The Colombian banking sector - a contingent claims analysis*

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Abstract

This paper uses contingent claims analysis to assess the credit risk of the Colombian banking sector. Moody's-KMV estimates of expected default frequencies (EDFs) based on market data are used to measure likelihood of default for a sample of five banks. This indicator has several advantages over traditional balance sheet measures of bank vulnerabilities, notably by incorporating market participants' forward-looking, collective view of banks' risk, as well as the effects of market volatility on the bank's risk of default. The paper assesses the effects of key macroeconomic and financial variables on EDFs for Colombian banks for which Moody's-KMV EDFs are available. Step-wise regressions for both individual banks and the aggregate system are estimated, as well as panel regression for the pooled data for individual banks. Consistent with the heterogeneity of banks included in the sample, step-wise regression results differ significantly across banks, although they generally show the vulnerability of banks to changes in key economic activity variables and financial market conditions. Granger causality tests show that EDFs are a leading indicator of non-performing loans.

Resumen

Este documento utiliza el análisis de créditos contingentes para evaluar el riesgo de crédito del sector bancario de Colombia. Las estimaciones de frecuencias de suspensión de pago esperadas (FQE) realizadas por Moody's-KMV miden la probabilidad de riesgo de quiebra para una muestra de cinco bancos. Este indicador tiene varias ventajas en comparación con los tradicionales obtenidos de los balances de los bancos, en particular mediante la incorporación de expectativas de los participantes en el mercado, una visión colectiva de los riesgos de los bancos y los efectos de la volatilidad de los mercados en los pagos de los bancos. El documento evalúa los principales efectos de las variables macroeconómicas y financieras sobre las FQE para los bancos colombianos en las que están estimadas por Moody's-KMV. Se estiman regresiones por etapas para cada banco y a nivel agregado así como una regresión de datos panel para los datos individuales (a nivel de banco). Los resultados de las regresiones por etapas difieren entre bancos debido a la presencia de heterogeneidad entre los mismos, aunque todos presentan vulnerabilidad a los cambios en las variables de la actividad económica y financieras. Las pruebas de causalidad de Granger indican que las FQE son un indicador que antecede el comportamiento de la calidad de la cartera.

Key words: Contingent Claims Analysis, Credit Risk, Banking Sector, Colombia.
Palabras Clave: Contingent Claims Analysis, Credit Risk, Banking Sector, Colombia.
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A. INTRODUCTION

The effects on macroeconomic and financial shocks on the banking system are of great interest to policymakers. Given the important linkages between the real and the financial sectors, particularly during volatile periods, a quantification of these effects may prove useful to anticipate potential changes in the level of risk faced by financial institutions. An option for estimating such effects is a modeling framework of banking system risk, combined with econometric models incorporating relevant macroeconomic and financial sector variables.

This paper uses contingent claims analysis (CCA) to assess risks to the Colombian banking sector. The CCA approach is based on the estimation of the default probability by an entity on its obligations, and is widely used by rating agencies to assess creditworthiness in the corporate sector. The paper builds on recent work using the CCA methodology undertaken in other Latin American countries (e.g., Gray and Walsh, 2008; Souto, 2008). It uses Moody's-KMV estimates of expected default frequencies (EDFs) for Colombian banks, which are constructed with market-based data[1]. The advantage of this indicator is that it incorporates a forward-looking, collective view of risk by market participants. Such a forward-looking element cannot be captured by traditional balance sheet measures of bank vulnerabilities. In addition, EDFs directly incorporate the effects of volatility on risk, and thus better capture the nonlinearities that are particularly important during periods of distress.

