Causality between public bond markets and financial stability in an emerging economy

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Abstract

In this paper we assess the impact of diverse macroeconomic shocks on both the public debt market and financial stability by identifying the channels affecting public bond interest rates and prices. The analysis is carried out by using Directed Acyclic Graphs (*DAG*) and Structural Vector Auto-Regression (*SVAR*) models. Our findings indicate that inflation, the policy interest rate, and indicators of risk perception are the variables that most affect the yield curve slope. And this in turn, when it increases, there is a positive concurrent effect on bank risk indicators.

Keywords: Empirical macroeconomics, Directed acyclic graphs, SVAR models.

1. Introduction

Emerging economies have experienced a huge transformation in government bond markets since the turn of the millennium. Though the degree of progress varies across countries, the share of total public debt financed by domestic securities has increased in several countries. Therefore, the development of these markets favored financial stability. This research aims to measure the effect of different shocks on the public debt market and consequently on bank financial stability indicators.

The origin of these shocks is not only associated with the government´s fiscal strategy but also with internal and external factors that could have a major effect on the price of bonds. For instance, the uncertainty surrounding monetary and fiscal policy observed recently in the United States and Europe has changed the price of these assets in emerging economies. In Colombia, the government bond market started in the early nineties, partly as result of the performance of the country's macroeconomic fundamentals. The size of the domestic debt market has been determined by government's fiscal deficit and by its strategy in the management of public debt, which favored domestic credit over external financing.

The causality analysis is carried out by a fusion between Directed Acyclic Graphs (DAG) and Structural Vector Auto-regression Models (SVAR). The identification process was completed taking into account historical information and interviews to the experts in the domestic debt market. DAG models provide an intuitive method for assessing information on sovereign bond markets, shedding light on both the degree of interconnectivity and the direction of causality in the market. Results indicate that inflation, the policy interest rate and indicators of risk perception are the variables that most affect the public bond market. In turn, changes in this market have significant effect on indicators of bank risk.

This paper contains four sections apart from this introduction. The second section contains the methodology we used, including DAG and SVAR models, and describe the data set. The third analyzes the results we obtained from the models. And the last section contains our main conclusions.

2. Empirical strategy and data

The structural causal analysis between macroeconomic variables and financial stability indicators is conducted into two stages. The first is through DAG models from which the contemporaneous effects between macroeconomic and financial variables are identified and quantified (Pearl, 2000). The second step relies on the implementation of DAG models into the SVAR models. In this stage DAG models are used to identify the sequence of causality among the main shocks that alter the public market, in order to estimate consistent impulse response functions (Swanson and Granger, 1997).

2.1 Directed acyclic graphs and Structural Vector-autoregressive Models

The field of graphical models combines ideas from graph and probability theory, facilitating the visualization of probability models, sometimes known as Probabilistic graphical models. The main components of a graph are nodes, which represent random variables, and directed arcs from a node A to a node B that can be interpreted as indicating that A "causes" B. In addition, the lack of arcs represents conditional independence assumptions. Moreover, DAG models are visual representations that allow researchers to encode expert knowledge and beliefs about how the analyzed market works. They reveal the structure of associations and independences that could be observed if the data were generated according to causal assumptions encoded in the DAG (Spirtes, Glymour, Scheines, 2000; Pearl, 2000 and Hoover, 2006). To build and estimate the DAG models relating the government debt market to financial stability, we rely on historical data and interviews with experts on the public debt market.

On the other hand, SVAR modeling is a useful tool in empirical macroeconomics to identify and estimate the dynamic causal structure underlying the data generating process of a system Thus, to find the appropriate causal order of the shocks for the SVAR model, we exploit the advantages of DAG models by testing independence among estimated VAR residuals, which in turn identifies the order taking into account the contemporaneous shocks. The methodology goes as follows: initially, the basic SVAR model in reduced form is described by

$$Y_t = A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + u_t$$

Then, we apply the following three steps (Swanson, N., Granger 1997): 1) Get the matrix of residuals $\hat{u}_t$, from a traditional *VAR* model. 2) Search for causality among $u_{1t} \ldots u_{kt}$ through the use of *DAG* models, which means, in turn, the causality among $y_{1t}, \ldots, y_{kt}$. 3) Estimate the impulse response functions from the *SVAR* model taking into account the order given in step 2. According to the results, the order of the selected shocks is shown in Figure 2 and their impulse response functions including the contemporaneous relationships are presented in Figure 3.

