Modelling Payments Systems: A Review of the Literature

Jonathan Chiu and Alexandra Lai

All non-barter economic exchanges have to be settled by a transfer of funds from the buyer to the seller. Payment systems are the infrastructure that facilitates these transfers. While policy-makers care about the efficiency and stability of payments systems, guidance from economic theory has, until recently, been limited. Standard models abstract from the mechanism through which payments take place and, thus, are not suitable tools for studying payments systems. Recently, a large body of economic research, drawing on techniques and insights from existing monetary, banking, and industrial organization theories, has been developed on the modelling of payments systems. A working paper by Chiu and Lai (2007) provides a non-technical review of this literature. This article summarizes that paper.

Methodology and Questions

Most modern payments systems are characterized by systems of economic transactions settled by payment instruments (such as cash and cheques) and institutions (such as banks and clearing houses) that facilitate the clearing and settlement of these instruments. The nature of payments systems therefore depends upon the instruments chosen and the structure of the institutions. This combined interest in instruments and institutions has important methodological implications. It implies that the use of payment instruments and institutional arrangements should be treated as an endogenous outcome in models of payments systems. For this reason, one of the emerging fields of research attempts to develop internally consistent, general-equilibrium models to analyze the roles of alternative payment instruments and institutions in facilitating trades. These are theories of rational, strategic agents, which explicitly model the underlying transactions of goods or financial assets that generate the use of the payments system.[1]

What key questions does the existing economic literature address? First, researchers ask, What are the fundamental frictions (such as informational or legal imperfections impeding the functioning of markets) that underlie the use of payment and settlement arrangements? Given those frictions, how should payments systems be structured to mitigate their effects? What efficiency-enhancing roles should central banks play in the payments system? What is the optimal design for large-value payments systems that allow the transfer of large, time-sensitive payments between banks and other financial institutions?

Fundamental Economic Frictions

The recent literature argues that *limited enforcement* and *limited information* are the two key microeconomic frictions that explain why particular payment arrangements are essential to an economy. Limited enforcement refers to a situation where some agents can default on their obligations at little or no cost. Limited information refers to a situation where some agents have limited or no knowledge about the current and/or past actions of other agents. To understand the consequences of these frictions,

1. In sharp contrast, the "practitioner-oriented" literature, based, for example, on payments-system simulators, takes the historical data on payment submissions as inputs, without modelling the behaviour of system participants. See Arjani (2005), Arjani and Engert (2007), and McVanel (2006) for examples of, and references for, this line of research. The academic literature also contains partial-equilibrium analyses that abstract from the underlying economic activities and focus on the interactions between participants within a payments system. Our literature survey also reviews this latter line of research.

it is useful to examine the reason for the circulation of a commonly used payment instrument—paper money.

Why would a seller be willing to give up valuable goods or services in exchange for an intrinsically worthless piece of paper that does not yield direct consumption or production value? In an ideal world with perfect enforcement and information, all trades could be facilitated by credit arrangements based on trust and reputation, and outside money would have no role. In the absence of enforcement and perfect information, however, trust and reputation cannot be maintained, and the use of money as a payment instrument can facilitate trade and improve welfare. In particular, by offering money to a seller, buyers are able to signal that they have supplied goods or services to other agents in the past. At the same time, sellers are willing to accept money because they anticipate that they will be able to use this instrument in the future to communicate the same information. As an information instrument, money therefore serves as a reliable indicator of a buyer's trading history. Kocherlakota (1998) shows how money plays the role of *memory* in a world of otherwise anonymous buyers and sellers.

The frictions of limited information and enforcement also make periodic settlement of private liabilities essential.[2] The need for periodic settlement is not obvious, since it merely involves the transfer of settlement assets between participants, without actually improving social welfare. In an ideal world with perfect enforcement and information, default would not be a concern, and thus it would be efficient to allow agents to accumulate obligations over time, as long as settlement occurred at some time in the future. In this case, efficient arrangements would not involve periodic settlement other than a lifetime budget constraint. When there are informational and enforcement frictions, however, agents are able to, and may have incentives to, default on obligations. In this environment, periodic settlement helps to reduce the net gain from default by limiting the obligations an agent can accumulate over time. Koeppl, Monnet, and Temzelides (2006) illustrate how periodic settlement with sufficiently high frequency can induce agents to fulfill their payment obligations and improve economic efficiency.

The Structure of Payments Systems

How should payments systems be structured to deal with these fundamental informational and enforcement frictions? Why do some banks use correspondent services provided by other banks, an arrangement that creates a tiered structure? Such structures are present in the payments systems (large-value as well as retail) of most industrialized countries.

In Canada, both the Large Value Transfer System (LVTS) and the Automated Clearing Settlement System (ACSS) exhibit a high degree of tiering. At the top of the hierarchy are settlement institutions (for example, a central bank) that provide settlement accounts to participants that connect directly to, and clear directly in, this "first-tier" network. Some of the participants that clear directly with the central bank act as settlement agents that operate a "second-tier" network. They provide settlement accounts to downstream institutions that clear and settle payments indirectly in the payments system.

