Box 2
Aggregate Vulnerability Indicator

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A new tool that will contribute to the monitoring of the vulnerabilities in the Colombian financial system is introduced in this box. The *overall vulnerability index* (OVI) seeks to identify risk accumulation phases that could contribute to the amplification of economic and financial shocks. Following the methodology proposed by Aikman et al. (2017) and Fisher and Rachel (2017), these types of indicators summarize a broad set of variables by classifying them into different risk categories. This kind of approach recognizes the fact that no variable on its own is sufficient to determine periods of accumulating vulnerabilities in a complex and changing financial system. Furthermore, even though the analysis offers a single indicator of vulnerability, the methodology allows the sectors that constitute the source of vulnerability at each point in time to be identified.

1. Methodology

The 48 indicators that were used to build the OVI and the hierarchical organization used to add the variables are presented in Diagram B2.1. The OVI is composed of vulnerabilities that bring together the accumulation of risks from pressure from abroad, imbalances in the indebtedness of the financial, non-financial, and sovereign sectors, and pressure from financial market valuation. Each vulnerability, in turn, consists of different components associated with economic sectors or financial risks. The OVI is calculated in three stages. In the first stage, the individual indicators in the components are added. This makes it possible to control the weight that each of the sectors of the economy has in the analysis regardless of the number of indicators available for each sector. In the second stage, the components in the vulnerabilities which are a key element for providing clarity regarding the sectors that determine the economy's risk profile during each period are added. The third stage is to construct the OVI based on the vulnerabilities and thus generate an indicator with the highest level of aggregation of the economy's weaknesses.

Prior to each stage of aggregation, the following treatment is done. In order to extract the signals that are targeted, the trend component that the variables may have is eliminated. To make the indicators comparable, the frequency of the information is homogenized by introducing the lower frequency series, and then, the series are standardized and restated using quintiles based on their historical empirical distribution. Thus, the range of the variable is between zero and one. In addition, if the variables are not available for the entire horizon of analysis, Fisher and Rachel (2017) recommend assuming an average value or the first value seen in the series for the information missing in the first few periods while for the information missing from the later periods, the variable is assumed to take on the value of the latest data seen.