2.2 Data

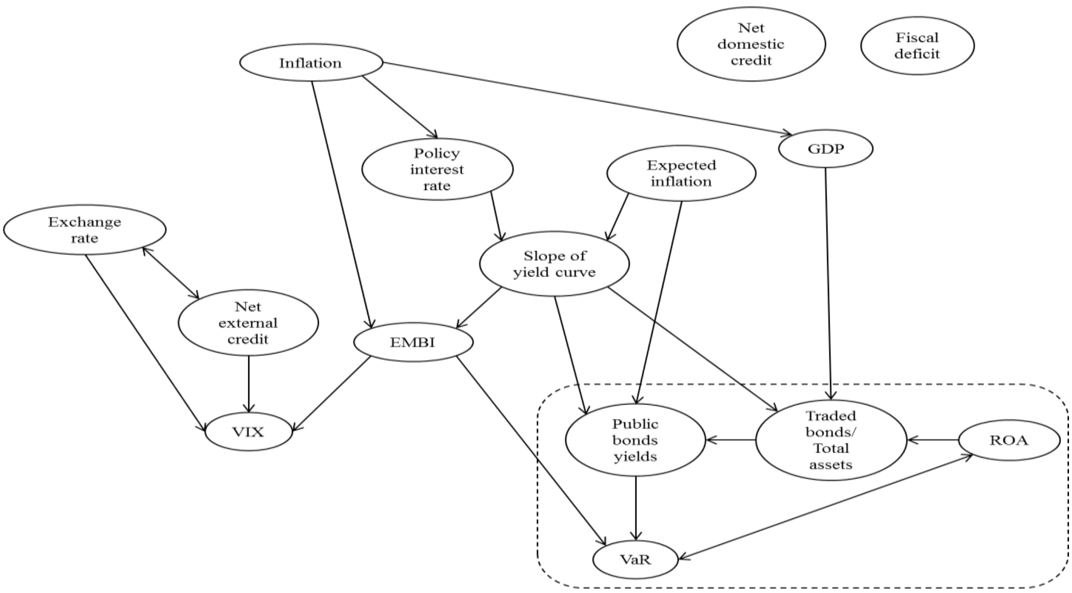
The data set used in the empirical analysis consists of Colombian time series, including output, fiscal and monetary variables, the EMBI (Emerging Markets Bonds Index) and the risk appetite of foreign investors, measured by the VIX (Chicago Board Options Exchange Market Volatility Index). The data frequency is on monthly bases for the period from October 2003 to March 2013. The domestic variables were obtained from the Colombian Central Bank and the EMBI and the VIX from

Bloomberg. The variables of banks including bonds holdings and risk and profitability indicators were calculated by using their financial statements. As indicator of the movements in the interest rate and prices of public bonds, we use the difference between the average monthly rate of 10-year bonds and the average monthly rate on 1-year bonds. This difference is related, in the empirical literature, with the slope of the yield curve, which in turn provides information on the behavior of bond rates at different maturities and, thus, summarizes a complete framework of the structure and behavior of the public bond market.

3. Results

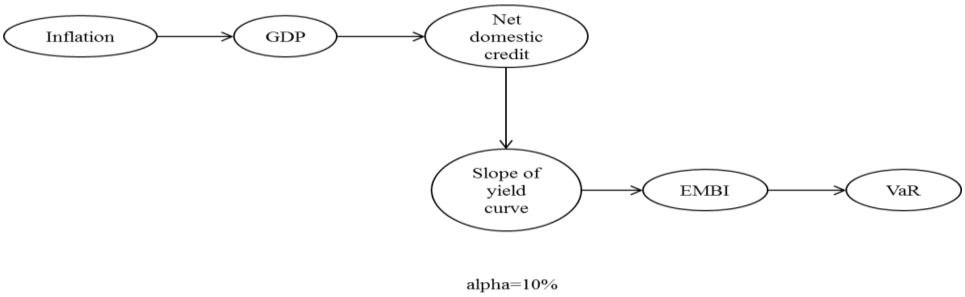
We estimate a DAG model with the evidence, which allows us to infer about the causal structure, retaining some logical relations. Results are observed in Figure 1, which is achieved by computing and testing several conditional independencies among the variables. However, several DAG models might describe the same conditional independence information with observational data. Next, on the inferred causal structure, we quantified the causal effect of the effect of the yield curve slope on the profitability and stability of banks indicators.