The paper estimates the effects of changes in selected macroeconomic and financial variables on default probabilities for a sample of Colombian banks. The sample includes five banks for which market-based default probabilities are available. These account for over one-half of the Colombian banking sector. The paper estimates step-wise regressions for both individual banks and the aggregate system, as well as panel regression for the pooled data for individual banks. Reflecting the heterogeneity of the financial institutions included in the sample, results from step-wise regressions differ significantly across banks, although they generally show the vulnerability of banks to changes in key economic activity variables and financial market conditions. The paper also tests for Granger causality between default probabilities and a traditional indicator of bank credit vulnerability (the ratio of non-performing loans to total loans—NPL ratio) for the banking sector as a whole. The results show that EDFs are a leading indicator of NPL ratios.

Our findings are comparable to those from similar studies undertaken for other emerging markets in Latin America. Using market data, Gray and Walsh (2008, on Chile), and Souto, Tabak, and Vazquez (2008, on Brazil) find that bank soundness is significantly related to macro-financial variables, while also finding evidence of heterogeneity between banks. Blavy and Souto (2008, on Mexico) using risk indicators estimated with book value data for the Mexican banking sector find equally consistent results. In a similar vein, Souto (2007) finds

[1] Other CCA-based indicators of risk include distance-to-distress and expected losses given a default. Gray and Walsh (2007) presents a brief description of these indicators and estimates for the Chilean banking system.

that CCA indicators capture well the episodes of bank stress in Uruguay.

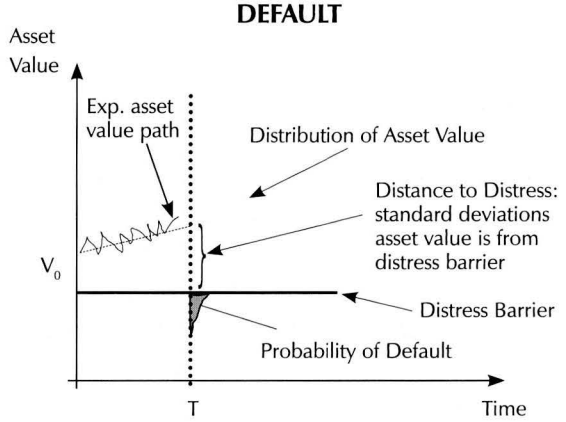
The paper is organized as follows. Section B presents a brief description of the CCA methodology. Section C provides some background on the Colombian banking system. Section D discusses the data and results of the CCA analysis. Section E presents some concluding remarks.

B. THE CCA FRAMEWORK

The CCA offers some distinct advantages over other approaches to vulnerability analysis[2]. First, the CCA takes balance sheet information and combines it with current and forward-looking financial market prices to compute risk-adjusted, marked-to-market balance sheets (i.e. asset values). Using financial market price information to derive forward-looking risk-adjusted balance sheets is a significant advantage compared to an analysis based on past balance sheet information. Second, the CCA distinguishes itself from other vulnerability analysis in that it incorporates market volatility when estimating credit risk. Volatility is crucial in capturing non-linear changes in risk, especially during times of stress, when small shocks can gain momentum and trigger systemic repercussions.

Under the CCA model, a firm's equity can be viewed as a (junior) contingent claim on the residual value of its assets. In the event of default, all the firm's assets are used to pay the senior stakeholders (e.g. debt holders); otherwise equity holders receive the difference between the value of assets and debt. Thus, the equity of the firm can be seen as a call option on the residual value of the firm's assets. This framework enables a rich characterization of a firm's (or sovereign's) balance sheet.

Graph 1. ASSET VALUE & PROBABILITY OF DEFAULT



Source: Author estimates.

With information on the market value and volatility of equity and the value of debt, it is possible to estimate the implied value for assets and volatility through the Black and Scholes option formula. Firms are assumed to default whenever the value of assets fall below a given "distress" barrier. It is then possible to estimate a set of credit risk indicators, including distance-to-distress, default probability, credit spread, and expected losses in the event of default.

At the same time, the CCA is only a tool to help understand credit risk, and certain caveats need to be kept in mind. First, as with any model that uses market information, the quality of the output of the CCA depends on how well market information reflects changes

[2] See Gapen, Gray, Lim and Xiao (2004) for a more in-depth discussion of the advantages and disadvantages of the CCA approach.

