BOX II.2

Network Analysis applied to Sistema LBTR

In modern economies, money transfers between financial institutions are carried out through Large-Value Payment Systems (LVPS) which, by using technological platforms operating under strict regulatory standards, allow transactions to be carried out efficiently, safely and without disruptions. From the perspective of central banks, LVPS has implication over the implementation of monetary policy and the financial stability promotion. In Chile, the most important LVPS is the Sistema LBTR (the Central Bank of Chile's RTGS system) and is regulated, managed and operated by the Central Bank of Chile (BCCh).

RTGS systems minimize settlement risk, since the payment is only transferred if the paying participant has sufficient funds in its current account at the Central Bank. However, as they require liquid money in the short term, these systems generate liquidity risk exposures: the participant will not be able to settle a payment if it lacks the funds, even if it expects to have them at a later date. To the extent that this payment is of greater value and is relevant for a larger number of recipient participants, the risk to the stability of the financial system and the overall economy increases. For this reason, central banks around the world, including the BCCh, directly operate RTGS systems and provide a set of tools that traditionally allow their participants to manage their liquidity risks appropriately[1/]. In this context, network analysis has emerged as a useful tool for central banks to guide their management in this area. This Box reviews the application of this kind of exercises to the local banking system and its potential for future development.

If a participant defaults on its payments, it may directly affect the available liquidity of LVPS counterparties that were expecting to receive them. In a worst-case scenario, this could cause a liquidity shock in the large-value payment system that could temporarily hinder or stall the payment chain. Based on their potential to generate liquidity stress in the Sistema LBTR, either because of the liquidity they provide to other entities or because of their degree of connectivity in the payment system, it can be said that there are participants in the payment network with a higher incidence or greater relative importance in the network. In this sense, the participants with the greatest potential to generate stress are those that provide more liquidity to the Sistema LBTR, to a greater number of counterparties.

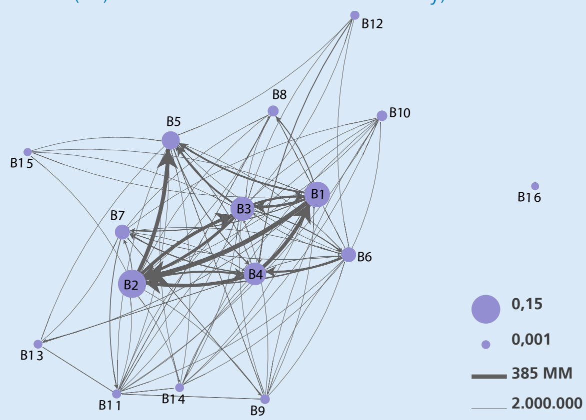
A payment network is formed among the participants of an RTGS system in which payment interactions take place, that are relevant to understand their relative importance within the network. Network analysis makes it possible to identify participants with greater relative importance in the payment system, through the construction of indicators that consider both the value of the

1/ Entities participating in the Sistema LBTR are required to have robust risk management systems to prevent and mitigate this type of exposures. The BCCh has a number of mechanisms to mitigate liquidity risk in the Sistema LBTR, including liquidity facilities for participants through interest - and non-interest bearing loans, the possibility of maintaining payments in a waiting queues in the event of temporary unavailability of funds, access to information on balances and movements, settlement of payments with the BCCh at times favorable to the banks' management (credits at the beginning of the business cycle and debits at the end of the day, allowing the participants to have more funds available during opening hours), the possibility of using cash reserve ratio funding during the day to settle transactions (allowing them to meet the requirement by depositing them at the end of the cycle), among other mechanisms defined in the regulations governing the Sistema LBTR.

payments that the participant transfers to the system and their degree of scope, measured through the Value Index (VI) and the Proximity Index (PI), respectively, among other relevant metrics[2]/. While the VI indicates the proportion of the value of payments made by a bank with respect to the total number of payments settled in the RTGS system, the PI quantifies the number of nodes (banks) existing between the bank making the payment and all the other participants in the system, which allows visualizing the degree of connection of the bank with respect to the rest of the network[3,4]/.

Under this approach, it is possible to build a Relative Importance Index (RII) in the Sistema LBTR, which can be represented as the product between the Value Index and the Proximity Index[5]/. The position of the participants in the network according to their RII can be visualized in Diagram II.3. Note also that the width of the arcs is proportional to the total value of the payments transferred from one bank to another.

DIAGRAM II.3 SISTEMA LBTR PAYMENT NETWORK
(Relative Importance Index (RII) in the Sistema LBTR for one day)



Source: Sistema LBTR.
(*) Bi denotes Bank i participant in the Sistema LBTR. Arc width varies according to settled amounts.

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[2]/ The relevant literature offers a series of additional tools that allow this type of analysis, e.g., LSI (Liquidity Spreading index), Conway's model, Contagion Velocity Indexes and cluster studies, among others. There are also other types of analysis that address the study of the payment network as a whole and not at the participant level (e.g., density index, reciprocity, diameter, or average distance).

[3]/ The distance represents the number of connections that separate one bank from another. For example, if during the day Bank 1 transfers a payment to Bank 2, and Bank 2 to Bank 3, the distances from Bank 1 to Bank 2 and Bank 3, correspond to 1 and 2, respectively.