Figure 1: Estimated Directed Acyclic Graph



Note: All links are statistically significant at the 10% level. Source: Authors´ design based on DAG model results.

Figure 2: Order's configuration of the shocks by using a DAG model



Source: Authors´ design based on *DAG* model results and logical relations.

3.1 Effects of the shocks on the yield curve and financial stability

In Table 1, the column 2 provides the size of the causal effect and column 3 displays the p-value to control the sampling error. Results indicate that an increase in inflation has a negative contemporary effect on the slope of the yield curve, indicating that innovations in inflation cause changes in the short-term rates on public bonds. Higher inflation also leads to a response in the policy rate, which negatively impacts short-term rates, affecting even more the slope of the yield curve. The slope of the yield curve is also negatively affected by innovations in expected inflation, suggesting adjustments in bond rates at different maturities.

On the other hand, changes in profitability (ROA) and financial stability (Traded bonds/ Total Assets) caused by innovations in the slope of the yield curve is positive in both cases, suggesting that a rise in the slope of the yield curve increase the profitability of banks and especially the return obtained on the possession of government bonds as observed by the direct relation between the slope of the yield curve and the public bond rates in Figure 3. This might be because banks will take advantage of changes in the slope of the yield curve when deciding on their transactions in the public bond market.

Results also suggest that innovations in the slope of the yield curve trigger positive contemporary effects on the share of public bonds in total bank assets. This could be due to the increase in bond yields explained earlier. Moreover, the results show that an increase in the slope of the yield curve has a small positive contemporary effect on the indicator of risk, VaR. The positive impact of this variable is consistent with the result of the SVAR model for the first period, and might be a consequence of the banks taking risk in response to movement in bond prices in the short term. This risk is reduced in the third and fourth periods, due to market adjustments, and stabilizes at around zero from the fifth month (Figure 3).

Table 1: Contemporary effects on the yield curve and on indicators of stability of banks

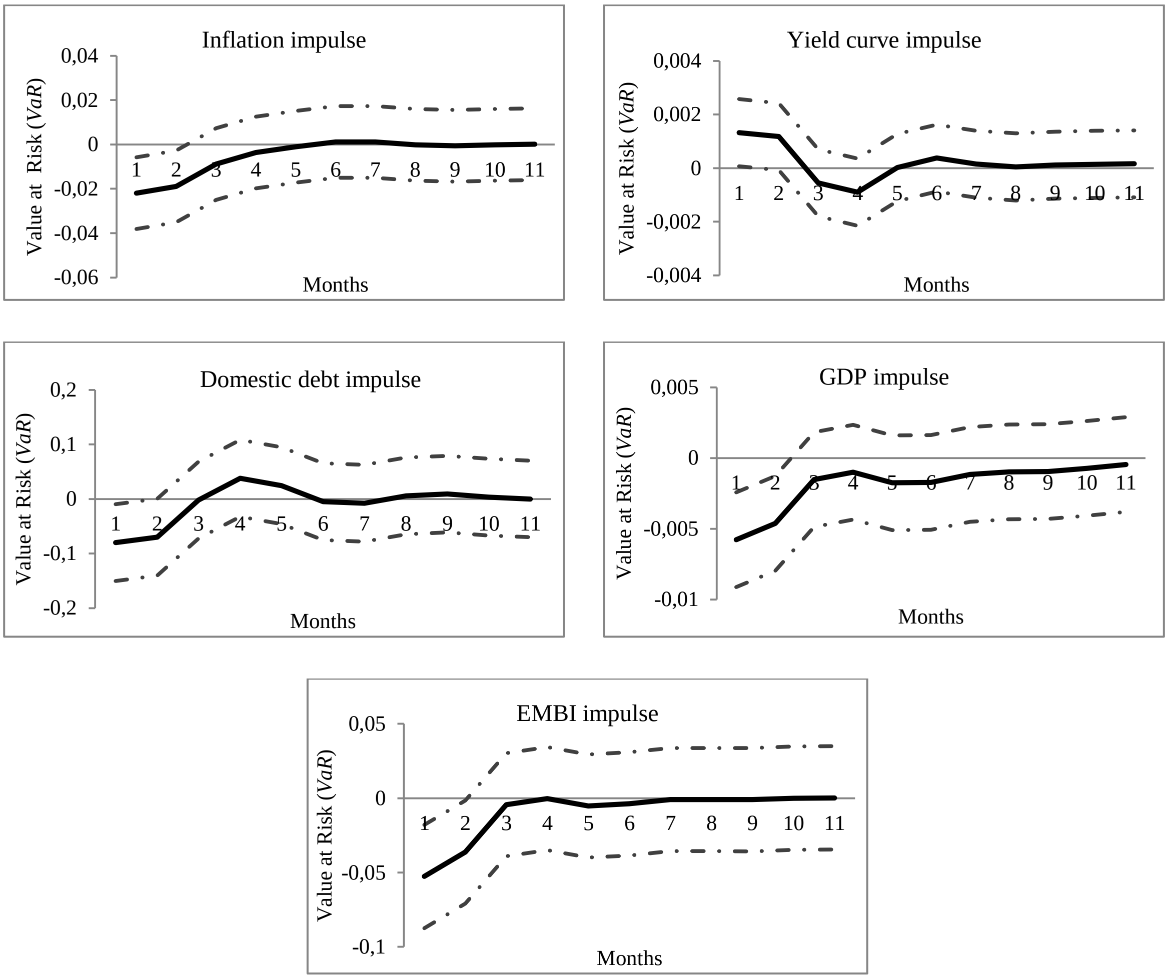
Target variable: Slope of the yield curve	Effect	P-value	
Inflation	-0.1361	0.0000	***
Expected inflation	-0.7263	0.0316	**
Policy interest rate	-1.3402	0.0233	**
Causal variable: Slope of the yield curve			
ROA	0.0037	0.37	
Public Bond Yields	0.5122	0.1034	*
Traded bonds/ Total Assets	1.5579	0.1001	*
Value at risk	0.0002	0.1711	

