Chapter 4
Simulation Approaches to Risk, Efficiency, and Liquidity Usage in Payment Systems

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ABSTRACT
Payment systems constitute a critical aspect of modern economic infrastructure; yet understanding the payment system mechanisms remains elusive in the face of rapidly evolving financial markets and intricate institutional linkages. Computer simulations of payment systems have proven useful in determining optimal balances of risk, efficiency, and liquidity usage. Constructs such as gridlock-resolution algorithms and liquidity-saving mechanisms are now routinely applied in such areas as optimization of liquidity and payment delay, but can also be used to assess potential impacts of changes in policy or system setups. In addition, simulations can be extended to incorporate behavioral elements of participants by modeling their behavior with Agent-Based Modeling (ABM). The 2008 global financial crisis has increased interest in simulations to identify and quantify risk, particularly where new channels of contagion and complex interlinkages of markets and payment systems are involved. Payment system simulations offer central bank authorities broad possibilities to improve their risk monitoring and should be incorporated as a standard part of financial stability analysis.

DOI: 10.4018/978-1-4666-2011-7.ch004
INTRODUCTION

Nearly all transactions in advanced economies today are settled in payment systems. For this reason, payment systems are a critical part of the economic infrastructure (Kokkola, 2010). Boasting order-of-magnitude improvements in speed, reliability, and efficiency, and vast leaps in interconnectedness, payment systems have evolved so radically in just a few decades that they defy traditional methods of analysis (Manning, Nier, & Schanz, 2009). The good news for those involved in oversight of payment systems is that they can be treated as deterministic sets of logical rules or flows of discrete events processed according to given rules that lend themselves readily to computer simulation.

Simulation analysis of payment systems is especially useful in cases where the timing or exact outcome of the settlement process needs to be known. Applications fall into three categories: liquidity analysis, identification, and quantification of risk, and evaluating the impacts of rule changes or system setup.

In the following discussion, we review the current state of computer simulation of payment systems, including some of the operational aspects of simulations with payment system data, and offer some considerations on simulation design.

BACKGROUND

Liquidity is a central concept in the analysis of payment systems. We define it as the capacity of a payment system to settle payments. Such liquidity may come from various sources, including balances at the central bank account, incoming payments, and intraday credit. The lack of liquidity can delay settling of payments between parties, so sophisticated algorithms have been developed for managing payment systems during episodes of low liquidity. The practice of netting (i.e. offsetting incoming and outgoing payments within a certain time period), for example, allows a payment system operate at lowered liquidity levels. Here, we use intraday liquidity as defined by the Bank for International Settlements (BIS, 2001).

Efficiency and adequate safety margins are key in defining an appropriate level of liquidity in a payment system (BIS, 2001). An efficient payment system is typically seen as one with low liquidity requirements and settlement costs. Efficiencies in this respect can often be gained by adopting straightforward practices such as netting of payments (BIS, 1990). A safe payment system, in contrast, must be sufficiently robust to overcome events where a share of system participants is temporarily affected by low liquidity or breakdowns occur in the settlement process.

Speed of settlement is affecting the efficiency and risks in two ways. Faster final settlement may decrease the accumulation of risks. It will also directly decrease the delays of settlement and enhance the circulation of money. Thus with improved speed, the payment system can be seen more efficient in its basic task. However, increased speed of settlement typically decreases the efficiency of liquidity use. As an example, RTGS (Real-Time Gross Settlement) payment systems are geared to minimizing credit and settlement risk but participants in RTGS system must provide more liquidity for the settlement and thus sacrifice liquidity efficiency for the sake of safety and decreased delays. Optimizing the efficiency of systems creates tradeoffs between risks, liquidity consumption and delays and the policymaker must decide where to place the emphasis in the design of the payment system (Leinonen & Soramäki, 2003).

Not surprisingly, much of current payment system modeling aspires to optimal satisfaction of safety and efficiency requirements (Chiu & Lai, 2007). A popular theme, exemplified in Europe’s TARGET2 system (Kokkola, 2010), is integration of multiple payment systems into a single platform to take advantage of economies of scale. Like RTGS, the emphasis remains on robustness and
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