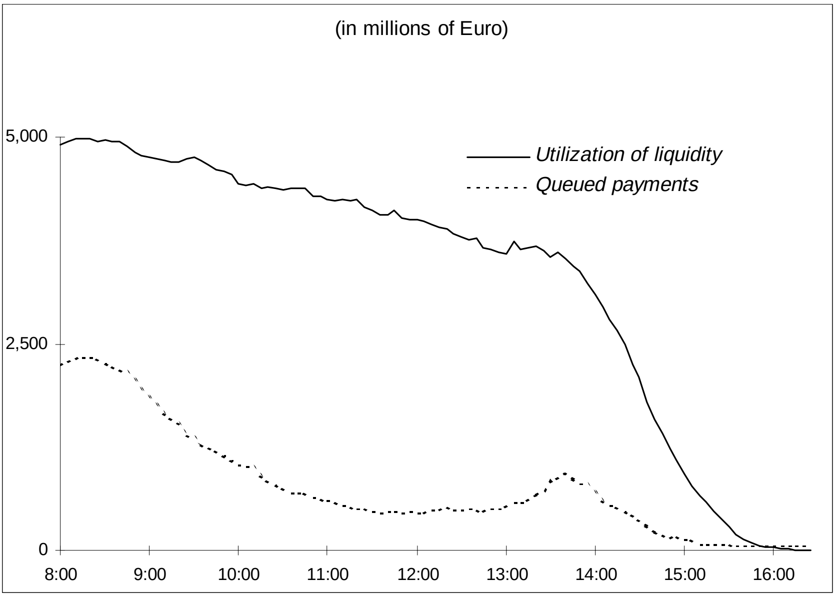


Figure 3: Queued payments and intraday liquidity utilization during the day



Member institutions of the system can carry out all types of operation (outright purchases and sales, repurchase agreements, free-of-payment deliveries, securities lending). The balances in securities resulting from multilateral clearing are automatically sent to the two central securities depositories—Monte Titoli and Banca d'Italia's CAT procedure—and settled by way of book entries in the accounts opened at LDT participants. Cash balances are automatically forwarded to the clearing of bank items and settled along with other banks' credit and debit positions. As only banks are admitted in the clearing procedure, non bank-participants have to designate an agent bank to pay and receive these balances on their behalf. Since February 1996 the Italian SSS has worked on a daily basis: all securities are traded on a rolling settlement basis, with different maturities depending on the type of security; for instance Treasury bonds are settled at T + 3, whereas listed shares are settled at T + 5.

The structure of LDT allows participants to know their final balances on the afternoon of the day before the settlement day, giving them time to turn to the money market to procure the cash and the securities they need to cover debit positions. This advance notice should reduce the effect of the volatility of final balances; in practice, however, the effect of unexpected balances is hardly eliminated during the settlement day, owing to the lack of a well organised system for securities lending and of a real-time gross delivery versus payment mechanism (DVP model 1) for government bonds. Hence, even if final balances of SSS are known the day before the settlement, the probability of a settlement delay is related to the forecastability of final balances over a longer time-period than one day.

Considering the time series of data in both the Italian SSS and RTGS system, the probability *P* can be proxied by:

$$p = \mathrm{CV/V} + \mathrm{sf}. \tag{4}$$

The term *1/V*, the inverse of the turnover ratio, is extremely low, always less than 0.1: the payment 'traffic' per unit of available reserves is high, which reflects an efficient timing of incoming and outgoing payments during the day. Also *sf* is well below 0.1; this variable is relevant only for specific groups of banks, mainly the domestic branches of foreign banks. Given the structure of the Italian securities market, the *CV* in (4) is calculated for three time extensions (one week, two weeks, one month) in order to consider the main factors affecting banks' management of the final balances of SSS: the weekly payments' flow, the bi-weekly auctions of Italian Treasury bonds, and the monthly trend of financial markets.

The analysis is referred to both system data and two homogeneous groups of participants in the SSS, namely the top 20 credit institutions by SSS volume (more than 70 per cent) and the domestic branches of foreign banks. The first group includes essentially the main Italian banks; considering the size of these institutions it can be of interest to see how far the delays in SSS are counterbalanced by the arrival of funds from the other procedures of the RTGSS. The second group is very important for the particular activity in the Italian payment system. Each domestic branch of foreign banks usually presents: (very) low amounts of funds on the central bank's accounts; structural dependence on the home-office for financial assistance and consequent greater exposure to different kinds of settlement risk.