Source: Author's calculations.
Note: (*), (**) and (***) denote statistical significance at 10, 5 and 1 percent, respectively. The p-values reported come from the estimated *DAG* model. The lower and upper bands are excluded because they are very close to mean effect.
Source: Author's calculations

Finally, it is worth mention that the impulse responses from the SVAR model indicate that innovations in inflation, net domestic debt, the EMBI and GDP have a negative impact on the financial system risk's indicator, VaR, during the first two periods. From the third month, they stabilized at close to zero, suggesting a small impact on this dimension of risk to financial stability (Figure 3).

Figure 3: Impulse response of the value at risk (*VaR*)

Innovation to:



Source: Author's calculations

4. Conclusions

In this study, we apply DAG and SVAR models to evaluate the impact of different shocks on the financial stability and profitability indicators. Although the financial sector is recognized as having benefited from the development of the public bond market, through an alternative form of financial intermediation and the diversification of credit risk, volatility in the debt market also brings potential risks for banks with public bonds in their portfolios.

Government debt markets are affected by internal and external economic shocks that are shown in the slope of the yield curve, which provides information on the behavior of bond rates at different maturities and, therefore, offers a complete framework of the structure and behavior of the bond market. On the other hand, changes in the slope of the curve have effects on banks' profitability and financial stability.

From the DAG results and from the impulse responses functions, we conclude that inflation, expected inflation, and the policy interest rate have a negative contemporary impact on the slope of the yield curve, suggesting these variables affect the short end of the Colombian yield curve. Conversely, the slope of the yield curve has a significant impact on the EMBI behavior. When analyzing the dynamics, our findings suggest that the slope of the yield curve tends to stabilize at around zero to shocks in the mentioned variables.

It is important to highlight that fiscal policy, contrary to what one would expect, has a small contemporary effect on bond interest rates, which may be due to the relatively stable fiscal situation shown during the study period. This could be due to the fact that the market does not internalize changes in the fiscal deficit. Finally, when the gap between the short and long-term rate widens, the contemporary response in the profitability of banks is positive, suggesting banks take advantage, in the short term, of movements in the curve by increasing their trading in the secondary market. As a result, banks tend to increase the share of bonds in their portfolios. Likewise, there is a positive contemporary effect on the indicator of risk due to changes in the slope, which dynamically decreases and tends to stabilize at around zero, suggesting a small impact on this dimension of financial stability.

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