Journal of Banking & Finance 34 (2010) 314–323

Contents lists available at ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

Banks' intraday liquidity management during operational outages: Theory and evidence from the UK payment system

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ARTICLE INFO

Article history:
Received 7 January 2009
Accepted 25 July 2009
Available online 6 August 2009

JEL classification:
G2
G3

Keywords:
Payment system
Operational outages
Liquidity sink

ABSTRACT

We investigate how settlement banks in the United Kingdom's large-value payment system deal with intraday liquidity and operational risk. In particular, we are interested in payments behaviour towards a bank that is, for operational reasons, unable to make but able to receive payments. If other banks did not sufficiently monitor their outgoing payments, these operational shocks could impact the entire payment system because the affected bank could absorb liquidity from the system. Our game-theoretic model predicts that only early in the day, when they are uncertain about the payment instructions they might have to execute, banks stop sending payments to a counterparty which is unable to make payments. Using a non-parametric method, we find that this prediction is supported by the data, implying that banks effectively contain the disruption caused by the operational outage: payment flows between healthy banks remain unaffected.

1. Introduction

Intraday liquidity requirements in large-value real-time gross payment systems can substantially exceed the liquidity that its direct members hold overnight on their accounts with the central bank. As an illustration, UK banks' aggregate holdings of reserve balances with the Bank of England fluctuated around £30 billion in 2008, while the daily amount of liquidity that banks pass through the United Kingdom's large-value payment system, CHAPS, was in the order of £250 billion. Effective intra-day liquidity management in these systems is therefore crucial to allow the completion of large transactions such as house purchases, interbank loans, and other financial market transactions. To this purpose, banks recycle liquidity in these systems during the day: that is, they partly rely on incoming funds to settle their outgoing payments.

The IT systems that member banks use to access large-value payment systems are occasionally affected by operational problems. These member-level operational outages are of concern to central banks (who oversee payment systems) particularly because they can inhibit the efficient intra-day recycling of liquidity. Not only can prolonged outages lead to a misallocation of liquidity between banks: they can ultimately also damage the stability of the financial system.[1] The reason is that a comparatively common class of operational problems prevents the affected bank from sending payments but not from receiving payments on its account with the central bank. There is therefore a risk that the bank experiencing operational problems involuntarily absorbs liquidity and becomes a 'liquidity sink'. The liquidity that the affected bank holds becomes unavailable for the settlement of payments between other, healthy settlement banks. Thus, if (healthy) banks fail to sufficiently control their intraday liquidity requirements, operational risk at one bank can be a source of systemic risk.[2]

We investigate how settlement banks[3] in CHAPS react to outages experienced by another CHAPS settlement bank. Our aim is to improve our understanding of how banks manage intraday liquidity risk, and to assess the systemic importance of member-level operational outages.[4]

We first build a game-theoretic model in which a bank's decision to make payments depends on whether another bank experiences operational problems, and on the time of the day at which

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[1] Hasman and Samartin (2008) develop a model where payment systems propagate financial crises through bank runs.

[2] Manning et al. (2009) provides a recent overview of the theory and policy questions that central banks face in the area of large-value payments and settlement.

[3] Settlement banks are direct members of the payment system and settle payments on behalf of their clients (consumers, corporates and banks without direct membership). In the following, we use the term settlement bank and bank interchangeably.

[4] See also Cummins and Embrechts (2006) for an introduction into a special section on operational risk in the Journal of Banking and Finance.

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doi:10.1016/j.jbankfin.2009.07.024

the problems arise. To our knowledge, this is the first paper to analyse how banks' reaction to operational outages changes during the day. Our model addresses two questions: How does the possibility of member-level outages affect equilibrium behaviour throughout the day? How is behaviour affected when an outage occurs? Our answers are as follows: First, operational risk makes it more costly for banks to delay (even non-urgent) payments. This is simply because banks risk not being able to make these payments at all should their own IT systems suffer from operational problems later in the day; and failing to make payments by the end of the day would trigger the bank's default. Second, and more importantly, when an outage occurs, banks stop paying to a bank that suffers from operational problems early in the day, when they are still uncertain about their payment flows, and hence their liquidity needs. Towards the end of the trading day, when there is no further uncertainty regarding payment flows, healthy banks make payments even to a bank that suffers from operational problems (henceforth referred to as the 'stricken' bank).

Next we test these predictions using eight operational outages experienced by direct participants in CHAPS in 2007. We apply an econometric approach suited to the analysis of irregularly spaced high-frequency transaction level data, following Engel and Russell (1998). In particular, this approach does not require aggregating data in arbitrary fixed intervals. This is important for this study because the average length of outages in our sample is about 1 h, varying between 2.30 h and 16 min. Further, this method allows to apply non-parametric techniques that provide a full picture of changes in payment activity before, during and after outages.

