Chapter 82
The Use of Simulations as an Analytical Tool for Payment Systems

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ABSTRACT
Simulations are among the analytical tools in payment systems analysis. They can be used to overcome epistemological weaknesses of models and calibrations, and they are virtual experiments that do not affect the real performance of payment systems. The chapter is intended to give an inside view into the use of simulations as an analysis tool for payment systems as well as settlement systems. Section 1 highlights the basic features of payment systems in order to explain the usefulness of, and the most important questions addressed by, simulations. Based on these features, an epistemological assessment of simulations versus other analytical tools will show the range and limits of simulations (section 2). Following the historic development, the use of simulations for functional development will be explained in section 3, before dealing with oversight aspects (section 4). Finally, in section 5, the authors list a couple of practical tools to do simulations and to discuss tendencies in simulation tools and speculate on the future direction of research.

1. BASIC FEATURES OF PAYMENT SYSTEMS
The economics of payment systems requires a sound knowledge and understanding of institutional features. Payment economics mainly deals with features that were formerly subsumed under the term “transaction costs.” Without transaction costs such as costs for searching, transferring, monitoring, bookkeeping, etc., neither the existence of money nor that of payment systems would be explainable. Therefore, economics of payment systems deals by definition with deviations from a pure economic theory in the sense of an Arrow-Debreu-World. In addition, knowledge of institutional features of payments system is at the very heart of it. Therefore, we will first have a look at the prominent features of payment systems in our times. Thereby, a first idea about the complexity of real existent payment systems and the considerable amount of variations may come up.

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1.1. Settlement Procedure

The settlement procedure is the core of a payment system. It defines how the incoming payment orders are settled. The possible choices can be ranged on a continuum from delayed net settlement to gross settlement. Gross settlement means that the settlement of incoming orders is done individually, one by one. Net settlement, however, implies the netting of at least two (at least partially) offsetting orders. In an extreme version, all payment orders for a day are collected and cleared altogether, and the net demands are settled at the end of a day. Net settlement requires less liquidity since usually many offsetting payments occur. It incurs, however, higher risks, since the whole bilateral credits could be at stake in case of a failure before settlement. Therefore, net settlement requires complex risk management schemes. On the other end of the continuum is a pure Real Time Gross Settlement (RTGS), which can be understood as settling all payment orders immediately after submission and with ultimate finality. This reduces the risk of settlement failures significantly, requires, however, a lot more liquidity, particularly when offsetting payments are unevenly distributed over the day.

RTGS has become the dominating settlement procedure in Large Value Payment Systems (LVPS) where the settlement risk is more prominent due to the higher value and urgency of the payments. In 1985 only three central bank operated RTGS systems, ten years later already sixteen, mainly industrialized countries, used RTGS, by the end of 2006 the number had risen to 93 (CPSS, 2005; Bech, et al., 2008) and in 2008 the World Bank counted 112 RTGS-systems out of 142 payment systems (Allsopp, et al., 2008). Retail Payment Systems (RPS), however, still settle mainly with net settlement procedures.

Between the two pure procedures, many hybrid versions are conceivable and some of them are realized: e.g. RTGS with liquidity saving mechanisms, and RTGS with bilateral or multilateral netting procedures that leave unsettled payments in a queue. These last schemes, if the procedures are executed very frequently, are known as continuous net settlement.

1.2. Governance

The higher the risks the more prominent is the role of central banks in payment systems. Central Banks are able to provide the ultimate settlement asset (central bank money) which in normal times does not bear a significant credit risk. Therefore, most LVPS and also some RPS settle in central bank money. Moreover, central banks have a decisive role in most LVPS, be it as operator, owner or overseer. This is warranted since the provision of the ultimate settlement asset creates a link for central banks between its role in payment systems and its functions in monetary policy and financial stability.

Some payment systems are settled in commercial bank money and are operated and owned by private institutions. They are, however, also subject of payment system oversight.

1.3. Systemic Interdependencies

LVPS are important financial infrastructures, and most other financial infrastructures rely on them. Foreign exchange settlement systems, security settlement systems, central counterparties and settlement banks, retail payment systems and sometimes other large value payment systems depend on LVPS. Frequently, LVPS also rely on other financial market infrastructures, such as security settlement systems that may play an important role in collateral management for liquidity provision.

1.4. Liquidity Provision

The operator of payment systems especially of LVPS faces several options about the intraday credit and liquidity: Whether or not they shall
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