2. Results

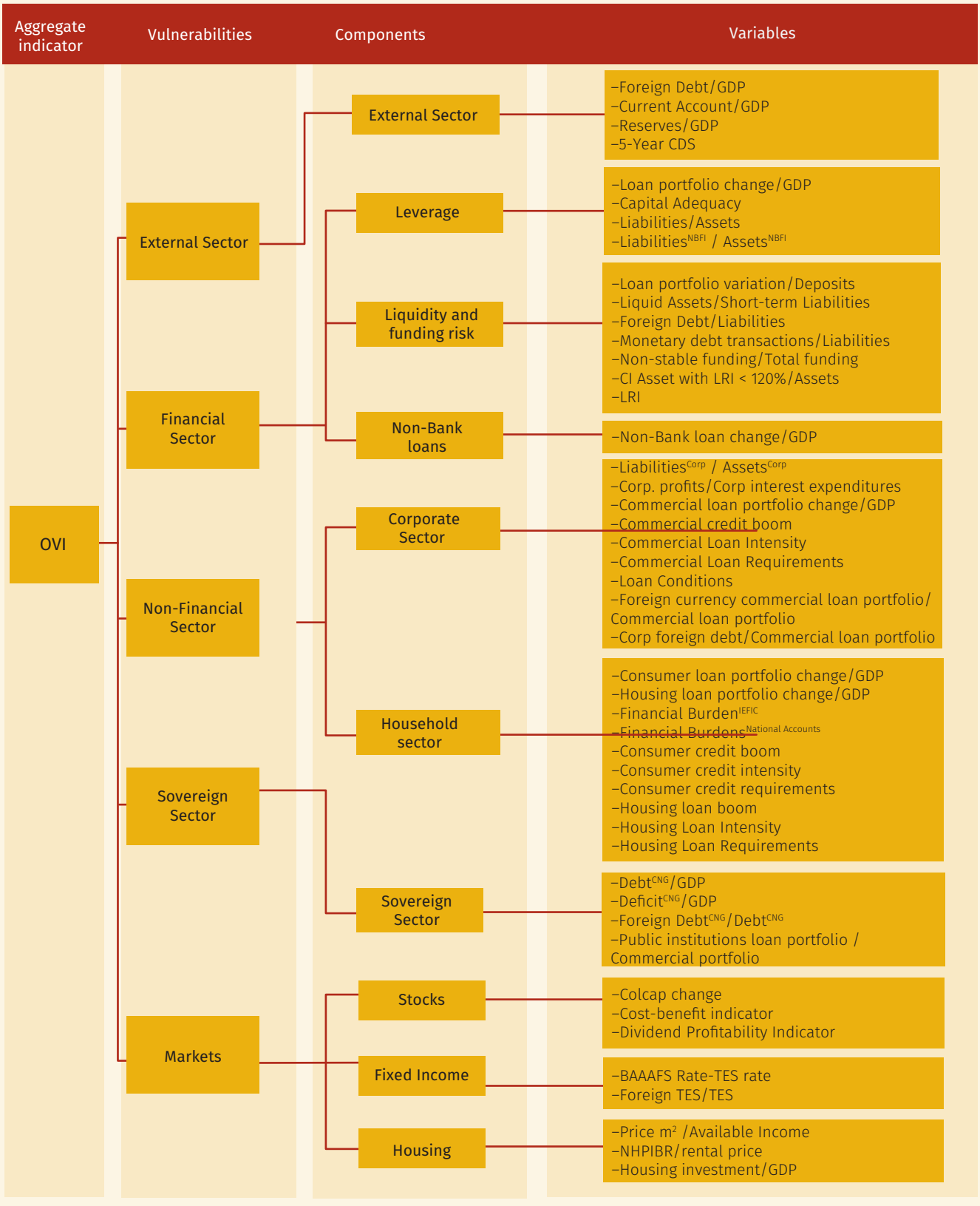
Graph B2.1 shows the results of the OVI and its breakdown for a horizon of analysis between January 1995 and December 2018. The analysis identifies four periods of high vulnerability: 1) November 1997 to December 1998, the period prior to the financial crisis at the end of the century, 2) October 2001 to May 2003, a stage that coincides with the crisis in local public debt market, 3) June 2006 to January 2007, the time when a credit boom was seen in the commercial and consumer loan portfolios, and 4) January 2015 to December 2016, the period after the fall of crude oil prices that was registered in the last quarter of 2014.

The indicator for each of the vulnerabilities and their components is presented in Graph B2.2. This analysis makes it possible to examine the sectors that drive the risk accumulation in the economy for the previously mentioned periods of vulnerability as shown below.

- Period (i) is characterized by imbalances in the foreign, financial, and non-financial sectors that were associated with the worst historical levels of perception of country risk and foreign reserves and high levels of indebtedness in companies, households, and the financial sector. These vulnerabilities were part of the conditions that led to the financial crisis in the late 90s.
- Period (ii) presents growing vulnerabilities in the sovereign sector and higher valuation pressure on the financial and housing markets. The above coincided with a high degree of uncertainty in the region due to the political environment in Brazil, the TES market crisis, and reductions in the country's credit rating which generated significant losses for financial institutions as a result of the valuation of these securities.
- Period (iii) presents high levels of leverage in financial and non-financial sectors. In spite of the fact that improvements in the foreign and sovereign sectors were registered during this period of time, the aggregate indicator reached high levels due to the growth spurt in the loan portfolio and the CIs' exposure to those assets.

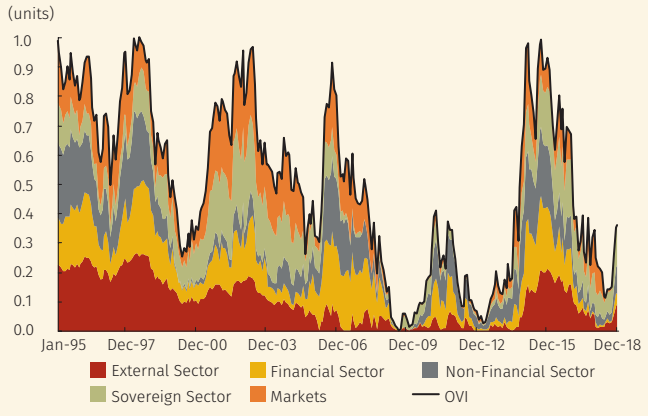
* The authors are part of the Financial Stability Department in *Banco de la República*. The opinions expressed here are the sole responsibility of the authors and do not imply any commitment on the part of *Banco de la República* or its Board of Directors.

