A dynamic approach to intraday liquidity needs

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A dynamic approach to intraday liquidity needs ‡

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Abstract

This paper presents a methodology to estimate the intraday liquidity that systemically important entities (SIE) need to fulfill all its obligations in a timely fashion, when a simulated failure-to-pay from its main liquidity supplier by discretionary concepts of payment occurs. Using the Bank of Finland's simulator and the fund transfer data from Colombian large value payment system, we achieve a dynamic estimation measuring three types of effects (direct, second round and feedback). The results validate the existence of a non-linear relationship between the initial failure-to-pay of a specific institution and extended failures-to-pay to the rest of system. An Intraday Liquidity Sufficiency Index is proposed to quantify the average amount of additional liquidity needed to fulfill timely all SIE's obligations without generating second-round effects. Our methodology and recommendations contribute to the international discussion on management intraday liquidity risk, to efficiency and security of the payment system, and ultimately to financial stability.

Key Words: Large value payment system, intraday liquidity, counterparty stress test, discretionary payments, simulation, direct effect, second-round effect, feedback effect, network topology.

Classification JEL: D53, D85, E51, C63, G21, G23

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1. Introduction

As a result of the growing importance of intraday liquidity risk management there have been significant changes in international regulations. In this regard, is worth noting the consideration of a principle (the eighth) of Basel Committee which states: "A bank should actively manage its intraday liquidity positions and risks to meet payment and settlement obligations on a timely basis under both normal and stressed conditions and thus contribute to the smooth functioning of payment and settlement systems" (CPSS-BIS 2008).

The cited document mentions that the inability of a financial institution to effectively manage intraday liquidity could leave it unable to meet its payment obligations at the expected time, thereby affecting its own liquidity position and that of other parties. First, particularly in the face of credit concerns or general market stress, counterparties may view the failure to settle payments when expected as a sign of financial weakness. They could, in that case, withhold or delay payments to the financial institution that initially failed to meet its obligations and thus cause additional liquidity pressures. Second, it could also cause counterparties unexpectedly short of funds, impair those counterparties' ability to meet payment obligations, and disrupt the smooth functioning of payment and settlement systems. In this sense, given the interdependence that exists among systems, a financial institution's failure to meet certain critical payments could lead to liquidity dislocations that cascade quickly across many systems and institutions.

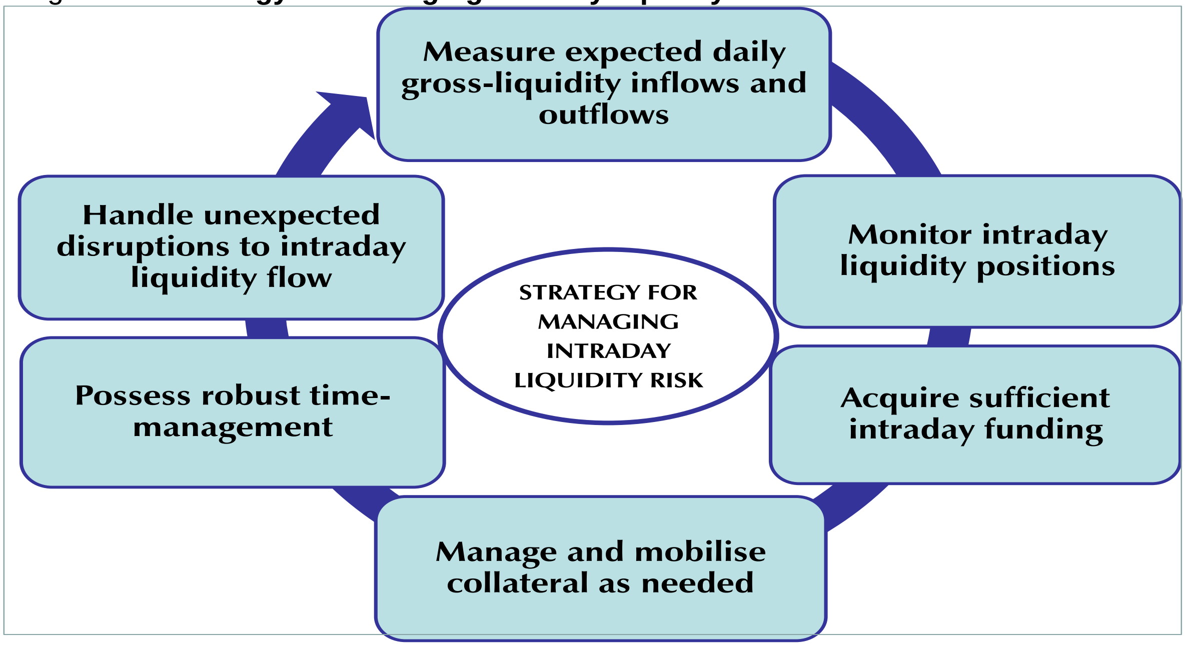
Diagram 1 shows six operational elements that according to the Principle 8 should be included in the strategy management of intraday liquidity.

The same committee issued the document "Monitoring tools for intraday liquidity management" in April 2013. It recommends to have the capacity to monitor the following set of indicators for each participant in the payment system: i) daily maximum intraday liquidity usage; ii) available intraday liquidity at the start of the business day; iii) total daily payments; iv) time-specific obligations or critical time payments; v) value of payments made on behalf of correspondent banking customers and credit lines granted to them; and vi) percentage of intraday payment processing done at specific points throughout the day. It further suggests four possible intraday liquidity stress scenarios to quantify the availability and use of intraday liquidity under conditions of non-normality, one of which is counterparty stress.

In this vein, our purpose is to design and develop a methodology to respond to "how" to address certain recommendations issued by the BCBS-BIS, and more specifically, "how" to implement counterparty stress scenarios in order to quantify reliably the impact and systemic effects of liquidity risk. As an additional product of this document, we formulate effective policy recommendations that could mitigate their potential impact.

Therefore, the developed methodology identifies the systemically important entities and considers their discretionary payments. The discretionary payments, correspond to the transfer of funds for which the responsibility to settle is not exercised by a clearing and settlement infrastructure, but depends on the willingness of the originating entity to make the payment. Among there are uncollateralized interbank loans, for which there is evidence that, in times of crisis, the liquidity vanishes since lending providers for precautionary reasons retain this liquidity source or reduce it.

Diagram 1 – **Strategy for managing intraday liquidity**



Source: Authors based on Basel Committee on Banking Supervision, Monitoring tools for intraday liquidity management.