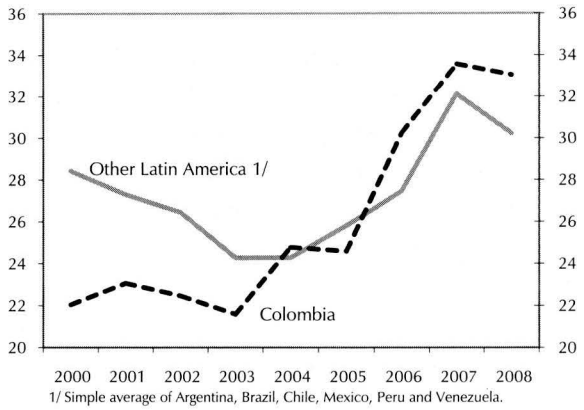
in fundamentals. If markets are imperfect, or react excessively to changes in fundamentals, the CCA indicators may overstate risk. It should also be noted that the CCA's capacity to capture off-balance sheet risks is also imperfect, as it depends on how well these are incorporated into equity prices.

C. SOME BACKGROUND ON THE COLOMBIAN BANKING SYSTEM

Financial intermediation in Colombia has grown considerably in recent years and compares well with regional levels. The recovery from the crisis of the late 1990s and strong economic growth have contributed to a sizeable expansion of financial intermediation during the current decade. As of mid-2008, credit to the private sector was equivalent to 33 percent of GDP, over 10 percentage points up from the beginning of the decade, and slightly above the average for the largest economies in the region. Credit growth in Colombia was very strong in 2005-07 but decelerated significantly over the last year, following substantial monetary tightening by the Banco de la República aimed at containing inflationary pressures and protecting financial sector stability[3]. Consumer credit expanded particularly fast, and currently accounts for slightly under 30 percent of total credit to the private sector.

The Colombian banking system exhibits somewhat high levels of concentration. The system is made up of 17 institutions, all but one privately-owned. In mid-2008, the 5 largest banks accounted for about 70 percent of the system's total assets and liabilities. This level of concentration is comparable to that in other large Latin American countries.

Graph 2. CREDIT TO THE PRIVATE SECTOR, 2000-08 (in percent of gdp)



1/ Simple average of Argentina, Brazil, Chile, Mexico, Peru and Venezuela.

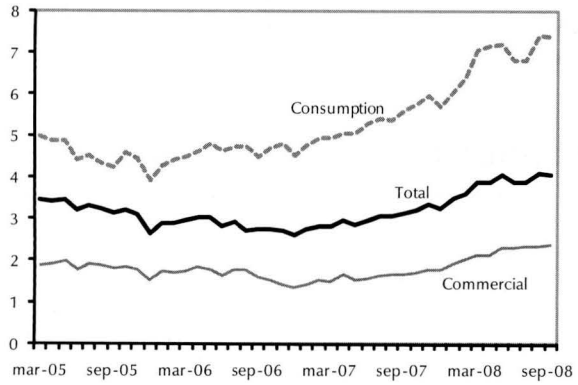
Source: IMF.

Foreign presence in the sector is relatively modest. As of mid-2008, subsidiaries of foreign banks accounted for slightly over 20 percent of the system's total assets and liabilities. While featuring a rising trend over the last few years, this level of foreign participation is significantly smaller than the average for the region, which currently exceeds 30 percent.