Diagram B2.1
Overall Vulnerability Index



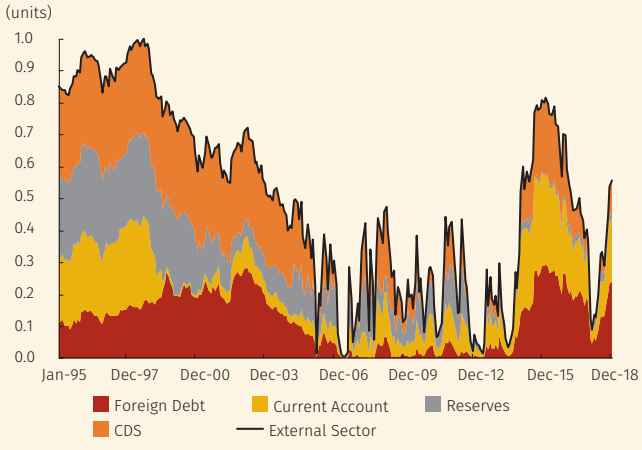
Note: FC: foreign currency, Corp: companies in the private corporate sector, CNG: Central National Government, IEFIC: Survey of Education and Financial Burden INHPBR: Index of New Housing Prices calculated by *Banco de la República*, BAAAFS: yield curve for banks with AAA rating at a simple, fixed-rate, Credit boom: sum of the cyclical component of the per capita loan portfolio and the cyclical component of the annual growth of the per capita loan portfolio, Credit intensity: quarterly growth of the loan portfolio to the quarterly GDP, The financial variables without superscript refer to information from CIs.
Source: authors' calculations.

Graph B2.1
OVI



Sources: Office of the Financial Superintendent of Colombia, DANE, Bloomberg, Ministry of the Treasury, and *Banco de la República*, calculations by *Banco de la República*.

Graph B2.2
Indicator of Vulnerability of the External Sector

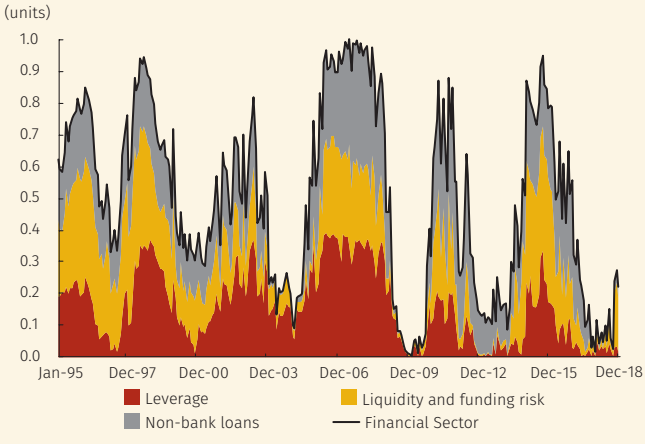


Sources: Office of the Financial Superintendent of Colombia, DANE, Bloomberg, Ministry of the Treasury, and *Banco de la República*, calculations by *Banco de la República*.

In the months that followed, the accumulated credit risk materialized at the same time that the effects of the global financial crisis, which generated a downturn in the Colombian economy, began to appear. However, the implementation of various macroprudential measures that helped contain the growing vulnerabilities of the financial and non-financial sectors as well as sound fiscal and foreign positions contributed to making the impact smaller than expected.

