Box 5

An Analysis of Financial Vulnerability using the Heuristic Method

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The test proposed by Aikman et al. (2014) as an early warning mechanism of financial vulnerabilities in the credit establishments (CIs) is duplicated in this Box. This test combines *cluster* techniques (to classify the CIs into homogeneous subgroups), methodologies for calculating financial indicator thresholds, and a fast and frugal decision tree on financial vulnerability in order to predict the individual financial situation of each CI. The method used is heuristic inasmuch as it consists of a simple rule that omits part of the information available in order to make inferences about the future performance of the institutions.[1] The results obtained with the tree methodology suggest its potential to be used as an early warning mechanism for the CIs in Colombia.

1. Definition of Financial Vulnerability and Breakdown of CI Subgroups

In order to establish any kind of early warning mechanism of financial vulnerability, it is essential to specify what is meant by the latter. In this Box, an institution was considered vulnerable if it experienced any of the following events at any point between 2014 and 2016: 1) Resorting to transitory liquidity support from *Banco de la República*; 2) being into special monitoring, capitalization plans or adjustment plans ordered by the Office of the Financial Superintendent of Colombia (FSC), and 3) needing to carry out voluntary clearings authorized by the FSC. The CIs are summarized by the kind of financial intermediaries that were identified as vulnerable at some point during the period under analysis in Table B5.1.

Table B5.1
Number of Fragile and Non-Fragile CIs

Period	CI	Banks	FC	FCs	FCo
Total CI (December 2013)	54	23	21	5	5
Vulnerable (2014-2016)	8	1	7	0	0

Sources: Office of the Financial Superintendent of Colombia and *Banco de la República*.

Additionally, given the heterogeneity of the CIs in the Colombian financial system, it is essential that the methodology be applied separately to subgroups of CIs that are relatively homogeneous in their financial intermediation business in order for it to be successful. The cluster approach,[2] which made it possible to classify the ECs into four groups, was used for this. Group 1: twenty-seven CIs —seven small banks,[3] fifteen finance companies (CFC) and five financial cooperatives (FCO)—; of these, one bank and three CFCs experienced situations of financial vulnerability. Group 2: Five CFCs; of these, four were financially vulnerable. Group 3: fifteen CIs (fourteen banks and one CFC); in this group, none showed a state of financial vulnerability. Group 4: six CIs (one bank and five financial corporations -FC), none of which showed evidence of financial vulnerability. Given that, between 2014 and 2016, there were no CIs that met the characteristics of institutions with financial vulnerability as defined in this study for groups 3 and 4, it was necessary to resort to a statistical procedure to identify institutions that were vulnerable in each one of these groups.[4] For group 3 there were three financially vulnerable banks and for group 4, only one.

* The author works in the Financial Stability Department of *Banco de la República*. The opinions expressed here are the sole responsibility of the author and do not imply any commitment on the part of *Banco de la República* or its Board of Directors. The author would like to thank Linda Mondragón for her valuable contribution to this box as well as Felipe Clavijo and Santiago Gamba for their collaboration in applying the Cluster approach and minimizing the loss function to find some of the thresholds for the groups of credit institutions..

1 According to Gigerenzer et al. (2009) the heuristic fast and frugal tree methodology is also characterized by its transparency and simplicity. Indeed, these processes, which are based on experience in problem-solving and seeing how others solve them, are usually precise, clear, and non-complex. They are also robust in their results in spite of the changes in the environment.

2 This approach was carried out while considering: i) financial deposit structure (CD/deposits and deposits/assets); (ii) allocation structure (loan portfolio/assets, investments/assets, and cash available/assets), and iii) market niche characterized by its administrative and labor expenses as well as its gross financial margin (administrative and labor expenses/assets, and gross financial margin/assets). Information in the financial statements of CIs as of December 2013 was used for this.

