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Modeling, simulation and analysis of a securities settlement system: The case of Central Securities Depository of Mexico

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ABSTRACT

The *Instituto para el Depósito de Valores* (INDEVAL) is the Central Securities Depository of Mexico. It is the only Mexican institution authorized to perform, in an integrated manner, the activities of safe-keeping, custody, management, clearing, settlement and transfer of securities. In this article, we report the modeling, simulation and analysis of a new Securities Settlement System (SSS) implemented by INDEVAL, as part of a project for the implementation of a safer and more efficient operating system. The main objective of this research was to use reduced amounts of cash and securities, within reasonable periods of time, for the settlement of securities of the Mexican market. A linear programming model for the netting and clearing of operations was used. The performance of the new SSS was evaluated by performing experiments using a deterministic simulation model under different operation parameters, such as the number and monetary value of transactions, the time between clearing cycles and also under a new set of rules for pre-settlement operations. The results presented may be used by other Central Securities Depositories to make decisions related to the efficient and safer use of their resources. The implementation of the model took more than three years. Now many transactions that would remain pending if processed individually are settled together, thus reducing liquidity requirements dramatically –by 52% in cash and 26% in securities.

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Modelado, simulación y análisis de un sistema de liquidación de valores: el caso del Depositario Central de México

RESUMEN

El *Instituto para el Depósito de Valores* (INDEVAL) es el Depositario Central de Valores de México. Es la única institución mexicana autorizada para ejecutar, de manera integrada, las actividades de guarda, custodia, administración, compensación, liquidación y transferencia de valores. En este artículo se reporta el modelado, simulación y análisis de un nuevo sistema de liquidación de valores (SLV) implantado por INDEVAL, como parte de un proyecto para la construcción de un sistema de operación más seguro y eficiente. El objetivo principal de esta investigación fue el de utilizar cantidades menores de efectivo y de valores en el proceso de liquidación del mercado mexicano, dentro de un período adecuado, empleando para ello un modelo de programación lineal para la compensación de valores y efectivo. El desempeño del nuevo SLV se evaluó conduciendo experimentos, utilizando un modelo de simulación determinística, bajo diferentes parámetros de operación, los cuales incluyen el número y monto de las transacciones y el lapso que determinan los ciclos de compensación, así como de reglas usadas en una operación de pre-liquidación. Los resultados generados en esta investigación pueden ser utilizados como referencia por otros SLV para tomar decisiones relacionadas con la eficiencia y la seguridad en el uso de sus recursos. La implementación del modelo llevó más de tres años. Actualmente, muchas operaciones que quedarían pendientes de liquidar si se hiciesen en forma individual, son liquidadas en grupo, por compensación, reduciendo dramáticamente los requerimientos de liquidez: en 52% en el caso del efectivo y en 26% en el caso de valores.

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1. Introduction

In Mexico, the public services of safe-keeping, custody, management, clearing, settlement and transfer of securities can only be offered by institutions authorized by the Federal Government. These services are offered by the Central Securities Depository (CSD), which was created on April 28, 1978, as a government agency. In 1987, the agency was privatized and legally constituted as the "S.D. INDEVAL, S.A. de C.V." (from here on, INDEVAL), starting operations October 1st of that year and also serving as a Securities Settlement System (SSS).

To improve the quality of their services, INDEVAL developed a project to re-design their business processes which included the implementation of a new system that takes advantage of the existing technology, increases the security and reliability of their operations and incorporates better industry practices. The implementation of the new system (named Dali) obtained the "2010 Edelman Award" as an outstanding example of the application of Operations Research tools (see Horner, 2010, for details). In this article we report the details on the modeling and simulation of the clearing system that are not reported in Muñoz et al. (2011).

The functional model that was proposed for this project has the following three areas:

- System interaction. This area includes functions that allow the system to communicate with customers, as well as to manage its access security.
- Information management. This area provides the services that INDEVAL offers as a CSD, and directly involves the areas of safe-keeping, custody and management of securities.
- Operations. This functional area constitutes the SSS, which is responsible for processing all the transactions for settlement received by INDEVAL from its clients in the financial system. The SSS is responsible for concluding transactions through transfers of titles and/or cash in the accounts of the clients involved in the operation. For this, the SSS may use support functions such as the clearing of securities and cash.