Size indicators of these groups of banks are presented in Table 1.

5 Results

The main results are presented in Tables 2 and 3, which report respectively the factors affecting the probability of settlement delay *p* and the *estimated maximum settlement delay costs* MDC for the Italian SSS-RTGSS link.

As for the CVs, the adoption of two time-extensions, 5 and 30 days (the 15-day horizon is not reported, as the results do not differ significantly from those of the 5-day CVs), highlights two kinds of differences, attributable to *seasonal effects* and to *operational features of* the selected groups of banks, respectively:

i) CV5 are generally (and significantly) greater than CV30, due to the strong intra-month effect stemming from the bi-weekly auction of short-term Treasury paper. On average, the amount of securities settled in the LDT system in the auction days is three times as great as on other days. On a 30-day basis this intra-month seasonal effect obviously disappears;

ii) the CV of debit balances of Italian branches of foreign banks is the lowest, even if their securities market activity is as large as that of the major 20 Italian banks. As expected, anyway, the difference with the major 20 banks decreases as the time extension increases.

The operational peculiarities of Italian branches of foreign banks in comparison with other banks, however, are reflected by the inverse of the turnover ratio (*1/V*) and by the settlement failure ratio (*sf*). The lower *1/V*, *ceteris paribus*, signals higher efficiency in the management of liquidity. On the other hand, the higher settlement failure ratio of the branches of foreign banks reflects their well-known dependence on funds deriving from currency and foreign exchange activity to settle the daily LDT net balances.

Table 1

Main balance sheet items of the Italian banks (*)

(period: 26.1.1998 - 30.6.1998)

Groups of banks	Loans		Deposits		Interbank liabilities		Intermediated funds	
	Absolute values	%	Absolute values	%	Absolute values	%	Absolute values	%
First 20 banks	505,411	45.1	452,126	49.9	65,224	45.3	1,100,921	44.5
Branches of Foreign Banks	21,556	1.9	2,229	0.2	14,851	10.3	82,558	3.3
System	1,121,129	100.0	905,980	100.0	143,870	100.0	2,476,395	100.0

(*) Averages of end-of-month data - billions lire

Italian payment system: Flows of funds (*)

(period: 26.1.1998 - 30.6.1998)

Groups of banks	SSS: LDT flows				RTGS: BIREL flows		Net settlement: BICOMP flows	
	cash leg		securities leg					
	Absolute values	%	Absolute values	%	Absolute values	%	Absolute values	%
First 20 banks	31,372	40.8	88,291	47.8	189,275	64.3	17,234	34.6
Branches of Foreign Banks	27,212	35.4	64,251	34.8	60,085	20.4	3,203	6.4
System	76,926	100.0	184,820	100.0	294,401	100.0	49,817	100.0

(*) Daily averages - billions lire

Table 2: Factors affecting the probability of settlement delay
(period: 26.1.1998 - 30.6.1998)

Groups of banks	*CV5*	*CV30*	*1/V*	*sf*	*Mbal* (*)
First 20 banks	1.076	.528	.054	0	6140
Branches of Foreign Banks	.809	.374	.031	.012	3044
System	1.358	.558	.066	.003	8638

(*) Average of daily negative balances - billions lire

Table 3: Maximum settlement delay cost
(period: 26.1.1998 - 30.6.1998)

Groups of banks	*p5*	*p30*	*MDC5* (*)	*MDC30* (*)
First 20 banks	.058	.028	356	172
Branches of Foreign Banks	.036	.023	110	70
System	.093	.040	803	346

(*) billions lire

On the whole, from a *macro-perspective* the maximum cost stemming from a delay in the settlement of the final balances of LDT is generally low if compared with either the gross flow of funds channelled daily through the LDT or the value of the daily payments settled in the Italian RTGS system (Table 1). However, the magnitude of settlement delay cost might become significant if payments become increasingly time-critical in RTGS systems, in particular when the system is used in conjunction with DVP or PVP settlements.[8]