Are there any economic explanations for this tiered structure? While the presence of economies of scale in the provision of payment and settlement services is one potential explanation, the fundamental frictions discussed above may also play a role. Kahn and Roberds (2002) argue that the tiered structure can be an optimal arrangement in an environment with limited enforcement and limited information. In the presence of these frictions, default of obligations is a concern, and some banks may be more likely to default than others. In this case, efficiency requires that either a central bank or private banks perform costly monitoring of risky banks. If private banks incur lower monitoring costs than the central bank, it is efficient for "low-risk" banks to undertake peer monitoring of "high-risk" banks. But since monitoring activity is not perfectly observable, incentives to monitor must be provided by making these low-risk banks bear the burden of defaults by high-risk banks. As a result, it is desirable to have a tiered structure of settlement in which low-risk, first-tier banks settle their transactions directly with the central bank, while high-risk, second-tier banks settle through reliable banks

2. For example, credit card transactions settle monthly, while interbank transactions settle daily.

that act as their settlement agents and their monitors.[3]

The Central Bank's Role in Payments Systems

Theory generally suggests that central banks may have a comparative advantage in two main payments system functions. The first is the management of the accounts that participants own and use to settle transactions. Central banks are suited to this role because of their trustworthiness and public policy mandate. The second is the supply of very short-term credit (e.g., intraday credit) to intermediaries to facilitate settlement, or to facilitate the resolution of settlement disruptions. In a world with limited enforcement and information, the provision of cheap central bank credit may distort private sector choices by inducing participants to take excessive risks and overuse central bank credit, leading to the so-called "moral hazard" problem. This potential moral hazard problem may provide a rationale for a certain degree of central bank oversight of the payments system.[4] To deal with this problem, central banks are increasingly requiring collateral for such credit.

The Design of Large-Value Payments Systems

There is also a growing literature that examines the design of large-value payments systems with regard to settlement rules, pricing, credit policy, and risk control. At the core of these issues is how the system should trade off the cost of liquidity against the risk of settlement failure. For example, some of the theoretical work compares two extreme designs of payments systems: real-time gross settlement (RTGS) and (uncollateralized) deferred net settlement (DNS). In an RTGS system, funds are transferred between participants on a real-time and gross basis. In a DNS system, funds are transferred with a delay, and gross payments are netted against each other, with only the net balances having to be settled. In general, the literature finds that the key trade-off between these two types of settlement systems is the cost of intraday liquidity and payment postponement associated with RTGS and the cost of potential default and contagion associated with DNS. Furthermore, this trade-off will depend on intraday credit policies and on other system policies, such as risk management and collateral requirements, that affect the cost and size of potential default. Therefore, the optimal design of settlement systems requires joint consideration of these policy instruments.

Conclusions

The main lesson we have learned from the literature is that payment instruments and institutions emerge in the presence of fundamental informational and enforcement frictions. Therefore, the analysis of payments system policy should take these frictions into account in order to make robust and reliable predictions.[5] Moreover, the behaviour of system participants should not be taken as invariant to changes in policy, information technology, and other aspects of the environment. To study the full effects of policy, we need to better understand the underlying trading and banking activities that generate the use of payments systems.

References

Arjani, N. 2005. "Simulation Analysis: A Tool for Examining the Balance between Safety and Efficiency in Canada's Large Value Transfer System." Bank of Canada *Financial System Review* (December): 55–63.

Arjani, N. and W. Engert. 2007. "The Large-Value Payments System: Insights from Selected Bank of Canada Research." *Bank of Canada Review* (Spring): 31–40.

3. Another aspect of the tiered structure is the competition between clearing agents and indirect clearers in the retail market for payment services. See Lai, Chande, and O'Connor (2006) for a theoretical model of this issue.
4. Green and Todd (2001) argue that the rationale for more extensive provision of services by central banks will depend on whether or not there are economies of scope between such additional services and the central bank's basic settlement account function.
5. For example, a policy-maker who intends to regulate the high degree of tiering in a particular payments system should consider the underlying imperfections in enforcement and information, as well as the potential monitoring function provided by this structure.

Chiu, J. and A. Lai. 2007. "Modelling Payments Systems: A Review of the Literature." Bank of Canada Working Paper No. 2007-28.

Green, E.J. and R.M. Todd. 2001. "Thoughts on the Fed's Role in the Payments System." Federal Reserve Bank of Minneapolis *Quarterly Review* (Winter): 12–27.

Kahn, C.M. and W. Roberds. 2002. "Payments Settlement under Limited Enforcement: Private versus Public Systems." Federal Reserve Bank of Atlanta Working Paper No. 2002-33.

Kocherlakota, N.R. 1998. "Money Is Memory." *Journal of Economic Theory* 81: 232–51.

Koeppl, T., C. Monnet, and T. Temzelides. 2006. "A Dynamic Model of Settlement." European Central Bank Working Paper No. 604.

Lai, A., N. Chande, and S. O'Connor. 2006. "Credit in a Tiered Payments System." Bank of Canada Working Paper No. 2006-36.

McVanel, D. 2006. "The Impact of Unanticipated Defaults in Canada's Large Value Transfer System." Bank of Canada *Financial System Review* (June): 69–72.