Financial soundness indicators for the banking system are solid. The ratio of non-performing loans (NPLS) to total loans has risen over the last couple of years - especially for consumer credit - but remains low at about 4 percent, and NPLS are well provisioned[4]. The system is well capitalized, with risk-adjusted capital ad-

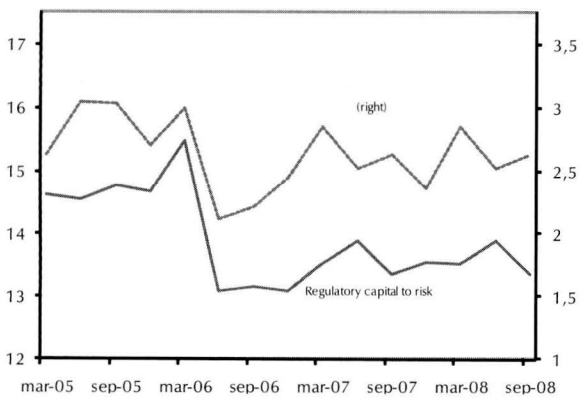
[3] The Banco de la República raised its policy rate by 400 basis points, to 10 percent, between April 2006 and July 2008. It also increased marginal reserve requirements in May 2007, although these were lowered in late 2008 as a preventive measure to ensure adequate levels of liquidity in the system.

Graph 3. NON-PERFORMING LOANS (in percent)



Source: Author estimates.

Graph 4. CAPITAL ADEQUACY AND PROFITABILITY



Source: Author estimates.

equacy well above minimum requirements (9 percent) for most banks. Despite the recent rise in NPL ratios, indicators of profitability have remained strong, with returns on assets hovering around 2½ percent over the last year. Liquidity levels appear adequate, with short-term assets exceeding short-term liabilities by a comfortable margin. With the pace of economic activity decelerating rapidly from the high levels of 2006-07[5], credit risk has become an important source of risk in the banking system (Banco de la República, 2008).

D. THE MODELS

Separate models are estimated for individual banks and the banking system as a whole. Table 1 presents the variables included in the models, along with their expected signs and their data sources. The dependent variables are the EDFs of individual banks (Bank KMV EDF), as estimated by Moody's-KMV; and the banking system's EDF (System KMV EDF), estimated as the weighted average (by banks' total assets) of individual banks' EDFs. Four main channels of propagation are considered: (i) a bank-specific channel; (ii) systemic bank effects; (iii) domestic macrofinancial factors; and (iv) an external macrofinancial channel.

On the bank-specific channel, credit risk from borrowers plays the central role. As the credit quality of banks' lending portfolios deteriorates, there should be a negative impact on their EDFs. We proxy the quality of the loan portfolio by the NPL ratio. Another important variable is bank credit growth, measured as the quarter-on-quarter percentage change in individual banks' total lending. The expected sign of this variable is not clear. On the one hand, a more aggressive bank lending strategy could be associated with lower lending standards, leading higher NPLs and EDFs. However, the same strategy could also lead, at least initially, to an increase in net income, lowering EDFs.

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[4] The data referred to in this paragraph are for September 2008.

[5] GDP growth declined from an average of 7¼ percent in 2006-07 to about 4 percent in the first half of 2008 . It is expected to decelerate further in 2009, against the backdrop of weaker global growth and less buoyant domestic demand conditions.

The systemic variables are defined, and are related to EDFs, in a very similar way. The variable System NPL is estimated as the weighted average (by banks' total assets) of individual banks' NPL ratios. Its sign is as in the specific-bank channel. A variable on credit growth for the banking system is also included. Again, for the reasons discussed above, the sign of this variable is not clear.