The proposed methodology let us to answer five questions about the "how" mentioned. The two first related to identification of entities: i) how to select systemically important entities that could be subjected to simulated attacks; and ii) how to identify the main liquidity provider counterparty for discretionary payments for each systemically important entity. And the remaining three about procedures and policies: iii) how to simulate attacks on systemically important entities in counterparty stress scenarios; iv) how to quantify the direct, second-round, and feedback effects; and v) how to establish policies to mitigate the impact of systemic risk caused by stress of intraday liquidity.

2. Theoretical framework

Liquidity is a broad concept, which manifests itself in different ways: i) Market Liquidity that corresponds to the ability to quickly buy or sell without causing significant changes in prices. This is related to the maturity and depth of financial markets; ii) Liquidity funding or financing understood as ability to obtain funds when required to meet obligations; iii) Intraday Liquidity that means the ability to make payments when they are due or to get access to funds during the business day usually to make payments in real time.[1]

Although each of the concepts of liquidity is different from the theoretical point of view, they tend to interact, especially in times of stress. For example, a problem with intraday or market liquidity can quickly become a problem of funding liquidity, or vice versa.

The recent global financial crisis has led to a growing consensus on the importance of liquidity risk management within financial institutions, financial infrastructure, and the financial system as a whole. Within that consensus, the importance of having a stable,

[1] CPSS: Glossary of terms used in payments and settlement systems, March 2003.

reliable, and diversified funding base that contributes to mitigating liquidity risks caused by failures in the interbank market, stock market, and long-term securitizations has been highlighted.

Therefore, international institutions and individual studies have diagnosed and made new recommendations to address the systemic effect of a liquidity crisis. Among these we quote: i) Ackerman (2008), who mentions that as in a market-based financial system liquidity crises are more likely than solvency crises, liquidity management is a better response than higher capital cushions; ii) Tirole (2009) who, considering the systemic risk and under the externality-based rationale, insists that banks have to hold enough liquidity to not expose the rest of the financial system to a widespread crisis; iii) Borio (2009), who said that to better prevent liquidity crises the cushion system needs to be improved and the macro-prudential orientation of regulation and supervision must be reinforced; iv) French et al. (2010), who stated that regulators should enforce and monitor liquidity requirements for systemically important banks and broker-dealers; v) IMF (2010), which says enhancing liquidity buffers and lowering maturity mismatches between assets and liabilities will help to reduce the possibility that an individual institution will fall into liquidity difficulties.

In the same vein, as recognized by several authors (IMF, 2010a; Tucker, 2009; León, 2012), even though a liquidity regulatory framework and some tools for managing liquidity risk exist, they are only at an early stage of development and discussion. In addition, the prevailing concept of liquidity in the literature and in regulation corresponds to the ability to generate cash from the asset and liability positions on institutions' balance sheets (i.e. market liquidity and funding liquidity), so risk management liquidity has traditionally focused on the mismatch between liquid assets and short term liabilities.

Although a consensus on the need to improve the management of liquidity risk became apparent after the 2008 financial crisis, the emergence of a particular type of risk mentioned very little in the past—Intraday liquidity risk—is remarkable.

As a result of the growing importance of risk management, there have been significant changes in the international regulation of intraday liquidity. In this regard, several examples should be noted. One of them, as already mentioned, was the inclusion of a principle (the eighth) which states: "A bank should actively manage its intraday liquidity positions and risks to meet payment and settlement obligations on a timely basis under both normal and stressed conditions and thus contribute to the smooth functioning of payment and settlement systems" in the document entitled "Principles for the management and supervision of liquidity risk" Basel Committee (BCBS, BIS, 2008).

The same Committee in April 2013 issued a document entitled "Monitoring tools for intraday liquidity management" in which they recommended to develop four possible stress scenarios (not exhaustive) to quantify the availability and use of intraday liquidity under conditions of non-normality, one of which is counterparty stress.

Another example is the inclusion of intraday liquidity requirements for financial institutions, banks, and non-banks by the Financial Services Authority (FSA) in the UK. As described by Ball et al. (2011), the new FSA liquidity regime includes intraday liquidity risk as a key factor that requires banks to calibrate their liquidity reserves based on their intraday liquidity needs under normal and stress circumstances.

In Colombia, in particular, the last evaluation done by the IMF and the World Bank (Financial Sector Assessment Program-FSAP, 2013) included recommendations aimed at improving other aspects. One is to tighten liquidity standards for broker-dealers and other non-bank financial intermediaries (NBFIs), and another is to adopt more rigorous stress testing for broker-dealers and other NBFIs.

On October 24, 2013, the Federal Reserve Board proposed a rule to strengthen liquidity positions of large financial institutions. The proposal creates a standardized minimum liquidity requirement for the first time. This requirement applies to both large and internationally active banking organizations, and systemically important non-bank financial companies. These institutions would be required to maintain minimum amounts of high quality liquid assets such as reserves at the central bank, and government and corporate bonds that can be easily and quickly converted into cash to guard against restrictions on funding in times of financial turmoil.

As recognized by Ball et al. (2011), prior to the 2008 financial crisis regulators were not focused on intraday liquidity risk, and there were no standardized measures for monitoring or managing it. Before the crisis, there were only general principles and recommendations (not requirements) with respect to the benefit of a proper management of intraday liquidity. However, even though the crisis revealed the importance of this type of liquidity, this importance arises from the progressive structural change that large value payment systems (LVPS) have experienced worldwide. This has resulted in the transition from a system of deferred net settlement payments to real time gross settlement (RTGS).[2]

The implementation of the RTGS, which consists of continuous settlement (in real time) by transferring funds or securities individually (i.e. one at a time), received intense support from the banking authorities as an effort to reduce settlement risk and systemic risk (CPSS-BIS, 1997). However, mitigating settlement risk occurs at the expense of: i) an increase in the liquidity needs of the entities involved in the payment system, and ii) an increase in the entities' dependency on recirculation liquidity within the payment system, which carries a higher liquidity risk.

As a result of the increased demand for liquidity that an RTGS system causes, participants may choose between the following (non-exclusive) alternative sources to meet payments during the day: i) use the available balance in deposit accounts in the central bank; ii) use the money market (with - without collateral); iii) use central bank liquidity, and iv) use payments received from other participants (recirculation of balances).