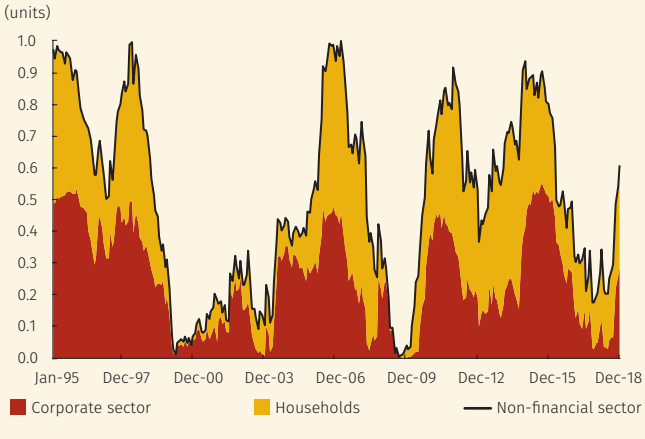
- Period (iv) exhibits a rise in foreign and sovereign imbalances as a direct consequence of the shock to the Colombian economy's terms of trade generated by the drop in petroleum prices. The above resulted in an economic downturn which, in turn, reduced the debtors' ability to pay their obligations with the financial system. This is what is seen in an increase in the corporate sector's vulnerability because of more deterioration in the indicators of debt service and leverage. These vulnerabilities resulted in high levels of default and in a prolonged period of low growth for the credit portfolio.

Graph B2.3
Indicator of Financial Sector Vulnerability



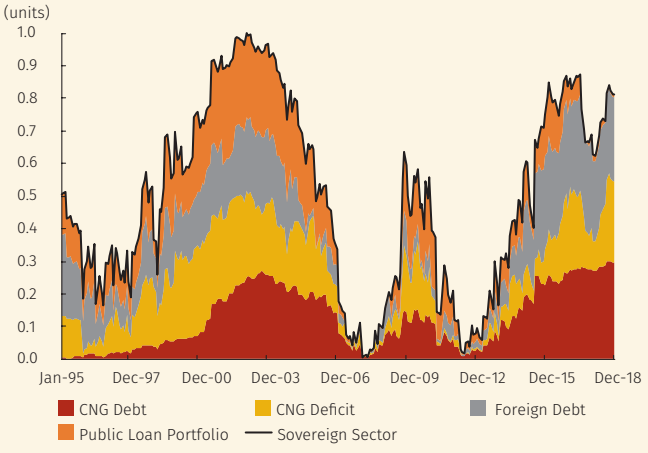
FSources: Office of the Financial Superintendent of Colombia, DANE, Bloomberg, Ministry of the Treasury, and *Banco de la República*, calculations by *Banco de la República*.

Graph B2.4
Indicator of the Non-financial Sector Vulnerability



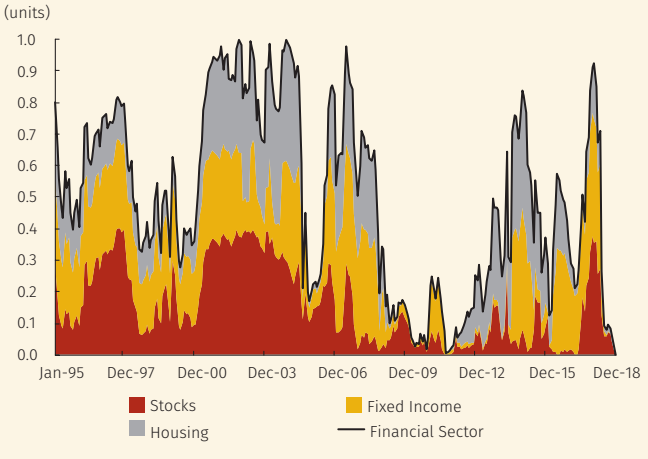
Sources: Office of the Financial Superintendent of Colombia, DANE, Bloomberg, Ministry of the Treasury, and *Banco de la República*, calculations by *Banco de la República*.

Graph B2.5
Indicator of Sovereign Sector Vulnerability



Sources: Office of the Financial Superintendent of Colombia, DANE, Bloomberg, Ministry of the Treasury, and *Banco de la República*, calculations by *Banco de la República*.

Graph B2.6
Indicator of Market Vulnerability



Sources: Office of the Financial Superintendent of Colombia, DANE, Bloomberg, Bloomberg, Ministry of the Treasury, and *Banco de la República*, calculations by *Banco de la República*.

References

Fisher, J., & Rachel, L. (2017). Assessing vulnerabilities to financial shocks in some key global economies. Journal of Risk Management in Financial Institutions, 10(1), 12-35.

Aikman, D., Kiley, M., Lee, S. J., Palumbo, M. G., & Warusawitharana, M. (2017). Mapping heat in the US financial system. Journal of Banking & Finance, 81, 36-64.