Table 1. MODEL VARIABLES - DEFINITION, EXEPCTED SIGNS AND DATA SOURCES

Variable	Definition	Expected signs	Data sources
Bank KMV EDF	Individual bank expected default frequency, as estimated by Moody's-KMV.		Moody's-KMV Database
System KMV EDF	Aggregated expected default frequency estimated as a weighted average (by banks' total assets), using the individual banks EDF.		Moody's-KMV Database and authors' estimation
Bank Credit Growth	Percentage growth rate from quarter to quarter on individual banks total loans.	+ or -	Superfinanciera
Bank NPL	Non-performing loans divided by total loans (which include both performing and non-performing loans).	+	Superfinanciera
System Credit Growth	Percentage growth rate from quarter to quarter on the banks aggregated total loans.	+ or -	Superfinanciera and authors' estimation
System NPL	Aggregated banks NPL.	+	Superfinanciera and authors' estimation
IGBC	Colombian broad equity market index.	-	DataStream
FX Rate	Colombia Peso/US Dollar exchange rate.	+	Bloomberg
Domestic Interest Rate	Interest rate of 90 day certificate of deposit for banks and financial corporations.	-	Banco de La Republica
CPI Inflation	y-o-y inflation rate.	+	DANE
Unemployment Rate	Quarterly unemployment rate for Colombia.	+	DANE
Real GDP Growth	y-o-y percentage change in the real domestic GDP.	-	DANE
EMBI Spread	The J.P. Morgan Emerging Markets Bond Index (EMBI). It is a total return index that tracks the traded market for U.S. dollar denominated Brady and other similar sovereign restructured bonds.	+	Bloomberg
VIX	Chicago Board options exchange volatility index.	+	Bloomberg
S&P 500	US broad equity market index.	+	Bloomberg
Commodities Price	Index for fuel and non-fuel products.	-	International Financial Statistics
US Federal Rate	US interest rate at which depository institutions lend balances at the Federal Reserve to other depository institutions overnight.	+	Federal Reserve

Source: Authors´ elaboration.

Domestic macrofinancial factors come from a number of sources, with different impacts on banks' EDFs. The IGBC is the broad index for the Colombian equity market. In the model, decreases in IGBC would be associated with a deterioration in banks' equity, relative to other more senior claims, and thereby with higher banks' EDFs. A depreciation (decrease) of the exchange rate would imply higher bank exposure to foreign currency, which in the model is expected to lead to an increase in banks' EDFs. Increases in the domestic interest rate are expected to lead to an appreciation of the exchange rate, and an improvement in banks' EDFs. Higher domestic inflation and unemployment , as well as lower GDP growth, would be linked to a deterioration of the macroeconomic environment, which would increase the rate of loans in arrears and banks' EDFs.

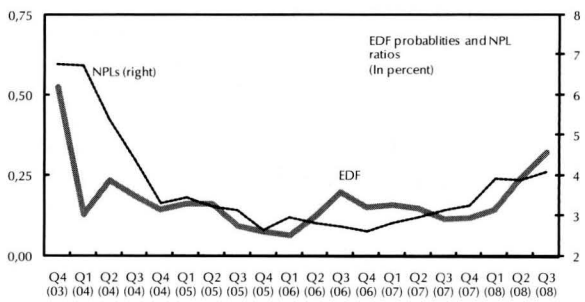
Finally, a few external macrofinancial variables are assumed to affect bank credit risk. The VIX (the Chicago Board Options Exchange Volatility Index) is used as a proxy for risk volatility, risk aversion, and the required premia to bear risk. An increase in the VIX is thus expected to cause EDFs to rise. The S&P500 is the broad U.S. market index. Increases in the S&P500 index are expected to lead investors to migrate from emerging equity markets to U.S. equity markets. This would have a negative impact on the local equity market, causing an increase in banks' EDF. Increases in the the U.S. Federal Funds Rate would be associated with exchange rate depreciation, which, as mentioned above, would lead to a deterioration of banks' EDFs. For commodity prices, we use an index which includes both fuel and non-fuel price export products. An increase in this index would be associated with higher exports by Colombia and an improved macroeconomic environment, which would lead to lower EDFs.

E. IMPLEMENTING THE CCA APPROACH FOR COLOMBIA DATA

Available market-based EDF estimates for Colombia cover about half of the banking system over a relatively short time period. Moody's-KMV estimates of EDFs are available for five banks (two domestically-owned institutions and three foreign subsidiaries), which as of mid-2008 accounted for about 55 percent of total banking system assets and liabilities. The data series starts in the fourth quarter of 2003. While data on EDFs are available on a monthly (and even daily) frequency, this paper uses a quarterly series, given that information for key macroeconomic variables affecting bank risk are available only on a quarterly basis.