The participant's preference for one or more of these alternatives depends mainly on the related cost each one has. In this regard, one participant that seeks to minimize the cost of getting liquidity to meet the intraday obligations prefers a resource that has no cost, such as the use of payments received from other participants (recirculation of balances). A participant's preference for one of the other sources is determined by the trade-off between the opportunity cost of keeping cash in the accounts and the financial cost of

[2] Bech (2008) documents that the number of central banks that had implemented a payment system based on large value RTGS went from 3 in 1985 to 96 at the end of 2006. According to the World Bank (2010), 116 central banks (out of 139) had an RTGS implemented for the payment system. Also 17 central banks in Latin America and the Caribbean with a total of 20 respondents had implemented this type of settlement in their payment systems.

using assets as collateral with third parties such as the central bank and other financial institutions.[3]

Now, while obtaining liquidity by receiving payments from other participants in the system carries no charge, it has the disadvantage of being subject to uncertainty and, therefore, may result in delays in meeting one's own payments. In addition, due to the existence of timing mismatches between incoming and outgoing flows, any tension that exacerbates these mismatches can lead to significant increases in intraday liquidity needs.

Therefore, we can say that the main source of uncertainty with respect to the intraday liquidity needs of a participant in an RTGS system is the timing mismatch between the receipt of liquidity and its use. That is, if the reception is not timely (i.e. the reception does not occur before the entity is required to make payments), the entity may face difficulties in meeting its own payments. This could result in delays in the payment system and negatively impact other participants that, in turn, would not have enough liquidity to meet their payment obligations. This negative externality can lead to higher liquidity requirements for the system as a whole and possibly a higher level of systemic risk.

Once the relevance of the intraday liquidity risk is recognized, a methodological approach to dynamically estimating intraday liquidity needs should be designed and developed. This approach must consider the failure-to-pay (simulated) by the participant's main liquidity provider counterparty through discretionary payments. The purpose of this document is to contribute to this effort.

Simulation exercises were done using the simulator developed by the Bank of Finland BoF-PSS2 and with information on fund transfers that financial institutions make through the Colombian large value payment system (CUD-RTGS).

3. Methodology

In order to follow BIS(2013) recommendations to develop counterparty stress scenarios with respect to intraday liquidity, the methodological proposal described in this document will take advantage of two technical tools—simulation and network topology. While the network topology allows us to identify those critical participants in the system from the point of view of connectivity, simulation enriches the analysis by allowing us to identify and quantify the impacts exerted by the failure to pay and critical entities on the amount paid in the system.

Simulation scenarios were purposefully designed to impact a set of systemically important entities with failures in the delivery of discretionary payments from their primary counterparties.

These scenarios were created considering as opening balances for each entity[4], the existing balance in deposit accounts of the participants in the CUD-RTGS plus the

[3] The cost incurred in participating in systems where the central bank provides liquidity support without a collateral requirement corresponds to setting an explicit fee for overdraft. When it comes to providing collateralized liquidity, this refers to the sum of the opportunity cost of immobilized securities and explicit cost at which the central bank provides that liquidity. The same calculation is applied when estimating the cost of funds in the money market.

estimated minimum intraday balance of local sovereign debt securities (TES) in proprietary portfolio[5] in securities central depository DCV.[6]

The reason for adding the TES balance is that it can be easily converted into cash through the liquidity facilities offered by the central bank as the owner/manager of large value payment system CUD-RTGS and in its task to achieve the payment system's stability. The inclusion of these intraday TES balances rests on the assumption that voluntarily the institutions would use these idle daily minimum balances as collateral to fund their payments.

Diagram 2 summarizes the sequence of steps for the simulation scenario carried out. The information sample that was considered in our analysis corresponds to the fund transfers that financial institutions made through the CUD system for the months of April 2012 and 2013. These two months were used because April 2012 turned out to have a daily average that was the closest to the one calculated for the annual average, and the same month in 2013 was chosen to eliminate seasonality effects.

For the selection of systemically important entities within the universe of participants in the system, we first considered the types of entities with greater participation in the total value of payments sent so that the aggregate reach 85% of the whole system. By this way were selected types of entities such as Commercial Banks (CB), Financial Corporations (FC), Brokerage Firms (BF) and Trust Companies (TC).

Once these types of entities were selected, we proceeded to identify within each type the systemically important entities. The identification procedure combines two criteria, one relative to topology network to capture the importance of the entities in the payments network, and another related to the value of sent payments.

The metric used to capture the connectivity and substitutability of the entities in the LVPS network was the hub centrality index estimated with the HITS (hyperlink induced topic search) algorithm designed by Kleinberg (1998). According to Langville and Meyer (2012), this index has the ability to measure the importance of a node recognizing the interdependent relationship origin-destination that reinforces itself. Therefore, it could be inferred that a central distributor (hub-central) node that will point to the higher authority node, and likewise, a central authority node will be the one receiving connections of the largest distributors.[7]

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[4] Other scenarios were developed taken as opening balances just the existing in deposit accounts in CUD, but their results are not shown in this document because they are considered as extreme stress test, given the possibility that entities have to get additional liquidity with the central bank using their local sovereign debt securities as collateral.

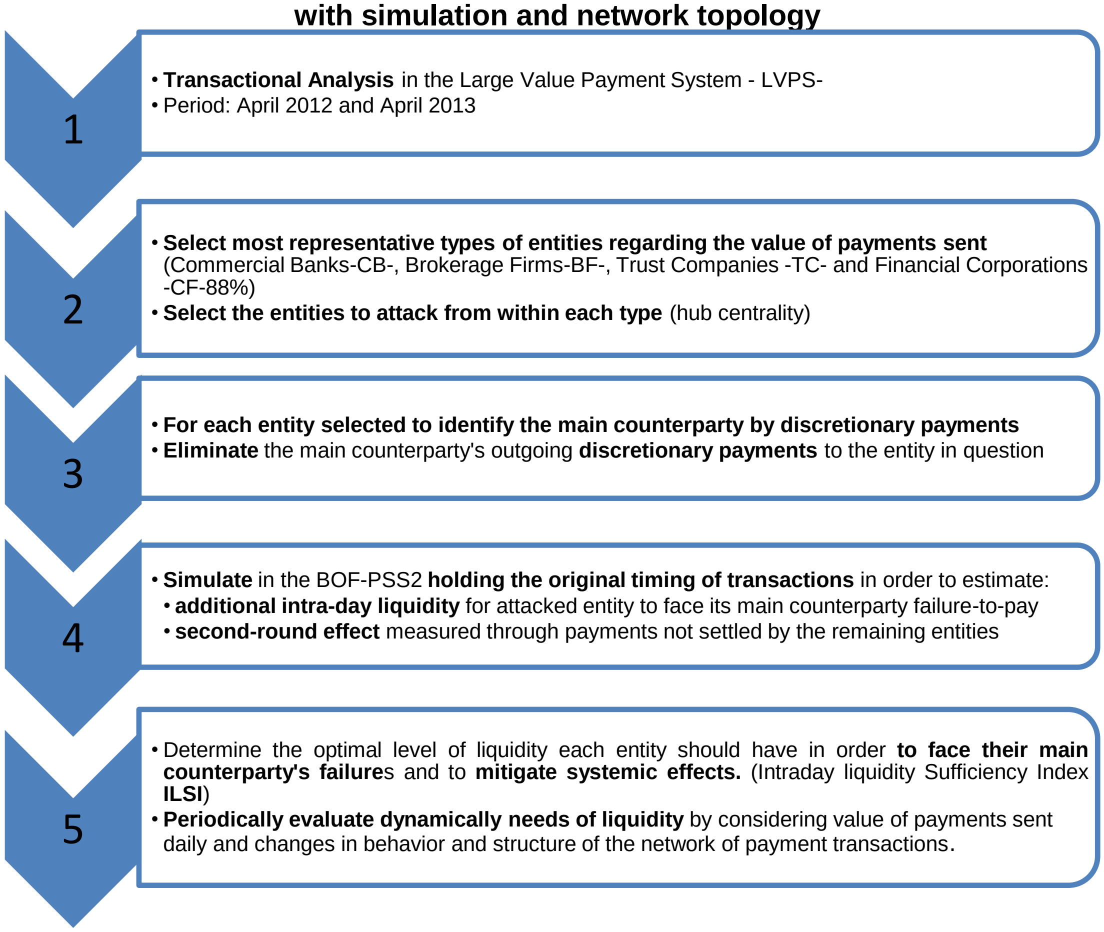
[5] The average haircut estimated to these sovereign bonds was 2.2%.