In order to weight the MDC with the duration of the delay, our estimated MDCs should be multiplied by the length of delay in hours and by an hourly interest rate. These *actual settlement delay costs* entail an opportunity cost concept, assuming that the receiving banks or customers need to raise funds to bridge the period from the time at which payments are expected to the time at which they are actually made. In the Italian system, however, the actual MDCs are not significantly different from estimated ones for several reasons.[9] Firstly, the determinants of *p* in (4) include the turnover ratio, which is related to the duration of queued payments. Secondly, as mentioned, the average settlement delay observed in BIREL for large value payments is very low—less than two minutes—due to the structure of the system (centralised queuing mechanism and unlimited supply of intraday liquidity through fully collateralised overdrafts). In fact, the screen-based self-regulated Italian interbank market does not quote intraday liquidity funds. Moreover, according to the main Italian banks, the time-criticality of payments settled in the RTGS system seems to be very low and, up to now, the settlement delays are not perceived as costly by banks and customers.

More interesting indications can be deduced at a *disaggregated level*. On the one hand, the results for *p* show that the two selected groups manage the liquidity needed to operate in the LDT system more efficiently than the other banks and, above all, they are less risky than the medium-sized and small intermediaries, no matter which time horizon is used. This result is reflected in lower CVs and higher turnover ratios, which play the main role in determining *p*. If the longer horizon is selected, i.e. if it is assumed that banks' financial divisions formulate their relevant funding and hedging plans on average on approximately a monthly basis, *p30* tells us that the top 20 and the foreign branches perform very similarly, and differently from the other banks.

On the other hand, extending the time horizon the risk of the Italian branches of foreign banks decreases slightly more than one third, *significantly less* than the top 20 group and the system (which has a reduction of more than 50 per cent). This result is clearly due to their higher settlement failure rate which, in turn, is an operational feature of these intermediaries. For *oversight* purposes, figures of the *Italian branches of foreign banks* seem to indicate that risky positions may be

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[8] The relevance of MDC might grow if Angell's proposal (Angell 1994) for a minute-by-minute daily average reserve requirement were implemented. In this scenario a large negative MDC would significantly lower the daily average reserves of the receiving bank.

[9] The settlement delay interest cost per minute, calculated at the official discount rate (July 1998) of 5% for the maximum estimated MDC (803 billion lire) is negligible (2,300 lire).

assessed and, to some extent, prevented by:

- focusing on different homogeneous groups of banks and
- monitoring the stable time-sequence dependence of their payment and their intraday liquidity flows.

6 Conclusions

Results on the estimated settlement delay cost for the Italian RTGSS in case of a linking problem with the SSS suggest that the worry over a potential disruptive effect of a settlement delay on the functioning of RTGSS, and hence on intraday liquidity costs, need not be very great. Nonetheless, the effect of the interrelationships between settlement systems and the measures to neutralise their potential negative outcomes should represent a major concern for central bankers and individual institutions.

The European TARGET system is structured on the interlinking of the national RTGS systems. In this framework, each European RTGS participant has to manage intraday liquidity flows knowing the interconnections between the open positions (net debit or credit) in each different system settling through the national RTGSS. It is important that the national central banks of the EMU arrange the timing of clearings in such a way that funds received in one system can be used for paying a debit position in another. As a result, the minimisation of settlement delay risk in the European payment system would enhance efficiency.

As noted earlier, the Italian SSS is still not based on a real-time gross approach (DVP model 1). However, according to the international stance on payment systems the Italian central bank is planning to move towards SSSs with a higher degree of intraday finality. In the light of the increasing participation of domestic and foreign intermediaries in domestic systems, the adoption of real-time gross DVP systems, by eliminating settlement risk, might reduce the need for regulations aimed at countering it in the financial markets. However, the implementation of a fully integrated payment system in a global context—for the settlement not only of cash but also of securities on a gross DVP basis—inevitably encounters much greater difficulties mainly owing to heterogeneous operational, legal and regulatory frameworks. The shift of the Italian SSS to a DVP model 1 would require reconsidering our estimate of settlement delay costs, due to the crucial role played by securities markets in our financial system and to the increased probability of gridlock.

Moreover, the introduction of the BI-REL system is very recent, and further empirical research on its main functioning features is highly desirable. Much work is needed, especially at the disaggregated level; empirical analysis of the efficiency of individual banks that play a major role in the management of liquidity would be of great utility for the *oversight* function of the central bank, both at the national and at the international level.

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