Estimated EDFs are highly correlated with traditional measures of bank risk. The market-based EDF data show a decline in bank risk through the first quarter of 2006, and a subsequent upward movement of risk. These trends are strongly correlated with the evolution of the banking system's non-performing loan ratio over the sample period.

Graph 5. ESTIMATED EDFS AND BANK RISK



Source: Creditedge (Moody´s - KMV).

MAIN RESULTS

Stepwise regressions reveal that economic activity and financial market conditions have an important impact on EDFs, but with significant differences across banks. OLS stepwise regressions were ran over time series for individual banks and a set of macrofinancial variables (Table 1). We started with the full set of variables and allowed the regressions to extract the variables for which the covariate coefficient were found to be significant at the 10 percent level or greater. The optimal model specification differed across banks (Table 2). Among the most salient results are the following:

- An increase in the Colombian stock market index (IGBC) is associated with a decrease in the individual KMV EDF for two of the five banks. This is consistent with the CCA framework, in which a higher equity/capital would result in an improved credit risk profile for banks. For one bank, an increase in risk aversion (as measured by the VIX index) is associated with a decrease in the KMV EDF. This would be consistent with the view that, as the degree of risk aversion increases, investors would shift their investment positions away from Colombia and into safer assets.

- For another bank, real GDP growth is associated with an improvement in the KMV EDF, reflecting the impact of real sector 'good periods' into the financial sector.

- The differences in the optimal specification are surprising. The fit of the equations is good, even though the same variable is rarely significant across different banks. These results mirror those of Gray and Walsh (2008).

Table 2. VARIABLES USED IN REGRESSIONS

Dependent Variable:			
Bank KMV EDF			
System KMV EDF			
Covariates:			
Bank Specific	**Bank System**	**Macrofin Domestic**	**Macrofin Foreign**
- Bank Cred. Growth	- Syst. Cred. Growth	- IGBC	- VIX
- Bank NPL	- System NPL	- FX Rate	- S&P 500
		- Dom. Int. Rate	- Comm. Prices
		- CPI Inflation	- US Federal Rate
		- Unemp. Rate	
		- Real GDP growth	
		- EMBI Spread	

Source: Authors´ elaboration.

A stepwise regression for the aggregate banking system also underscores these macro-financial linkages (Table 3). The results suggest that the Moody's-KMV EDF indicator would improve (decrease) if: (i) real GDP growth increases; (ii) the Colombian stock market increases (revealing an increase in equity/capital); (iii) credit growth increases (potentially associated with the higher returns that banks can reap from these loans)[6]; and (iv) the U.S. S&P500 index decreases (in which case investors may look for better returns in other markets such as Colombia).

Table 3. STEPWISE REGRESSIONS FOR INDIVIDUAL BANKS

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5
VIX	0.002 **				
IGBC			-0.004 ***	-0.002 **	
FX Rate			0.009 **		
Real GDP Growth					-0.046 **
Bank NPL				-0.132 *	
Domestic Int. Rate		9.636 **			
US Federal Rate		0.081 *			-0.181 ***
R-Square	31.2%	33.4%	68.6%	37.8%	55.0%
F-Stat	6.81 **	3.51 *	15.32 ***	4.25 **	8.54 ***

Note: ***, **, * indicate that the regression coefficients are statistically different than zero at the 1%, 5%, and 10% significance levels respectively.
Source: Authors´ estimates.

Table 4. STEPWISE REGRESSION FOR THE BANKING SYSTEM

	Bank System
Real GDP Growth	-0.009 **
System Credit growth (LC)	-0.002 *
IGBC	-0.003 ***
S&P 500	0.007 ***
R-Square	82.9%
F-Stat	14.55 ***

Note: ***, **, * indicate that the regression coefficients are statistically different than zero at the 1%, 5%, and 10% significance levels respectively.
Source: Authors´ estimates.