[6] DCV is central depositary of securities for local sovereign debt, which is owned and managed by Banco de la República.

[7] Leon & Pérez (2013) used the hub-centrality to analyze the centrality in the net exposures in the money market and in the Colombian LVPS.

Diagram 2

Methodology for stress-testing counterparty failures with simulation and network topology



Once we estimated the hub centrality indices of entities inside of each type, we selected those with higher index until completing the 80% of payments sent by the respective group. These chosen entities were subjected to simulated failure-to-pay from its main counterparty by discretionary payment concept. Henceforth we define this failure-to-pay as an “attack”. In this way, as shown in Table 1, the number of participants chosen to be attacked in April 2012 (April 2013) was 31 (27).[8]

To implement the simulated attacks we eliminated the corresponding discretionary payment transactions from our daily payment data sample of CUD-RTGS. This way we built the input information for the simulation exercises done with the BoF-PSS2 simulator under RTGS settlement configuration (1183 scenarios).

[8] Their payments exceeded 75% (72%) of the total excluded from value paid by the National Treasury and Central Bank.

Table 1
Entities Selected for Attack by Type

Institution type	April 2012			April 2013		
	Number of selected entities	% share in outgoing payments		Number of selected entities	% share in outgoing payments	
		By type	Total System*		By type	Total System*
Commercial Banks	10	85.22%	45.4%	9	81.72%	47.6%
Financial Corporations	2	96.41%	8.7%	2	87.05%	6.4%
Trust Companies	11	82.73%	5.6%	9	83.27%	6.3%
Brokerage Firms	8	82.59%	15.4%	7	81.58%	12.6%
Selected entities	**31**		**75.2%**	**27**		**72.9%**

* This does not include outgoing payments from National Tresury or Banco de la República
Source: Authors with information from CUD-RTGS

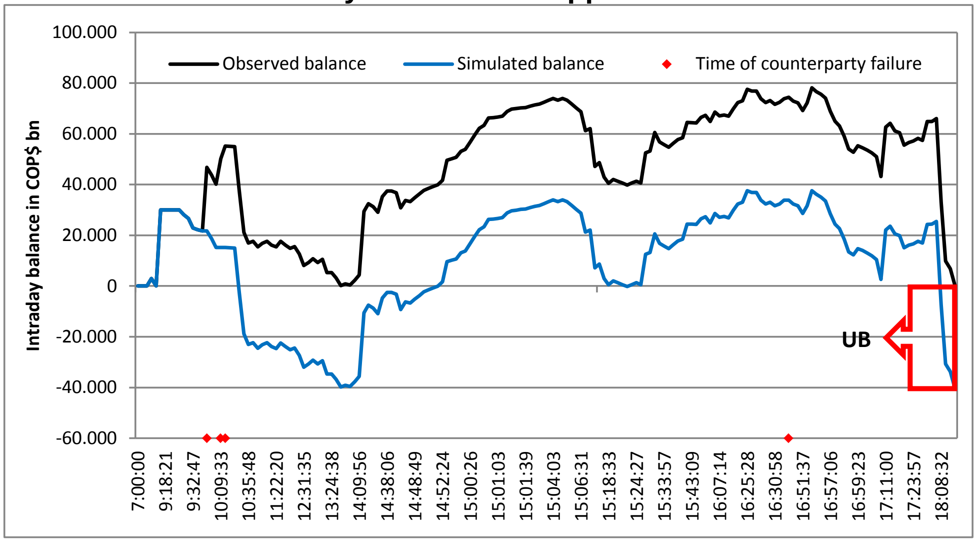
The simulated attack scenarios were carried out against 31 (27) entities for 19 (22) days in April 2012 (2013). From these, it was possible to obtain the value of the payments each participant failed to settle and to calculate the minimum liquidity amount that each one should maintain to settle all its payment obligations in a timely fashion. Koponen and Soramäki (1998) defined this concept as Upper-Bound balance (UB) in equation (1)

$$UB = \min(0; min \sum_{j=0}^{t} P_j^I - P_j^O); \ \ \forall\, t\, [0, T] \quad (1)$$

where P_j^I and P_j^O correspond to incoming and outgoing payments, respectively.