[4]/ For any bank i, the value index and the proximity index (VI and PI, respectively) correspond to:

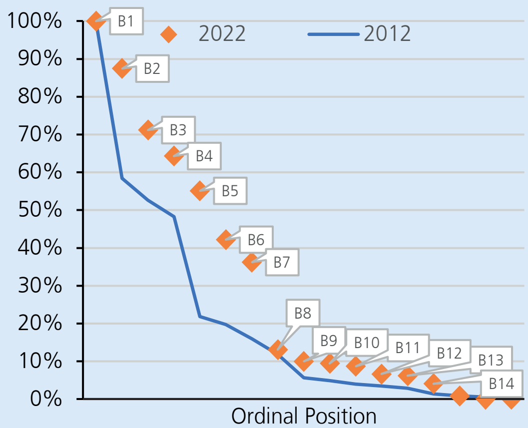
$$IV_i = \frac{\text{Payments settled by Bank}_i}{\text{Total payments settled}} \qquad IC_i = \frac{1}{D_i}\,\frac{I_i}{n-1}$$

Where D_i is the average distance between Bank i and the rest of the participants, I_i is the number of participants with which Bank i connects either directly or indirectly, and n denotes the number of participants in the network.

[5]/ A similar application of this methodology is observed in the document "Topology of the Hungarian Payment System" (Central Bank of Hungary, 2006). Among other research that analyzes the importance of systemic banks in local LVPS from a network analysis there is Baek et. al (2014), Soramäki et al. (2007), Becher et al. (2008), Prepper et al. (2009), Boss et al. (2009) and Embree and Roberts (2009).

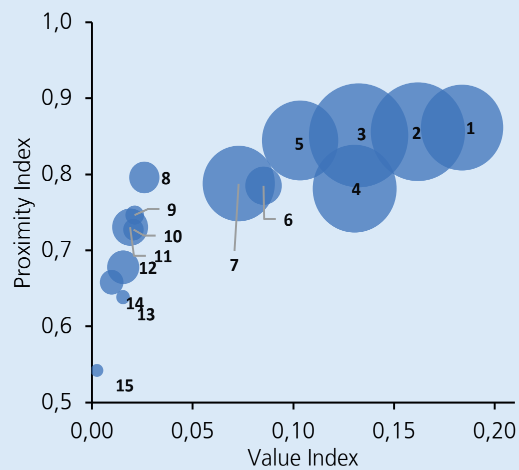
The RII in the Sistema LBTR improves its distribution over time. Figure II.20 shows how the RII is distributed among the different participants in the Sistema LBTR, ranking the banks in descending order from the highest to the lowest index, with bank 1 as 100% and the rest as a proportion of it. In 2012, the bank with the highest RII (bank 1) was considerably distant from the runner-up (bank 2), whose RII was equivalent to 58% of the RII of bank 1. However, this distance shortened substantially in 2022, when bank 2's RII reached 87% of bank 1's.

FIGURE II.20 DISTRIBUTION OF RELATIVE IMPORTANCE INDEX IN 2022 AND 2021
(proportion of Bank 1 index)



(*) Bi denotes Banco i participant in the Sistema LBTR.
Source: Central Bank of Chile.

FIGURE II.21 INDEX RELATIVE TO TOTAL ASSETS
(stock of assets for one month of 2022)



(*) Nro. i denotes Banco i participant in the Sistema LBTR.
Source: Central Bank of Chile and CMF.

This change in the RII's distribution suggests that the Sistema LBTR is a payment network in which the concentration of liquidity risk has tended to decrease. This is so because this risk is distributed among a greater number of participants with similar RII levels. Likewise, in the period analyzed, there is a greater number of interconnections, which can be seen as an additional resilience factor in that the liquidity shortage derived from the unavailability of one participant can be covered by the rest. In part of the literature reviewed, the latter is in contrast with the possibility that more interconnections could also involve a greater risk of propagation in the network in the event of problems in one of the participants.

The magnitude of the value and proximity indexes is generally related to banks' size, measured as a function of the value of their assets, although exceptions are identified. It is these exceptions that are particularly interesting to identify through the methodology proposed in this Box, since it is possible to note the relative importance of entities with respect to their impact on the payment system, beyond the most common metrics such as banks' total assets. For example, Figure II.21 illustrates that the banks located in the upper right quadrant are also the biggest banks, with the exception of bank 7, which, while bigger than bank 5, has a lower VI and is located in the upper left quadrant. The opposite occurs with bank 6, whose size is more or less equivalent to banks 8, 10 and 12, but which nevertheless has higher indexes, with a higher VI, which is more than 3, 4 and 6 times that of those banks of a similar size.

Identifying the participants of greater relative importance in the Sistema LBTR network is important for guiding the monitoring of payment flows among participants. The proper identification of these participants may constitute an additional tool for the BCCh to monitor and manage liquidity risk in the Sistema LBTR, anticipating liquidity needs arising from the unavailability of a participant. Likewise, it could also provide an additional tool for analyzing and identifying local systemic banks[6/]. Methodologies such as network analysis are quite useful to achieve this objective, as they consider both the characteristics of the participant and their relationship with the other participants in the network. It is expected that future reports will deepen the analysis of the results obtained, for example, from the perspective of the main factors underlying the relative importance of banks in the network, other than the size of their assets.

[6/] The systemic importance of banks is evaluated in Chile by the CMF with the favorable opinion of the BCCh following BIS recommendations and in accordance with the provisions of the General Banking Act (Chapter 21-11 of its Recopilación Actualizada de Normas (RAN) - Updated Compilation of Standards). This assessment comprises four factors (size, substitutability, interconnectedness and complexity), each of which is constructed based on a number of additional sub-factors. The analysis presented in this Box relates to the substitutability dimension.