In line with the theoretical predictions, we find that healthy banks reduce their payment flows to a stricken bank. This decline continues on average until about one hour into the outage. The reduction is considerably more pronounced if the outage occurs in the morning rather than in the afternoon. Last, we find that this precautionary delay of payments enables healthy banks to continue paying other healthy banks as they would have in the absence of an outage. Put differently, good intraday liquidity management avoids that the operational shock becomes a source of systemic risk.

The paper is organized as follows. Section 2 provides a brief overview of related literature. Section 3 presents the theoretical model; Section 4 the empirical results. Section 5 concludes.

2. Related literature

Game-theoretic models of behaviour in large-value payment systems (such as CHAPS) predict that the timing of payments in real-time gross settlement systems is the result of banks trading off delay costs with liquidity costs. The argument runs as follows. Intraday liquidity can be drawn from two sources: (1) from the central bank (the settlement agent in CHAPS) against collateral; (2) from incoming payments. In the first case, the cost of liquidity is the opportunity cost of having to hold (and transfer) securities eligible as collateral. In the second case, banks may not receive sufficient payments in time to execute their payment instructions promptly; delay, however, could be expensive when contractual obligations or market practice are violated. As banks seek to minimise the cost associated with sending payments, their choice determines the distribution of payments throughout the day.

The starting point of our theoretical model is Bech and Garratt (2003). In their model, high liquidity costs encourage banks to delay payments, awaiting the receipt of incoming payments to fund their outflows. We retain their assumption that there are two banks that pay each other but increase the number of periods in which settlement banks can make payments to each other to three (morning, afternoon, and evening) to be able to describe the incentive to delay payments in the morning and the afternoon. To be able to analyse why they react differently to shocks in the morning and the afternoon, we further extend their analysis: we allow operational shocks to occur in each period; that banks do not know all their payment instructions at the beginning of the day; and we distinguish two types of payment instructions, 'normal' and 'urgent' ones.

Angelini (1998) considers the behaviour of banks with both liquidity and delay costs in a RTGS system. In a model with two banks, who regard their incoming payments as exogenous, he shows that banks will delay payments somewhat, balancing delay costs and the costs of a daylight overdraft. Mills and Nesmith (2008) and Khan et al. (2003) consider the effect of settlement risk[5] on timing decisions. They illustrate another rationale for delays: uncertainty about whether the other participants might either default or delay can prompt the participants to delay their payments to obtain a better forecast of the cost of funding their own outflows. Mills and Nesmith's (2008) model differs in two aspects. First, their model only contains one operational shock; given that our aim is to see how a bank's response depends on the time at which the shock occurs, we need at least two. (One in the morning, the other in the afternoon – an additional third shock in the evening provides banks with an incentive to pay in the afternoon rather than wait for the evening.) Second, we need two payment instructions that differ in their urgency to explain why a stricken bank's response depends on the time of the outage.

Willison (2005) and Martin and McAndrews (2008) also investigate the role that urgent payments play for banks' decision-making behaviour. Their focus is, however, on a different question (how liquidity-saving mechanisms affect settlement); in addition, their models have only two periods, which makes them unsuitable for our task. Devriese and Mitchell (2006) investigate liquidity risk in securities settlement and find that security settlement systems are vulnerable to the default of the largest player. Angelini et al. (1996) investigate corresponding risks of contagion in net payment systems.

A few, so far mostly descriptive, empirical papers analyse payments data in normal and stressed environments. McAndrews and Rajan (2000) document the distribution of the timing of volume and value of payments in the Fedwire Funds Service (a US large-value payment system) using data aggregated within ten minutes intervals. Becher et al. (2008) carry out a similar descriptive analysis for CHAPS Sterling. McAndrews and Potter (2002) estimate the average bank's reaction to incoming payments in Fedwire following the events of September 11th, using a panel fixed effect estimator on minute-by-minute data. Armentier et al. (2008) evaluate the relationship between liquidity costs (proxied by payments values and volumes) and the timing distribution of Fedwire Funds transfers using hourly data.

Klee (2008) estimates the impact of *inferred* operational outages on the federal funds rate. Klee does not study the impact of operational outages on banks' payment behaviour. In the absence of data on these outages, Klee proxies them by unusually long intervals in which a bank did not send payments to its counterparties. Klee conjectures that operational outages have an effect on money market rates because the stricken bank becomes a liquidity sink which creates aggregate uncertainty on the level of balances available in the system. While this appears to be a reasonable interpretation for the large system she is investigating (Fedwire has over 9500 participants), we show that this conjecture does not hold for the considerably smaller CHAPS, which only has 15 members. CHAPS member banks cut their payment flows to a stricken bank

[5] Settlement risk is the risk that a payment instruction that a client sends to a bank is not executed.