Graph 1 lets us compare intraday paths of observed balance (including TES) with simulated balance of an entity as a product of discretionary payment failure-to-pay (identified by red dots) by its primary counterparty. As can be seen from the observed intraday trajectory, despite having low initial balances, high coordination of incoming and outgoing payments enables the entity to comply with its payment obligations (i.e. intraday balance greater than zero). As this situation vanishes when failures-to-pay are simulated, the simulated trajectory indicates that the entity should get additional resources equivalent to UB

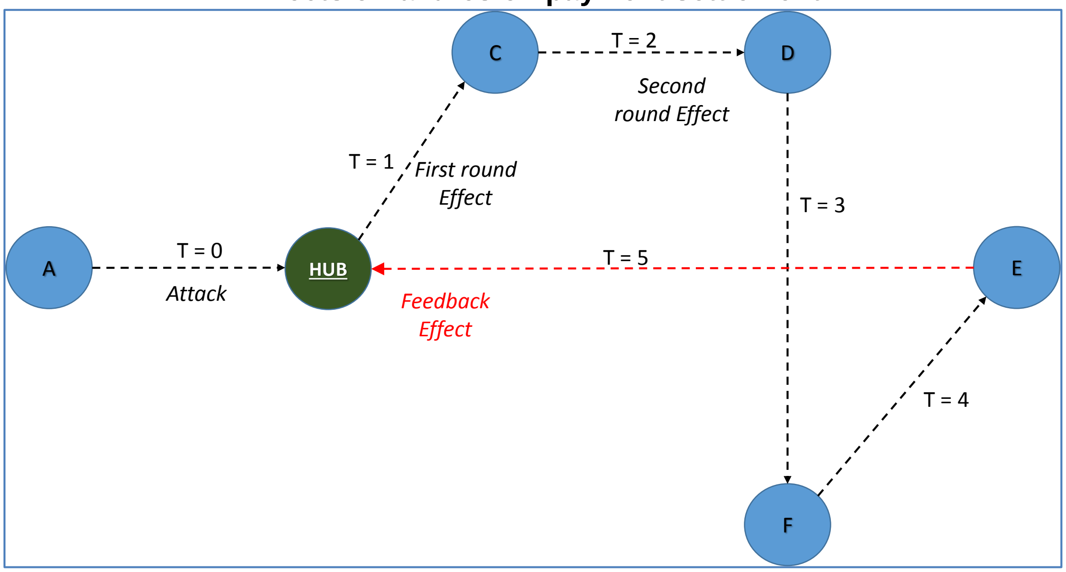
Graph 1
Intraday balance and Upper Bound



Source: Authors

The Diagram 3 exemplified a possible sequence of effects after the simulated attack. The failure to send discretionary payments from the main counterparty (entity A) to one particular entity (entity B) in time T=0, can impede to this latter entity in time T=1 fulfill its payment order to others (direct effect), and thus cause a string of failures to pay affecting other entities (second-round effect) in times T=2, 3 and 4. This failures to pay chain could as consequence of non-settled payments by second-round effect even result in a feedback effect, in which the attacked entity (entity B) as receiver of payments ends up being affected too in time T=5.

Diagram 3
Effects of failures on payment settlement



Source: Authors

Based on these Upper-Bound balances estimated through simulations and on the observed daily opening balances plus the minimum value of local debt sovereign securities (TES), it is possible to establish the percentage by which an entity should increase its initial balance in order to opportunely meet all its mandatory payments. Using these prior concepts, an Intraday Liquidity Sufficiency Index -ILSI- was proposed in equation (2) to measure the ratio between the observed opening balance –OB- and estimated UB balance of each entity j,

$$ILSI_j = \frac{OB_j}{UB_j}\ ; (2)$$

$$so\ that \begin{cases} ILSI_j < 1; & additional\ required\ liquidity\ \ UBj - OB_j \\ ILSI_j \geq 1, & sufficient\ liquidity\ to\ meet\ its\ \ payment\ obligations\ in\ a\ timely\ fashion \end{cases}$$

Note that the value of this index depends on the value and the timing[9] of payments made by each entity and the liquidity available from alternate sources (Bernal et al., 2012).

As the value of UB is highly sensitive to changes in the sequence of payment order (timing), entities with an observed opening balance that is normally much higher than

[9] The "timing" in this context means that the original schedule of payments (observed) holds in the simulation scenarios that imply that we are not assuming behavioral changes of the entities as reaction after the attacks and their effects.

required to meet all their payments promptly (UB), (i.e. high ILSIs) could find themselves unable to meet them. This would be the result of being denied liquidity by simulated failures-to-pay from its counterparties.

The new $\widehat{UB}s$ were estimated using the Bof-PSS2 simulator when the attacked entities experienced the reduction in discretionary incoming payments as a result of failures-to-pay by their major counterparts (Graph 1). Given this scenario, the $\widehat{UB}$ balance of attacked entities shall be,

$$\widehat{\mathrm{UB}} = \min(0; min \sum_{j=0}^{t} \widehat{P_j^I} - P_j^O) = \min(0; \sum_{j=0}^{T} \widehat{P_j^I} - P_j^O);\ \ \forall\ t\ [0, T]\ (3)$$

Where $\widehat{P_J^I}$ is the value of the simulated incoming payments (funds not received from the main counterparty) and P_j^O represents out-going payments (which correspond to all the payments the entity should have sent). In this kind of scenario where just incoming payments were eliminated, it is possible to demonstrate that simulated $\widehat{UB}s$ will be equivalent to the net value of the observed outgoing payments and simulated incoming payments as can be seen in the last part of this equation (3).

Given that the timing of payment orders is decisive in these transfer payment networks, the failure to pay of a participant can spillover failures-to-pay to the remaining participants, increasing the $\widehat{UB}s$. This situation could happen even if the value of payments of one participant is relatively small with respect to the total sent by the system. The systemic impact increases even more if incoming payments constitute the main source of liquidity not only for this participant but also for a large share of their counterparties and other participants.

This analysis allows to quantify intraday liquidity that each financial institution should hold to deal with a failure on the part of its main counterparty liquidity provider without generating effects on whole system. The results of this exercise provide valuable elements that could support the financial authorities' decision-making and the design of macro-prudential policies to mitigate liquidity risk and systemic risk.

4. Results

Due to confidentiality reasons, we summarized the main results obtained from our simulation exercises as averages by type of institution. They reflect the direct, second-round and feedback effects with information from April 2012 and 2013.

For April 2012, Table 2 shows the results of the simulation scenarios are carried out when the minimum intraday TES balance had in proprietary holding was added to the observed opening balance in deposit accounts of the Colombian LVPS to meet its obligations. Lines in shadow gray correspond to simulations which results show the nonexistence of systemic effects, given that attacked entities had enough average liquidity to confront failure-to-pay from main counterparty.