Panel regressions reveal similar results. In order to use all available market-based information for Colombian banks, we ran a linear dynamic panel-data model with fixed effects, based on the Arellano and Bond (1991) GMM estimator. The results (Table 4) show that: (i) an increase in the Colombian stock market index is associated with a decrease in EDFs, as predicted by the underlying framework; (ii) an increase in NPLs is also associated with a decrease in EDFs, consistent with the result found for credit growth in the stepwise regression for the aggregate baking system; and, finally, (iii) an increase in the interest rate is contemporaneously associated with an increase in EDFs. It is important to clarify that the interest rate used was the U.S. interest rate for the 3-month T-bill (proxy for the "risk-free" asset) plus the EMBI spread. Thus, an increase in this interest rate is consistent with a expected deterioration in the banks' EDFs.

Causality tests reveal that the system EDF is a leading indicator of the system NPL ratio, with

[6] There are two counterbalancing forces at play here. On one side, an increase in credit growth is usually associated with an increase in NPLs, which would reduce banks' capital and deteriorate the credit risk indicator. On the other side, these loans also earn a substantial rate of return that may more than compensate for the NPL-related losses (and increase in provisioning). That seems to be the case in Colombia, which would also be consistent with the view that banks have continued to pursue an aggressive policy of credit extension during most of the sample period.

a one-quarter lag. Granger causality tests fail to reject the hypothesis that the system EDF cannot explain the system NPL at the one percent confidence level[7]. At the same time, the tests indicate that the NPL ratio does not explain future movements in the EDF. These results suggest that the system EDF provides useful information beyond what is contained in the NPL ratio and can thus be useful in early warning systems.

Table 5. **DYNAMIC PANEL RESULTS**

	Bank EDF
Bank EDF (lag1)	0.185 ***
Domestic Int. Rate	1.670 ***
IGBC	-0.002 ***
Bank NPL	-0.015 ***

Note: ***, **, * indicate that the regression coefficients are statistically different than zero at the 1%, 5%, and 10% significance levels, respectively.

Source: Authors´ estimates.

E. CONCLUDING REMARKS

Contingent claims analysis can be a useful tool to assess risk in the Colombian financial sector. When compared to traditional measures of bank risk, EDF estimates capture well developments in banking system over the period for which EDF market-based data are available. Importantly, Granger causality analysis shows that the EDFs are a leading indicator of traditional measures of bank risk. Given the availability of EDF estimates on a high frequency, CCA could thus be a helpful tool in improving the monitoring of the financial system's health.

Table 6. **RESULTS FOR GRANGER CAUSALITY TESTS**

Equation	Excluded	Chi-Square
System EDF	System NPL	16.36
System NPL	System EDF	3.53

Source: Authors´ estimates.

Empirical estimates show that macroeconomic and financial shocks have an important bearing on banking sector vulnerabilities. Econometric results show that a positive shock to economic growth reduces risk for the banking system as a whole. Interest rate increases and downward movements in the domestic stock market are associated with a rise in bank risk. Results for individual banks vary widely, reflecting the heterogeneity of the Colombian banking sector. However, financial institutions in general show vulnerability to changes in key domestic macroeconomic variables, as well as to changes in domestic and international financial market conditions. These results are consistent with findings for other Latin American countries in studies using CCA.

There is scope to improve and extend the application of the current analysis of the Colombian banking system. The quality of the estimates for the relationship between macroeconomic and financial market variables, and banking sector risk could be strengthened through the use of longer time series. This could be done by using higher frequency data,

[7] This result holds even when we exclude the observations for 2004, a period when the system EDF clearly seems to cause the system NPL.

which are readily available for all variables included in the various models, except for economic growth. The latter could, however, be proxied by combined forward-looking indicators of economic activity currently produced on a monthly basis in Colombia (e.g., industrial production, retail sales, etc.)[8]. Another approach could be to use principal component analysis to summarize the impact on bank risk of changes in diverse macrofinancial variables, building, for example, on work done for Chile by Gray and Walsh (2008).

[8] Principal component analysis could be used to produce a leading indicator of economic activity that incorporates existing indicators.

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