3 Each one had less than 1% of the total banking system assets.

4 The ad hoc statistical procedure consisted of: a) all of the financial indicators to be assessed were standardized by applying a transformation to make them take values between zero and one; b) These indicators were grouped into five categories: capital adequacy, profitability, liquidity, efficiency, and credit risk. For each category a variable was calculated as the average of the transformed indicators belonging to that category; c) the indicators of efficiency and credit risk were lined up in the same direction of vulnerability as the remaining indicators (multiplying by -1) and, therewith, a simple average was calculated for the five categories in order to obtain a single indicator of vulnerability per entity, and d) vulnerable institutions in groups 3 and 4 were identified by the subtraction of one standard deviation from the mean.

2. Financial Indicators Used

Just as Aikman et al. (2014) indicated, banks go bankrupt due to a variety of factors that have an impact on the financial performance of the financial system from various angles. This suggests that it is important to combine the information from different indicators including the institutions' financial and administrative management. Twenty-one indicators that cover six financial areas are used in this Box: banking capability, capital adequacy, liquidity, profitability, efficiency, and credit risk. The full list of indicators and their definitions or explanations are presented in Appendix 1.

3. Relevant Thresholds for Individual Financial Indicators

Using the Sarlin loss function methodology (2013) that was applied by Aikman et al. (2014), it is possible to find thresholds for each indicator from which they ideally predict a situation of financial vulnerability. These optimal thresholds minimize the loss function:

$$0.5 \times Pr\ (false\ alarm) - 0.5 \times Pr\ (success)$$

Where success corresponds to the case in which the indicator exceeded the threshold in December 2013 and the CI actually experienced vulnerability at some point between 2014 and 2016, and false alarm corresponds to the case in which the indicator surpassed the threshold in December 2013 and the CI did not experience vulnerability at any time between 2014 and 2016.[5] The probabilities are calculated by means of frequencies. This loss function reflects an equal weighting of false alarms and success. Thus, the smaller the loss, the better the indicator. A perfect signal would detect all the "bankruptcies" with Pr (success) = 1 and would not produce false alarms, thus giving a loss function of -0.5.

4. Fast and Frugal Tree (fast and frugal tree: FFT)

According to Aikman et al. (2014), based on the thresholds calculated for each individual indicator, it is possible to get a lower loss function value by means of the heuristic design of a fast and frugal binomial tree (FFT). The FFT consists of a single signal of vulnerability composed of various financial indicators (with previously calculated thresholds) arranged in "levels." The first indicator (level) is evaluated for each institution, and it is marked with a red exit flag if it exceeds the threshold (and consequently has a forecast of financial vulnerability) or, with a green exit flag if it does not so. In this way, the indicator may be evaluated at the next level or, if this is the last level, it can be given a sign of no vulnerability. The key to the method lies in the number of levels and their arrangement, which is done by expert judgment.[6]

Five indicators (signals) or levels were used for this exercise for each one of the CI groups, which were organized by the value of the loss function, while taking care to choose only one per financial area. The rest of the indicators for each group are not used in the tree. In Diagram B5.1, using this method, the chosen tree is illustrated with five levels (in yellow) for each group. Each level contains the threshold of the respective indicator (to the right of the name of the indicator) and, in parentheses, the value adopted by the loss function when it is minimized, and the result with regard to false alarms. For groups 1, 3, and 4, all levels reached a 100% success rates with an ascending false alarm rates. In other words, all of the vulnerable CIs were, in fact, predicted correctly, but the rapid rise in the rate of false alarms (especially for groups 3 and 4) suggests that the additional levels are not adding relevant information and, therefore, that a smaller number of levels could be desirable. In the case of group 2, the minimum value of the loss function was obtained on the five levels (-0.5) with a success rate of 100% and a false alarm rate of 0%. Theoretically, there could be an absolute certainty that, with this methodology, the CIs in this group would correspond to those that actually had experienced vulnerability between 2014 and 2016.