Table 2
Effects of simulated attack on the settlement of payments with observed opening balance + TES (April 2012)

Number of Attacked Entities	Number of days simulated[2]	Amount of liquidity left to receive by attacked entity from its main counterpart		Payments not settled by attacked entity (First-round effect)			Payments not settled by remaining affected entities in the system (Second-round effect)			Payments not received by attacked entity (Feedback effect)			Total average of unsettled payments as % of total payments sent for settlement
		Average daily value (*in thousands of millions of COP$*)	as % of average total value settled in the system	Number of days[3]	Average daily value (*in thousands of millions of COP$*)	as % of average total value settled in the system	Number of affected entities[4]	Average daily value (*in thousands of millions of COP$*)	as % of average total value settled in the system	Number of days[5]	Average daily value (*in thousands of millions of COP$*)	as % of total value settled in the system	
Commercial Banks													
10	19	86	0.23%	0	0.0	0.00%	0	0.0	0.00%	0	0.0	0.00%	0.00%
Financial Corporations													
2	17	35	0.09%	0	0.0	0.00%	0	0.0	0.00%	0	0.0	0.00%	0.00%
Brokerage Firms													
8	19	43	0.11%	12	210.3	0.55%	9	527.2	1.38%	6	12.3	0.03%	1.97%
Trust Companies													
11	18	39	0.10%	12	80.0	0.21%	1	16.8	0.05%	0	0.1	0.00%	0.26%

[1] Hub entity that was subjected to failure-to-pay from its main counterparty by discretionary payment concept

[2] Number of days when simulations were done. For some entities, this number was lower than the observed days in the sample (19 for April 2012), because during some days these entities did not recieve funds by discretionary payment concept from anyone participant.

[3] Number of days when attacked entity was not able to fulfill all its payment obligations after the failure-to-pay from its main counterparty.

[4] Corresponds to the remaining affected entities which did not fulfill some of their payments obligations after the failure-to-pay of the attacked entity.

[5] Number of days when attacked entity did not receive some payment from the remaining affected entities.

Source: Authors' calculations.

For example, Commercial Banks were able to pay all their obligations without generating an effect on other entities (i.e. no direct effect or second round effects) although they had stopped receiving on average COP$86 billion (bn[10]) from its main counterparty daily, which accounted for 0.23% of the average total payments settled daily in the system.

Another type of entity, that with their beginning of day balance plus TES, were able to pay all their obligations timely were Financial Corporations. The amount average of liquidity left to receive by this type COP$35.0 bn, which is equivalent to 0.09% of the daily average total payments settled in the system.

The results for Commercial Banks and Financial Corporations could be explained by the reserves requirement, which these types of entities are subjected.

Meantime, in the same Table 2 as result of the attack, in average the Brokerage Firms stopped receiving from their corresponding main counterparties, a daily average of COP$43 bn during 19 simulated days, representing 0.11% of the daily average total payments settled in the system. As a consequence of not receiving these funds for 12 of the 19 days with simulated failures, the Brokerage Firms could not meet part of their obligations that amounted to COP$210.3 bn as a daily average (direct effect), which represented 0.55% of the average total payments settled in the system daily.

The Brokerage Firms failure generated second-round effects. It affected an average of 9 entities in the system, which in turn were unable to fulfill part of their obligations amounting to a daily average of COP $527.2 bn which represented 1.38% of the daily average total payments settled in the system. Following the same type of entity and as result of the effects mentioned above, we can see that for 6 of the 19 simulated days some entities in

[10] Billions (bn) correspond to nine zeros.

the system failed to send payments that they owed to Brokerage Firms, amounting to COP$12.3 bn (Feedback effect).

As can be seen from our results, an initial minimal failure of COP$43 bn (0.11% of the payments in the whole system) finally generated an extended impact of failures to pay that impeded to settle on average COP$749.7 bn (1.97% of payments settled) in the system. This was due to the concurrency of the three effects mentioned above (direct, second round, and feedback).

In the case of Trust Companies our results show after the attack of its main counterpart, equivalent to an average of 0.10% of total payments sent by the system, that although the three types mentioned effects were generated, its impact on the system was modest, this is on average 0.26% of total payments.

A comparative analysis of our results makes it possible to recognize that by type of institution, Brokerage Firms generate on average the most intense effects on the whole system after the attack[11].

It can be seen that under this scenario, Commercial Banks and Financial Corporations have no difficulty making their payments after the attack of their major counterparties and are, therefore, not generating any effect on the system (direct, second round, and feedback). For Brokerage Firms and Trust Companies, our results show on average by type of entity the existence of direct, second-round, and feedback effects.

These results show that the addition of minimum intraday TES balance to the balance in deposit accounts could to operate as a mechanism to mitigate systemic risk. However, caution is advised because the decision to take the liquidity provided by the central bank depends on the willingness of the financial institution to use this liquidity source.

As for the Commercial Banks, high ILSIs are related to minor impacts on the system. For Trust Companies and Brokerage Firms these relationship does not apply. It could also disrupt payment synchronization given the weight that the funds not received from their main counterparty have as a liquidity source to meet their obligations.

The results of average observed and average estimated ILSIs presented in Tables 3 make possible to recognize the following facts[12].

Based on the observed payment timing, Commercial Banks have on average a daily opening balance that far exceeds the UB balance (i.e. the balance required to settle all of its obligations in a timely fashion) in 117%. By their side, Financial Corporations and Trust Companies had average daily opening balances that barely fit the UB balance. Respect to the eleven Brokerage Firms considered here, the average observed daily opening balance was 18% greater than UB estimated.

As average values estimated by type of entity result from adding individual estimation of entities with high and low balances at the beginning of the day, it is worth to recognize that there could exist entities that because hold liquidity balances very close to UB liquidity would be highly exposed to shortage of liquidity by failure-to-pay of their counterparties.

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[11] For April 2013, in the same terms such entities generated a reduced systemic impact corresponding to an average 0.98%. (See Appendix Table A1)

[12] The results for April 2013 show in Appendix Table A2.

Such situations are unveiled for Brokerage Firms and Trust Companies in Table 3 when failure-to-pay by discretionary concepts were simulated. In effect after the attack during 12 days the estimated ILSIs were on average lower than one for Brokerage Firms (0.449) and Trust Companies (0.380). These results mean additional liquidity needs, that in terms of average weighted by submitted payments are equivalent to 5.5% and 15.6% for Brokerage Firms and Trust Companies respectively.

Table 3
Intraday Liquidity Sufficiency Index (ILSI) and required liquidity to face simulated counterparty failure to pay - April 2012

Number of Attacked Entities	Number of days simulated	ILSI estimated for original observed payments	Simulated attack of counterparty failure with observed opening balance + TES		
			Number of days	ILSI estimated	Additional required liquidity (as % of payment sent)
Commercial Banks					
10	19	2.17	0	>1	0.0%
Financial Corporations					
2	17	1.04	0	>1	0.0%
Brokerage Firms					
8	19	1.18	12	0.449	5.5%
Trust Companies					
11	18	1.08	12	0.380	15.6%

Source: Authors' calculations.