The problem that constitutes the main object of study for this investigation originates in the functional area of Operations. For a more detailed description of the scope of the first two areas of this project see Romero et al. (2008).

The performance of many of the innovations proposed for the Operations area are not easy to predict since they depend upon a set of operation parameters that must be adjusted empirically. For example, the implementation of a linear programming model (which is described in the INDEVAL's Settlement System section) is proposed for the clearing of securities and cash; whereas, the performance of this model is highly dependent upon both the duration of the cycles between clearings as well as the number and monetary value of the transactions to clear. For this reason, a simulation model was also implemented to determine the settlement instructions that will allow the system to process transactions quickly and efficiently, without the need to insert large amounts of cash into the system. After developing a simulation model for the SSS, the performance of the system was analyzed to determine the values of the operation parameters that work best for the settlement system.

Applying simulation to a SSS may offer several advantages, such as:

- A given SSS becomes increasingly complex due to the adoption of new technology, infrastructure modifications or changes in the behavior of financial markets, increasing the need to study the systems under new operational conditions. This situation highlights the importance of simulation, since it is an effective method to study these complex systems in a reasonable time (Bank for International Settlements, 2005).

- Simulation is capable of replicating a SSS with great precision, using real historic information from the previously processed transactions and incorporating specific operational circumstances in the generated models. On the other hand, simulation also enables us to measure the impact of changing important system characteristics without actually altering the current system. Furthermore, using simulation we can measure and compare different SSS performances, originated by varying several parameters and decision variables that determine its processes (Leinonen & Soramäki, 2003).
- In general, transactions processing is based on a data transfer and management approach, which, in many occasions, does not take into account certain critical factors such as the order in which settlement instructions are executed, the prevalence of certain operations depending on their monetary value in titles and/or cash and the risks associated to their processing, among others. For this reason, simulation may be useful to help in the design and development of strategies for the SSS that integrate data availability as well as specific business criteria and rules, reducing operating costs and risks.
- Simulation models may be used to obtain relevant information regarding risks associated to SSSs, which are usually not reported in the system's operation statistics. Examples of these risks are the effect of flaws in important clients of the financial market, the consequences of credit defaults from the parties involved in the transaction or the impact of rare events such as system malfunction. These incidents are very difficult to analyze without the use of simulation (Bedford et al., 2005).

The advantages previously mentioned justify the use of a simulation model for the SSS to measure the impact on the level of liquidity and the time taken to settle the operations when varying certain parameters of the SSS.

After this introduction, the components of the SSS system for INDEVAL are described in the section on INDEVAL's Security Settlement System. In the section on Simulation of a Securities Settlement System, we describe the relevant characteristics of the developed simulator and then, in the Results Analysis section, we discuss the main results obtained from experimenting with the simulation model. Finally, the paper ends with a presentation of the conclusions obtained in this research.

2. INDEVAL's security settlement system

INDEVAL is a private institution whose stockholders include brokerage firms, banks, insurance and bond companies, Banco de México (The Central Bank of Mexico), the Mexican Stock Market (BMV) and Nacional Financiera (NAFINSA). As the only CSD in Mexico, INDEVAL keeps a deposit of all settlements registered in the Registro Nacional de Valores that are negotiated in the financial markets (Centro de Estudios Monetarios Latinoamericanos and World Bank, 2003).

In Figure 1, we may observe both INDEVAL's functions (encircled in the larger rectangle) as well as the company's interactions with external agents (elements outside the rectangle), which include different institutions (issuers, clients, other custodians and CSDs), trade mechanisms (BMV, trade-floor positions) and payment systems.

The institutions that may interact with INDEVAL include: Banco de México, the Contraparte Central de Valores (CCV), credit institutions, brokers, international custodians, stock markets, bond institutions, stock market specialists, issuers, insurance companies and investment funds.

Trade mechanisms are places in which certain financial operations, such as transactions, stock loans, repurchase agreements (repos) may be arranged. Since these transactions involve the titles

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