References

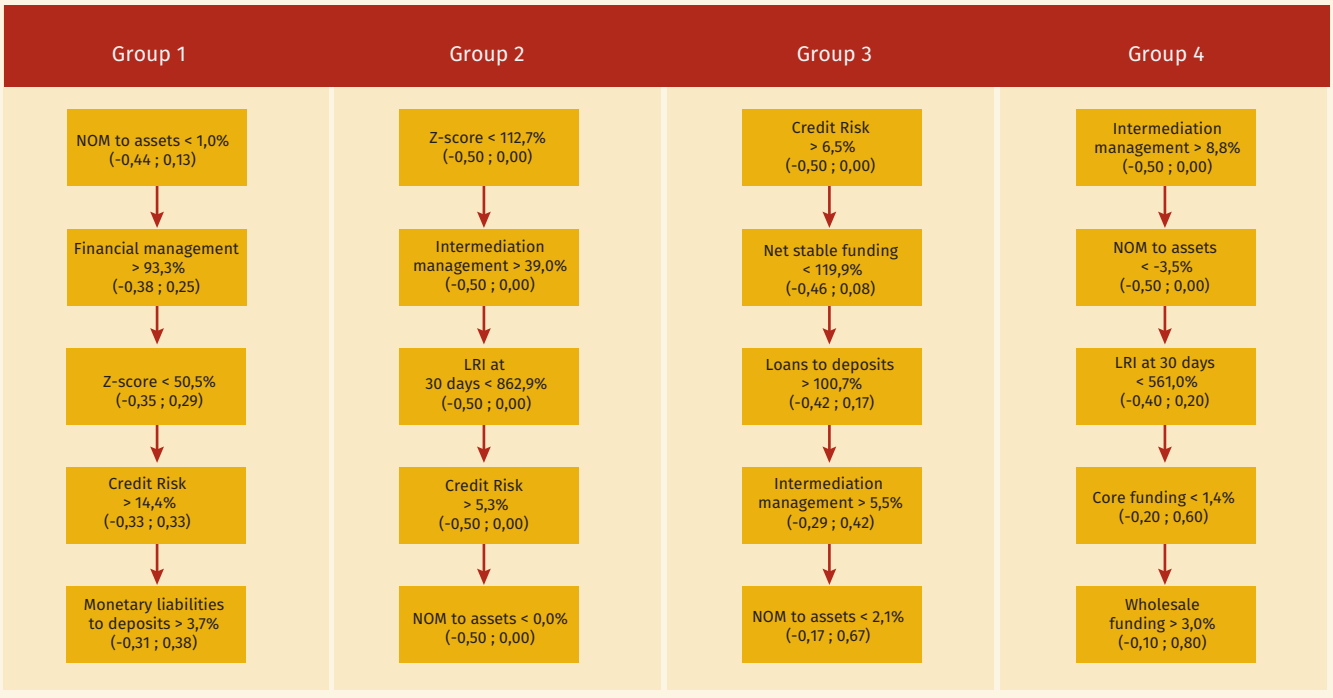
Aikman, D.; Galesic, M.; Gigerenzer, G.; Kapadia, S.; Katsikopoulos, K.; Kothiyal, A.; Murphy, E.; Neumann, T. (2014). "Taking Uncertainty Seriously: Simplicity versus Complexity in Financial Regulation", Financial Stability Paper, No. 28, May, Bank of England.

Gigerenzer, G.; Brighton, H. (2009). "Homo Heuristicus: Why Biased Minds Make Better Inferences," *Topics in Cognitive Science*, vol. 1, pp. 107-143.

5 In general, Pr (success) is the probability of success (success rate), and it captures the number of CIs that are correctly identified as subsequently going into "bankruptcy", given a cut-off threshold, compared to the total number of banks that actually did go bankrupt. Pr (false alarm) is the probability of error (false alarm rate), and it captures the number of CIs that are identified incorrectly as subsequently going into "bankruptcy."

6 If the levels were arranged randomly, a larger number of levels could trivially imply a greater probability of vulnerability due to the fact that each level represents an additional filter that the institutions would have to overcome.

Diagram B5.1
Financial Vulnerability Trees by Group of CIs



Source: Office of the Financial Superintendent of Colombia; calculations by the author.