As can be seen, despite the fact that on average Brokerage Firms register observed ILSIs (opening balances observed greater 18% than its UB), once they are subjected to simulated failures-to-pay from their main counterparty, they do not have enough liquidity to comply with their payment obligations. This fact can be explained by i) the timing of the funds that were not received in their payment sequence and ii) the weight that these resources represent with respect to the payment obligations.

Therefore, if each entity remains frozen in its deposit account, as additional liquidity, an amount equal to the average of the resources that by concept of discretionary payments usually receives from its major counterparty, would contribute to mitigate or even eliminate the extended impact of failure-to-pay in the system.

5. Conclusions

As in RTGS requirements of liquidity are high and participant entities rely strongly in incoming funds to support their payments, a singular failure-to-pay between entities could trigger a widen chain of failures-to-pay in the system. Therefore, if participant entities have higher opening balances than required balances to liquidate opportunely all its payment obligations, the extended effect in the system could be mitigated or even eliminated.

In our exercise for the two one-month sample for 2012 and 2013, when the minimum intraday balance of an entity's proprietary position in sovereign securities (TES) in the DCV discounted by a haircut is added to the opening balance in deposit accounts, the results about failure-to-pay extended effect on the system depends on the type of entity. On average Commercial Banks and Financial Corporations would have sufficient liquidity to settle their payment obligations without generating any failure-to-pay impact on the system. Instead Trust Companies and Brokerage Firms, with these balances allow to mitigate but not to eliminate the impact of the failure on the settlement of payments of the entire system.

When we take into account the TES balances above mentioned together opening balance in deposit account, for 2012 (2013) the average minimum liquidity required to fulfill the total payment obligations in a timely manner, as weighted percentage of its submitted payments, would be 15.6% (24.6%) for Trust Companies and 5.5% (8.4%) for Brokerage Firms for 2012 (2013). Note that as intraday liquidity requirements can exceed the estimated "averages" values, systemic effects of individual failures-to-pay of intraday liquidity could still persist.

These facts, together with the dynamic nature and the network structure of this kind of system, make possible to recognize the existence of complexity. These reveal a non-linear relationship between liquidity that has not been received by a particular systemically important participant as a result of the attack and the total liquidity that has not been delivered by the remaining participants.

It is valuable to identify those systemically important entities because if their major counterparties fail to send the discretionary payments, this failures-to-pay to an individual entity could magnify the impact on the liquidity of the rest of the system in a non-linear fashion. Therefore, if each entity keeps immovable, as additional liquidity, the amount of resources that regularly receive by concept of discretionary payments from its main counterparty could contribute to mitigate or even eliminate the systemic impact of failures-to-pay in the system.

As a result of our simulation of counterparty stress scenarios (attack) it is possible to distinguish and to quantify the value of failures-to-pay i) that originated from the entity subject to attack (direct effect); ii) that occurred between other entities (second-round effect); and iii) in which the attacked entity is the recipient of other participants' defaults (feedback effect).

Recognizing the potential effects of network externalities in these systems is valuable because it creates awareness of how an entity's individual actions may cause problems to other participants in the system and, in the end, affects itself. In addition to quantifying the amount of payments that was not received from a primary counterparty, it is possible to estimate how much additional liquidity each attacked entity should have in order to face these failures without causing illiquidity problems to spill over into the system.[13]

As our figures of estimated liquidity requirements to meet these counterparty stress scenarios are the result of estimated average values, it may be the case that the additional required liquidity will not be sufficient in non-typical scenarios. Setting the level of liquidity required to confront these kinds of failure-to-pay situations should, among other

[13] As forthcoming research related to this issue, would be useful carry out simulation exercises to identify effects on the liquidity of each of the participants and the liquidity of the aggregate system when one or more entities considered systemically important (as example hubs) stop sending payments. Another possibility in this area, which could contribute as novel tool for monitoring financial market infrastructure and its participants, would be use network topology to analyze the structure the network of defaults that result from stress-test exercises.

considerations, take into account both the cost of liquidity the participants must incur and the coverage degree desired to shield the system in extreme situations.

Appendix

Table A1

Effects of simulated attack on the settlement of payments with opening balance observed + TES - April 2013

Attacked Entity	Number of days simulated	Amount of liquidity left to receive by attacked entity from its main counterpart: Average daily value (*in thousands of millions of COP$*)	Amount of liquidity left to receive by attacked entity from its main counterpart: as % of average total value settled in the system	Payments not settled by attacked entity (First-round effect): Number of days	Payments not settled by attacked entity (First-round effect): Average daily value (*in thousands of millions of COP$*)	Payments not settled by attacked entity (First-round effect): as % of average total value settled in the system	Payments not settled by remaining affected entities in the system (Second-round effect): Number of affected entities	Payments not settled by remaining affected entities in the system (Second-round effect): Average daily value (*in thousands of millions of COP$*)	Payments not settled by remaining affected entities in the system (Second-round effect): as % of average total value settled in the system	Payments not received by attacked entity (Feedback effect): Number of days	Payments not received by attacked entity (Feedback effect): Average daily value (*in thousands of millions of COP$*)	Payments not received by attacked entity (Feedback effect): as % of total value settled in the system	Total average of unsettled payments as % of total payments sent for settlement
Commercial Banks													
9	22	111.1	0.29%	0	0.0	0.00%	0	0.0	0.00%	0	0.0	0.00%	0.00%
Financial Corporations													
2	17	49.0	0.13%	0	0.0	0.00%	0	0.0	0.00%	0	0.0	0.00%	0.00%
Brokerage Firms													
7	22	60.0	0.16%	15	167.8	0.44%	5	200.3	0.52%	6	4.9	0.01%	0.98%
Trust Companies													
9	21	66.0	0.17%	17	135.9	0.35%	1	17.9	0.05%	0	0.1	0.00%	0.40%

Source: Authors' calculations

Table A2

Intraday Liquidity Sufficiency Index (ILSI) and required liquidity to face simulated counterparty failure to pay April 2013

Number of Attacked Entities	Number of days simulated	ILSI estimated for original observed payments	Simulated attack of counterparty failure with observed opening balance + TES: Number of days	Simulated attack of counterparty failure with observed opening balance + TES: ILSI estimated	Simulated attack of counterparty failure with observed opening balance + TES: Additional required liquidity (as % of payment sent)
Commercial Banks					
9	22	2.77	0	>1	0.0%
Financial Corporations					
2	17	1.10	0	>1	0.0%
Brokerage Firms					
7	22	2.18	15	0.334	8.4%
Trust Companies					
9	21	1.10	17	0.240	26.4%

Source: Authors' calculations.

Bibliography

Ackermann, J. “The subprime crises and its consequences”, Journal of Financial Stability No. 4, September 2008.

Bernal J., Cepeda, F. and Ortega, F. “Estimating the contribution of liquidity sources in the Colombian large-value-real-time gross settlement payment system: A preliminary approach” Journal of Payments Strategy & Systems: Vol 6 No 2. Summer 2012.

Ball A., Denbee, E., Manning, M. and Wheterilt, A. “Intraday liquidity: Risk and Regulation”. Financial Stability Paper No. 11, Bank of England, June 2011,

Capel, J., “The post-crisis world of collateral and international liquidity”, DNB Ocassional Studies Vol.9, No.3, De Nederlandsche Bank, 2011.

CPSS-BIS, “Principles for Sound Liquidity Risk Management and Supervision” September. 2008

CPSS-BIS, “Monitoring tools for intraday liquidity management” April 2013

French, K., Baily, M., Campbell, J., Cochrane, J., Diamond, D., Duffie, D., Kashyap, A., Mishkin, F., Rajan, R., Scharfstein, D., Shiller, R., Shin, H., Slaughter, M., Stein, J., and Stulz, R. “The Squam Lake report: fixing the financial system”, Princeton University Press, 2010.

International Monetary Fund, “Systemic risk and the redesign of financial regulation”, Global Financial Stability Report, April 2010.

International Monetary Fund, “Systemic liquidity risk: improving the resilience of financial institutions and markets”, Global Financial Stability Report, April, 2010a.

International Monetary Fund, “COLOMBIA: Financial System Stability Assessment”. IMF country Report No. 13/50, February 2013

Kleinberg, J., “Authoritative sources in a hyperlinked environment”, Proceedings of the ACMSIAM Symposium on Discrete Algorithms, 1998.

Koponen, R. and Soramäki, K. “Intraday Liquidity Needs in a Modern Interbank Payment System -A Simulation Approach” Bank of Finland StudiesE:14 • 1998.

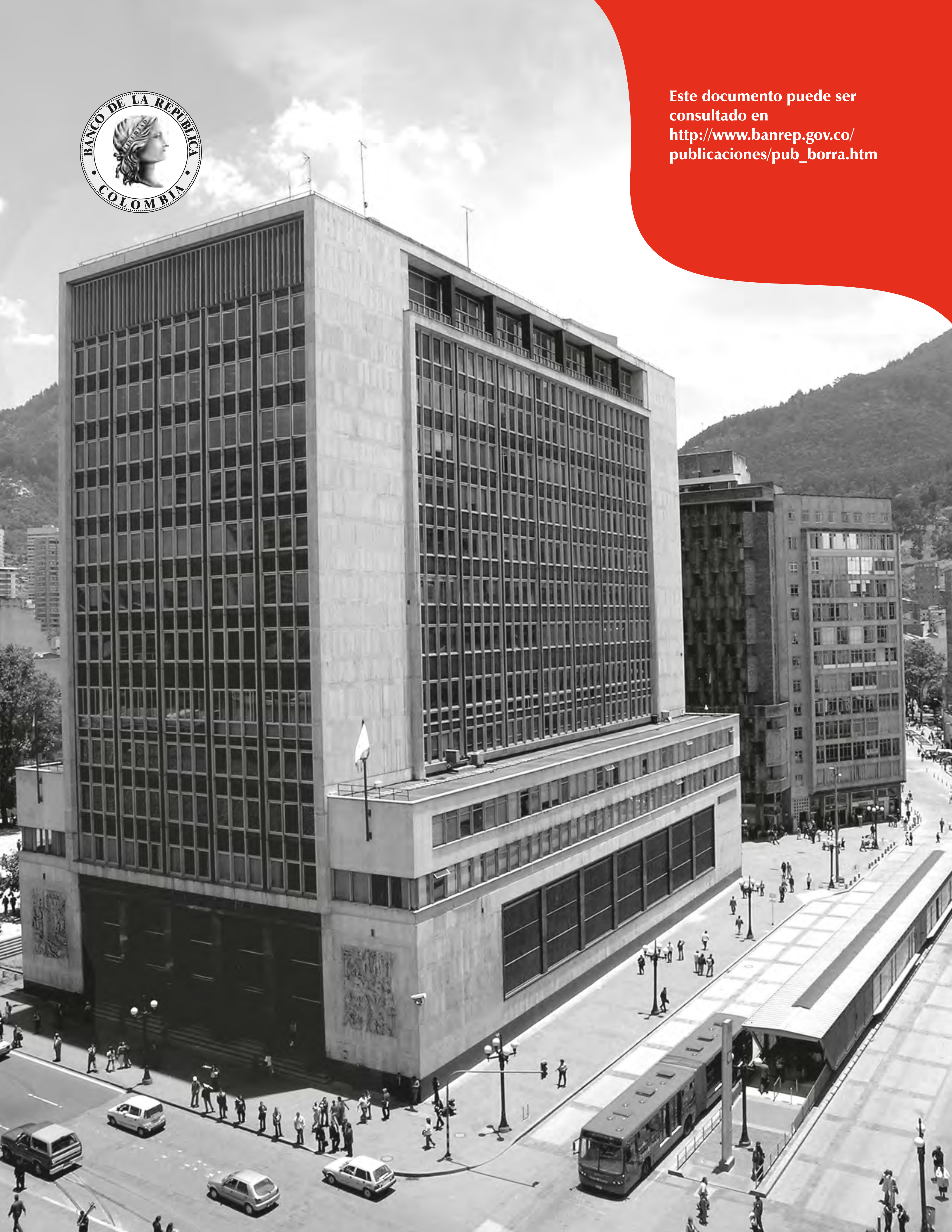
Langville, A.N. and Meyer, C.D.D., Google’s PageRank and beyond: the science of search engine rankings, Princeton University Press, 2012.

Leon, C. and Machado, C. “Designing an expert knowledge-based Systemic importance Index for financial institutions”. Borradores de Economía No. 669, Banco de la República, September 2011.

Leon, C. and Perez, J. “Authority Centrality and Hub Centrality as Metrics of Systemic Importance of Financial Market Infrastructures” Borradores de Economía No. 754, Banco de la República, February 2013.

Tirole, J., “Illiquidity and all its friends”, 8th BIS Annual Conference on "Financial Systems and Macroeconomic Resilience: Revisited”, 2009.

Tucker, P., “The debate on financial system resilience: macroprudential instruments”, Barclays Annual Lecture, London, October 22, 2009.



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