Annex 1

A1.1 Banking activity

Annual growth of total assets
(*total asse*$_t$ - *total asse*$_{t-1}$) / *total asse*$_{t-1}$

A1.2 Sufficiency of capital to absorb those derived from the financial intermediation business

a. Z-score
   (*average ROA + RST*) / *DS ROA*
   Where *average ROA* is the average annualized return of assets, RST is the total solvency ratio, and *DS ROA* is the standard deviation of the *ROA* for the last twelve months to the date of the indicator.
b. Risk-based capital ratio (RST)
   Technical assets / risk-weighted assets
c. Capital-to-asset ratio Total
   technical assets/total assets
d. Bankruptcy
   Net equity / share capital
e. Liabilities equity
   leverage / net equity
f. Ratio of loans to deposits
   Loans Retail/retail deposits
   where *retail loans* are represented by gross consumer portfolio and gross home portfolio, and *retail deposits* are constituted as the difference between *total deposits* and *wholesale deposits*.

A1.3 Profitability

a. Capital profitability (ROE)
   net profit / average equity
   Net profit takes into account the cumulative flow side of that item in the last twelve months (annualized), and the *average equity* is equity corresponding to the balances of the last twelve months to the date of the indicator.
b. Net operating profitability
   MON / Average total asset
   Where *MON* is the net annualized operating margin. The MON is the sum between the non-financial MON and the MFB (see the following literal). The non-financial MON corresponds to operational income minus labor and ad ministerial expenses, less expenses for net provisions of recoveries. The *total average asset* is the balances of the last twelve months at the date of the indicator.

c. Gross financial return
MFB / average assets
Where the MFB is the difference between financial income and annualized financial outflows.

A1.4 Liquidity

a. Liquid asset ratio
The thirty-day liquidity risk indicator (IRL) was chosen, which is defined as:
IRL = ALM/RNL
where *ALM* is the liquid assets adjusted for market liquidity and exchange risk, and *RNL* are the net liquidity requirements over a 30-day horizon.
b. Ratio of liquid assets to total asset
ALM / total asset
c. Ratio from available to total available
asset / total asset
d. Basic funding ratio
(retail deposits + more than one year funding) / total asset
Where *retail deposits* result from the difference between *total and wholesale deposits*; *Total deposits* are represented by deposits in current account, savings deposits, CDTs, bonds, repos and passive interbank, and the *funding greater than one year* corresponds to bonds greater than eighteen months and CDTs greater than one year.
e. Ratio of wholesale
funding / total asset
where *wholesale funding* is the sum of the SI guiding items: Wholesale deposits, bonds, repos and passive interbank; *wholesale deposits* correspond to the difference between total deposits and deposits originating from households (natural persons) they are extracted from a format sent by the EC to the SFC, which are then adjusted by the total deposit balances obtained from the balance sheet.
Bonds are represented by general guarantee bonds and other bonds less than one hundred months old, general guarantee bonds and other bonds equal to or greater than eighteen months, and mortgage bonds.
Repos and interbank were obtained as the monthly average of daily balances.
Los repos e interbancarios se obtuvieron como el promedio mensual de los saldos diarios.
f. Net stable anchoring (NSFR)
NSFR = ASF / RSF
where the *NSFR* is the reason between the *available stable anchoring* (*ASF*) and the *required stable anchoring* (*RSF*) in the terms provided by Basel III[7].
g. Ratio of monetary liabilities to monetary
passive deposits / deposits
Monetary liabilities are made up of: Simultaneous, transfer of securities, repo and interbank transactions, which were obtained as the monthly average of daily balances.

A1.5 Efficiency

a. Financial management
(*administrative and labor expenses + provisions*) / *MFB*
The items that make up this indicator are annualized flows.
b. Mediation management
(*administrative and labor expenses + provisions*) / *average total asset*
Administrative and labor expenses, and *provisions* are annualized flows, and *total assets* is the average of the balances obtained during the last twelve months to the date of the indicator.

A1.6 Credit and market risks

a. Credit Risk
Total Risky Portfolio / Total Gross Portfolio
Where the *total risk portfolio* is the classified portfolio in categories B, C, D and E.
b. Ratio for participatory investments
investments variable income – investments of subordinates / total investments

7 For a better understanding, see "Basel III: Coefficient of Net stable financing", Committee of Banking Supervision of Basel, Bank for International Settlements, October 2014.